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EVALUATION OF SOIL TILLAGE PROCESS TO IMPROVE SEEDBED PREPARATION AND CROP DENSITY
/
ŽEMĖS DIRBIMO PROCESO VERTINIMAS SĖKLOS GUOLIAVIETĖS PARUOŠIMUI IR PASĖLIO TANKUMUI OPTIMIZUOTI

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Abstract: *The humidity of the soil and the quality of seedbed preparation is an important factor influencing crop density and early establishment. It largely depends on weather conditions, but partly it can be controlled by soil management system.*

Field experiments of different soil tillage methods were carried out at Experimental Station of Aleksandras Stulginskis University in 2009. Treatments involved: 1) direct drilling, 2) shallow ploughing (10 cm depth), 3) deep ploughing (20 cm depth). In the experiment spring barley (Hordeum vulgare L.) variety 'Simba' was cultivated. The soil of experimental site – Calc(ar)i-Endohypogleyic Luvisol (Drainic).

The aim of the research was to estimate the influence of soil management system on seedbed parameters and crop density. It was estimated, that the highest roughness of the soil surface (31.8 mm) was, when the soil was ploughed at 20 cm depth, but contrarily the seedbed roughness was the lowest (15.2 mm). Estimated direct drilling depth was 15.6 mm and in ploughed soil it was 51.7–57.4 mm. In ploughed soil at 20 cm depth the seeds were sown too deep – 88.4 % of them were below sowing depth. When direct drilling was used – too shallow – 57.8 % of seeds were above sowing depth. The highest accuracy was estimated in shallow ploughed soil – 43.8 % of the seeds were at sowing depth. Nevertheless in the dry weather conditions spring barley germinated faster when direct drilling was used, later on, experimental results showed, that spring barley crop density was significantly thinner (180 plants per m^2) compared to deep or shallow ploughing, whereas depth of the ploughing did not influence thickness of crop stand: it was 431–445 plants per m^2.

Keywords: *deep and shallow ploughing, direct drilling, seedbed, crop stand density*

Santrauka: *Dirvos drėgnumas ir sėklos guoliavietės paruošimas yra svarbūs veiksniai nulemiantys sėklų sudygimą ir daigų augimą. Daugiausia tai priklauso nuo aplinkos sąlygų, bet tam turi įtakos ir žemės dirbimo būdas.*

Skirtingų žemės dirbimo būdų lauko eksperimentai buvo atlikti 2009 m. Aleksandro Stulginskio universiteto bandymų stotyje. Eksperimento variantai: 1) tiesioginė sėja; 2) seklus arimas (10 cm); 3) gilus arimas (20 cm). Buvo auginami vasariniai miežiai (Hordeum vulgare L.) 'Simba', dirvožemis – drenuotas karbonatingas giliau glėjiškas ištplaužemis (Calc(ar)i-Endohypogleyic Luvisol (Drainic).

Tyrimų tikslas – nustatyti žemės dirbimo būdo įtaką sėklos guoliavietės parametrams bei pasėlio tankumui. Buvo nustatyta, kad didžiausiais dirvos paviršiaus nelygumas (31,8 mm) buvo taikant gilųjį arimą iš rudens, tačiau sėklos guoliavietės nelygumas buvo mažiausiais (15,2 mm). Tiesioginės sėjos gylis buvo 15,6 mm, o artame dirvožemyje – 51,7–57,4 mm. Giliai artame (20 cm) dirvožemyje net 88,4 % sėklų buvo pasėta per giliai, o taikant tiesioginę sėją – 57,8 % per sekliai. Tiksliausiai sėklos buvo pasėtos ariant sekliai – 43,8 % sėklų buvo sėjos gylyje. Nežiūrint to, kad esant sausiems orams, tiesioginės sėjos laukeliuose vasariniai miežiai sudygo greičiau, vėliau buvo nustatyta, kad pasėlis esmingai retesnis (180 vnt. m^2) nei artame dirvožemyje. Arimo gylis neturėjo esminės įtakos pasėlio tankumui, artame dirvožemyje augalų buvo 431–445 vnt. m^2.

Raktiniai žodžiai: *seklus ir gilus arimas, tiesioginė sėja, sėklos guoliavietė, pasėlio tankumas.*

INTRODUCTION

Seedbed preparation is crucial for the growth of seedlings, plant establishment and the final yield of crops. A great consideration is needed to determine the most suitable conditions for crop growth. An important aspect of this is the physical characteristics of the seedbed such as soil strength, bulk density, water content, water retention, aggregate size and distribution, aggregate stability, temperature, oxygen and nutrient availability [2,8]. Experimental evidence suggests that different soil tillage and sowing methods has a significant effect on soil structure, soil bulk density, total and air-

ĮVADAS

Sėklos guoliavietės paruošimas yra labai svarbus veiksnys turintis įtakos sėklų sudygimui, daigų ir augalų augimui ir galutiniam derliui. Dėl to labai svarbu nustatyti ir sudaryti pačias tinkamiausias sąlygas augalų augimui jau pačioje pradžioje. Svarbiausi sėklos guoliavietės agrofizikiniai parametrai yra: dirvožemio šlytis, tankis, vandens kiekis, dirvožemio vandentalpa, dirvožemio agregatų dydis ir jų pasiskirstymas, agregatų stabilumas, temperatūra, deguonies ir maisto medžiagų kiekis [2,8]. Eksperimentiniai tyrimai rodo, kad skirtingi žemės dirbimo ir sėjos būdai labai įtakoja dirvožemio struktūrą, tankį,

filled porosity, soil moisture and crop yield [5,14,12,9,6]. A seedbed is defined as a loose shallow surface layer, tilled during seedbed preparation with a basal layer underneath which is untilled and usually firm [3]. A seedbed is required to provide a medium for germination, root growth, emergence and establishment [1], as such this covers a wide range of determinate factors. Seedbed preparation and sowing, often referred to as secondary tillage, aim primarily to create suitable soil conditions for germination, plant emergence and subsequent crop growth: the seed should be placed at a desired depth; the soil at sowing depth should contain enough water and suitable temperature and aeration conditions for germination; the seedbed should act as an evaporative barrier; the soil should not be over-compacted; tillage operations should also control weeds [1]. Seedbed practices are therefore key as cultivation implements impose varying degrees of alterations to both the surface soil and sub-soil. As such it is crucial to determine the best practice for seedbed preparation to maximise crop establishment and yield. The aim of our experiment was to estimate the influence of soil management system on seedbed parameters and crop density.

MATERIALS AND METHODS

Experimental site and soil. Field experiments were carried out at the Experimental Station of the Aleksandras Stulginskis University (former Lithuanian University of Agriculture) (54°53′ N, 23°50′ E) in 2009. The soil of the experimental site is Calc(ar)i-Endohypogleyic Luvisol (Drainic) according to the WRB 2014 [4]. The main soil properties were: soil pH_{KCl} 6.7–7.2, arable layer 25 cm, humus content in the arable layer 2.2–3.0%, total N 1.47 g kg^{-1}, available phosphorus (P_2O_5) 119–242 mg kg^{-1}, and available potassium (K_2O) 100–124 mg kg^{-1}.

Experimental design. The experiment had a one-factor design. It was performed in four replications. Spring barley (*Hordeum vulgare* L.) variety 'Simba' was cultivated using different soil management practices: 1) direct drilling, 2) minimum tillage (10 cm depth), 3) deep tillage (20 cm depth).

Method to characterize the quality of a seedbed. Immediately after sowing the mean depth is determined by transferring all loose soil within a 40x40 cm^2 steel frame to a measuring cylinder. Before this, the difference in elevation between the highest and the lowest points of the soil surface within the frame is measured to give a simple characterization of the roughness of the surface, and afterwards, the roughness of the base of the seedbed is determined in the same way. The seedbed in the open frame at the side is separated into two or three sub-layers using a scoop and simple hand tools. The soil from each sub-layer is transferred to a hand sieve set to determine the aggregate size distribution and the number of seeds.

Crop density. Density of spring barley crop was evaluated by counting method (with 20 x 30 cm frame) in 16 places of each plot.

Meteorological conditions. April 2009 was 2.8 times warmer compared to the annual average and extremely dry. Rainfall was 4.5 times less than usual and all it dropped out during the first ten days, the hydrothermal coefficient of the April was 3.8 (very wet). During the sowing time of spring crops, the hydrothermal coefficient

bendrąjį ir aeracinį poringumą, dirvožemio drėgmę ir augalų derlių [5,14,12,9,6]. Sėklos guoliaviete vadinamas sėjos metu supurentas paviršinis dirvos sluoksnis su apatiniu dirvos sluoksniu, kuris įprastai yra kietas [3]. Sėklos guoliavietė apima daug lemiančių veiksnių, tai vieta, kurioje dygsta sėklos, auga šaknys, daigai ir augalai. Sėklos guoliavietės paruošimu ir sėja, kurie dažnai vadinami antriniu žemės dirbimu, visų pirma siekiama sukurti tinkamas sąlygas sėklų dygimui, daigų ir vėliau augalų augimui: sėklos turi būti įterpiamos reikiamu gyliu; dirvožemis sėjos gylyje turi būti pakankamai drėgnas, tinkamos temperatūros, turi pakakti oro ir vandens; sėklos guoliavietė turėtų neišdžiūti; dirvožemis neturėtų būti per daug tankus, turėtų būti sunaikintos piktžolės [1]. Taigi sėklos guoliavietės paruošimas yra labai svarbus veiksnys turintis įvairiapusės įtakos tiek dirvos paviršiui, tiek podirviui. Labai svarbu nustatyti optimaliausią sėklos guoliavietės paruošimo metodą, kad pasėlis kuo geriau augtų ir duotų didžiausią derlių. Mūsų tyrimų tikslas buvo nustatyti žemės dirbimo būdo įtaką sėklos guoliavietės parametrams bei pasėlio tankumui.

TYRIMŲ METODIKA

Eksperimento vieta ir dirvožemis. Tyrimai buvo atlikti 2009 m. Aleksandro Stulginskio universiteto (anksčiau Lietuvos žemės ūkio universitetas) Bandymų stotyje (54°53′ N, 23°50′ E). Dirvožemis – drenuotas vidutinio sunkumo priemolis ant moreninio molio drenuotas karbonatingas giliau glėjiškas ištplaužemis (Calc(ar)i-Endohypogleyic Luvisol (Drainic) (IUSS Working Group WRB, 2014). Dirvožemio pH_{KCl} 6.7–7.2, ariamasis sluoksnis – 25 cm, humuso– 2.2–3.0%, $N_{(sum.)}$ 1.47 g kg^{-1}, judriųjų P_2O_5 – 119–242 mg kg^{-1} ir K_2O – 100–124 mg kg^{-1}.

Bandymo schema: Eksperimentas atliktas taikant vienfaktorinę analizę, keturiais pakartojimais. Eksperimento variantai: 1) tiesioginė sėja; 2) seklus arimas (10 cm); 3) gilus arimas (20 cm). Buvo auginami vasariniai miežiai (*Hordeum vulgare* L.) 'Simba'.

Guoliavietės kokybės nustatymo metodas. Vidutinis guoliavietės gylis nustatomas iškarti po sėjos, nuimant visą supurentą dirvožemį iš 40x40 cm^2 dydžio metalinio rėmo ir supilant į matavimo cilindrą. Prieš tai nustatomas dirvos paviršiaus nelygumas, kurį parodo išmatuoto aukščiausio ir žemiausio dirvos paviršiaus taško aukščio skirtumas. Po to, pašalinus supurentą dirvožemį iš rėmo, tokiu pačiu būdu nustatomas ir sėklos guoliavietės paviršiaus nelygumas. Sėklos guoliavietės dirvožemis rėme suskirtomas į du ar tris sluoksnius naudojant kastuvėlį. Kiekvieno sluokslio dirvožemis sijojams atskirai ir nustatomas skirtingo dydžio agregatų pasiskirstymas bei sėklų kiekis kiekviename tiriamame dirvožemio sluoksnyje.

Pasėlio tankumas. Vasarinių miežių pasėlio tankumas nustatomas skaičiavimo metodu su 20 x 30 cm rėmeliu, 16-koje kiekvieno laukelio vietų.

Meteorologinės sąlygos. 2009 m. balandžio mėnuo buvo 2,8 karto šiltesnis palyginti su daugiamečiu vidutiniu ir ypatingai sausas. Kritulių iškrito 4,5 karto mažiau nei įprasta ir visi jie iškrito per pirmąją balandžio dekadą, jos

of the second and third ten days was 0; there were no rainfall at all. At May, the average temperature was 2°C below the annual average. At the end of the first ten days started to rain, but moisture, however, was too low, because during the second ten days was too little rainfall. A little more rainfall was only at the end of May. This month's average hydrothermal coefficient was 1.3 (sufficient moisture). June was nearly 1°C cooler and precipitation was 1.7 times more than the usual, hydrothermal coefficient 2.6 (very wet). The air temperature and precipitation in July was a close to the annual average estimate hydrothermal coefficient 1 (sufficient moisture). August was wet (hydrothermal coefficient 1.7), although the average air temperature and precipitation was close to the annual average. However, the first ten days was favourable for harvesting, there were no rainfall.

Statistics. Statistical significance of differences between treatments was evaluated by Fisher's protected least significant difference test at $P_{(level)} < 0.05$ was performed using package of statistical programmes SELEKCIJA [15].

RESULTS

The roughness of the soil surface shows the difference in elevation between the lowest and highest points of the surface. In our experiment the influence of soil management practices on soil surface roughness was significant (Fig. 1). The highest unevenness of soil surface after barley sowing was when the soil was deep ploughed in autumn, compared with shallow ploughing (8.5 %) and direct drilling (18.6 %). The lowest soil surface roughness was in direct sowing plots. A. Kairyte (2005) found that all methods of minimised soil tillage and direct drilling significantly reduced the soil surface roughness in comparison with deep ploughing in autumn [7]. In our experiment the highest roughness of the base of the seedbed was in shallow ploughed soil – 39.9 % higher compared to direct drilling, and 49.0% if compared with deep ploughing in the autumn.

hidroterminis koeficientas 3,8 (labai drėgna). Vasarojaus sėjos metu, antrą ir trečią dekadas visai nelijo – hidroterminis koeficientas 0. Gegužės mėnesio vidutinė oro temperatūra buvo 2°C žemesnė nei daugiametė vidutinė. Pirmos dekados pabaigoje pradėjo lyti, tačiau drėgmės vis dar trūko, nes antrąją dekadą kritulių vėl buvo mažai, daugiau kritulių iškrito tik gegužės pabaigoje. Šio mėnesio vidutinis HTK – 1,3 (pakankamas drėgnumas). Birželio mėnuo buvo beveik 1° C vėsesnis ir kritulių iškrito 1,7 karto daugiau nei įprasta HTK – 2,6 (labai drėgna). Liepą oro temperatūra ir kritulių kiekis buvo artimi daugiamečiams vidurkiams HTK – 1,5 (pakankamai drėgna). Rugpjūčio mėnuo buvo drėgnas – HDK 1,7, nors vidutinė oro temperatūra ir kritulių kiekis buvo artimi daugiamečiams vidurkiams. Tačiau pirmoji dekada, buvo palanki derliaus nuėmimui, visai nelijo.

Statistinė analizė. Statistinė duomenų analizė buvo atlikta naudojant kompiuterinę programą SELEKCIJA [15], įvertinant mažiausio esminio skirtumo ribą R pagal Fišerio kriterijų, esant 95 proc. tikimybės lygiui (P < 0.05).

REZULTATAI

Dirvos paviršiaus nelygumas parodo atstumą tarp žemiausio ir aukščiausio paviršiaus taško. Žemės dirbimo būdų įtaka paviršiaus nelygumui buvo esminė (1 pav.). Didžiausias dirvos paviršiaus nelygumas, miežių pasėlyje nustatytas giliai rudenį artoje dirvoje palyginus su sekliu arimu (8,5 proc.) ir tiesiogine sėja (18,6 proc.). Mažiausias dirvos paviršiaus nelygumas buvo taikant tiesioginę sėją. A. Kairytė, 2005 m. nustatė, kad visi supaprastinto žemės dirbimo būdai ir tiesioginė sėja iš esmės mažina dirvos paviršiaus nelygumą, palyginti su giliuoju arimu rudenį [7]. Mūsų eksperimente didžiausias sėklos guoliavietės nelygumas nustatytas sekliai artoje dirvoje: 39,9 proc. didesnis palyginti su tiesioginės sėjos ir 49,0 proc. su rudenį giliai artu pasėliu.

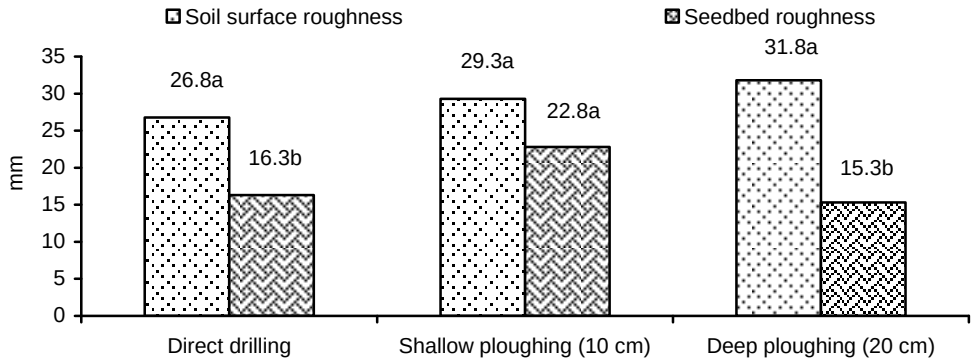

Fig. 1 – The roughness of the soil surface (LSD_{05} = 6.40) and the roughness of the base of the seedbed (LSD_{05} =4.34) using different soil management practices

Seedbed quality/conditions determine plant uniformity and growth intensity in the beginning of the vegetation. Fast and uniformly emerged crops have capability to smoother weeds and are the basis for a good harvest. The quality of seedbed depends on tillage and quantity of organic matter [16,11].

According to I. Hakansson et al. (2002), A. Velykis and A. Satkus (2005) the optimal depth for sowing in heavy

Sėklos guoliavietės sąlygos lemia augalų vienodumą pasėlyje ir vystymosi intensyvumą vegetacijos pradžioje. Greitai ir vienodai sudygę pasėliai vešliai auga ir gerai stelbia piktžoles ir yra gero derliaus pagrindas. Sėklos guoliavietės kokybė priklauso nuo žemės dirbimo ir organinių medžiagų kiekio [16,11].

Kaip teigia I. Hakansson su bendraautoriais (2002), A. Velykis ir A. Satkus (2005) geriausias sėklų įterpimo gylis

soils is 3–5 cm [3,16]. In our experiment sowing depth closest to the optimal was in the shallow and deep ploughed soil (51.7–57.4 mm) (Fig. 2). In direct drilling sowing depth was on average 3.4 times shallower than in autumn ploughed soil. This difference was significant.

sunkiuose dirvožemiuose yra 3–5 cm [3,16]. Mūsų eksperimente sėklų įterpimo gylis artimiausias nustatytam buvo iš rudens sekliai (10 cm) ir giliai (20 cm) artoje dirvoje (52–57 mm) (2 pav.). Tiesioginės sėjos pasėlyje sėkla įsiterpė vidutiniškai 3,4 karto sekliau negu iš rudens dirbtoje dirvoje. Šis skirtumas buvo esminis.

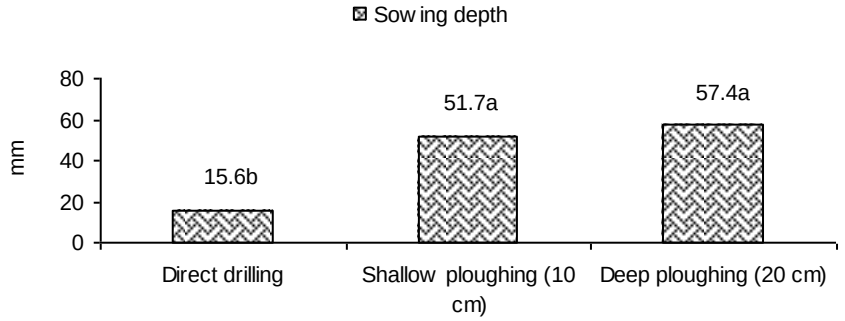

Fig. 2 – Sowing depth using different soil management practices (LSD_{05} = 13.45)

The highest quantity of seeds (57.8%) in the top seedbed layer (L1) were distributed when direct drilling was used, that was significantly higher (5.8 times more) compared to shallow ploughing plot (Table 1). In this layer no seeds were found when deep ploughing in the autumn was used. In the sowing depth (L2) the most quantity of seeds (43.8%) were when soil was shallow ploughed in the autumn: that was 1.2 times and 3.8 times more compared with direct drilling and deep ploughing, accordingly. When soil was shallowly ploughed in the autumn, almost half of seeds (45.5%) were distributed deeper than the optimum sowing depth (4–5 cm), and when the soil was ploughed deeply, most of the seeds (88.4%) were incorporated too deep. It could be stated that sowing depth of spring crops in direct drilling largely depends on soil compaction. Autumn and pre-sowing tillage allows more even seed distribution in soil and less seeds remains on soil surface. Experiments made by other authors showed that even seed introduction was also reduced when the intensity of soil tillage was minimized, because the soil surface became harder, the greater part of the plant residues remained in the soil surface or was introduced into the upper soil layers, preventing seed introduction [11].

Viršutiniame sėklų guoliavietės sluoksnyje (L1) daugiausiai sėklų išbiro tiesioginės sėjos pasėlyje, tai yra 57,8 proc. visų pasėtų sėklų ir esmingai 5,8 karto daugiau palyginti su sekliu arimu (1 lentelė). Visai sėklų šiame sluoksnyje nerasta giliai artame pasėlyje. Sėjos gylyje daugiausiai 43,8 proc. visų pasėtų sėklų rasta iš rudens sekliai artame (L2) pasėlyje – 1,2 karto daugiau palyginti su tiesiogine sėja ir 3,8 karto – su giliuoju arimu. Rudenį sekliai suarus beveik pusė (45,5 proc.) visų išsėtų sėklų įsiterpė giliau, nei optimalus sėjos gylis (4–5 cm), o suarus giliai beveik visos sėklos (88,4 proc.) įsiterpė per giliai. Galima teigti, kad sėjant vasarinius augalus į nedirbtą dirvą, sėklos įterpimo gylis priklauso nuo dirvos suslėgimo. Rudeninis ir priešsėjinis žemės dirbimas leidžia tolygiau įterpti sėklą ir jos mažiau lieka dirvos paviršiuje. Kitų autorių atliktų eksperimentų duomenimis, sėklų įterpimo tolygumas sumažėja mažinant žemės dirbimo intensyvumą, dėl sutankėjusio dirvos paviršiaus bei didesnio augalinių liekanų kiekio ant dirvos paviršiaus ar viršutiniame dirvos sluoksnyje, dėl to pablogėjusių sąlygų tolygiam sėklų įterpimui [11].

Table 1

The effect of primary soil tillage on the seed distribution in seedbed layers

Soil management practices	Spring barley seed distribution %		
	Soil surface (L1)	Sowing depth (L2)	Under sowing depth (L3)
Direct drilling	57.8	37.0	5.2
Shallow ploughing (10 cm)	10.7	43.8	45.5
Deep ploughing (20 cm)	0	11.6	88.4
	LSD_{05} = 10.44	LSD_{05} = 13.39	LSD_{05} = 25.43

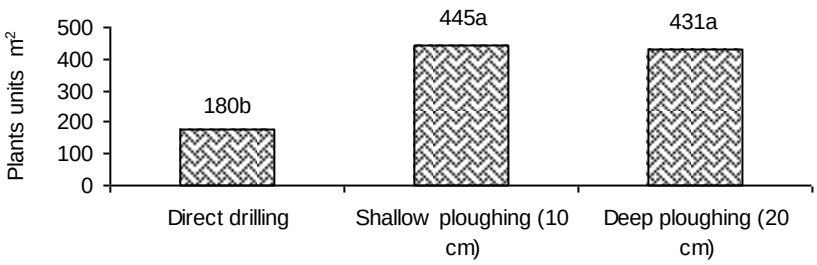

Fig. 3 – Spring barley germination using different soil management practices (LSD_{05} = 87.14)

The quality of soil preparation for sowing, soil physical mechanical properties, and moisture content has a great influence on the field seeds germination. Proper seedbed preparation significantly increases seeds contact with the soil. Our experiment showed that a soil management practice has a significant effect on the germination of spring barley (Fig. 3).

When the soil in the autumn was deeply or shallowly ploughed the germination of barely was on average 2.4 times higher than in direct drilling. Nevertheless the moisture content in the no tilled soil was sufficient, but during winter soil was compacted therefore the seed was sown too shallow and that had significant influence on poor germination of barley. Minimum soil tillage according to seedbed quality in heavy soils is more suitable for the winter crops than for spring crops [16,10]. Reduced primary soil tillage can be applied in cereal cultivation on Central Lithuania's cultivated sandy light loamy soils: instead of conventional soil tillage (stubble breaking at a depth of 10–12 cm and deep ploughing at a depth of 22–25 cm) it is feasible to apply direct drilling or minimal soil tillage at a depth of 10–12 cm. Replacement of conventional soil tillage by direct drilling into non-tilled and into minimally tilled soil suits best for oats and winter wheat grown after good preceding crops [14]. Application of shallow ploughing for the pea provided the worst germination [17]. Spring barley and peas were more susceptible to the simplification of autumn soil tillage: when barley and peas were sown into minimally tilled soil or direct-drilled into non-tilled soil spray-applied with Roundup (4 l ha^{-1}), a significantly lower yield was obtained [14].

CONCLUSIONS

Experiments of different soil tillage methods showed, that the highest roughness of the soil surface (31.8 mm) was when the soil was ploughed in the autumn at 20 cm depth, but contrarily the seedbed roughness was the lowest (15.2 mm).

Sowing depth of spring crops in direct drilling largely depended on soil compaction. Deep or shallow soil ploughing allowed more even seed distribution in soil and less seeds remained on soil surface. The highest accuracy was estimated in shallow ploughed soil – 43.8 % of the seeds were at sowing depth.

When the soil in the autumn was deeply or shallowly ploughed the germination of barely was on average 2.4 times higher than in direct drilling. Nevertheless in the dry weather conditions spring barley germinated faster when direct drilling was used. Later on, spring barley crop density was significantly thinner (180 plants per m^2) compared to deep or shallow ploughing, whereas depth of the ploughing did not influence thickness of crop stand: it was 431–445 plants per m^2.

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Sėklų lauko daigumui didelę įtaką turi dirvos paruošimo sėjai kokybė, dirvožemio fizikinės mechaninės savybės bei drėgnis. Sėklų kontaktą su dirvožemiu iš esmės padidina tinkamas sėklų guoliavietės paruošimas. Mūsų eksperimente žemės dirbimo būdai turėjo esminės įtakos miežių sudygimui (3 pav.).

Iš rudens giliai ir sekliai artuose pasėliuose miežiai dygo vidutiniškai 2,4 karto geriau palyginti su tiesiogine sėja. Drėgmės pakako, tačiau per žiemą susigulėjusi nedirbama žemė buvo supuolusi ir kieta, miežių sėkla įsiterpė per sekliai, kas ir turėjo esminės įtakos miežių sudygimui. Nustatyta, kad supaprastintas žemės dirbimas sunkiuose dirvožemiuose sėklų guolio kokybės požiūriu labiau tinka žieminiams augalams negu vasariniams [16,10]. Supaprastintas žemės dirbimas gali būti naudojamas javams Centinėje Lietuvos dalyje lengvuose smėlio dirvožemiuose: vietoj tradicinio žemės dirbimo (ražienų skutimo 10–12 cm gyliu ir gilaus arimo 22–25 cm gyliu) galima taikyti tiesioginę sėją ar minimalų žemės dirbimą 10–12 cm gyliu. Tiesioginė sėja į nedirbtą ar minimaliai dirbtą žemę tinkamiausia avižoms ir žieminiams kviečiams po gerų priešsėlių [14]. Seklus arimas pablogina žirnių sudygimą [17]. Vasariniai miežiai ir žirniai jautresni supaprastintam rudeniniam žemės dirbimui: kai miežiai ir žirniai buvo sėjami į minimaliai dirbtą ar taikant tiesioginę sėją į minimaliai dirbtą ar nedirbtą, raundap (4 l ha^{-1}) nupurkštą dirvą, gautas esmingai mažesnis derlius [14].

IŠVADOS

Atlikus skirtingų žemės dirbimo būdų eksperimentus, buvo nustatyta, kad didžiausiais dirvos paviršiaus nelygumas (31,8 mm) buvo taikant gilųjį arimą iš rudens, tačiau sėklos guoliavietės nelygumas buvo mažiausiais (15,2 mm).

Tiesioginės sėjos gylis labiausiai priklausė nuo dirvos tankio. Taikant gilųjį ar seklųjį arimą sėklų įterpimas buvo tolygesnis ir mažiau sėklų lieko dirvos paviršiuje. Tiksliausiai sėklos buvo pasėtos ariant sekliai – 43,8 % sėklų buvo sėjos gylyje.

Taikant rudeninį gilųjį ar seklųjį arimą miežių sudygimas buvo vidutiniškai 2,4 kartus didesnis lyginant su tiesiogine sėja. Nežiūrint to, kad esant sausam orui, tiesioginės sėjos laukeliuose miežiai sudygo greičiau, vėliau buvo nustatyta, kad pasėlis žymiai retesnis (180 vnt. m^2) nei giliai ar sekliai artame dirvožemyje. Arimo gylis neturėjo esminės įtakos pasėlio tankumui, artame dirvožemyje augalų buvo 431–445 vnt. m^2.

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AN ANALYSIS OF CORN TILLAGE AND CULTIVATION ENERGY CONSUMPTION AND GHG EMISSIONS
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ŽEMĖS DIRBIMO TECHNOLOGIJŲ KUKURŪZAMS ENERGIJOS IR ŠESD RODIKLIŲ ANALIZĖ

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Abstract: *This article discusses various corn tillage technologies and analyses their energy consumption and GHG emissions. The experimental research and analytical calculations took place in Lithuania and were carried out using five different tillage technologies of varying intensities: deep ploughing, shallow ploughing, deep cultivation, shallow cultivation, and the no-tillage system (NT). The research has determined that lower intensity tillage technologies expend 12-58% less energy than deep ploughing. NT technology causes the least pollution: the agricultural machines involved only emit only an average of 107 kg ha^{-1} of CO_2. The most efficient technologies in terms of energy efficiency are the NT and the conventional deep ploughing.*

Keywords: *tillage, fuel consumption, CO_2 emissions, energy indicators, corn.*

Santrauka: *Šiame straipsnyje pateikiama skirtingų žemės dirbimo technologijų, auginant kukurūzus, energijos sąnaudų ir šiltnamio efektą sukeliančių dujų (ŠESD) analizė. Eksperimentiniai tyrimai ir analitiniai skaičiavimai Lietuvos sąlygomis atlikti taikant 5 skirtingo intensyvumo žemės dirbimo technologijas: gilų arimą plūgu, seklų arimą plūgu, gilų kultivavimą, seklų kultivavimą ir tiesioginę sėją (NT). Tyrimais nustatyta, kad taikant mažesnio intensyvumo žemės dirbimo technologijas, degalų sąnaudas galima sumažinti nuo 12 iki 58 %, lyginant su gilaus arimo technologija. Mažiausiai aplinką teršia NT technologija, kurioje žemės ūkio mašinos, degindamos degalus, į aplinką išmeta vidutiniškai apie 107 kg ha^{-1} CO_2 dujų. Geriausi energetinio efektyvumo koeficientai nustatyti taikant NT ir įprastinę gilaus arimo technologijas.*

Raktiniai žodžiai: *žemės dirbimas, degalų sąnaudos, CO_2 dujų emisija, energetiniai rodikliai, kukurūzai.*

INTRODUCTION

The most important objective of tillage is to create favorable soil conditions for plant growth. Annual deep ploughing has usually negative consequences: the values of good soil properties decrease and the subsurface soil layer condenses [1, 2, 3]. Crop type, meteorological conditions, terrain, soil fertility level, organic matter content, weed infestation, moisture conditions, soil structural level, available tillage techniques, know-how, etc. most influence the tillage technology choice. Without a doubt, every tillage system has advantages and disadvantages. A higher yield is more likely with traditional plough tilling, but due to the low performance of tillage operations and the need for high-power tractors, the tillage costs are usually the highest. In addition, the adverse effect of conventional tillage on the environment, soil, and biodiversity is also very high [2, 3]. Irrational selection of tillage machines and their working mode can also adversely affect the environment. More toxic gases may be emitted due to increased load on the machines in such cases, which damage the natural ecosystem environment [4].

Environmentally sustainable systems with minimum tillage and no-tillage are increasingly used searching for alternatives to reduce the intense tillage with the plough. Thus the tillage machinery effects on soil degradation and soil properties are reduced; the subsurface soil layer condenses less, which preserves more the natural water filtration and the plant root penetration into the various layers of the soil [5].

The main challenge of sustainable agriculture is to limit its intense impact (mechanical, chemical and biological) on soil and plants, to reduce its negative consequences to ensure a continuous renewal of soil

ĮVADAS

Svarbiausias žemės dirbimo tikslas yra sudaryti palankias sąlygas augti augalams. Kasmetinis gilus arimas plūgu labai dažnai neigiamai veikia daugelį dirvos savybių bei skatina poarmeninio dirvos sluoksnio sutankėjimą [1, 2, 3]. Didžiausią įtaką tinkamos žemės dirbimo technologijos pasirinkimui daro numatomų auginti augalų rūšis, meteorologinės sąlygos, reljefas, dirvos sukultūrinimo lygis, organinių medžiagų kiekis, piktžolėtumas, drėgmės sąlygos, dirvos struktūringumo lygis, turima žemės dirbimo technika, technologinė patirtis ir kt. Be jokios abejonės, kiekviena žemės dirbimo sistema turi savų privalumų ir trūkumų. Taikant tradicinį žemės dirbimą ariant plūgu yra didesnė tikimybė gauti didesnį augalų derlių, tačiau dėl mažo žemės dirbimo technologinių operacijų našumo ir didelės galios traktorių poreikio, tokio žemės dirbimo išlaidos dažniausiai būna pačios didžiausios. Be to, tradicinio žemės dirbimo neigiamas poveikis aplinkai, dirvai ir bioįvairovei taip pat yra labai didelis [2, 3]. Neracionalus žemės dirbimo mašinų arba jų darbo technologinių rėžimų parinkimas taip pat neigiamai veikia aplinką. Tokiais atvejais, dėl padidėjusių mašinų apkrovų, gali būti į aplinką išmetama daugiau nuodingų deginių, o visa tai stipriai pažeidžia natūralią aplinkos ekosistemą [4].

Ieškant alternatyvių galimybių mažinti intensyvų verstuvinį žemės dirbimą, vis plačiau taikomos aplinką tausojančios minimalaus žemės dirbimo ir tiesioginės sėjos technologijos. Tokiu būdu mažinamas žemės dirbimo mašinų poveikis dirvos degradacijai, dirvos savybėms, mažiau sutankinami dirvos sluoksniai, dėl ko išsaugoma natūralesnė vandens filtracija ir augalų šaknų skverbimasis į įvairius dirvos sluoksnius [5].

productivity, protect the biosphere, and maintain cost-effective production. Sustainable agriculture has a number of objectives: a more rational use of materials, energy, and labour resources to meet stringent environmental requirements for the production of healthy and cheap agricultural products. But perhaps the most important objective of sustainable agriculture is soil conservation. The aim is to preserve soil, prevent the loss and degradation of humus, reduce the nutrient leaching and soil water pollution, protect soil from erosion and structure depletion, promote natural biological processes, better balance of field organic metabolism, and improve the topsoil layer aeration and irrigation [6].

One of the most important tasks of environmental sustainability is to reduce the human impact on climate change through economic activity. Over the past few decades, CO_2, methane (NH_4), nitrous oxide (N_2O), and other gas emissions have been increasing. The popular term for these is *greenhouse gases* or *GHG* [7]. CO_2 has the greatest impact among the greenhouse gases. Its level in the atmosphere, compared to pre-industrial revolution era level, has increased from 280 ppm to 366 ppm [8].

No less important than environmental aspects are the energetic and economic features of cultivation technology. For the purposes of no-plough minimum tillage or no-tillage systems plant the yield and the quality are likely to be lower, but the costs of land cultivation and sowing operations are also lower. In addition, recent technological impact on the environment and biodiversity is also more positive than conventional tillage.

Reducing the tillage and seeding operations and the number of machines driving over the soil can significantly reduce fuel consumption and thus greenhouse gas emissions from the tractor/machinery agricultural units. Research done in Germany demonstrated that burning 1.0 litre of diesel emits about 3.76 kg of gas into the atmosphere [9]. The energy costs of implementing these operations are an important variable for assessing the pollution of tillage operation in Lithuania.

The aim of the work is to evaluate energy and environmental aspects of deep and shallow ploughing, deep and shallow hoeing, and no-tillage systems to determine their technological energy efficiency.

MATERIAL AND METHOD

The research was carried out at Aleksandras Stulginskis University Experimental Station with its mid Lithuanian meteorological conditions and loamy soil in 2009-2012.

Five different technologies were researched in terms of the energy and environmental impacts of tillage:

1. Uncultivated soil – no-tillage system (NT)
2. Shallow cultivating with a disc harrow at a depth of 12-15 cm (SC)
3. Deep cultivating with a cultivator at a depth of 25-27 cm (DC)
4. Shallow ploughing at a depth of 12-15 cm (SP)
5. Deep ploughing at a depth of 23-25 cm (control)

The purpose of choosing the traditional tillage technology as the control was to be able to compare it

Tausojamosios žemdirbystės pagrindinis uždavinys – ribojant intensyvų technologinį (mechaninį, cheminį, biologinį) poveikį dirvai ir augalams, mažinant neigiamas jo pasekmes, užtikrinti nuolatinį dirvos produktyvumo atsinaujinimą, tausoti biosferą ir išlaikyti ekonomiškai efektyvią gamybą. Tausojamajai žemdirbystei keliama daug tikslų: racionaliau naudoti materialinius, energetinius ir darbo išteklius, tenkinti griežtus aplinkosaugos reikalavimus, gaminti sveiką ir pigią žemės ūkio produkciją. Tačiau bene svarbiausias tausojamosios žemdirbystės tikslas yra dirvosauga. Siekiama nealinti dirvos, stabdyti jos humuso nykimą ir degradaciją, mažinti maisto medžiagų išplovimą ir dirvos nuotekų taršą, saugoti dirvą nuo erozijos ir struktūros ardymo, skatinti natūralius biologinius procesus, geriau subalansuoti laukuose organinių medžiagų apykaitą, gerinti armens sluoksnio aeraciją ir drėkinimą [6].

Vienas iš svarbiausių aplinkos tausojimo uždavinių yra mažinti žmogaus ūkinės veiklos daromą įtaką klimato kaitai. Pastaruosius kelis dešimtmečius vis didėjo CO_2, metano (NH_4), azoto suboksido (N_2O) ir kitų dujų emisijos į aplinką. Šios dujos populiariai vadinamos šiltnamio efektą sukeliančiomis dujomis ŠESD [7]. Tarp šiltnamio efektą sukeliančių dujų pagal daromą įtaką svarbiausios yra CO_2 dujos, kurių kiekis atmosferoje, lyginant buvusį prieš industrinę revoliuciją su šiomis dienomis, padidėjo nuo 280 ppm iki 366 ppm [8].

Greta aplinkosauginių aspektų, nemažiau svarbūs yra ir energetiniai, bei ekonominiai žemės dirbimo technologijų aspektai. Taikant nearimines minimalaus žemės dirbimo arba tiesioginės sėjos technologijas – augalų derlius ir kokybė tikėtina gali būti mažesni, tačiau ir išlaidos žemės dirbimo ir sėjos technologinėms operacijoms atlikti būna mažesnės. Be to, pastarųjų technologijų poveikis aplinkai ir bioįvairovei taip pat yra labiau teigiamas negu įprastinio žemės dirbimo.

Mažinant žemės dirbimo ir sėjos technologinių operacijų skaičių bei mašinų važinėjimą po dirvą, galima ženkliai sumažinti degalų sąnaudas, o tuo pačiu ir šiltnamio efektą sukeliančių dujų išmetimus iš žemės ūkio agregatų, sudarytų iš traktorių ir žemės ūkio mašinų. Vokietijoje atlikti tyrimai, kuriais nustatyta, kad sudeginus 1.0 l dyzelinių degalų, CO_2 dujų emisija į aplinką yra apie 3.76 kg [9]. Norint įvertinti, kaip įvairios žemės dirbimo technologinės operacijos teršia aplinką Lietuvoje, būtina žinoti, kiek toms technologinėms operacijoms įgyvendinti reikia energetinių sąnaudų.

Šio darbo tikslas yra energetiniais ir aplinkosauginiais aspektais įvertinti gilaus ir seklaus arimo, gilaus ir seklaus purenimo bei tiesioginės sėjos technologijas, nustatyti technologijų energetinį efektyvumą.

TYRIMŲ METODIKA

Eksperimentiniai moksliniai tyrimai vykdyti 2009–2012 metais vidurio Lietuvos meteorologinėmis sąlygomis Aleksandro Stulginskio universiteto Bandymų stoties lengvo priemolio dirvoje.

Žemės dirbimo technologijų poveikio energetikai ir aplinkai eksperimentiniams tyrimams atlikti taikytos penkios skirtingos technologijos:

6. Neįdirbta dirva – tiesioginė sėja (sutrumpintai NT);
7. Seklus purenimas lėkštinėmis akėčiomis 12–15 cm gyliu (SC);
8. Gilus purenimas kultivatoriumi 25–27 cm gyliu (DC);
9. Seklus arimas plūgu 12–15 cm gyliu (SP);
10. Gilus arimas plūgu 23–25 cm gyliu (kontrolė).

Kontrolinė tradicinė žemės dirbimo technologija pasirinkta dėl to, kad būtų galima palyginti su kitų 4

with the four sustainable tillage technologies in terms of energy costs and CO_2 emission.

The placement of research plots was random. The original size of the plot was 126 m^2 (14 × 9 m), the size for the observation plot was 84 m^2 (12 × 7 m). The researches was repeated four times.

The Väderstad Carrier 300 stubble cultivator was used at all the fields, except for the NT; after the winter wheat (*Triticum aestivum* L.) harvesting, NT technology was used to spray each ha with 4 litres of Roundup herbicide. Autumn tillage as described above was carried out at the end of September or October depending on the meteorological conditions.

Before corn (*Zea mays* L.) for sowing in all technologies, with the exception of NT, the shallow topsoil (6-8 cm) was tilled with a cultivator in spring. The corn Pioneer P8000(x027) was planted at the beginning of May. The seed rate was 100,000 per hectare with an inter-row width of 45 cm. The entire corn field during planting was fertilized with NPK 16:16:16 at a rate of 250 kg ha^{-1}. The Maister (150 g $ha^{-1)}$ and Actirob (2 l $ha^{-1)}$ herbicides were used for post-sowing weed control. In late June, the corn was fertilized with ammonium nitrate (NH_4NO_3), at a rate of 180 kg ha^{-1}. The corn biomass was harvested at the end of September or beginning of October (depending on meteorological conditions).

Energy indicators were calculated in accordance with the Lithuanian Institute of Agrarian Economics recommendations developed for agricultural and other companies, farmers, and other organizations providing services to farmers carrying out agricultural work [10]. Because the average farm in Lithuania is about 14-15 hectares, the calculations reflect exactly such operating scope for farm machinery under normal conditions, i.e. proper contour and not rocky land.

Energy values were chosen in MJ for agriculture assemblies, fuel, fertilizer, pesticides, and other inputs based on scientific works published by various researchers. Energy assessment assumes that the energy value of work is 1.96 MJ h^{-1} [11, 12], diesel fuel is 39.6 MJ l^{-1} [13, 14], agricultural machinery (including automotive) is 1.38 MJ kg^{-1} or 357.2 MJ h^{-1} [15], corn seed is 15.3 MJ kg^{-1} [12, 16], herbicides is 295.0 MJ kg^{-1} [11, 17], fungicides is 115.0 MJ kg^{-1} [11, 17], insecticides is 58.0 MJ kg^{-1} [11, 17], nitrogen fertilizer is 40.0 MJ kg^{-1} [17], phosphate fertilizers is 15.8 MJ kg^{-1} [14, 18], potassium fertilizers is 9.3 MJ kg^{-1} [14, 18], and the corn harvest is 14.7 MJ kg^{-1} [12, 16].

The EE energy efficiency ratio for different tillage and corn growing technologies is determined by this formula [19]:

tausojančių žemės dirbimo technologijų įtaką energijos sąnaudoms ir CO_2 dujų emisijai į aplinką.

Eksperimentinių tyrimų laukeliai buvo išdėstyti rendomizuotu būdu. Pradinis laukelių dydis – 126 m^2 (14 × 9 m), apskaitomasis – 84 m^2 (12 × 7 m). Tyrimai vykdyti 4 pakartojimais.

Po žieminių kviečių nuėmimo, visuose laukeliuose, išskyrus NT technologiją, buvo atliekamas ražienų skutimas Väderstad firmos Carrier 300 skutiku. NT technologija buvo nupurkšta herbicidu Roundup 4 l ha^{-1}. Priklausomai nuo meteorologinių sąlygų rugsėjo mėn. pabaigoje arba spalio mėn. buvo atliekami rudeniniai žemės dirbimai pagal anksčiau aprašytas žemės dirbimo technologijas.

Pavasarį, prieš kukurūzų sėją, visose technologijose, išskyrus NT, buvo atliktas paviršinis seklus (6–8 cm) žemės dirbimas kultivatoriumi. Kukurūzai Pioneer P8000(x027) buvo pasėti gegužės mėnesio pradžioje. Sėklos norma 100 tūkst. vnt. į hektarą daigių sėklų. Tarpueilių plotis 45 cm. Sėjos metu visi kukurūzų laukeliai buvo tręšiami NPK 16:16:16 trąšomis, kurių norma 250 kg ha^{-1}. Po sėjos piktžolių kontrolei buvo naudojami herbicidai Maister 150 g ha^{-1} ir Actirob 2 l ha^{-1}. Birželio pabaigoje kukurūzai patręšti amonio salietra (NH_4NO_3), norma 180 kg ha^{-1}. Kukurūzų biomasės derlius buvo nuimtas rugsėjo mėnesio pabaigoje arba spalio mėnesio pradžioje (priklausomai nuo meteorologinių sąlygų).

Energetiniai rodikliai apskaičiuoti vadovaujantis, Lietuvos agrarinės ekonomikos instituto parengtomis rekomendacijomis žemės ūkio bendrovėms, ūkininkams, įmonėms ir kitoms paslaugas žemdirbiams teikiančioms organizacijoms, atliekančioms žemės ūkio paskirties darbus [10]. Kadangi Lietuvoje vidutinis ūkis yra apie 14–15 ha, tai skaičiavimai atlikti įvertinant, kad žemės ūkio mašinos dirba būtent tokio dydžio sklypuose normaliomis sąlygomis, tai yra taisyklingų kontūrų, lygaus reljefo neakmenuotuose laukuose.

Žemės ūkio agregatų, degalų, trąšų, pesticidų ir kitų sąnaudų energetinės vertės MJ parinktos, vadovaujantis įvairių mokslininkų paskelbtais moksliniais darbais. Energetiniam vertinimui atlikti priimama, kad darbo energetinė vertė yra 1.96 MJ h^{-1} [11, 12], dyzelinių degalų – 39.6 MJ l^{-1} [13, 14], žemės ūkio mašinų (įskaitant savaeiges) – 1.38 MJ kg^{-1} arba 357.2 MJ h^{-1} [15], kukurūzų sėklų – 15.3 MJ kg^{-1} [12, 16], herbicidų – 295.0 MJ kg^{-1} [11, 17], fungicidų – 115.0 MJ kg^{-1} [11, 17], insekticidų – 58.0 MJ kg^{-1} [11, 17], azoto trąšų – 40.0 MJ kg^{-1} [17], fosforo trąšų – 15.8 MJ kg^{-1} [14, 18], kalio trąšų – 9.3 MJ kg^{-1} [14, 18], kukurūzų derliaus – 14.7 MJ kg^{-1} [12, 16].

Energetinis efektyvumo koeficientas EE skirtingoms žemės dirbimo ir kukurūzų auginimo technologijoms nustatytas pagal formulę [19]:

$$EE = \frac{E_P Y}{E_T} \tag{1}$$

here E_P is the energy value of corn, MJ kg^{-1}; Y is corn harvest, kg ha^{-1}; E_T is the energy cost of one technology, MJ ha^{-1}.

Total energy consumption for a particular technology E_T is calculated thus [3, 19]:

čia E_P – kukurūzų energetinė vertė, MJ kg^{-1}; Y – kukurūzų derlius, kg ha^{-1}; E_T – vienos technologijos energijos sąnaudos, MJ ha^{-1}.

Visos vienos technologijos energijos sąnaudos E_T apskaičiuojamos pagal tokią formulę [3, 19]:

$$E_T = E_F + E_{SFP} + \frac{E_H + E_{AM}}{FC} \quad (2)$$

here E_F is fuel energy costs, MJ ha^{-1}; E_{SFP} is seed energy costs, fertilizer and pesticides, MJ ha^{-1}; E_H is work energy costs, MJ h^{-1}; E_{AM} is agriculture assembly energy costs, MJ h^{-1}; FC is agriculture assemblies efficiency, ha h^{-1}.

An environmental assessment of the different tillage and corn cultivation technologies determines how much fuel is required for individual mechanized operations and the total fuel consumption for an entire technology to be implemented. Based on the research results published by other scientists [9, 20], burning 1.0 litre of diesel fuel emits 3.76 kg of CO_2, including all of the tillage and corn growing technologies researched.

The results are 95% reliable according to standard statistical and mathematical methods for determining a least significant difference [21].

RESULTS

Energy, performance, and economic evaluation indicators for different tilling, sowing, spraying, fertilizing, and other mechanized operations of agricultural machinery are presented in Table 1.

čia E_F – degalų energijos sąnaudos, MJ ha^{-1}; E_{SFP} – energijos sąnaudos sėklai, trąšoms ir pesticidams, MJ ha^{-1}; E_H – darbo energijos sąnaudos, MJ h^{-1}; E_{AM} – žemės ūkio agregatų energijos sąnaudos, MJ h^{-1}; FC – žemės ūkio agregatų našumas, ha h^{-1}.

Vertinant skirtingas žemės dirbimo ir kukurūzų auginimo technologijas aplinkosauginiu aspektu buvo nustatyta, kiek degalų reikalinga atskiroms mechanizuotoms technologinėms operacijoms atlikti ir kiek iš viso degalų sunaudojama visai technologijai įgyvendinti. Remiantis kitų mokslininkų [9, 20] skelbiamais tyrimų rezultatais, jog sudeginus 1.0 litrą dyzelinių degalų, į aplinką išsiskiria apie 3.76 kg CO_2 dujų, įvertintos visos tirtos žemės dirbimo ir kukurūzų auginimo technologijos.

Gautų rezultatų patikimumas analizuotas standartiniais statistiniais ir matematiniais metodais įvertinant esminio skirtumo ribą esant 95% tikimybės lygmeniui [21].

REZULTATAI

Skirtingų žemės dirbimo, sėjos, purškimo, trėšimo ir kitų mechanizuotų technologinių operacijų vertinimui atlikti reikalingų žemės ūkio mašinų energetiniai, eksploataciniai ir ekonominiai rodikliai pateikti 1 lentelėje.

Table 1

Energy and economic indicators of various agro-technological operations

Agro-technological operation	Machinery power (kW)	Working width (m)	Field capacity (ha h^{-1})	Working time (h ha^{-1})	Fuel consumption (l ha^{-1})	Operations costs (EUR ha^{-1})
Stubble cultivation	83	3.0	1.41	0.71	10.7	30.1
Deep ploughing	67	1.05	0.52	1,92	24.5	53.1
Shallow ploughing	67	1.05	0.68	1.47	16.5	45.1
Chiselling	83	3.0	1.28	0.78	15.8	35.6
Discing	83	3.0	1.41	0.71	10.7	30.1
Pre-sowing cultivation	67	3.0	1.30	0.77	4.6	14.4
Fertilization	67	15.0	19.43	0.05	0.5	1.5
Conventional drilling	54	4.5	2.37	0.42	2.3	22.7
Direct drilling	83	3.0	2.24	0.45	6.9	25.4
Spraying	54	15.0	6.86	0.15	0.9	4.37
Fertilization	67	15.0	19.43	0.05	0.5	1.5
Harvesting	200	4.0	1.24	0.80	23.2	99.7

Diesel fuel consumption is one of the key factors that have a major impact on both individual operations, as well as the entire corn growing technology in terms of energy and economic costs. In assessing sustainable tillage technologies, we established that compared with the traditional technology (control) all other corn growing technologies reduce diesel fuel consumption. Fuel costs are similar when using sustainable SP, DC, and SC technologies (about 53.4–58.5 litres ha^{-1}); however, compared with the control technology fuel consumption was 12.9 to 20.5% less (Figure 1). NT technology has demonstrated the lowest fuel consumption (about 28.4 litres ha^{-1}).

In terms of individual technological operations, mostly diesel (about 24.5 litres ha^{-1}) is used in deep soil ploughing. Diesel fuel consumed in tillage and sowing is about 63% (about 42 litres ha^{-1}) of all control technology fuel. Researchers in other countries have obtained very similar results. Long-term German research has shown

Dyzelinių degalų sunaudojimas yra vienas iš svarbiausių veiksnių, darančių labai didelę įtaką tiek atskirų technologinių operacijų, tiek ir visos kukurūzus auginimo technologijos energetinėms ir ekonominėms sąnaudoms. Vertinant tausojančio supaprastinto žemės dirbimo technologijas, nustatyta, kad visos kukurūzų auginimo technologijos, lyginant su tradicine kontroline technologija, mažina dyzelinių degalų sąnaudas. Taikant tausojančias supaprastintas SP, DC ir SC technologijas, degalų sąnaudos yra panašios (apie 53,4–58,5 l ha^{-1}), tačiau lyginant su kontroline technologija degalų sunaudojama nuo 12,9 iki 20,5 % mažiau (1 pav.). Mažiausiai degalų sunaudojama taikant NT technologiją (apie 28,4 l ha^{-1}).

Vertinant pagal atskiras technologines operacijas, daugiausia dyzelinių degalų (apie 24,5 l ha^{-1}) sunaudojama atliekant gilų dirvos arimą. Žemės dirbimui ir sėjai sunaudojami dyzeliniai degalai sudaro apie 63 %

that traditional tillage consumes about 35 litres ha^{-1}, various environmentally friendly sustainable tilling methods from 14 to 25 litres ha^{-1} and no-tillage systems about 6 litres ha^{-1} of diesel fuel [22]. Researchers in Croatia analysed three different tilling and sowing technologies: conventional, sustainable, and no-tillage systems. They established that the conventional technique consumes 48 to 61 litres ha^{-1} of fuel for soil preparation and sowing. By using a sustainable cultivation technology, not ploughing, fuel consumption is reduced 1.5 to 2.0 times compared with a conventional technology. And using no-tillage direct drilling the fuel consumption is 5 to 8 times lower than conventional technology [23]. Dicle University researchers have came to similar conclusions, stating that in no-tillage system the fuel consumption was 6.6 litres ha^{-1}, while fuel consumption seeding by conventional means is 5 times higher [24].

(apie 42 l ha^{-1}) visų kontrolinei technologijai tenkančių degalų. Labai panašius tyrimų rezultatus yra gavę ir kitų šalių tyrėjai. Vokietijoje atlikti ilgalaikiai tyrimai parodė, kad tradiciniam žemės dirbimui sunaudojama apie 35 l ha^{-1}, įvairiems tausojantiems supaprastintiems žemės dirbimo būdams nuo 14 iki 25 l ha^{-1}, o tiesioginei sėjai apie 6 l ha^{-1} dyzelinių degalų [22]. Kroatijoje analizuotos trys skirtingos žemės dirbimo ir sėjos technologijos: įprastinė, supaprastinta ir tiesioginė sėja. Nustatyta, kad žemės dirbimui ir sėjai įprastiniu būdu sunaudojama nuo 48 iki 61 l ha^{-1} degalų. Dirvos neariant, bet įdirbant supaprastintu būdu, degalų sąnaudos sumažėja nuo 1,5 iki 2,0 kartų lyginant su įprastine technologija. O sėjant tiesiai į neįdirbtą dirvą, degalų sąnaudos yra nuo 5 iki 8 kartų mažesnės negu įprastinėje technologijoje [23]. Panašiai teigia ir Dicle universiteto mokslininkai, nustatę, kad sėjant tiesiogiai į neįdirbtą dirvą degalų sąnaudos buvo 6,6 l ha^{-1}, o sėjant į įprastiniu būdu įdirbtą dirvą 5 kartus didesnės [24].

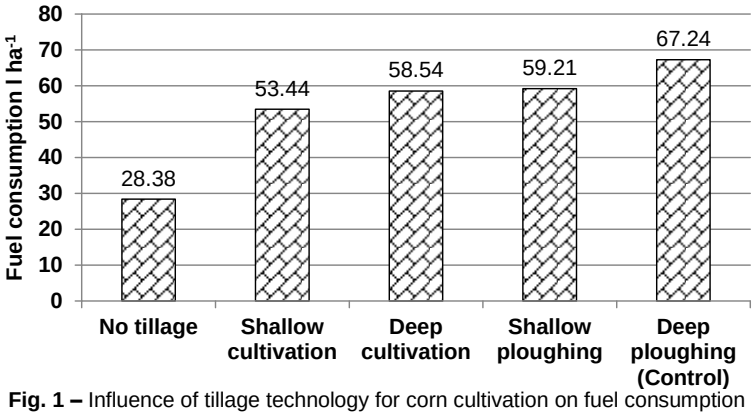

Fig. 1 – Influence of tillage technology for corn cultivation on fuel consumption

Tillage is not only difficult work, but at the same time very energy-susceptible, requiring high power machines. Fuel consumption and hence greenhouse gas emissions depend on tilling process parameters: the depth of tillage, working width, speed, soil properties, etc. Evaluating the different corn-growing operations in terms of environmental aspects, CO_2 pollution is the lowest using NT technology. Analytical calculations show the following for all the mechanized operations provided for by NT technology for one hectare: agricultural machinery (tractors, combine harvester) emit about 107 kg ha^{-1} of CO_2 (Figure 2) into the environment, while all other simplified sustainable tilling technologies (SP, DC, and SC) pollute twice as much. The control technology produced the most CO_2 (about 253 kg ha^{-1}).

Analysing mechanized corn production operations separately we can see that the cleanest technology is NT, because requires only one operation, which emits about 26 kg ha^{-1} CO_2. For the other tillage and sowing technologies the pollution is between 4 (SC – 106.4 kg ha^{-1}) and 6 (control – 158 kg ha^{-1}) times more than NT. Sørensen and Nielsen [25] states that NT reduces energy consumption with 75-83%. CO_2 is similarly reduced as an output of agricultural machinery compared with the control technology. The fewer agricultural operations there are, the lower CO_2 emission is. Greenhouse gas emissions are strongly influenced by

Žemės dirbimo darbai yra ne tik sunkūs, bet tuo pačiu ir labai energoimlūs, reikalaujantys didelės galios mašinų. Degalų sunaudojimas, o tuo pačiu ir šiltnamio efektą sukeliančių dujų išmetimas į aplinką priklauso nuo žemės dirbimo technologinių parametrų: dirbimo gylio, darbinio pločio, greičio, dirvos savybių ir kt. Vertinant skirtingas kukurūzų auginimo technologines operacijas aplinkosauginiu aspektu, nustatyta, kad CO_2 dujomis mažiausiai aplinką teršia NT technologija. Analitiniai skaičiavimai rodo, kad vieno hektare ploto atlikus visas NT technologijoje numatytas mechanizuotas technologines operacijas, į aplinka iš žemės ūkio mašinų (traktorių, derliaus nuėmimo kombainų) išmetama apie 107 kg CO_2 (2 pav.), kai tuo tarpu visos kitos supaprastinto tausojančio žemės dirbimo technologijos SP, DC ir SC aplinką teršia dvigubai daugiau. Daugiausiai CO_2 (apie 253 kg ha^{-1}) į aplinką išmetama taikant kontrolinę technologiją.

Analizuojant atskirai mechanizuotas kukurūzų auginimo technologines operacijas, galime matyti, kad švaresnė technologija yra NT, nes atliekama tik viena technologinė operacija, kurios metu į aplinką išmetama apie 26 kg ha^{-1} CO_2 dujų. Kitose technologijose žemės dirbimas ir sėja aplinką teršia nuo 4 (SC – 106,4 kg ha^{-1}) iki 6 (kontrolė – 158 kg ha^{-1}) kartų daugiau negu NT. Sørensen ir Nielsen [25] teigia, kad, taikant NT energijos sąnaudos sumažėja apie 75–83 %. Panašiai CO_2 emisija sumažėja ir iš žemės ūkio mašinų, lyginant su kontroline technologija. Mažinant technologinių operacijų skaičių žemės dirbimo paruošimui, mažėja ir CO_2 emisija. Šiltnamio efektą sukeliančių dujų emisijai į aplinką didelę

appropriate selection of agricultural machinery and the optimal engine load [4].

During the agricultural technology energy assessment, it is important to know not only the total energy costs incurred, but also the amount of energy generated by farmed production. Each technology's energy recovery was estimated based on the corn crop. Assessing three survey years of corn averages yield, the highest levels of energy were achieved by the NT and control technologies (Table 2).

įtaką daro tinkamas žemės ūkio mašinų parinkimas ir optimalus variklio apkrovimas [4].

Atliekant energetinį žemės ūkio technologijų vertinimą, labai svarbu žinoti ne tik visos technologijos patiriamas energetines sąnaudas, tačiau ir iš auginamos produkcijos gaunamą energijos kiekį. Priklausomai nuo kukurūzų derliaus, atitinkamai buvo apskaičiuota ir gaunama energija iš kiekvienos technologijos. Vertinant trijų tyrimo metų kukurūzų derliaus vidurkį, didžiausias energijos kiekis gautas NT ir kontrolinėje technologijose (2 lentelė).

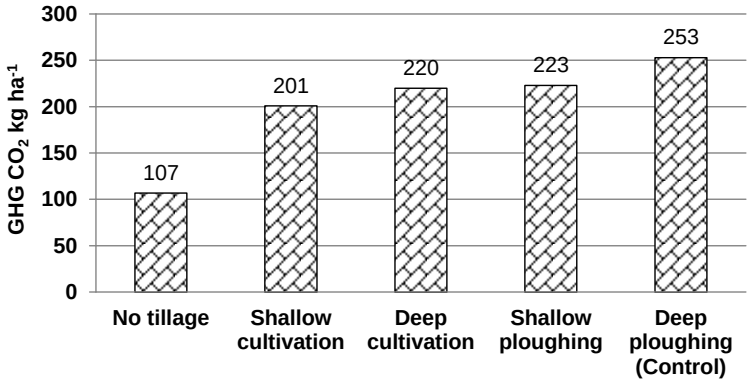

Fig. 2 – Greenhouse gas CO_2 emissions from agricultural machineries under different tillage technologies for corn cultivation

Table 2

Yield and energy indicators for various tillage and corn cultivation technologies in 2010–2012 (average data)

Tillage technologies	Dry mass yield of corn Mg ha^{-1}	Energy output of corn yield MJ ha^{-1}	Energy inputs in corn cultivation MJ ha^{-1}	Energy efficiency ratio EE
NT	15.39	226233	16153.5	14.0
SC	14.00	205800	17146.8	12.0
DC	13.40	196980	17373.9	11.3
SP	13.99	205653	17478.2	11.7
Control	15.25	224175	18127.9	12.4

The calculation of values for each corn-growing technology's energy consumption revealed that under Lithuanian conditions different technologies' energy consumption ranged from 16.15 to 18.13 GJ ha^{-1}. By comparison calculations of sugar beet technology energy efficiency in Germany showed that total energy consumption was from 11.1 to 35.8 GJ ha^{-1} [14].

In all the corn growing technologies, the fertilizer and the diesel fuel accounted the majority of energy consumption. In the traditional control technology it is about 70% fertilizers and 15% fuel, while for NT it is 78% and 7%.

Energy efficiency balance calculations show that the best energy efficiency ratio (14.0) is achieved using the NT technology. The energy efficiency ratio was 12.4 in the control technology when deep tillage ploughing was performed.

CONCLUSIONS

Fuel consumption research have determined that sustainable tillage technologies expend 12-58% less energy than deep ploughing.

In the control technology (deep ploughing) agricultural machines emit an average of 253 kg ha^{-1} CO_2. The sustainable technologies (SC, DC, and SP), emit 2 to 22 % less CO_2. NT technology pollutes the least with a rate of CO_2 emission 2.4 times lower than the control

Apskaičiavus kiekvienai tirtai kukurūzų auginimo technologijai tenkančias energijos sąnaudas, nustatyta, kad Lietuvos sąlygomis skirtingų technologijų energijos sąnaudos svyravo nuo 16.15 iki 18.12 GJ ha^{-1}. Palyginimui Vokietijoje atlikti cukrinių runkelių technologijos energijos efektyvumo skaičiavimai, parodė, kad bendros energijos sąnaudos cukriniams runkeliams išauginti buvo nuo 11.1 iki 35.8 GJ ha^{-1} [14].

Visose kukurūzų auginimo technologijose didžiausią dalį nuo visų energijos sąnaudų sudarė trąšos ir dyzeliniai degalai. Tradicinėje kontrolinėje technologijoje trąšos sudarė apie 70 %, degalai – apie 15 %, o NT technologijoje atitinkamai 78 % ir 7 %.

Energetinio efektyvumo balanso skaičiavimai rodo, kad geriausias energetinio efektyvumo koeficientas (14.0) pasiektas taikant NT technologiją. Kontrolinėje technologijoje, kai atliekamas gilus žemės dirbimas plūgu, energetinio efektyvumo koeficientas buvo 12,4.

IŠVADOS

Degalų sąnaudų tyrimais nustatyta, kad taikant tausojančias žemės dirbimo technologijas, degalų sąnaudas galima sumažinti nuo 12 iki 58 % lyginant su kontroline gilaus arimo technologija.

Kontrolinėje technologijoje žemės ūkio mašinos, degindamos degalus, į aplinką išmeta vidutiniškai apie 253 kg ha^{-1} CO_2 dujų. Taikant tausojančias SC, DC ir SP technologijas, CO_2 dujų į aplinką išmetama nuo 12 iki 22

technology.

Having evaluated the technological energy consumption with energy efficiency calculations and energy generated from the corn crop, the optimum energy efficiency ratio (14.0) is achieved using the NT technology. The conventional deep ploughing has an energy efficiency ratio of 12.4.

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% mažiau. Mažiausiai aplinka teršiama NT technologijoje, kurioje CO_2 dujų emisija į aplinką apie 2.4 karto mažesnė lyginant su kontroline technologija.

Energetinio efektyvumo skaičiavimais įvertinus technologines energijos sąnaudas ir gaunamą energiją iš kukurūzų derliaus, nustatyta, kad geriausias energetinio efektyvumo koeficientas (14.0) pasiekiamas taikant NT technologiją. Įprastinėje gilaus arimo technologijoje energijos efektyvumo koeficientas – 12.4.

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DEVELOPMENT OF MECHATRONIC DIBBLING MACHINE FOR IMPROVING THE QUALITY OF FORESTRY SEEDLINGS
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РАЗРАБОТКА РОБОТИЗИРОВАННОЙ ЛУНКОВАТЕЛЬНОЙ МАШИНЫ ДЛЯ УЛУЧШЕНИЯ КАЧЕСТВА ЛЕСНЫХ САЖЕНЦЕВ

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Abstract: A forestry nursery in Tokoroa, New Zealand grows approximately 3 million Radiata pine seedlings per annum of which about 65% (2 million) are of suitable quality for forestry plantations. The high rejection rate of 35% was attributed to poorly trained, seasonal workers and unsophisticated equipment. It was estimated that about 22% of seedling rejection (approximately 220,000 per year) was due to poorly dibbled holes that caused bends in the stems. The bends occurred when planters pinched the stems of the seedlings in an attempt to make them vertical. A research and development project was undertaken to develop a mechatronic dibbling machine that could produce vertical holes of specified depth. The machine also had to produce 120,000 holes per day and be flexible with regard to spacing and size. The completed mechatronic dibbling machine was tested at the Tokoroa nursery and produced 98% of the holes at the required angle and 100% of useable depth. Harvesting, the following season, showed that the unwanted stem bends had been eliminated with a subsequent reduction in rejects. Furthermore, it was found that worker productivity increased by approximately 10% as they did not have to spend time setting seedlings vertically.

Keywords: *forestry, dibbling, mechatronic, cuttings, seedlings, machinery*

Аннотация: В лесном питомнике, расположенном в регионе Токороа, Новая Зеландия за год выращивается около 3 миллионов саженцев Pinus radiata, из которых только около 65% (2 миллиона) пригодны для лесных посадок. Высокий уровень брака, в 35%, связан с плохой квалификацией, сезонными рабочими и устаревшим оборудованием. Было подсчитано, что порядка 22% саженцев (около 220000 в год) были забракованы из-за плохого качества лунок, приводивших к искривлению стеблей саженцев. Искривления происходили, когда рабочие зажимали стебли растений для придания саженцам вертикального положения. Настоящий научно-исследовательский проект направлен на создание роботизированной машины, позволяющей делать вертикальные лунки заданной глубины. Эта машина позволяет производить 120000 лунок в день и задавать их глубину и размер. Созданная роботизированная лунковательная машина была протестирована в питомнике Токороа и произвела 98% лунок под заданным углом и 100% лунок необходимой глубины. Сбор саженцев в следующем сезоне показал, что нежелательные изгибы стволов были устранены, что привело к снижению брака. Кроме того, было установлено, что производительность труда увеличилась примерно на 10% так как не приходилось тратить время на вертикальную установку рассады.

Ключевые слова: лесное хозяйство, лунки, роботизированный, черенки, саженцы, техника

INTRODUCTION

A forestry nursery located in Tokoroa, New Zealand supplies approximately 3 million Radiata Pine seedlings per year to the forestry industry. Once harvested, the seedlings are transported to forestry blocks for planting. The vast majority of seedlings (over 90%) are Radiata Pine as shown in fig.1, but larger seedlings such as Plug Plus and Douglas fir are also grown. In peak season, up to 120,000 Radiata Pine seedlings per day are planted.

ВВЕДЕНИЕ

Лесное хозяйство, расположенное в регионе Токороа, Новая Зеландия, за год выращивает для лесной индустрии около 3 миллионов саженцев Pinus radiata. После сбора саженцы транспортируются на лесные участки для посадки. Подавляющее большинство саженцев - Pinus radiata - как показано на рис. (fig.) 1, но также выращиваются и более крупные саженцы, такие как Plug Plus и Douglas fir. В пик сезона в день высаживают до 120000 саженцев.

Fig. 1 – Bed of Radiata pine seedlings after 1 year growth

This spiked wheel dibbling process, though fast, produced non-circular holes due to the rotation of the spike in the soil. In the forestry nursery this is called 'tearing' and the plan shape of a spiked wheel produced hole is represented in fig.3. Consequently, when juvenile seedlings were planted in the non-circular holes they did not stand vertically as required

Each Radita Pine seedling requires a vertical hole, +/- 3 degrees from vertical, lateral spacing of 80mm (+/- 2mm), longitudinal spacing of 125mm (+/- 2mm) and hole of 10mm (+/- 0.5mm) diameter of depth of 40mm (+/- 3mm). These requirements were given by the nursery manager and are based on experience. As approximately 90% of holes are for Radiata Pine, this research focussed on improving the quality of Radiata Pine holes. Once the holes are produced, juvenile seedlings are manually planted in the holes. The process of producing holes for planting seedlings is called dibbling. To compensate for rejects, the nursery had to plant approximately 5 million seedlings to achieve a yield of 3 million. Poor quality holes, caused by antiquated dibbling methods, was one of the major causes of inconsistent quality. Formerly, dibbling for Radiata Pine was achieved using a spiked wheel towed behind a tractor as shown in fig.2. The spiked wheel method could not meet the required hole specification under any conditions.

Такой процесс лункования является быстрым, но получаемые лунки имеют не круглую форму из-за "разрыва" почвы, вызванного вращающимся шипом, как это показано на рис. (fig.) 3. При посадке молодых саженцев в такие лунки они устанавливаются не вертикально, как это требуется

Каждый саженец требует прямой и вертикальной лунки определенной глубины и размера в зависимости от его вида. Например, для саженцев Pinus radiata требуются отверстия диаметром примерно 10 мм и глубиной 40 мм. После того как лунки сделаны, молодые саженцы помещают в них вручную. Процесс производства лунок для посадки саженцев называется лункованием. Для компенсации потерь, полученных в результате брака, питомнику необходимо посадить около 5 миллионов саженцев в год, чтобы на выходе получить результат в 3 миллиона. Низкое качество лунок вызвано устаревшими методами лункования, являющимися одной из главных причин непостоянного уровня качества. Лункование для Pinus radiata осуществлялось при помощи шипованного колеса, буксируемого трактором как показано на рис. (fig.) 2

Fig. 2 – Radiata Pine dibbling mac hine

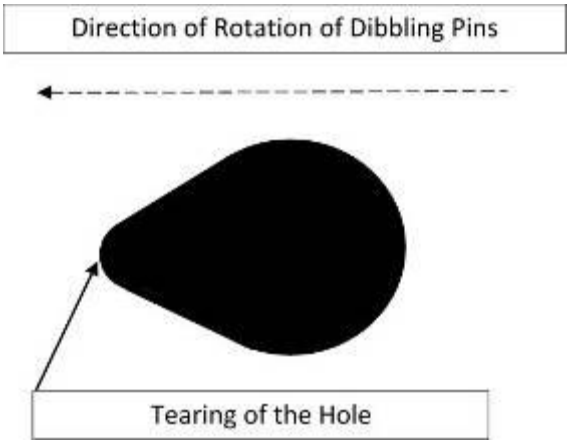

Fig. 3 – Non-circular holes caused by the spiked wheel dibbling machine `tearing'

To compensate for this, planters manually set each juvenile seedling visually. They then used their fingers to gather the soil around the stem to fix it in position. It was found that the manual setting caused bends in the stems, accounting for approximately 22% (220,000 per annum) of rejects. Furthermore, the Plus Plug and Douglas Fir seedlings required manual dibbling as the holes were too large to be produced by a spiked wheel. This was labour intensive and therefore costly. To overcome these problems, research was undertaken at the University of Waikato into the feasibility of a mechatronic dibbling machine.

Automated dibbling and seeding has been

Чтобы исправить данную ситуацию, рабочие вручную, на глаз, устанавливают каждый молодой саженец и для фиксации "зажимают" почву вокруг стебля. Было установлено, что "зажимание" приводит к изгибу стеблей, что составляет примерно 22% (220000 в год) брака. Кроме того, саженцы Plus Plug и Douglas fir требовали ручного лункования, так как для них нужны слишком большие лунки, чтоб их можно было сделать шипованным колесом. Такой процесс является трудоемким и, следовательно, дорогостоящим. Для преодоления этой проблемы в университете Вайкато (University of Waikato) было проведено исследование о целесообразности применения роботизированной машины для лункования.

Исследования по автоматизированному лункованию и посадке растений проводились рядом

investigated by a number of researchers. Commonly, spiked wheels are used for dibbling holes, especially for seed planting and are often combined with an integrated seed dropping mechanism [3, 4]. Whereas this is effective for seeds, it is not viable for planting juvenile seedlings due to 'tearing' of the holes by the spike.

Investigations into plunger type dibblers and seeders as alternatives to the commonly used Coulter drill have been undertaken [1, 6]. However, the emphasis of that research was on how to make a hole and drop a seed in it rather than producing holes to meet a defined specification for planting seedlings. Furthermore, these dibblers lacked the flexibility and speed required for the forestry nursery.

Lawrence et al [5], developed a dibbler using microprocessor control that offered greater opportunity for varying hole spacing too suit a range of crops. They found that using the new design, 96% of the hole spacing for potatoes and 98% for onions were within the required +/-10% specification. This flexibility and controllability highlights the advantages of using computer technology compared to purely mechanical systems. However, their system was not suitable for forestry nurseries as the holes have to be deeper and straighter for forestry seedlings and they had no method of achieving this.

Consequently, it was found that no dibbling machine existed that met the requirements of the forestry nursery and therefore a new machine had to be developed.

MATERIAL AND METHOD

Firstly, a detailed investigation of dibbling and associated issues was undertaken in close collaboration with the forestry nursery managers. One requirement from the managers was that they wanted drilled holes, not punched. This was because punched holes compress the soil and inhibit root growth. Laboratory experiments were undertake to determine the best drilling speed, drill types and power for a range of soil conditions. Five seedling trays, each comprising forty eight cells were filled with nuresry soil. The soil was then compacted until it resembled the soil consistency in the nursery for a range of conditions from wet to dry. It was very difficult to quantify these conditions so they were based on the experience of the nursey manager. An electric drill was used for the testing and was modified such that its speed could be controlled over a range from approximately 100 to 3000 rev/min. This was achieved using voltage control with a switching DC power supply. The drill speed was measured with an optical tachometer. A scissor mechanism was used to keep the drill vertical during testing. It was found that for Radiata Pine, the optimal drilling speed was approximately 1000 rev/min with a 10mm auger drill. At 1000 rev/min, the drilling left soil at the edge of the hole that planters could use to set the seedling. Furthermore, the centrifugal force on the dirt ensured the drill did not clog with soil. The vertical drill speed was approximately 0.25m/s. The drilling power consumption was found from the product of the current and voltage and at optimal speed, in dry soil conditions was approximately 2W. The mechatronic dibbling

исследователей. Как правило, для производства лунок используются шипованные колеса, также они часто интегрируются с механизмами подачи семян [3, 4]. В то время как такой подход эффективен для семян, он неприменим для молодых саженцев ввиду "разрывов" отверстий шипами.

Исследования лункователей плунжерного типа и сеялок в качестве альтернативы широко применяемому сверлу Coulter продемонстрировано в работах [1, 6]. Тем не менее, акцент этих исследований заключался в том, как произвести отверстие и обеспечить падение семени в него, а не в том, как производить отверстия, удовлетворяющие определенной специфике посадки саженцев. Кроме того, этим машинам не хватало гибкости настроек и скорости, необходимой для лесного питомника.

Лоуранс (Lawrence) и др. [5] разработали лункователь с микропроцессорным управлением, предоставляющим большие возможности по изменению пространства между лунками, что делает его подходящим для различных сельскохозяйственных культур. Обнаружено, что с помощью новой конструкции, 96% от расстояния между лунками для картофеля и 98% - для лука были в пределах требуемого, +/- 10% от спецификации. Эта гибкость и управляемость подчеркивает преимущества использования компьютерных технологий по сравнению с чисто механическими системами. Тем не менее, их разработка не подходит для питомников лесного хозяйства, так как лунки для саженцев деревьев должны быть глубже и ровнее, а методы достижения этих требований в работе отсутствуют.

Таким образом, было установлено, что не существовало лунковательных машин, отвечающих требованиям питомника, что и привело к разработке нового устройства.

МАТЕРИАЛ И МЕТОД

Вначале, в тесном сотрудничестве с управляющими лесного хозяйства, было проведено детальное исследование процесса лункования и связанных с ним вопросов. Управляющие выдвинули следующее требование - отверстия должны быть просверленными, а не пробитыми. Это связано с тем, что пробитие лунки прессует почву и подавляет рост корней. Были проведены обширные лабораторные эксперименты для определения наилучших скорости, типа и мощности бурения. Кроме того, машина для лункования должна была постоянно буксироваться имеющимся в питомнике трактором, а не в режиме "старт-стоп". Кроме того, только тракторист должен был управлять лункователем и легко перенастраивать диапазон размеров и расстояний между лунками.

Наиболее сложным было производить лункование прямых, вертикальных, цилиндрических лунок в то время как машина буксировалась за трактором, едущем с переменной скоростью. Даже на низкой передаче изменение скорости трактора может привести к ухудшению качества лунок, однако этого можно избежать, применяя систему управления с обратной связью между скоростью трактора и лункователем.

Следовательно, было принято решение

machine had to be towed by an existing nursery tractor in a continuous process. Also, only the tractor driver was to operate the dibbler and it had to be easily reconfigured to accommodate a range of sizes and hole spacing.

In order to achieve the requirements, the machine had to produce straight vertical cylindrical holes whilst the machine was being towed behind a tractor driving at variable speed. The speed of the nursery tractor when driving with a creeper gearbox was between 0.2 to 0.4 m/s. Even in lowest gear, the speed variation of the tractor would have led to poor quality holes unless there was some sort of closed loop control that linked the dibbling to tractor speed.

To achieve closed loop control, a programmable logic controller (PLC) coupled with sensors and precision pneumatics was used. A rotary encoder was mounted in a roller at the front of the dibbler. Therefore, the rotational speed of the roller was directly proportional to the horizontal speed of the tractor. The PLC then calculated the instantaneous speed requirement of a horizontal pneumatic cylinder such that it would match the tractor speed. A control signal was then sent to a Norgren pneumatic speed control valve. A horizontal, speed controlled pneumatic cylinder then moved forward at the speed of the tractor.

As the cylinder moved horizontally, a second pneumatic cylinder, with 16 rotating drill bits, descended to drill the holes. The matching of the horizontal cylinder speed with tractor speed ensured there was zero relative velocity between the vertical drilling cylinder and the planting bed. Once the holes were drilled, the vertical cylinder lifted the drills from the bed and the horizontal cylinder rapidly returned the starting position ready for another cycle. The entire cycle took approximately 1 second.

It was found that to achieve the 120,000 holes per day and given the limitations of the pneumatics, that 16 drill bits were required. An arrangement drawing of the mechatronic dibbler is shown in (fig.4).

использовать программируемый логический контроллер (ПЛК) в совокупности с сенсорами и высокоточной пневматикой. Датчик угла поворота был установлен в ролике в передней части лункоделателя. Скорость вращения ролика прямо пропорциональна горизонтальной скорости трактора. ПЛК рассчитывает требование к мгновенной скорости горизонтального пневматического цилиндра таким образом, чтобы она соответствовала скорости трактора. Управляющий сигнал направляется к Norgren клапану регулирования скорости. Горизонтальный пневматический цилиндр с управляемой скоростью перемещается вперед в соотвествии со скоростью трактора.

При движении цилинда в горизонтальном направлении, второй пневматический цилиндр с 16 вращающимися бурами сверлит лунки. Установка скорости горизонтального цилиндра в соответствии со скоростью движения трактора обеспечивает нулевую относительную скорость между вертикально-сверлильным цилиндром и рассадочной грядой. После того, как лунки были просверлены, вертикальный цилиндр поднимает сверло из гряды, а горизонтальный цилиндр быстро возвращает его в исходную позицию для начала очередного цикла. Обратный цикл намного быстрее по сравнению с циклом сверления в соответствии с требованиями питомника по интервалам.

Было установлено, что необходимо 16 буровых долот для достижения 120000 лунок в день, с учетом ограничений на пневматику. Устройство роботизированного лункователя показано на рис. (fig.) 4

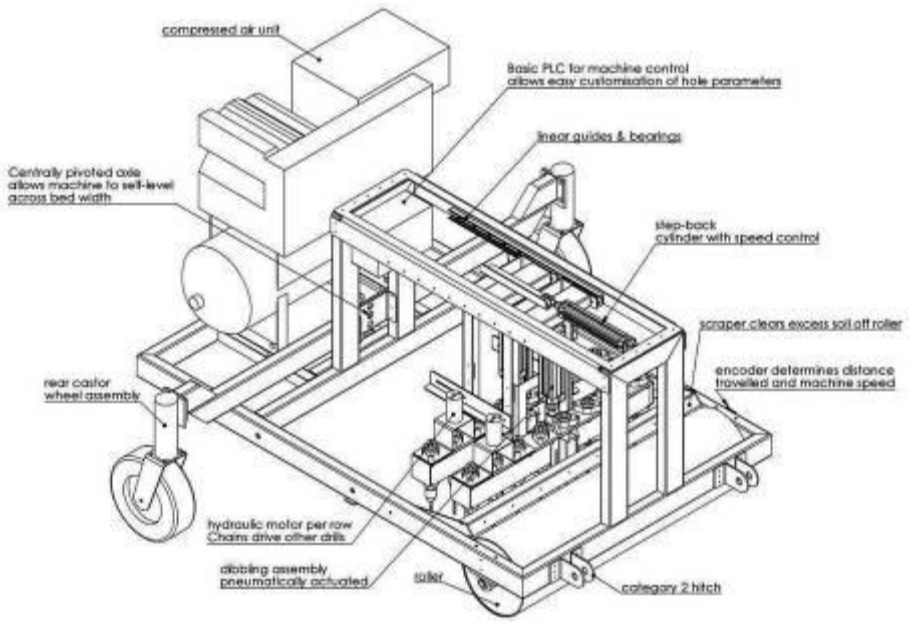

Fig. 4 – Arrangement of mechatronic dibbling machine concept

Even though this was a research exercise, the nursery wanted to permanently replace the spiked wheel dibbler

Несмотря на то, что это было научное исследование, питомник хотел полностью заменить лункование

with the mechatronic dibbler prototype. Therefore, extra design criteria were added to the original mechatronic dibbler requirements as listed below:

- Must be able to operate in all weather conditions – as dibbling is done in winter, weather conditions include hard frosty ground, severe wind and rain with associated mud.
- Easy repair and maintenance.
- Easy and fast transportation from the storage building to the planting beds (up to 1.5km).
- Easy movement from one bed row to the next.
- Minimal disturbance to the bed surface, to protect the pesticide layer.

To accommodate these extra requirements the machine used components such as electronics and bearings rated to Ingress Protection (IP 67). This allowed the machine to operate in severe weather conditions and be easily cleaned by waterjet at the end of each day.

For easy maintenance and repair, only high quality, respected brand components were used. Therefore, If a component failed it could be easily sourced and replaced. Non-bought in components were manufactured directly using laser cutting which is fast and readily available in New Zealand.

Rear wheels were added that kept the machine stable when in use but also robust enough for transportation. The machine had hoist attachments so it could be easily connected to a hydraulic tractor hoist for lifting the front for movement from storage to bed and bed to bed.

A front roller provided support and was also used for sensing forward speed without disturbing the pesticide layer.

Once the concept was agreed by the nursery managers, detail design was undertaken using 3D computer aided design (CAD). This was combined with computer aided engineering (CAE) tools to undertake stress calculations using finite element analysis (FEA) to ensure machine robustness. CAE dynamic tools were also used to ensure the machine could achieve the required speed.

The final design was manufactured using Computer Aided Manufacture (CAM), assembled and commissioned by the University of Waikato's AgriEngineering Research Group.

RESULTS

The completed mechatronic dibbler was tested on site at the Tokoroa nursery and achieved the 120,000 required holes per day. The finished dibbler in operation is shown in fig. 5.

шипованными колесами роботизированным концептом в соответствии с требованиями, указанными ниже:

- Работа в любых погодных условиях - т.к. лунки делаются зимой, погодные условия включают твердый, мерзлый грунт, сильный ветер и дождь с грязью.
- Легкость в ремонте и обслуживании.
- Легкая и быстрая транспортировка от здания склада до посадочных гряд (до 1,5 км).
- Легкое передвижение с одного ряда гряды, на другой.
- Минимальное повреждение поверхностного слоя гряды для защиты слоя пестицидов.

Для того, чтобы выполнить дополнительные требования к машине, были использованы электронные компоненты и подшипники рассчитанные на степень защиты (IP 67). Это позволяет машине работать в тяжелых погодных условиях и обеспечивать её легкую очистку водной струей в конце каждого дня.

Для простоты обслуживания и ремонта использованы только высококачественные компоненты. Таким образом, если компонент ломается, он может быть легко заменен. Некоторые компоненты были изготовлены непосредственно с использованием лазерной резки, которая легко доступна в Новой Зеландии.

Для сохранения стабильности машины и обеспечения транспортировки были добавлены задние колеса. Машина имеет подъемное приспособление и поэтому может легко подключаться к гидравлическим подъемникам трактора для поднятия передней части при транспортировки со склада к гряде и от гряды к гряде.

Передний ролик обеспечивает поддержку, а также используется для определения скорости движения вперед, не повреждая при этом слой пестицидов.

Как только концепция была согласована с управляющими питомника, детали конструкции были смоделированы с использованием 3D системы автоматизированного проектирования (CAD). Проведение прочностных расчетов с использованием метода конечных элементов (FEA) для обеспечения устойчивости машины сочеталось с использованием систем инженерного анализа (CAE). CAE динамические инструменты были также использованы для обеспечения требуемой скорости.

Итоговая конструкция была произведена, используя компьютерную систему изготовления (CAM), собранную и предоставленную исследовательской группой AgriEngineering университета Вайкато.

РЕЗУЛЬТАТЫ

Готовый роботизированный лункователь был протестирован на участке питомника в регионе Токороа и достиг требуемого показателя в 120000 лунок в день. Работа готового лункователя показана на рис. (fig.) 5.

Fig. 5 – Completed mechatronic dibbling machine during testing

For the mechatronic dibbling machine, a sample of 100 holes was used to determine the consistency of the depth and angle. As the vast majority of holes were for Radiata Pine, they were used in the sampling. A simple measuring system was built that comprised a rod of 10mm diameter, a protractor for measuring hole angle and a rule for measuring hole depth, see fig. 6. The scales of the measuring system could be read to +/- 1mm and +/- 0.5 degrees. 100 holes were randomly chosen from a mechatronically dibbled bed. The rod was inserted in the holes and depth and angle ready by eye. The results from the testing are shown in (fig. 7).

Для определения стабильности глубины и угла лунок, производимых роботизированной лунковательной машиной были выбраны 100 лунок. Поскольку подавляющее большинство лунок используется для посадки Pinus radiata, они и были использованы в качестве образца. Была создана простая измерительная система, состоящая из стержня диаметром 10 мм, транспортира, для измерения угла лунки и линейки для измерения глубины лунки, см. рис. (fig.) 6. Шкалы измерительной системы могли быть прочитаны с точностью до +/- 1мм и +/- 0.5 градусов. 100 лунок были произвольно выбраны с гряды, после её роботизированной обработки. Стержень также вставлялся в лунки, сделанные на глаз, для определения глубины и угла наклона. Результаты испытаний представлены на рис. (fig. 7).

Fig. 6 – Measuring device for hole depth and angle

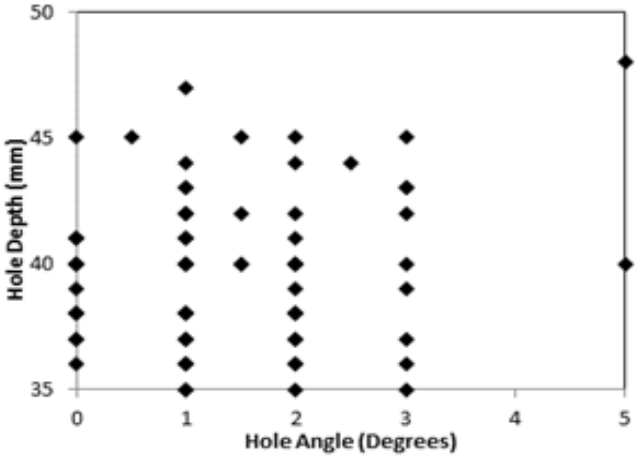

Fig. 7 – Hole depth v hole angle for mechatronically dibbled Radiata pine seedlings

The basic requirement was that holes for Pine Radiata were 40mm +/- 3mm deep and +/- 3 degree angle from the vertical. Due to the lack of resolution of the measurement method, many of the 100 measurements had the same value.

It can be seen that the even with the uneven planting bed, the dibbler achieved 76% of holes within the +/- 3mm tolerance. Only 2% of holes are outside the required +/- 3 degree angle. The average hole depth was 39.7 mm and angle 1.3 degrees with standard deviations of 3.3mm and 1.1 degrees respectively. With regard to the angle, this is at least an order of magnitude better than the spiked wheel dibbled holes. It was found that all the spiked wheel dibbled holes were outside the requirements. The nursery managers were confident that even the 24 holes outside the depth tolerance would produce saleable seedlings, suggesting that the +/-3mm tolerance should be increased to +/-5mm.

It was observed that the uneven surface of the planting bed caused varying hole depth and angle. This was because the machine's depth sensor is located in one place on the bed whereas there are 16 holes, each in different places. Furthermore, it was also observed that the level of the bed was not even.

Even though the hole data provides useful information on quality, the best indicator is the position of the juvenile seedlings when placed into a mechatronically dibbled hole and spiked wheel hole respectively. Fig. 8 shows 5

Основными требованиями к лункам для Pinus radiata были 40мм +/- 3 мм глубина и+/- 3 градуса угол от вертикали. Из-за недостатка разрешающей способности метода измерения, многие из 100 измерений имели одинаковое значение.

Видно, что даже при неравномерном посеве лункователь делает 76% лунок с допуском +/-3 мм. Только 2% лунок выходят за требуемый угол в +\- 3 градуса. Средняя глубина отверстия 39,7 мм, а угол 1,3 градуса со стандартными отклонениями 3,3 мм и 1,1 градусов соответственно. Что касается угла, это, по крайней мере на порядок лучше, чем производство лунок шипованными колесами. Было установлено, что нет смысла измерять лунки, сделанные шипованными колесами, так как все они выходили за пределы установленных требований. Управляющие питомника были уверены, что даже 24 лунки, выходящие за допуски будут подходить для выращивания саженцев, предполагая, что допуски даже можно увеличить с +/- 3 мм до +/-5 мм.

Было отмечено, что неровная поверхность посадочной гряды приводила к различной глубине и углу лунок. Это происходило потому, что датчик глубины аппарата находится в одном месте на гряде в то время как каждое из 16 отверстий в разных местах. Кроме того, было также отмечено, что уровень гряды был неровным.

Несмотря на то что сами лунки являются полезным источником информации о качестве саженца, лучшим индикатором является позиция молодого саженца, помещенного в лунку, сделанную при помощи роботизированной машины и шипованного колеса соответственно. На рис. (fig.) 8 показаны 5 молодых

juvenile seedlings in holes made by the spiked wheel dibbler. It can be seen that the 'torn' hole causes non vertical seedlings. These then have to be manually set to the vertical position. It can also be seen that the surface of the planting bed is very 'disturbed' due to the tearing effect of the spikes.

саженцев, посаженых в лунки сделанные шипованным колесом. Можно видеть, что "разрыв" лунки приводит к невертикальной посадке саженцев. Затем они должны быть установлены вертикально. Также можно видеть, что поверхность посадочной гряды сильно разрушается в связи с разрывами от шипов.

Fig. 8 – Juvenile seedlings in spiked wheel dibbled holes

Fig. 9 – Juvenile seedlings in mechatronically dibbled holes

Fig. 9 shows 5 juvenile seedlings placed in holes made by the mechatronic dibbler. It can be seen that all the seedlings are vertical and of even height. The nursery managers decided that all holes produced by the mechatronic dibbler, including those outside their original specification, were suitable for planting.

It can also be observed that the bed surface is far less disturbed than the spiked wheel bed surface. This highlights the superior quality of the mechatronic dibbling process. An unexpeted advantage of the mechatronic dibbler was that planter productivity increased by approximately 10% because they did not have to spend time setting the seedlings vertical.

The mechatronic dibbler has now been operating for three seasons and has produced several million holes. The bent stem problem has been eliminated and planter productivity increased.

CONCLUSIONS

A Tokoroa forestry nursery in New Zealand was suffering approximately 220,000 per annum seedling rejects due to poorly dibbled holes. A research and development project was under taken by the University of Waikato to develop a mechatronic dibbling machine that could produce good quality holes at the required rate and also be flexible with regard to spacing and hole sizes. Furthermore, the nursery wanted the dibbling machine to be towed by a tractor operating at close to a constant speed, to ensure a continuous system.

To achieve the requirements, a computer controlled mechatronic dibbler was developed. The dibbler used an encoder on a roller to provide feedback of the tractor speed to a PLC. This then provided a closed loop signal to a horizontal pneumatic cylinder that matched the forward speed of the tractor. The holes were then drilled by a second vertical pneumatic cylinder with 16 drill bits. The relative horizontal velocity between the bed and drill bits was zero. After drilling, the cylinders rapidly returned to the start position to begin the process again.

The completed dibbling machine was tested at the

На рис. (fig.) 9 показаны 5 молодых саженцев в лунках, сделанных роботизированной машиной. Можно видеть, что они посажены вертикально и одинаковые по высоте. Управляющие питомника пришли к заключению, что лунки, сделанные роботизированной машиной, даже выходящие за требования спецификаций, подходят для посадки.

Также можно видеть, что поверхностный слой гряды разрушается гораздо меньше по сравнению с воздействием шипованного колеса. Это подчеркивает превосходство роботизированного процесса создания лунок. Неожиданным преимуществом роботизированного создания лунок было повышение продуктивности работы сеятелей на 10% ввиду того, что они не тратили время на вертикальную установку саженцев.

Роботизированный лункователь используется уже три сезона и произвел несколько миллионов лунок. Проблема изгиба стебля была устранена, что привело к увеличению продуктивности посадок.

ЗАКЛЮЧЕНИЕ

Лесной питомник в регионе Токороа в Новой Зелнадии терял приблизительно 220000 саженцев ежегодно в связи с низким качеством лунок. В университете Вайкато был предложен научно-исследовательский проект по созданию роботизированной лунковательной машины, способной производить лунки с необходимой скоростью, а также гибко настраиваться на расстояние и размер лунок. Кроме того, в питомнике хотели, чтоб лунковательная-машина буксировалась трактором и при работе на скорости, близкой к постоянной обеспечивала непрерывную работу.

Для достижения требований, был разработан управляемый компьютером роботизированный лункователь. Лункователь использует датчик на ролике, обеспечивающий обратную связь со скоростью трактора через PLC. Это обеспечивает обратную связь сигнала с горизонтальным пневаматическим цилиндром, связанную со скоростью движения трактора вперед. Лунки были просверелены вторым, вертикальным пневматическим цилиндром с 16 сверлами. Относительная горизонтальная скорость между

Tokoroa nursery and performed as expected, producing 98% of holes at the required angle and 76% at the required depth. All the holes were considered good quality by the nursery manager suggesting that the current depth tolerances should be increased to +/- 5mm, especially when considering the uneven surface of the planting bed. The machine is now fully commissioned and dibbling holes on a daily basis at the nursery.

Acknowledgement

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грядой и сверлами равна нулю. После сверления лунок, цилиндры быстро возвращаются в начальную позицию и готовы к повторению процесса.

Собранная лунковательная машина была протестирована в питомнике Токороа и, как и ожидалось, произвела 98% лунок под требуемым углом, а также 76% лунок – требуемой глубины. Все рассмотренные лунки были хорошего качества, а от управляющих питомником поступило предложение, что допуск текущей глубины может быть увеличен до +/- 5 мм, особенно принимая во внимание неровную поверхность гряд. Сейчас машина находится в ежедневной эксплуатации.

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ENERGY USE IN AGRICULTURE SECTOR OF TURKEY / *TÜRKİYE TARIM SEKTÖRÜNDE ENERJİ KULLANIMI*

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Abstract: *In this review, the energy consumption is examined in agricultural sector of Turkey. Several indicators are defined to evaluate for energy consumption in agriculture and some considerations are made taking into account these indicators. Energy conservation measures for the agricultural sector and suggestions for energy use are given. Energy used per cultivated area in Turkish agriculture is calculated as 82245.95 TOE/TL in the period of 2000-1010 years. Petroleum and electrical energy consumed per cultivated area in Turkish agriculture was 3996.83 thousand TOE and 4991 GWh respectively, in the period of 2000-2010 years.*

Key words: *Agriculture, Energy use, Turkey*.

INTRODUCTION

The agricultural sector produces agricultural raw materials needed for industry and contributes to the economy more than other sectors in Turkey. Some indicators like as national income, population and active population shares in domestic and foreign trade are taken into account in order to determine the importance of the agricultural sector in the national economy. Individual sectors constitutes the overall gross domestic product (GDP) are considered separately, the importance of this situation is emerging more clearly. Because of the great agricultural potential of Turkey, this situation has a special importance in the overall economy.

In the recent years, energy use and associated greenhouse gas emissions and their potential impacts on the global climate change have been the worldwide concern. Improving the end-use energy efficiency is one of the most effective ways to reduce energy consumption in the industrial, commercial, transportation, utility, residential and agricultural sectors and their associated pollutant emissions [5]. Energy use in the agricultural sector depends on the size of the population engaged in agriculture, the amount of arable land and the level of mechanization. Effective energy use in agriculture is one of the conditions for sustainable agricultural production, since it provides financial savings, fossil resources preservation and air pollution reduction. The detailed studies based on the agricultural products and production systems and the total energy use have been conducted in the agricultural sector of the different countries. Considerable reviews have been performed on energy input and output in agricultural production of regional and across the countries of world [1-25].

In the world of today's industry, the usage of energy and energy resources have crucial value. While the amount of natural resources (especially fossil fuel resources) has been decreasing, the damage to the

Özet: *Bu çalışmada, Türkiye tarımında enerji tüketimi incelenmiştir. Tarımda enerji tüketiminin değerlendirilebilmesi için, bazı etkinlik ölçütleri tanımlanmış ve bu ölçütler dikkate alınarak değerlendirmeler yapılmıştır. Tarım sektöründe enerji kullanımı ve enerji korunumu önlemlerine ilişkin öneriler verilmiştir. 2000–2010 yılları arasında tarımsal üretim başına tarımda tüketilen enerji miktarı ortalama 82245,95 TEP/TL olarak hesaplanmıştır. İşlenen ve ekilen tarım alanları başına tüketilen toplam enerji değeri, 2005 yılından sonra, 2011 yılına kadar düzenli olarak artış göstermiş olup, belirtilen dönemde ortalama olarak sırasıyla 0,209 TEP/ha ve 0,275 TEP/ha olarak gerçekleşmiştir. Türkiye tarımında, 2006–2011 yılları arasındaki dönemde, işlenen tarım alanı başına petrol ve elektrik tüketimi ortalama olarak sırasıyla 3996,83 bin TEP ve 4991 GWh olarak belirlenmiştir.*

Anahtar Kelimeler: *Tarım, Enerji, Türkiye*.

GİRİŞ

Tarım sektörü, gerek hammadde üretmesi ve gerekse tarımı ilgilendiren sanayisi ile birlikte ülkemizde ekonomiye diğer sektörlere göre daha fazla katkı sağlamakta ve ekonomik öneme sahip durumdadır. Tarım sektörünün genel ekonomi içerisindeki önem ve derecesini belirlemek amacıyla genellikle; mili gelir, nüfus ve aktif nüfus ile iç ve dış ticaretteki paylar dikkate alınmaktadır. Genel gayri safi yurt içi hasılayı (GSYİH) oluşturan sektörler tek tek dikkate alındığında, bu daha açık bir şekilde ortaya çıkmaktadır. Bu durum, ülkemizin büyük tarım potansiyeli nedeniyle, genel ekonomide ayrı bir öneme sahip olduğunu göstermektedir. Tarım sektörünün ekonomiye katkısı, diğer bir deyişle ekonomideki yeri, Türkiye İstatistik Kurumu (TÜİK) tarafından üretim yöntemiyle hesaplanan tarımsal GSYİH belirlemektedir. Tarımsal GSYİH'nın genel ekonomi içindeki payı bu katkının büyüklüğünü ortaya koymaktadır. GSYİH mal ve hizmet üretiminde ekonominin etkinliğinin temel ölçütüdür. Tarımla ilgili mal ve hizmet üretimi de, ekonominin tarım sektörü açısından performansını belirlemektedir. Bu etkinlik, sadece tarımın üretim yönünü göstermektedir. Tarım sektörünün hizmet üretimine, ekonominin diğer sektörlere katkısı, tarımın ekonomi için önemini belirtir.

Günümüz endüstri dünyasında, enerji ve diğer kaynaklarının kullanımı önemli düzeye ulaşmıştır. Bu nedenle, bir taraftan doğal kaynakların miktarı azalmaya başlamış, diğer taraftan da çevre kirliliği gibi doğal ortama verilen zararlar artarak devam etmektedir. Bununla birlikte, enerji dönüşümüne ilişkin teknik iyileştirmeler yeterince etkin bir şekilde gerçekleştirilememektedir. Gelişmiş ve gelişmekte olan ülkelerde, gelecekteki enerji üretim ve tüketim düzeylerinin belirlenebilmesi için; nüfus artışı, ekonomik üretkenlik, tüketici alışkanlıkları ve teknolojik gelişmeler gibi dikkate alınması gereken birçok

natural environment has been increasing with different types of pollution. Additionally, the technical improvements for the energy conversion can not be carried out as effective as it is needed. In order to determine the level of future energy production and consumption in developed and developing countries, many factors are to be considered, such as population growth, economic productivity, consumer habits and technological advances. The style of energy sectors management will play an important role for the future of energy production, consumption and distribution. Careless use of energy resources and their scarcity, resulting unwanted side effects, so energy consumption must be planned and evaluated carefully and accurately. The benefits of the right evaluation of the energy consumption in agricultural sector can be summarized as follows:

(1) To ensure the usage of energy resources more effectively,
(2) To determine true value of losses and wastes of which types and places in the cultivation systems,
(3) To reduce inefficiency in current cultivation methods and develop more efficient methods,
(4) To ensure sustainable development by targeting the use of energy resources in a sustainable manner,
(5) To determine the priorities of energy sources those have high and low quality in terms of their usage areas and benefits,
(6) To identify the areas that improvements can be achieved by using effective technologies.

In this study, the energy consumption in Turkish agriculture has been investigated. In order to assess the energy consumption in agriculture, some indicators for energy use in agriculture was defined and evaluations was made considering these indicators for Turkish agriculture. Some conclusions related to energy use in the agricultural sector and energy conservation measures have been provided.

AGRICULTURAL SECTOR IN TURKEY

Agricultural gross domestic production (GDP) is a indicator of the contribution of the agricultural sector in the national economy, in other words the importance in national economy. The agricultural GDP determined by Turkey Statistical Institute (TSI) agricultural is calculated by the production method. The share of agricultural GDP in national economy reveals the magnitude of this contribution. The GDP in the production of goods and services is the basic parameter of economy efficiency. Similarly, the production of goods and services related to agriculture determine the performance of the economy in terms of the agricultural sector. This performance only shows the direction of agricultural production. The contribution of the agricultural sector to service production and other sectors of the economy indicates the importance of agriculture for the national economy.

In Turkey, the share of agricultural production in the GDP is given in Table 1. While the share of agricultural production in the GDP was 10.1% in 2000, it declined in 2009. In this period, Turkey has continued the economic transformation from agriculture sector towards industry and services sectors. Despite the fall in the share of the GDP, the agricultural production of Turkey has been increasing since 2000. The amount of production reduced due to drought in 2007, started to rise again from the beginning of 2008. In 2008, the agricultural production which was 73 billion TL, it was reached to 79 billion TL in 2009 (Table 1) (1 TL= 3.0317 euro=2.2087

etmen vardır. Enerji sektörüne ilişkin yönetim biçimleri, gelecekteki enerji üretim ve tüketim düzeyi ve dağılımında önemli rol oynayacaktır. Enerji kaynaklarının kıtlığı ve dikkatsiz kullanılması sonucunda oluşan istenilmeyen yan etkiler, enerji tüketimini doğru bir şekilde planlanma ve dikkatli bir şekilde değerlendirmeyi gerektirmektedir. Tarımsal üretim işlemlerinde tüketilen enerji miktarını dikkate alarak yapılan değerlendirmenin yararları aşağıdaki gibi özetlenebilir:

(1). Enerji kaynaklarının daha etkin olarak kullanılmasını sağlamak,
(2). Üretim sistemlerindeki atık ve kayıpların gerçek değerlerini, tiplerini ve gerçekleştiği yerleri belirlemek,
(3). Mevcut üretim yöntemlerindeki etkinsizlikleri azaltmak ve daha etkin yöntemler geliştirmek,
(4). Enerji kaynaklarının sürdürülebilir bir şekilde kullanılmasını hedefleyerek, sürdürülebilir bir kalkınma sağlamak.
(5). Yüksek ve düşük kaliteli enerji kaynaklarının kullanım alanlarını ve yararlanma açısından önceliklerini belirlemek,
(6). Etkin teknolojilerden yararlanarak iyileştirme sağlanabilecek alanları belirmek.

Türkiye tarım sektöründe bölgesel ve ülke genelinde, üretim sistemleri ile ürün bazında ve toplam enerji kullanımına ilişkin ayrıntılı çalışmalar yapılmıştır. Bu çalışmada, ülkemiz tarımında enerji tüketimi incelenmiştir. Tarımda enerji tüketiminin değerlendirilebilmesi için, bazı etkinlik ölçütleri tanımlanmış ve bu ölçütler dikkate alınarak değerlendirmeler yapılmıştır. Tarım sektöründe enerji kullanımı ve enerji korunumu önlemlerine ilişkin öneriler verilmiştir.

TÜRKİYE TARIM SEKTÖRÜ

Tarım, daha çok doğal nedenlerden, bir başka deyişle; zengin toprak kaynakları, biyolojik çeşitlilik, elverişli iklim ve jeolojik koşullardan dolayı, Türkiye için her zaman önde gelen bir sektör olmuştur. Zengin toprak yapısı, tarıma elverişli arazi varlığı ve uygun iklimiyle Türkiye, hububatlar, baklagiller, meyveler, sebzeler ve hayvancılıktan oluşan geniş bir tarımsal ürün yelpazesine sahiptir. Son dönemlerde, özel girişimcilerin tarım sektöründe yatırım yapmaya olan ilgileri artmaktadır. Tarım sektörü nüfusun büyük çoğunluğunun gıda ihtiyaçlarını karşılayarak Türkiye'yi dış kaynaklara bağımlı olmaktan korumakta, tarıma bağlı diğer sektörlerin ham madde tedarikini de gerçekleştirerek Türkiye'nin sosyal ve ekonomik gelişiminde çok önemli bir rol oynamaktadır.

Türkiye'de 2000 yılında, % 10,1 olan tarımsal üretimin gayrisafi yurt içi hasıladaki payı 2009 yılında, % 8,3'e gerilemiştir (Tablo 1). Bu dönemde, Türkiye tarım sektöründen endüstri ve hizmet sektörüne doğru gerçekleşmekte olan ekonomik dönüşümünü sürdürmüştür. Gayrisafi yurt içi hasıladaki payı düşmesine rağmen, tarımsal üretim 2000 yılından beri artış göstermektedir. 2007 yılında kuraklığa bağlı olarak azalan üretim miktarı, 2008 başından itibaren tekrar artışa geçmiştir. 2008 yılında, 73 milyar TL olan tarımsal üretim, 2009 yılında 79 milyar TL seviyesine ulaşmıştır (Tablo 1).

Türkiye'de TÜİK verilerine göre uyumlaştırılmış,

USD).

According to harmonized data of the TSI in Turkey, in the period between 2000 – 2010 the share of agriculture in GDP is given in Table 1. While the value of agricultural production at current prices was 16.832 billion TL in 2000, it increased to 88.299 TL billion in 2010. Despite this increase, while the share of agriculture in GDP in 2000 was 10.1% it reduced to 8% in 2010. The average share of agriculture in GDP has been determined as 8.89% in 10-year period between 2000 and 2010. The amount of energy consumed in agriculture per Turkey's agricultural production value has followed a path parallel to the increase in agricultural production value. While it was 182568.9 TOE/TL in 2000, it has raised to the value 57633.72 TOE/TL in 2010. Energy consumed in agriculture per the value of agricultural production was calculated as 82245.95 TOE/TL in the period of between 2000 and 2010 (Table 1).

2000–2010 yılları arasındaki dönemde tarımın GSYİH içindeki payı Çizelge 1'de verilmiştir. Cari fiyatlarla 2000 yılında tarımsal üretim değeri, 16,832 Milyar TL iken, 2010 yılında 88,299 Milyar TL değerine yükselmiştir. Bu artışa rağmen, tarımın GSYİH içindeki payı 2000 yılında % 10.1 oranından % 8 oranına azalmıştır. 2000–2010 yılları arasındaki 10 yıllık dönemde, tarımın GSYİH içindeki payı ortalama % 8.89 olarak belirlenmiştir.

Türkiye'de tarımsal üretim değeri başına tarımda tüketilen enerji miktarı, tarımsal üretim değerinin artışına paralel bir seyir izlemiş olup, 2000 yılında 182568,9 TEP/TL iken, 2010 yılında 57633,72 TEP/TL değerine yükselmiştir. 2000–2010 yılları arasında tarımsal üretim başına tarımda tüketilen enerji değeri ortalama 82245,95 TEP/TL olarak hesaplanmıştır (Tablo 1).

Table 1

The share of agricultural production in the GDP in Turkey *(TSI, 2014)*

Years	The gross domestic product (GDP, Billion TL)	The share of agricultural production in the GDP at current prices (%)	Agricultural production (Billion TL)	Energy use in agriculture/ Agricultural production (TOE/TL)
2000	166.658	10.10	16.832	182568.9
2001	240.224	8.80	21.139	140214.8
2002	350.476	10.30	36.099	83935.84
2003	454.780	9.90	45.023	68542.74
2004	559.033	9.50	53.108	62401.14
2005	648.931	9.40	60.999	54755.00
2006	758.390	8.30	62.946	57318.97
2007	843.178	7.60	64.081	61547.10
2008	950.534	7.60	72.240	71622.37
2009	952.558	8.30	79.062	64164.83
2010	1103.749	8.00	88.299	57633.72
Mean		*8.89*		*82245.95*

Turkey's agriculture sector, as of March 2010, 5.2 million people were provided employment. This figure is corresponding to approximately 24% of total employment in Turkey. Agricultural employment from 2000 until the first quarter of 2010 has fallen nearly 33%. Taking into account the increase in agricultural production in this period, it is observed that productivity in agriculture sector increased. Due to economic development is a natural consequence of the process, the ratio of agriculture production value to national income was reduced proportionally. However, in those countries that provide income from agriculture, this sector is important for the economy.

ENERGY USE IN TURKISH AGRICULTURE

In Turkey, in the period between 1990–2011, total energy consumption in the industrial and agricultural sectors and value share in total energy consumption in this sector is given in Table 2. In Turkey in the 1990s, while the share of agricultural sector in total energy consumption at the 5% level, after 2008 it have reached a higher level than 6%. In this period, while the share of total energy consumption in the industrial sector was 37.85%, the share of the agricultural sector amounted to be 5.35% (Table 2). In order to assess the energy consumption in agriculture, some indicators was defined in Table 3.

Türkiye tarım sektörü, 2010 yılı Mart ayı itibarıyla, 5,2 milyon kişiye istihdam sağlamıştır. Bu rakam, Türkiye'deki toplam istihdamın yaklaşık olarak % 24'üne karşılık gelmektedir. Tarımsal istihdam 2000 yılından 2010 yılının ilk çeyreğine kadar yaklaşık % 33 oranında düşüş yaşamıştır. Bu dönemdeki üretim artışı dikkate alındığında, tarım sektöründeki verimliliğin artış gösterdiği görülmektedir. Tarımın mili gelire olan oranının oransal olarak azalması, ekonomik gelişme sürecinin doğal bir sonucudur. Ancak, kişilerin geçimini tarımdan sağlayan ülkelerde, bu sektör ekonomi için önemidir.

TÜRKİYE TARIMINDA ENERJİ TÜKETİMİ

Türkiye'de, 1990–2011 yılları arasındaki dönemde, sanayi ve tarım sektörlerinde toplam enerji tüketimi değerleri ve bu sektörün toplam enerji tüketimindeki payları Tablo 2'de verilmiştir. Türkiye'de 1990'lı yıllarda, tarım sektörünün toplam enerji tüketimindeki payı % 5 düzeylerinde iken, 2008 yılından sonra % 6'dan daha yüksek düzeylere ulaşmıştır. Belirtilen dönemde sanayi sektörünün toplam enerji tüketimindeki payı ortalama % 37.85 iken, tarım sektörünün payı ise % 5.35 olarak gerçekleşmiştir (Tablo 2). Tarımda enerji tüketiminin değerlendirilebilmesi için, Tablo 3'de verilen, etkinlik ölçütleri tanımlanmıştır.

Table 2

Energy consumption in industry and agriculture in Turkey *(TSI, 2015)*

Years	Energy consumption (Thousands TEO) TOE: tonne of oil equivalent (1 TOE = 11.63 MWh = 41.87 GJ)			The share of the total energy consumption (%)	
	Total	Industry	Agriculture	Industry	Agriculture
1990	52987	14543	1956	35	5
1995	63679	17372	2556	35	5
2000	80500	24501	3073	40	5
2001	75402	21324	2964	38	5
2002	78331	24782	3030	42	5
2003	83826	27777	3086	43	5
2004	87818	28789	3314	42	5
2005	91576	29396	3340	40	5
2006	77441	30996	3608	40	4.66
2007	82747	32466	3944	39	4.77
2008	79559	25677	5174	32	6.50
2009	80574	25966	5073	32	6.30
2010	83372	30628	5089	37	6.10
2011	86952	30830	5755	35	6.62
Mean				*37.85*	*5.35*

Table 3

Some indicators for energy consumption in agriculture

Indicators	Units
The total energy consumed per the cultivated area	TEO/ha
The total energy consumed per the sowed area	TEO/ha
The total oil consumed per the cultivated area	TEO/ha
The total electricity consumed per the cultivated area	MWh/ha
The total amount of energy consumed in fertilizer production per cultivated area	TEO/ha
The total amount of energy consumed per agriculture production value (agricultural GDP)	TEO/TL

The total energy consumed per cultivated and sowed farmland in the period between 1990 and 2011 years in Turkey is given in Table 4. The total energy consumed per cultivated and sowed farmland were 0.072 TOE/ha and 0.136 TOE/ha, respectively in 10-year period between 1990-2000. The total energy consumption per cultivated and sowed farmlands regularly increased after 2005 until 2011. In this period, on average, the values of these indicators were 0.209 TOE/ha and 0.275 TOE/ha, respectively. The total energy consumed per cultivated and sowed farmland in 21-year period between the years 1990-2011 were calculated on average 0.164, TOE/ha and 0.216 TOE/ha, respectively.

The main primary energy consumed in Turkey's agriculture consists of oil, electricity, natural gas, and geothermal heat and the other heat sources. While the oil consumption per the cultivated area was 0.135 TOE/ha in 2006, it increased to 0.234 TOE/ha in 2011 (Table 5). Similarly, while the number of tractors and combine harvesters were1037383 tractors and 12359 combine harvesters in 2006, these figures increased to of 112500 tractors and 14313 combine harvesters in 2011 (Table 6). In this period, electricity consumption per the cultivated area is realized in a variable manner. In the period between the years 2006-2011, the total oil

Türkiye'de 1990–2011 yılları arasındaki dönemde işlenen ve ekilen tarım alanı başına tüketilen toplam enerji değerleri Tablo 4'de verilmiştir. 1990–2000 yılları arasındaki 10 yıllık dönemde işlenen ve ekilen tarım alanları başına tüketilen toplam enerji değeri ortalama olarak sırasıyla 0.072 TEP/ha ve 0.136 TEP/ha olarak gerçekleşmiştir. İşlenen ve ekilen tarım alanları başına tüketilen toplam enerji değeri, 2005 yılından sonra, 2011 yılına kadar düzenli olarak artış göstermiş olup, belirtilen dönemde ortalama olarak sırasıyla 0,209 TEP/ha ve 0,275 TEP/ha olarak gerçekleşmiştir. 21 yıllık dönemde İşlenen ve ekilen tarım alanları başına tüketilen toplam enerji değeri ortalama olarak sırasıyla 0,164 TEP/ha ve 0,216 TEP/ha olarak hesaplanmıştır.

Türkiye tarımında tüketilen başlıca birincil enerjiler; petrol, elektrik, doğal gaz ve jeotermal ve diğer ısılardan oluşmaktadır. Tarımda işlenen tarım alanı başına petrol tüketimi değeri 2006 yılında 0,135 TEP/ha düzeyinde iken, 2011 yılında 0,234 TEP/ha düzeyine yükselmiştir (Tablo 5). Benzer şekilde, traktör ve biçerdöver sayıları da sırasıyla, 2006 yılında 1037383 adet traktör ve 12359 adet biçerdöver iken, 2011 yılında 112500 adet traktör ve 14313 adet biçerdöver olarak gerçekleşmiştir (Tablo 6). Belirtilen dönemde, işlenen tarım alanı başına elektrik tüketimi değişken bir şekilde gerçekleşmiştir. Türkiye

and electricity consumption in Turkish agriculture were on average 3996.83 thousand TOE (46483.13 GWh) and 4991 GWh, respectively. During this period, oil and electricity consumption per cultivated agricultural area, were on average 0.185 TOE/ ha and 0.302 MWh/ha, respectively.

tarımında, 2006–2011 yılları arasındaki dönemde, işlenen tarım alanı başına petrol ve elektrik tüketimi ortalama olarak sırasıyla 3996,83 bin TEP ve 4991 GWh olarak belirlenmiştir. Petrol ve elektrik tüketimi ortalama olarak sırasıyla, 0,185 TEP/ha ve 0.302 MWh/ha olarak hesaplanmıştır.

Table 4

The energy consumed per cultivated and sowed farmland in agricultural sector of Turkey *(TSI, 2015)*

Years	Energy consumption in agriculture (Thousands TEO)	The cultivated farmland (Thousands ha)	The sowed farmland (Thousands ha)	The total energy consumed per cultivated farmland (TOE/ha)	The total energy consumed per sowed farmland (TOE/ha)
1990	1956	24827	18868	0.078	0.103
1995	2556	24373	18464	0.104	0.138
2000	3073	23826	18207	0.128	0.168
2001	2964	23800	18087	0.124	0.163
2002	3030	23994	18123	0.126	0.167
2003	3086	23372	17563	0.132	0.175
2004	3314	23871	18110	0.138	0.182
2005	3340	23830	18148	0.140	0.184
2006	3608	22981	17440	0.156	0.206
2007	3944	21979	16945	0.179	0.232
2008	5174	21555	16460	0.240	0.314
2009	5073	21351	16217	0.237	0.312
2010	5089	21384	16333	0.237	0.311
2011	5755	20539	15712	0.280	0.366
Mean	***3711.6***	***22977.3***	***17476.9***	***0.164***	***0.216***

Table 5

Energy consumption of agricultural sector in Turkey

Years	Oil (1000 TOE)	Electricity (GWh)	The cultivated area (1000 ha)	The sowed area (1000 ha)	Oil consump/ The cultivated area (TOE/ha)	Electricity consump./ The cultivated area (MWh/ha)
2006	3119	4411	22981	17440	0.135	0.252
2007	3397	4981	21979	16945	0.154	0.293
2008	4304	5806	21555	16460	0.199	0.352
2009	4218	4879	21351	16217	0.197	0.300
2010	4134	5509	21384	16333	0.193	0.337
2011	4809	4360	20539	15712	0.234	0.277
Mean	***3996.8***	***4991***	***21632***	***16518***	***0.185***	***0.302***

Table 6.

The number of tractors and combine harvesters in Turkey *(TSI, 2015)*

Years	The number of tractors	The number of combine harvesters
2000	941835	12578
2001	948416	12053
2002	970083	11539
2003	997670	11721
2004	1006065	11519
2005	1022365	11811
2006	1037383	12359
2007	1056128	12775
2008	1070746	13084
2009	1073538	13360
2010	1096683	13799
2011	1125001	14313

One of the important energy input is indirect energy consumption used to produce fertilizers in agricultural production. In Turkey, natural gas is used mainly in fertilizer production process. In the period between 2006 and 2011 in Turkey, the amount of energy consumed in the production of fertilizers and energy consumed in the production of fertilizers per the cultivated area are given in Table 7.

Tarımsal üretimde önemli enerji girdilerinden birisini de gübre üretimi için kullanılan dolaylı enerji tüketimi oluşturmaktadır. Türkiye'de gübre üretim işlemlerinde çoğunlukla doğal gaz kullanılmaktadır. Türkiye'de 2006–2011 yılları arasındaki dönemde gübre üretiminde tüketilen enerji miktarları ve işlenen alan başına gübre üretiminde kullanılan enerji tüketimi değerleri Tablo 7'de verilmiştir.

While the total energy consumed in the production of fertilizer was 201.4 thousand TOE in 2006, it has increased to 650.4 thousand TOE in 2011.In this period, the total energy consumed for the production of fertilizers per the cultivated area was averagely 0.01 TOE/ha. Although the total production capacity of fertilizer factory in Turkey will be enough to level of fertilizer consumption, because of the economic reasons (energy-raw materials-cost) the fertilizer factories don't work with the full production capacity. The average production capacity of the fertilizer factories is 60 % in Turkey. Therefore, the fertilizers demands in agriculture sector of Turkey are met by fertilizers import instead of raw material import.

Gübre üretiminde tüketilen toplam enerji 2006 yılında 201,4 bin TEP değerinde iken, 2011 yılında 650,4 bin TEP değerine yükselmiştir. Belirtilen dönemde, işlenen tarım alanı başına gübre üretimi amacıyla tüketilen toplam enerji miktarı ortalama 0.01 TEP/ha olarak gerçekleşmiştir. Ülkemizdeki gübre fabrikalarının toplam üretim kapasiteleri gübre tüketimimize yetecek düzeyde olmasına rağmen, gübre fabrikalarının bazı ekonomik nedenlerle (enerji-ham madde-maliyet) tam üretim kapasitesi ile çalışmayıp, ortalama % 60 kapasite ile çalışmaları ham madde ithalatı yerine, gübre ithal edilerek ülkemizin gübre ihtiyacı karşılanmaktadır.

Table 7

Energy consumption in the production of fertilizers in Turkey

Years	Oil (1000 TEO)	Electricity (1000 TEO)	Natural gas (1000 TEO)	The total energy consumption (1000 TEO)	The cultivated area (1000 ha)	The total energy consumpt./ The cultivated area (TOE/ha)
2006	7.4	44	150	201.4	22981	0.009
2007	5	17	0	22	21979	0.001
2008	7	22	214	243	21555	0.011
2009	5	20	26	51	21351	0.002
2010	4	12	64	80	21384	0.003
2011	5.5	26.6	618.3	650.4	20539	0.031
Mean	***5.65***	***23.6***	***178.7***	***208***	***21631.5***	***0.01***

CONCLUSIONS

The structure of agricultural holdings in Turkey should be required to improve the efficiency and competitive with the effective use of technology. In Turkey, although fertilizer consumption has showed a rapid increase, due to the support and encouragement, the rate of increase has slowed in recent years. Growing population and changing eating habits is inevitable to increase agricultural production. To increase agricultural production, it is necessary that increasing productivity obtained from the unit area using the fertilizer, quality seeds and emerging technologies, minimization of production losses, to achieve farm size for economic production and farmers' awareness. Because of the excessive and unplanned use of fertilizers is a clear negative impact on quantity and quality of products and the environment, fertilizer consumption should be controlled and planned. Adhering to the principles of sustainable agriculture, use of correct type and amount fertilizer is critical to prevent damage of the fertilization on the environment. The most effective way to apply the correct type and quantity of fertilizer is based on the soil and plant analysis.

In recent years, energy use, greenhouse gas emissions and their potential effects on global climate change is one of the most hotly debated topics. Problems with the use of energy, is not only limited to global warming. The environmental issues such as air pollution, acid rain and ozone depletion are closely related energy use. Environmental effects caused by the use of energy, to be at the lowest level, all of the mentioned subject should be considered together. Increasing energy efficiency is important in terms of environmental impact assessment of energy sources. The efficiency of system should be increased to use less energy and to harm the environment at the lowest level. Because of the scarcity and careless use of energy resources resulting unwanted side effects, it is required that energy consumption accurately and carefully planned.

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SONUÇ VE ÖNERİLER

Türkiye, özellikle verimlilik ve rekabet gücünün artmasını sağlayacak etkin teknoloji kullanımı ve tarım işletmelerinin yapısının iyileştirilmesi gereklidir. Türkiye' de gübre tüketimi, uygulanan destek ve teşvikler sayesinde hızlı bir artış göstermekle birlikte, özellikle son yıllarda artış hızı yavaşlamıştır. Artan nüfus ve değişen beslenme alışkanlıkları tarımsal üretimi artırmayı kaçınılmaz kılmaktadır. Tarımsal üretimi artırmak ise gübre, kaliteli tohum ve gelişen teknolojileri kullanarak birim alandan elde edilen verimin yükseltilmesi, üretim kayıplarının asgariye indirilmesi, ekonomik üretim yapacak çiftlik büyüklüklerine ulaşılması ve çiftçilerin bilinçlendirilmesi ile mümkündür. Aşırı ve plansız gübre kullanımının ürün miktar ve kalitesi ile çevreye olumsuz etkileri açık olarak görüldüğünden, kontrollü ve planlı gübre tüketim artısı hedeflenmelidir. Sürdürülebilir tarım ilkelerine bağlı kalınarak gübrelemenin çevreye zararını önlemek için doğru cins ve miktarda gübre kullanımı kritik öneme sahiptir. Doğru cins ve miktarda gübre kullanımının en etkili yolu ise toprak ve bitki analizlerine dayalı uygulamalardır.

Endüstri, ulaştırma, ticaret, konut ve tarım sektörlerinde enerji kullanımını azaltmanın en etkin yöntemlerinden birisi de, enerji kullanma etkinliğini artırmaktır. Günümüz endüstri dünyasında, enerji ve diğer kaynaklarının kullanımı önemli düzeye ulaşmıştır. Bu nedenle, bir taraftan doğal kaynakların temini azalmaya başlamış, diğer taraftan da çevre kirliliği gibi doğal ortama verilen zararlar artarak devam etmektedir. Bununla birlikte, enerji dönüşümüne ilişkin teknik iyileştirmeler yeterince etkin bir şekilde gerçekleştirilememektedir. Gelişmiş ve gelişmekte olan ülkelerde, gelecekteki enerji üretim ve tüketim düzeylerinin belirlenebilmesi için; nüfus artışı, ekonomik üretkenlik, tüketici alışkanlıkları ve teknolojik gelişmeler gibi dikkate alınması gereken birçok etmen vardır. Enerji sektörüne ilişkin yönetim biçimleri, gelecekteki enerji üretim ve tüketim düzeyi ve dağılımında önemli rol oynayacaktır.

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STRUCTURAL INTENSITY METHOD APPLIED TO STUDY OF VIBRATIONS DAMPING
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METODA INTENSIMETRIEI STUCTURALE APLICATĂ LA STUDIUL AMORTIZĂRII VIBRAȚIILOR

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Abstract:
Article describes a practical method for determining the vibration damping of the material on the basis of use structural intensity measurements of longitudinal vibrations. Structural intensity is grounded on the analogy with the concept of acoustic intensimetry that use the correlation between the signals obtained from two accelerometers. The structural intensity method can be applied, by computation or by measurement, for identification of the vibration propagation trace and for vibration control. In this paper, after developing the theory on calculation longitudinal vibration power flow, one proposes an experimental method for determining the attenuation of longitudinal vibrations of materials according to their nature, size and terms of fixing the structure that takes the vibrations transmitted by means of a vibration absorber.

Keywords: *structural intensity, energy flow, inter spectral density, correlation function.*

INTRODUCTION

Acoustical intensimetry bases have grown substantially as theoretical fundamentals as well as applications [2]. In recent years, a more attention was directed to develop the method of structural intensimetry with practical applications [3], [5]. Measurements of vibration energy flow can give information about identification of the positions of vibration sources, energy transmited from source in different ways and different types of vibrations waves [7]

MATERIAL AND METHOD

1. Structural intensity

For the study of power transmission characteristics of structural vibrations is not enough to make simple measurements of vibration levels. In this case it is necessary to determine the distribution of energy flow through structural intensity measurements. This flow represents the instantaneous rate of energy transfer per unit area in a given direction and is called the structural intensity. For this purpose it shall determine interspectrale acceleration density in two closely related sections, similar to the technique of the two microphones in acoustical intensimetry technique.

In recent years, one have made great progress in measuring sound power. In the field of vibrations, practical measurements rise many and difficult problems.

Structural intensity of vibrations in a given direction, is obtained by the product of force F and vibration speed vector:

Rezumat:
Articolul descrie o metodă practică de detarminare amortizării vibrațiilor unor materiale pe baza măsurătorilor de intensimetrie structurală a vibrațiilor longitudinale. Intensimetria structurală se bazează pe analogia cu conceptul de intensimetrie acustică, care utilizează corelația dintre semnalele care provin de la două accelerometre. Metoda intensimetriei structurale se poate aplica, prin calcul sau prin măsurători, pentru identificarea căilor de propagare a vibrațiilor şi pentru controlul vibrațiilor. În această lucrare, după dezvoltarea teoriei privind calculul fluxului de putere al vibrațiilor longitudinale, se propune o metodă experimentală pentru determinarea atenuării vibrațiilor longitudinale a materialelor în funcție de natura lor, dimensiuni şi modul de fixare al structurii care preia vibrațiile transmise, prin intermediul unui absorbitor de vibrații.

Cuvinte cheie: *intensimetrie structurală, flux de energie, densitate interspectrală, funcție de corelație.*

INTRODUCERE

Bazele intensimetriei acustice s-au s-au dezvoltat substanțial ca fundamentare teoretică dar şi ca aplicații [2]. În ultimii ani, o mai mare atenție a fost orientată spre dezvoltarea metodei intensimetriei structurale cu aplicații practice [3], [5]. Măsurătorile fluxului de energie al vibrațiilor pot oferi informații referitoare la identificarea pozițiilor surselor de vibrații, energia transmisă de sursă în diferite moduri precum i diferitele tipuri de unde vibratorii [7]

MATERIAL ŞI METODĂ

1. Intensimetrie structurală

Pentru studiul caracteristicilor transmisiei de putere la vibrațiile structurale nu este suficient a se face simple măsurări ale nivelurilor de vibrații. În acest caz, este necesar să se determine distribuția fluxului de energie prin măsurători de intensimetrie structurală. Acest flux reprezintă rata instantanee a transferului de energie pe unitatea de suprafață într-o anumită direcție, i se numete intensitate structurală. În acest scop, se determină densitatea interspectrală de accelerație în două secțiuni apropiate, similar cu tehnica celor două microfoane din intensimetria acustică.

În ultimii ani s-au făcut mari progrese în măsurarea puterii acustice. În domeniul vibrațiilor, măsurătorile practice ridică probleme numeroase i dificile.

Intensitatea structurală a vibrațiilor, într-o anumită direcție, se obține prin produsul dintre forța F i vectorul viteză a vibrațiilor:

$$\langle \bar{I} \rangle_t = \frac{1}{T}\int_0^T F(r,t)\cdot \bar{v}(r,t)dt \quad \text{sau în complex:} \quad \langle \bar{I} \rangle_t = \frac{1}{2}\mathrm{Re}\left[\hat{F}\cdot \hat{\bar{v}}^*\right]. \tag{1}$$

The complex shape from (1) is used when the force and the particle velocities are treated as complex harmonic variables. The direction of intensity it is the same with the direction of the particle resultant velocity. The expression of intensity depends on the type of vibration of a structure, namely: longitudinal, bending and tosional. In the following we will establish a theoretical expression for the longitudinal vibrations of the beams.

2.Longitudinal vibrations of the beams

One studies the vibrations of the homogeneous beam, with a constant cross section that is acted by a longitudinal force. For an element of length *dx* (fig.1), we can write Newton'law

Forma complexă din relația (1) se utilizează în cazul în care forța şi vitezele particulelor sunt tratate ca variabile armonice complexe. Direcția intensității este aceeaşi cu direcția vitezei rezultante a particulelor. Expresia intensității depinde de tipul de vibrație a unei structuri, respectiv, longitudinală, transversală şi de răsucire. În cele ce urmează noi vom stabili o expresie teoretică pentru vibrațiile longitudinale ale barelor.

2.Vibrații longitudinale ale barelor

Considerăm vibrațiile unei bare omogene cu o secțiune transversală constantă pe toată lungimea, care este acționată de o forță longitudinală. Pentru un element de lungime *dx* (fig.1), se poate scrie legea lui Newton

$$m\frac{\partial^2 u}{\partial t^2} = F + \frac{\partial F}{\partial x}dx - F\,, \tag{2}$$

where *u(x,t)* is the movement of particles in section located at distance *x* and *F* is the normal force on the same section which it is assumed that varies linearly with the distance.

unde *u(x,t)* este deplasarea particulelor din secțiunea localizată la distanța x iar F este forța normală pe aceeaşi secțiune care se presupune că variază liniar cu distanța.

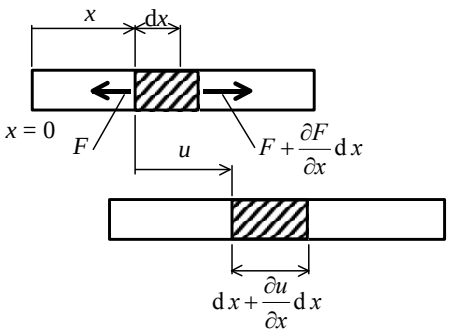


Fig. 2 - Toolbar element during longitudinal vibration

Relative elongation, by definition, the ratio between the elongation Δl and the original length *l*, it is written:

Alungirea relativă, prin definiție, raportul dintre alungirea Δl şi lungimea inițială *l*, se scrie:

$$\varepsilon = \frac{\Delta l}{l_0} = \frac{dx + \frac{\partial u}{\partial x}dx - dx}{dx} = \frac{\partial u}{\partial x}\,, \tag{3}$$

so that Hooke's law becomes:

astfel încât legea lui Hooke devine:

$$\frac{F}{A} = E\frac{\partial u}{\partial x}\,, \tag{4}$$

where *A* is the area of the bar's section and *E* is the Young's modulus.

Using the last three relationships one can obtain

unde *A* este aria secțiunii barei şi *E* este modulul lui Young.

Din utilizarea ultimelor trei relații se obține

$$\rho A dx\frac{\partial^2 u}{\partial t^2} = EA\frac{\partial^2 u}{\partial x^2}dx\,, \tag{5}$$

where *ρ* is the density of the bar material.

The final relationship

unde *ρ* este densitatea materialului barei.

Relația finală

$$\frac{\partial^2 u}{\partial t^2} = \frac{E}{\rho}\frac{\partial^2 u}{\partial x^2} \tag{6}$$

represents the equation of longitudinal vibrations of the beam. The report $\sqrt{E/\rho}$ is noted with c_L and has the dimensions of velocity. It is the speed of propagation of longitudinal vibrations and according to this, the transcribed form of equation (6) is:

reprezintă ecuația vibrațiilor longitudinale ale barei. Raportul $\sqrt{E/\rho}$ se notează cu c_L şi are dimensiunile unei viteze. Aceasta reprezintă viteza de propagare a vibrațiilor longitudinale şi corespunzător cu aceasta ecuația (6) se transcrie sub forma:

$$\frac{\partial^2 u}{\partial t^2} = c_L^2 \frac{\partial^2 u}{\partial x^2} \ . \tag{7}$$

Structural intensity, for longitudinal vibrations in a beam, can be written successively

Intensitatea structurală, pentru vibrațiile longitudinale ale barei, poate fi scrisă succesiv

$$I_L = \langle F.v \rangle = \frac{EA}{c^2}\left\langle \frac{\partial^2 u}{\partial t^2}dx \int \frac{\partial u}{\partial t}dt \right\rangle = \frac{EA}{c^2}\Delta\left\langle (\frac{a_1+a_2}{2})\int (a_2-a_1)dt \right\rangle, \tag{8}$$

where a_1 and a_2 are the accelerations at two nearby points 1 and 2, located at a distance Δ between accelerometers.

The relations (8) were obtained using the finite approximations [6]:

unde a_1 şi a_2 sunt accelerațiile a două puncte apropiate, 1 şi 2, situate la o distanță Δ între accelerometre.

Relațiile (8) s-au obținut cu ajutorul aproximărilor finite [6]:

$$a \cong \frac{1}{2}(a_1+a_2) \ \text{ and } \int a dt \cong \int (a_2-a_1)dt \ ,$$

$$F = \frac{EA}{\Delta r}(u_1-u_2) \tag{9}$$

$$v = \frac{du}{dt} \cong \frac{v_1+v_2}{2} = \frac{1}{2}\int (a_1+a_2)dt$$

For harmonic wave the normal force is

Pentru undele armonice forța normală este

$$F = \frac{EA}{i\omega\Delta}(a_1-a_2) \tag{10}$$

and the vibration velocity of a particle will be written

şi viteza de vibrație a unei particule se va scrie

$$v = \frac{a_1+a_2}{2i\omega} \ . \tag{11}$$

Structural intensity can also be measured using cross-correlation method between the two acceleration signals. Here the vibration intensity vector component, in the direction of the two accelerometer will be

Intensitatea structurală poate fi de asemenea măsurată utilizând metoda intercorelației între două semnale de accelerație. Aici, componenta vectorului intensitate a vibrației, pe direcția celor două accelerometre va fi:

$$I_L(\omega) = -\frac{EA}{\omega^3\Delta}\mathrm{Im}[G(a_1,a_2)], \tag{12}$$

where $\mathrm{Im}|G(a_1,a_2)|$ is imaginary part of cross-spectrum between the two accelerometers signals.

For bending waves in a rod, the energy flow may be written as

unde $\mathrm{Im}[G(a_1,a_2)]$ este partea imaginară a interspectrului dintre cele două semnale ale accelerometrelor.

Pentru undele transversale dintr-o bară, fluxul de energie poate fi scris sub forma

$$I_B(\omega) = \frac{2\sqrt{Bm}}{\omega^2\Delta}\mathrm{Im}[G(a_1,a_2)]2\pi/\lambda \ , \tag{13}$$

here B is bending stiffness and m is mass per unit length [1], [4], [8].

în care B este rigiditatea de încovoiere iar m este masa pe unitatea de lungime [1], [4], [8].

RESULTS

In the first experiment there were used two horizontal

REZULTATE

În primul experiment s-au utilizat două bare orizontale

bars with an outside diameter of 20 mm. Between the two bars a sample of cork with the role of damping longitudinal vibration transmitted from the first to the second bar has been fixed. The connection between the second bar and the outside has been carried out by means of a spring (fig.2,a).

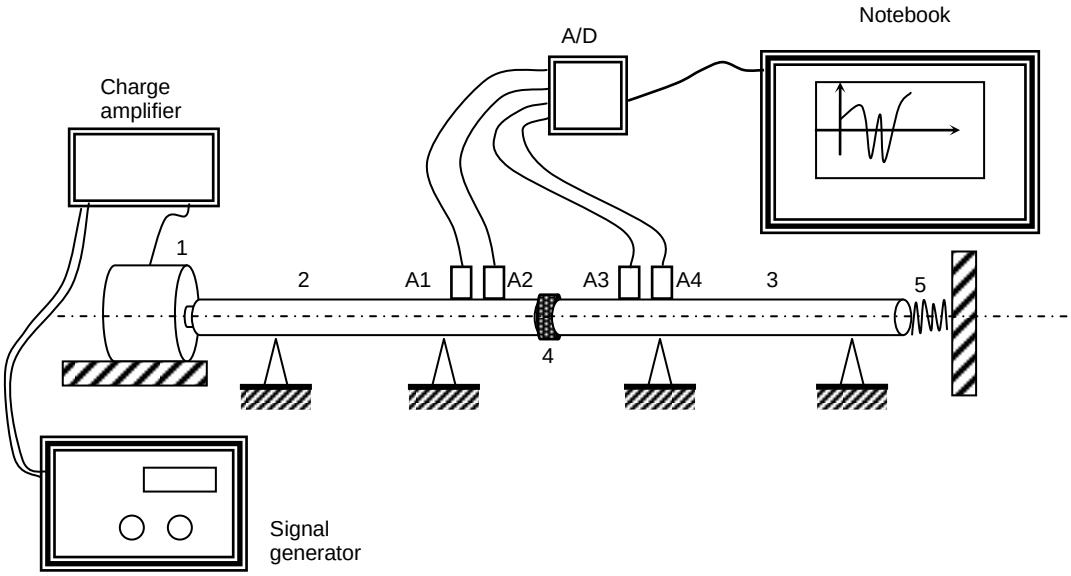
The second experiment was carried out by means of two vertical cylindrical bar with an outer diameter of 100 mm. Between the two bars was fixed too a sample of cork with the purpose of vibration damping, the second rod being rigidly fixed to the foundation (fig.2,b).

In both cases, the used accelerometers A1-A2 and A3-A4, of delta-share type (B&K 4507), having the phase difference of not more than 4°, were mounted such that their axes coincide with the axes of the bars and the mini shaker. The experiments were carried out also, for other types of material (rubber, felt) of different thickness (0.5 cm, 1 cm and 2 cm).

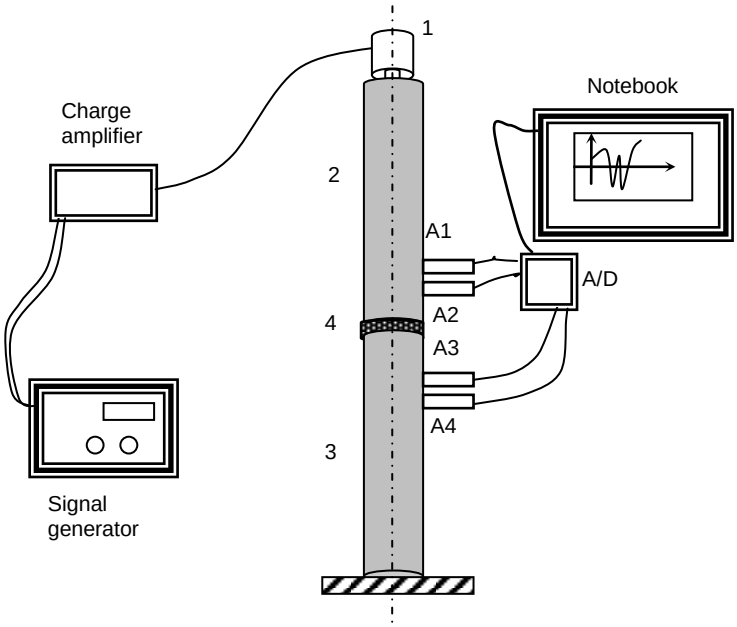
cu diametrul exterior de 20 mm. Între cele două bare a fost fixat un eşantion din plută cu rolul de amortizare a vibrațiilor longitudinale transmise de la prima bară la a doua bară. Legătura dintre bara a doua şi exterior a fost realizată cu ajutorul unui resort (fig.2,a).

Al doilea experiment a fost realizat cu ajutorul a două bare cilindrice verticale cu diametrul exterior de 100 mm. Între cele două bare a fost fixat un eşantion din plută cu rolul de amortizare a vibrațiilor, a doua bară fiind fixată rigid la fundație (fig.2,b).

În ambele cazuri, accelerometrele A1-A2 şi A3-A4 utilizate, de tip delta-share (B&K 4507), care au diferența de fază de cel mult 4°, au fost montate astfel încât axele lor să coincidă cu axele barelor şi ale excitatoarelor. Experimentele au fost realizate şi pentru alte tipuri de materiale (cauciuc, pâslă) de diferite grosimi (0.5 cm, 1 cm şi 2 cm)..



a)



b)

Fig. 2 - The block diagrams of the damped measurement

1.Shaker; 2,3 Beam ; 4 Sample; 5 Spring; A1-A4 Accelerometers; A/D

The signal generated by the mini shaker is a white noise signal. Vibration energy flow (vibration intensity) expressed by relation (12) as the cross-spectra density of two accelerometer signals is shown in fig.3 and fig.4, in the frequency range of 1-1000Hz, for a 1cm sample of cork.

Significant differences occur in the resonance frequencies of the bar that takes over the damped vibrations.

Semnalul generat de excitator este un semnal de zgomot alb. Fluxul de energie al vibrațiilor (intensitatea vibrațiilor) exprimată prin relația (12) ca densitate interspectrală a semnalelor accelerometrelor este reprezentat în figurile 3 şi 4, în banda de frecvențe de 1-1000Hz, pentru un eşantion de 1 cm din plută.

Diferențe semnificative apar în zona frecvențelor de rezonanță ale barei ce preia vibrațiile amortizate.

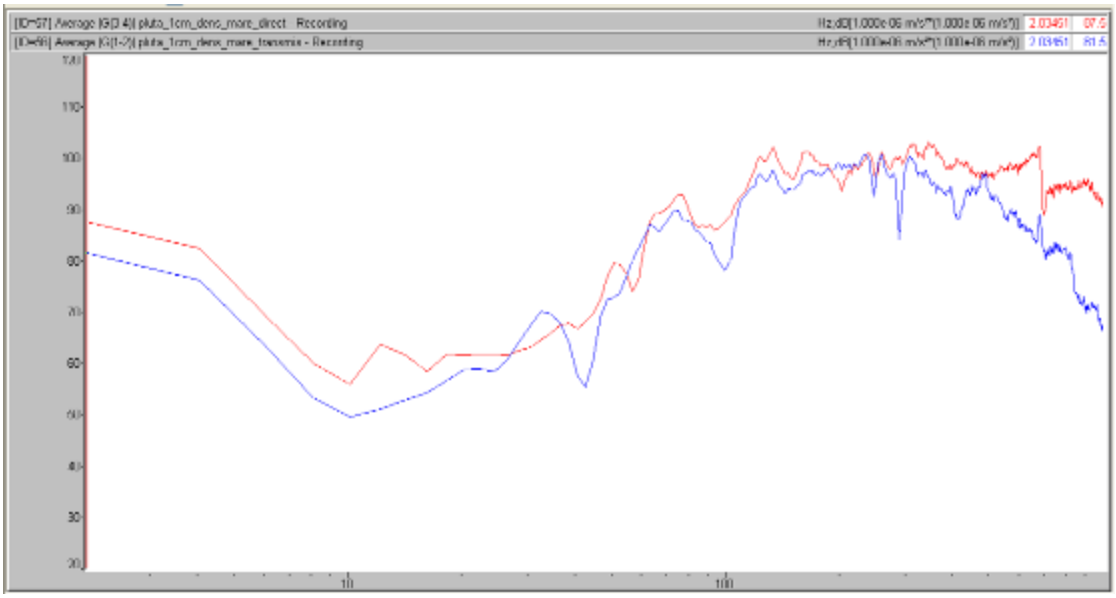


Fig. 3 - Power flow vibration spectrum
corresponding to the experiment from fig.2a, for sample of cork of 1 cm

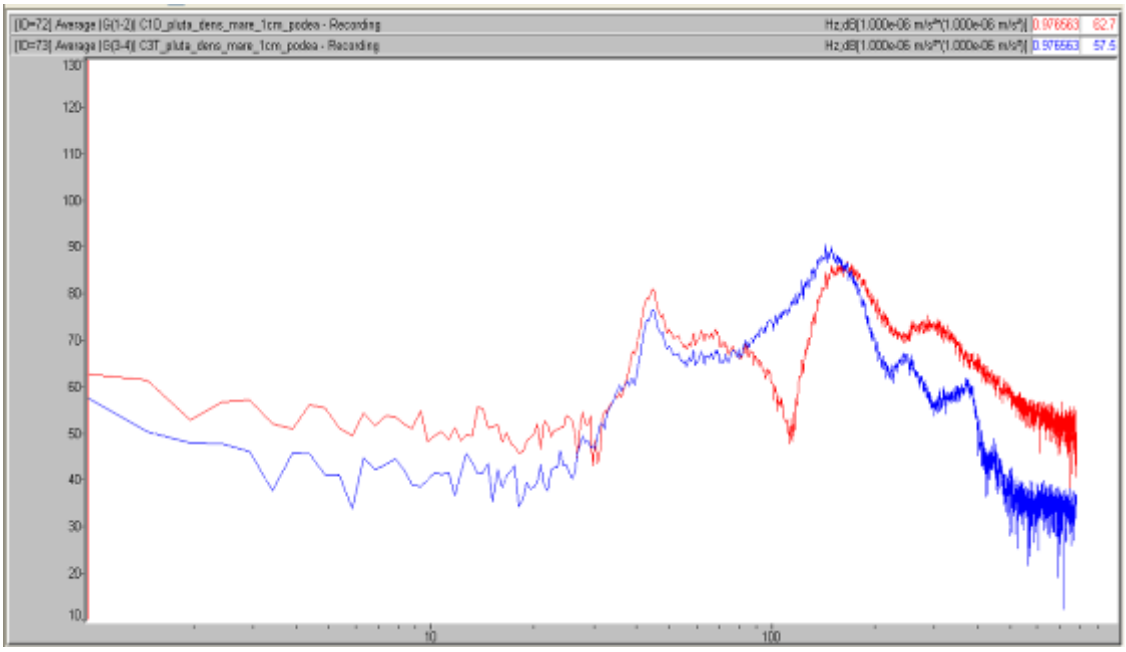


Fig. 4 - Power flow vibration spectrum
corresponding to the experiment from fig.2b, for sample of cork of 1 cm

CONCLUSIONS

The measurements made on the flow of vibration energy can provide qualitative and quantitative information on vibration damping longitudinal direction by

CONCLUZII

Măsurătorile fluxului de energie al vibrațiilor pot furniza informații calitative şi cantitative cu privire la amortizarea vibrațiilor longitudinale cu ajutorul unui

a vibration damper. Differences between the two experimental devices (fig.3 and fig.4) are not significant where there are no resonance frequencies of the bar behind the damper. It may occur increases of vibration power at the resonance frequencies of the structure behind the damper.

Measurements of structural intensity depend on:

- errors of tools by the phase difference between the measured accelerations and corresponding electrical signals;
- the transducer mass must be much smaller than the structural apparent mass;
- the spacing between the accelerometers produces errors proportional with ($\frac{2\pi}{\lambda} \cdot \Delta$), where λ is the wave length.

For the study of bending vibration damping, the excitation and measurement direction of accelerations are chosen perpendicular to bars.

For torsional vibrations, things are more complicated, both from the point of view of the excitation and of the transducer, which is specific for measurement of torsional vibrations.

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amortizor de vibraţii. Diferenţele dintre cele două dispozitive experimentale (fig.3 şi fig.4) nu sunt semnificative în domeniul de frecvenţă în care nu apar frecvenţe de rezonanţă ale barei din spatele amortizorului. Se pot produce creşteri ale puterii vibraţiei la frecvenţe de rezonanţă ale structurii din spatele amortizorului.

Măsurările de intensitate structurală depind de:

- erorile instrumentelor prin diferenţa de fază dintre acceleraţiile măsurate şi semnalele electrice corespunzătoare;
- masa traductorului trebuie să fie mult mai mică decât masa aparentă structurală;
- distanţa dintre accelerometre produce erori proporţionale cu ($\frac{2\pi}{\lambda} \cdot \Delta$), unde λ este lungimea de undă.

Pentru studiul amortizării vibraţiilor transversale, direcţia de excitaţie şi măsurarea acceleraţiilor se alege perpendiculară pe axa barelor.

Pentru vibraţiile de răsucire lucrurile sunt mai complicate, atât din punctul de vedere al excitaţiei cât şi al traductoarelor speciale pentru măsurări ale vibraţiilor de torsiune.

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THE INFLUENCE OF HYDROGEN ON THE COMBUSTION VELOCITY OF SOLID BIOMASS
/
INFLUENȚA HIDROGENULUI ASUPRA VITEZEI DE ARDERE A BIOMASEI SOLIDE

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Abstract: *Solid biomass combustion is characterized by two main issues: fuel high moisture weight (that generates some ignition failures) and the high rate of carbon monoxide from flue-gasses (that diminishes the efficiency of the burner an increases the pollution)*
Hydrogen injection (with a higher combustion velocity) disables the disadvantages mentioned above, allowing the design and operation of more efficient and less pollutant biomass boilers.
The paper enhances the theoretical and experimental issues related to the hydrogen use during solid biomass combustion.

Keywords: *combustion, solid biomass, efficiency, pollution.*

Rezumat: *Arderea biomasei solide este caracterizată de două aspecte importante: conţinutul ridicat de umiditate din combustibil (care-I conferă dificultăţi la aprindere) şi rata ridicată a emisiei de monoxid de carbon din gazele de ardere (care înrăutăţeşte eficienta instalaţiei de ardere şi creşte poluarea).*
Injecţia de hidrogen (care are viteză mare de aprindere) combate dezavantajele enunţate mai sus, permiţând construirea şi exploatarea unor instalaţii de ardere mai eficiente şi mai puţin poluante. Lucrarea evidenţiază aspecte teoretice şi experimentale privind utilizarea hidrogenului în arderea biomasei solide.

Cuvinte cheie: *ardere, biomasă solidă, hidrogen, eficienţă, poluare.*

INTRODUCTION

Romania has a huge potential to produce and use the solid biomass for energy purposes. Related to the agricultural biomass, we mention important achievements in the use of straw briquettes in hot water boilers up to 300 kW [7].

The both agricultural and wooden biomass is characterized by a high volatile matters amount, which influences the whole combustion process. The combustion is also dependent on the high moisture content of the fuel, especially the ignition phase. The large difference between the combustion velocity of volatile matters and respectively those of solid mass (fix carbon) composed of lignin and cellulose leads finally to a high Co concentration in the flue-gasses. This is the main obstacle to achieving an efficient combustion of solid biomass [2], [5].

According to the measurements, the higher calorific value (HCV) of the cellulose is lower than the lignin. In relation to the fixed carbon content C_f, HCV can be computed using (1), C_f being reported at anhydrous status of the fuel:

INTRODUCERE

România are un mare potenţial pentru producerea şi utilizarea energetică a biomasei solide. Referitor la biomasa agricolă se menţionează realizări importante în utilizarea paielor de cereale sub formă de brichete la cazane foarte performante cu puteri termice de până la 300 kW [7].

Biomasa, fie agricolă, fie lemnoasă, este caracterizată printr-o cantitate mare de volatile, procesul de ardere în ansamblu depinzând puternic de acest aspect. Umiditatea ridicată influenţează negativ arderea, în special pentru faza de aprindere. Diferenţa mare dintre viteza de ardere a volatilelor şi cea a masei solide (carbonul fix) formată din celuloză şi lignină conduce în final la o emisie ridicată de CO. Aceasta constituie principalul obstacol în realizarea unei arderi performante a biomasei solide [2], [5].

Referitor la puterea calorifică se constată că celuloza are o putere calorifică mai redusă decât lignina. În funcţie de conţinutul de carbon fix C_f, puterea calorifică superioară se poate calcula cu relaţia (1), C_f fiind raportat la starea anhidră:

$$HCV = 196\,C_f + 14{,}119 \quad [\text{kJ/kg}] \tag{1}$$

The hydrogen, with its own very high combustion velocity, contributes to the increase of volatile matters velocity combustion, canceling the combined combustion of volatile and fixed carbon. In this manner, a better control of the fixed carbon combustion is achieved, leading to a significant diminution of the CO emission content.

Hidrogenul, având o viteză foarte ridicată de ardere, contribuie la o creştere a vitezei de aprindere şi ardere a volatilelor, cu eliminarea arderii combinate (suprapusă) pentru cea a carbonului fix. Se realizează astfel un control mai bun asupra proceselor de ardere a carbonului fix, cu reducerea semnificativă a emisiei de CO.

În lucrarea [6] s-a utilizat un amestec special de

In paper [6] it was used a mixture of hydrogen, named hydrogen enriched gas (HRG), produced by an electrolytic system. This electrolytic system is a dynamic one, keeping the fluid in a permanent flow and it is producing a quasi-stoichiometric gaseous mixture of hydrogen and oxygen. In fact this gas consists of a mixture of hydrogen and oxygen molecules, almost respecting the stoichiometric water ratio [3].

HRG is a gas with a high degree of reactivity which, by adsorption, diffuses into the biomass. Thus, the ignition and combustion rate are improved and the pollutant emissions are reduced. HRG is a colorless gas which has a density of 0.503 kg/m^3, molecular weight 12.3 kg/kmol, auto-ignition temperature 591-605 °C and flammability limit concentration between 7.3–100 % [4]. The free diffusion process (equation Legendre) is the basis for HRG/porous biomass combustion technology. Maximum capacity of producing HRG is 1500 litters/h. Electricity consumed to produce 1000 litters of HRG is between 3–3.5 kWh. This means approximately 0.4 Euro/1000 litters.

HRG injection in solid biomass [4] contributes to reducing the carbon monoxide concentration (OH radical having leading role) by reactions (2) [1]:

hidrogen, cunoscut sub titulatura HRG (gaz îmbogăţit cu hidrogen), care a permis tranziţia către condiţiile reale de exploatare şi costuri scăzute. Gazul este produs într-un sistem electrolitic dinamic, care păstrează fluidul într-o curgere permanentă şi o proporţie cvasi-stoichiometrică a mixturii hidrogen-oxigen. De fapt, acest gaz constă dintr-un amestec de molecule de hidrogen şi oxigen,

HRG este un gaz cu un mare grad re reactivitate, care difuzează prin adsorbţie în biomasă. În acest fel, aprinderea şi rata reacţiei de oxidare a combustibilului sunt crescute, iar emisiile poluante sunt reduse. HRD este un gaz incolor, având densitatea de 0,503 kg/m^3, masa moleculară de 12,3 kg/kmol, temperatura de autoaprindere de 591-605 °C şi concentraţia limită de inflamabilitate cuprinsă în intervalul 7,3–100 % [4]. Tehnologia de ardere biomasă/HRG este bazată pe difuzia liberă conform ecuaţiei Legendre. Capacitatea maximă de producere este de 1500 l/h, iar electricitatea consumată este de 3-3,5 kWh/1000 l, ceea ce înseamnă cca. 0,4 Euro/1000 l.

Injecţia HRG în biomasa solidă [4] contribuie la reducerea concentraţiei de monoxid de carbon (radicalul OH având rolul decisiv) prin reacţiile (2) [1]:

$$CO + OH \rightarrow CO_2 + H; \quad H + O_2 \rightarrow OH + O; \quad O + H_2O \rightarrow 2OH. \tag{2}$$

The improvement of the biomass combustion performances by hydrogen injection is possible to be made for all known combustion technologies, such as:

- Fixed bed combustion systems: with fixed grate, with mobile-rolling grate, with forward or backward push, with inferior supply for pellets;
- Fluidized bed systems: stationary or recirculating;
- Air-driven system (fuel is milled and pulverized);

For biomass with high moisture content and ash, with particle dimension larger than 1 mm, it is recommendable to select boilers provided with fixed bed furnaces, with a maximum output of 20 MWt.

Some mixtures between agricultural biomass with wooden biomass can be prepared for combustion, excepting the mixture straw-wood, due to some large differences between combustion characteristics, such as moisture and ash melting temperature.

Îmbunătăţirea performanţelor arderii biomasei prin injecţie de hidrogen se poate realiza pentru toate tehnologiile de ardere, ce cuprind:

- Sisteme cu strat fix: cu grătar fix, cu grătar mobil–rulant, cu împingere înainte, sau răsturnată, cu alimentare inferioară pentru pelete
- Sisteme în strat fluidizat staţionar sau recirculant;
- Sisteme în curent de aer (combustibil pulverizat);

Focarele cu grătar, care în general au o putere sub 20 MWt sunt folosite pentru arderea biomasei cu conţinut mai mare de umiditate şi cenuşă şi de dimensiuni variabile, dar nu sub 1 mm.

Pot fi arse şi amestecuri de biomasă agricolă cu cele pe bază de lemn dar nu şi amestecuri ale acestora cu paiele, datorită diferenţei dintre caracteristicile de ardere, referitoare la umiditate şi temperatura de topire a cenuşii.

MATERIAL AND METHOD

The release and burning velocity for volatile matters is described in paper [8] by the differential equation (3):

MATERIAL ŞI METODĂ

Viteza de degajare şi arderea volatilelor este descrisă în lucrarea [8] de ecuaţia diferenţială (3)

$$\frac{dV_c}{d\tau} = (V_i - V_c) \cdot \alpha_v \tag{3}$$

where: V_i is the initial content of volatile, V_c – volatile burnt content in period τ , α_v - release and burning velocity of volatile matters (processes ruled by gaseous diffusion and the combustion reactions kinetic).

unde: V_i este conţinutul iniţial de volatile, V_c – conţinutul ars în timpul τ , α_v - viteza de degajare şi ardere a materiilor volatile (procese guvernate de difuzia gazoasă şi cinetica reacţiilor de ardere).

$$\alpha_v = \frac{1}{\frac{1}{\alpha_{v,dif}} + \frac{1}{\alpha_{v,cin}}} \quad [1/s] \tag{4}$$

$$\alpha_{v,dif} = \frac{2{,}22 \cdot 10^{-6}}{d^2} \quad [1/s] \tag{5}$$

$$\alpha_{v,cin} = K_{ov}\, e^{-\frac{E_v}{RT}} \quad [1/s] \tag{6}$$

Equation (5) is very common in literature [8], but not so accurate for biomass as it is for coal

However, due to bale or briquette breakage due to the swelling phenomenon in the first phase of combustion occurs an auto-correction by reconsidering the particle's diameter value; the hydrogen contributes too for reducing the diameter in the ignition phase. For equation (6), the values are:

d – particle diameter, [m]; K_{ov} - volatile release value, [1/s]; E_v – activation energy, [kJ/mol], *T* – temperature, [K]. For solid biomass, the reaction constants have the values: K_{ov} = 80–111 [1/s], E_v = 38.4–60.12 [kJ/kmol]

For fixed carbon combustion, the equation is given by (7), while for the combustion velocity was used equation (8) [8] :

Relaţia (5) este foarte utilizată în literatura de specialitate [8], la biomasă însă nu are gradul de precizie de la cărbune. Totuşi, datorită ruperii brichetelor sau a baloţilor ca urmare a fenomenului de umflare din prima fază de ardere apare o autocorectură prin reconsiderarea valorii diametrului; hidrogenul aduce şi el contribuţii la reducerea diametrului în faza de aprindere.

Pentru ecuaţia (6), valorile sunt următoarele:

d - diametrul particulei, în m; K_{ov} - constanta de degajare a volatilelor, 1/s; E_v – energia de activare, kJ/mol, *T* – temperatura, *K*. Pentru biomasă solidă, constantele reacţiilor sunt: K_{ov} = 80–111 [1/s], E_v = 38,4–60,12 [kJ/kmol]. Pentru arderea carbonului fix, relaţia de calcul este (7), pe când pentru viteza de ardere relaţia (8) [8]:

$$K_c = 8710\, e^{-\frac{35700}{RT}} \quad [1/s] \tag{7}$$

$$C_{CO_2} = \tau(\alpha_v + K_c) S \cdot d^2 \quad [m/s] \tag{8}$$

where: $\tau = \frac{12}{32}$ is the stoichiometric ratio $O_2 \longrightarrow CO_2$, and *S* the specific reaction surface, [m^2/m^3].

For the solid biomass, according to the physical process of densification, $\alpha_{v,dif}$ is dominant versus $\alpha_{v,cin}$. In such manner, it appears as necessary a limitation criterion for briquette dimension. The expertise allows to asses the optimal domain: $\alpha_{v,dif} = max(10\,\alpha_{v,cin})$.

unde: $\tau = \frac{12}{32}$ este raportul stoichiometric $O_2 \longrightarrow CO_2$, iar *S* suprafaţa specifică de reacţie, m^2/m^3 .

Pentru biomasa solidă, ca urmare a proceselor de densificare, $\alpha_{v,dif}$ este dominat faţă de $\alpha_{v,cin}$. Apare necesar un criteriu de limitare a dimensiunilor brichetelor. Experienţa indică drept optim domeniul $\alpha_{v,dif} = max(10\,\alpha_{v,cin})$.

RESULTS

In the paper [6] are presented the results of some experimental tests for the fixed bed combustion of five types of solid biomass injection HRG in the primary air.

The following biomass categories have been tested: sawdust (1), wooden pellets (2), cereal straw briquettes (3), vineyard wastes (4), corncobs (5).

Biomass power characteristics taken into account were: low calorific value – Q^i_i [kJ/kg]; moisture – W^i_t [%]; ash – A^i [%]. The results of the analysis are:

- Fuel 1: Q^i_i=16500 kJ/kg; W^i_t =14 %; A^i =2,5 %;
- Fuel 2: Q^i_i=17500 kJ/kg; W^i_t =10,5 %; A^i=0,5 %;
- Fuel 3: Q^i_i=14700 kJ/kg; W^i_t =10,2 %; A^i=4,7 %;
- Fuel 4: Q^i_i =13600 kJ/kg; W^i_t=16,1 %; A^i=4,9 %;
- Fuel 5: Q^i_i =12800 kJ/kg; W^i_t=18,8 %; A^i=3,9 %;

A constant thermal load of the boiler presented in figure 1 has been maintained during tests, by controlling the fuel mass-flow rate.

REZULTATE

În lucrarea [6] se prezintă rezultate ale unor testări experimentale de ardere în strat fix a biomasei solide cu insuflare de gaz HRG în aerul primar.

S-au testat următoarele categorii de biomasă: rumeguş (1), pelete lemn (2), brichete de paie de cereale (3), corzi de viţă de vie (4), coceni de porumb (5).

Caracteristicile energetice considerate pentru biomasă au fost: putere calorifică inferioară – Q^i_i [kJ/kg]; umiditate – W^i_t [%]; cenuşă – A^i [%]. Rezultatele analizelor sunt:

- Comb. 1: Q^i_i=16500 kJ/kg; W^i_t =14 %; A^i =2,5 %;
- Comb. 2: Q^i_i=17500 kJ/kg; W^i_t =10,5 %; A^i=0,5 %;
- Comb. 3: Q^i_i=14700 kJ/kg; W^i_t =10,2 %; A^i=4,7 %;
- Comb. 4: Q^i_i =13600 kJ/kg; W^i_t=16,1 %; A^i=4,9 %;
- Comb. 5: Q^i_i =12800 kJ/kg; W^i_t=18,8 %; A^i=3,9 %;

Pe parcursul experimentărilor s-a păstrat o sarcină termică constantă a cazanului prezentat în figura 1, realizată prin variaţia debitului de combustibil.

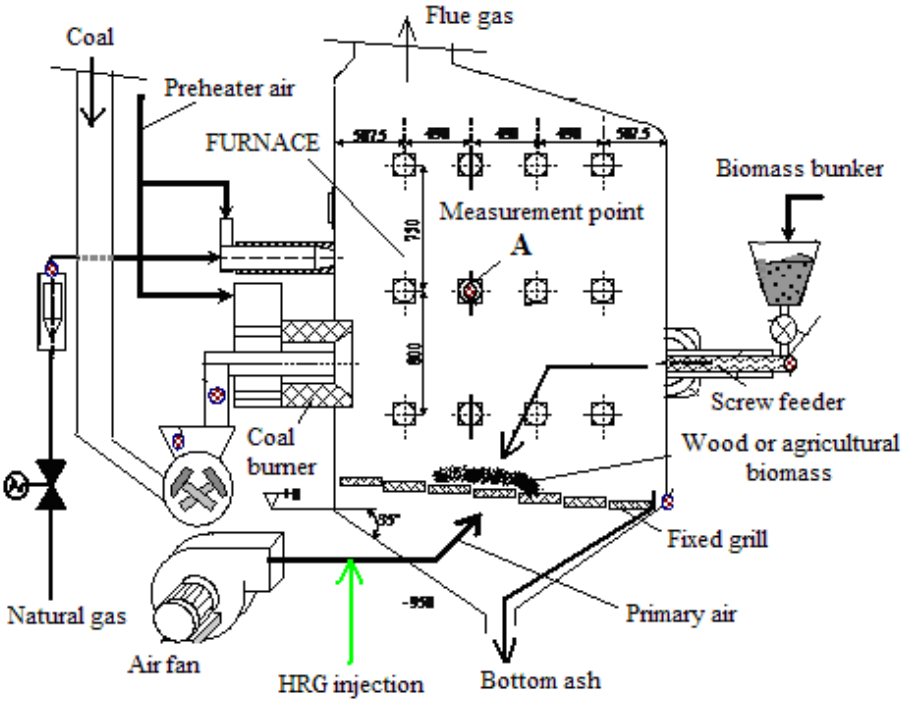

Fig. 1 - Pilot plant of 2 MWt used to test the hydrogen injection in biomass combustion

Findings:

- Significant reduction of CO emissions for wooden biomass derivates (reduction limit until 158 ppm);
- Lower reduction for agricultural biomass (upper limit to 1700 ppm);

In figures 2 and 3 is shown the flame shape for wooden and agricultural biomass, with and without HRG injection,

We found as remarkable the diminution of the flame length in the case of HRG combustion, due to a higher intensity of the oxidation processes in the inferior zone of the fuel bed.

S-au constatat:

- reducerea semnificativă a emisiei de CO pentru biomasa lemnoasă (limită de până la 158 ppm);
- o reducere mai puțin sensibilă pentru biomasa agricolă (limita superioară de până la 1700 ppm);

În figurile 2 şi 3 este arătat aspectul arderii pentru derivatele de lemn şi respectiv pentru biomasa solidă.

S-a remarcat o scădere a lungimii flăcărilor în cazul injecției de HRG, explicabilă prin mărirea intensității proceselor de ardere în zona inferioară a stratului de combustibil

a) wooden biomass b) agricultural biomass

Fig. 2 - Flame shape without HRG injection

a) wooden biomass

(b) agricultural biomass

Fig. 3 - Flame shape without HRG injection

Finaly, an elemental analysis of the ash was performed, presented in Table 1, in order to draw a conclusion related to future possible use.

The high phosphorus, potassium and calcium contents, related to very low concentrations of heavy metals, indicate the possibility to use the biomass ash as agricultural fertilizer. Such approach is very important not only for economic reasons, but give the hope to eliminate a potential hazard.

În final s-a efectuat şi o analiză elementală a cenuşii, prezentată în tabelul 1, pentru a putea trage o concluzie privind posibile utilizări ale acesteia.

Prezența ridicată a fosforului, ca şi a potasiului şi calciului precum şi valorile foarte reduse pentru metalele grele, indică posibilitatea utilizării cenuşilor drept îngrăşământ agricol. Această posibilă utilizare nu are doar un pozitiv efect economic, dar este de o maximă importanță deoarece elimină traseul pentru un potențial deşeu.

Table 1

Elemental analysis of the ash

Chemical Species	Wooden Biomass	Agricultural Biomass
Si	19.14 %	19.72 %
Ca	6.66 %	6.04 %
Fe	3.65 %	5.61 %
Al	2.88 %	4.30 %
Mg	1.44 %	1.26 %
S	1.31 %	1.23 %
P	0.81 %	0.59 %
Na	0.28 %	0.36 %
Ti	0.27 %	0.29 %
Cl	0.16 %	0.15 %
Ba	0.10 %	0.10 %
Zn	0.03 %	0.03 %
Cu	0.01 %	0.01 %
Cr	86 ppm	95 ppm
Ni	68 ppm	83 ppm

CONCLUSIONS

In order to challenge some obstacles occurred in biomass combustion, such as the ignition difficulties due to high moisture content, respectively the high concentration of carbon monoxide in flue-gasses; we have tested a new technology – hydrogen injection as HRG in the primary air flow, at a permissive cost in

CONCLUZII

În scopul depăşirii unor obstacole frecvente la arderea biomasei, cum sunt dificultățile la aprindere din cauza umidității ridicate, respectiv emisiile ridicate de monoxid de carbon, am testat surmontarea acestor bariere prin injecția hidrogenului sub forma HRG în aerul primar de ardere, la un cost permisiv pentru avantajele create.

comparison to the advantages. The research is fully original, according to our knowledge there are no similar paper in the literature.

The effects of this procedure were:

- Separation between the volatile and fixed carbon combustion trough high burning velocity of the hydrogen;
- Reduction of the flame length and flame stabilization;
- Decrease of pollutant emissions, especially carbon monoxide.

Beside these advantages, the ash resulted from biomass combustion is a good fertilizer for agriculture and horticulture.

Acknowledgement

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Cercetările reprezintă o noutate absolută, nemaifiind semnalate lucrări similare în literatura de specialitate.

Efectele acestui procedeu au fost:

- Separarea arderii volatilelor de arderea carbonului fix prin viteza mare de ardere a hidrogenului;
- Scurtarea flăcării şi stabilizarea acesteia;
- Reducerea emisiilor poluante, în special a monoxidului de carbon.

Pe lângă aceste avantaje, cenuşa rezultată din arderea biomasei reprezintă un foarte bun îngrăşământ pentru agricultură si horticultură.

Mulțumiri/Recunoştință

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MATHEMATICAL MODELING AND COMPARATIVE SIMULATION OF THE VIBRATIONS OF VIBRO-CULTIVATORS AND AGRICULTURAL CULTIVATORS
/
MODELARE MATEMATICA SI SIMULAREA COMPARATIVA A VIBRATIILOR COMBINATOARELOR SI CULTIVATOARELOR AGRICOLE

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Abstract: *Inspiration for investigations described in this article was explaining the differences between a cultivator and a vibro-cultivator. Starting from the basic model of linear damped oscillator, the authors complicated equations and terms significantly enriched customize or entering equations specific terms of agricultural machinery for soil. First, these models attempt to explain the behavior of oscillator working bodies in different operating modes of agricultural machinery. Subsequently, the practical application will consist the system vibration control using adjustable parameters of working processes. Moreover, the simulator presented is usable in theoretical research of nonlinear friction and amortization and complex phenomena including the equation of motion of the unit.*

Keywords: *mathematica model, simulation, vibrations, vibro-cultivator, cultivator*

Rezumat: *Sursa de inspiratie pentru relizarea investigatiilor descrise in acest articol a fost explicitarea deosebirilor dintre un cultivator si un vibrocultivator. Pornind de la modelul elementar al oscilatorului liniar cu amortizare, autorii complica ecuatiile si particularizeaza sau imbogatesc semnificatia unor termeni introducand in ecuatii termeni specifici masinilor agricole de lucrat solul. Pentru inceput, aceste modele incearca sa explice comportamentul oscilator al organelor de lucru in diverse regimuri de functionare ale masinilor agricole. Ulterior aplicatia practica va consta in controlul acestor vibratii folosind parametrii de regim reglabili. Mai mult, simulatorul prezentat este utilizabil si in cercetarea teoretica a unor frecari si amortizari neliniare, precum si la fenomene complexe incluzand ecuatia de miscare a agregatului.*

Cuvinte cheie: *model matematic, simulare, vibratii, combinator, cultivator*

INTRODUCTION

The mathematical model described in this article tries to describe the behavior of the whole body of work - working organ support (AOLSOL) in soil, characteristically subassembly of vibro - cultivator or of cultivator, [1].

This model has the following purposes:
-to describe the difference between the functioning of the cultivator and the vibro - cultivator AOLSOL in part to motivate the construction of the latter;
-to emphasize geometric constants or material that would make the most important difference between the working processes of the two machines, in terms AOLSOL;
-to investigate possible ways of optimizing the operating mode if vibro - cultivator.

MATERIAL AND METHOD

The mathematical model considered for a first approach is relatively simple, classic literature, for example [2]: linear damped oscillator described by second order differential equation:

INTRODUCERE

Modelul matematic descris in acest articol incearca sa descrie comportamentul ansamblului organ de lucru - suport organ de lucru (AOLSOL) in sol, subansamblu caracteristic al unui cultivator sau vibrocultivator, [1]. Acest model are urmatoarele scopuri:
-sa descrie diferenta dintre modul de functionare al AOLSOL al cultivatorului si cel vibrocultivatorului, in parte pentru a motiva constructia acestuia din urma;
-sa evidentieze constantele de material sau parametrii geometrici cei mai importanti care ar face diferenta intre procesele de lucru ale celor doua masini, in ceea ce priveste AOLSOL;
-sa investigheze eventuale posibilitati de optimizare a regimului de lucru in cazul vibrocultivatorului.

MATERIAL ŞI METODĂ

Modelul matematic considerat pentru o prima abordare este unul relativ simplu, clasic in literatura de specialitate, de exemplu [2]: oscilatorul liniar cu amortizare, descris de ecuatia diferentiala de ordinul al doilea:

.

$$m\ddot{x} + c\dot{x} + kx = \psi \,, \qquad (1)$$

where x is the relative displacement of the mass center of AOLSOL, m is the mass AOLSOL, c is damping coefficient of AOLSOL, k is the stiffness coefficient of AOLSOL and ψ is excitation force. The structure of each parameter will be subject to further clarifications. Obviously, the $\dot{x}$, and $\ddot{x}$ are derivatives

in care: x este deplasarea relativa a centrului de masa al AOLSOL, m este masa AOLSOL, c este coeficientul de amortizare al AOLSOL, k este coeficientul de rigiditate al AOLSOL, iar ψ este forta excitatoare. Structura fiecarui parametru va constitui subiectul unor precizari ulterioare. Evident, $\dot{x}$ si $\ddot{x}$, sunt derivatele de ordinul intai, respectiv al doilea ale deplasarii relative x.

of the first order and second order of relative displacement, x.

The relative displacement is a function of time t, which is subject to initial conditions:

Deplasarea relativa este o functie de timp, t, care trebuie sa respecte conditiile initiale:

$$x(t_0) = x_0,\ \dot{x}(t_0) = \dot{x}_0. \tag{2}$$

In physical terms damping coefficient c is given by the amortization of the soil and stiffness coefficient k is AOLSOL stiffness, mainly on the support of the working body.

Note: AOLSOL is not a classic oscillator. It can be likened more to a phenomenon hauling a very rigid linear pendulum through a viscous fluid.

The working body together the support are assimilate with pendulum mass, the amortization is given by the medium through which the body moves (soil) and the stiffness of the stiffness property of the working body support.

For damping can be considered a form more complex by combining viscous friction with the dry, taking into account the soil moisture:

Din punct de vedere fizic, coeficientul de amortizare c, este dat de amortizarea produsa de sol, iar coeficientul de rigiditate k este rigiditatea AOLSOL, data in principal de suportul organului de lucru.

Observatie: AOLSOL nu este un oscilator clasic. El poate fi asemanat mai mult cu un fenomen de tractiune a unui pendul liniar foarte rigid printr-un fluid vascos.

Organul de lucru impreuna cu o parte a suportului se asimileaza masei pendulului, amortizarea este data de mediul prin care organul se misca (solul), iar rigiditatea de proprietatea de rigiditate a suportului organului de lucru.

Pentru amortizare poate fi considerata de o forma mai complexa, prin combinarea frecarii vascoase cu cea uscata, tinand seama si de umiditatea solului:

$$c = c_v \cdot f(u) + \frac{c_u}{|\dot{x}|} \cdot g(u), \tag{3}$$

where c_v is the coefficient of viscous damping, c_u is the dry friction coefficient, f is an increasing function of soil moisture and g is a decreasing function of soil moisture, u. f and g function may be known in special cases only on experimental basis, depending on the texture and soil composition.

Exciter force, ψ is produced by the interaction between AOLSOL and soil. To simulate a large range of phenomena, it is considered for the exciter force the next form:

in care c_v este coeficientul de amortizare vascoasa, c_u coeficientul de frecare uscata, f este o functie crescatoare cu umiditatea solului iar functia g este o functie descrescatoare cu umiditatea, u. Functiile f si g se pot cunoaste particular numai pe baze experimentale, depinzand si de textura si compozitia solului.

Forta excitatoare, ψ este produsa de interactiunea dintre AOLSOL si solul. Pentru a simula o gama cat mai larga de fenomene, se considera pentru functia excitatoare forma:

$$\psi(t) = F(t) + \varphi(t), \tag{4}$$

where F is the force of resistance to deformation of the soil, which can be considered as:

in care F este forta de rezistenta la deformare a solului, care se poate considera de forma:

$$F(t) = Ka(t)b(t), \tag{5}$$

where K is the coefficient of resistance to deformation of the soil, it is working depth and width b is working. It is considered that the depth and width of work are functions of time, primarily due consideration of the phase transition from sleep to work in steady state, and secondly, that these two characteristics of farm machines for soil can random vary and, especially the working depth. On the other hand, in transitive stage, the working width increases with the working depth for many types of working body. If these issues can be neglected, then a and b can be considered constant as the the coefficient of resistance to deformation of the soil, K.

The solution of the problem (1), (2), completions (3), (4), (5), even with nonlinearity considered in (3) can be given using the techniques operational calculus [2] (even piecewise).

The presence of more complicated nonlinearities in x or $\dot{x}$ cancel the possibility of using operational calculus if not apply linearization. But the linearization limited decisive investigations. On the other hand, calculating the

in care K este coeficientul de rezistenta la deformare al solului, a este adancimea de lucru, iar b este latimea de lucru. Se considera ca adancimea si latimea de lucru pot fi functii de timp, in primul rand datorita considerarii etapei tranzitive de la starea de repaus la lucru in regim stabilizat, iar in al doilea rand, pentru ca aceste doua caracteristici ale masinilor de lucrat solul pot varia si aleator, mai ales adancimea de lucru. Pe de alta parte, in etapa tranzitiva latimea de lucru creste cu adancimea de lucru pentru multe tipuri de organe de lucru. Daca aceste aspecte pot fi neglijate, atunci a si b se pot considera constante ca si K.

Solutia problemei (1), (2), cu completarile (3), (4), (5), chiar cu neliniaritatea considerata in (3), se poate da folosind tehnicile calculului operational, [2] (macar pe portiuni).

Prezenta unor neliniaritati mai complicate in x sau $\dot{x}$ anuleaza posibilitatea folosirii calculului operational daca nu se aplica liniarizari. Liniarizarea limiteaza insa decisiv investigatiile noastre. Pe de alta parte, calculul produsului de convolutie folosind programe de calcul consacrate, este ineficient pentru timpi lungi si neliniaritati

convolution product using computer programs dedicated to, it is ineffective for long time and nonlinear complicated. For these reasons we chose to build the simulator AL SOL based on the numerical solution of the problem. This option offers the possibility of using a wide variety of nonlinearities. Convergence difficulties for long simulation times and using complicated nonlinearities may occur also in this case. They can solve partially modifying the numerical schemes used.

RESULTS

To facilitate understanding, in particular simulation example, I considered a linear viscous friction. In a future article will address the full friction type (3), and other types of friction and even stiff. Next objective is to investigate the existence of internal parameters of the model, capable of producing vibration even if the exciter function is constant in time. The subject is vast and currently with little chance of experimental covering. Following investigation it is only a long-term goal. AOLSOL physical model is the working bodies of the vibro-cultivator designed in a research project.

The total mass of the working of support (vibrating portion, AOLSOL) is the total mass m = 5388 kg. The own support damping (own metal) is not considered in this model. Stiffness coefficient is calculated in accordance with [3], using the formula:

complicate. Pentru aceste motive am optat pentru constructia simulatorului AOLSOL bazat pe solutia numerica a problemei. Aceasta optiune ofera si posibilitatea considerarii unei mari varietati de neliniaritati. Dificultati de convergenta pentru timpi lungi de simulare si folosind neliniaritati complicate, pot sa apara, de asemenea si in acest caz. Acestea se pot rezolva partial modificand parametrii schemelor numerice folosite.

REZULTATE

Pentru facilitarea intelegerii, in exemplul de simulare ales, am considerat o frecare vascoasa liniara. Intr-un articol viitor se va aborda frecarea integrala de tip (3), precum si alte tipuri de frecari si chiar rigiditati. Obiectivul urmator este cercetarea existentei unor parametri interni ai modelului, capabili sa produca vibratii chiar daca functia excitatoare este constanta in timp. Subiectul fiind foarte vast si, momentan cu putine sanse de acoperire experimentala. Ca urmare investigatia este numai un obiectiv pe termen lung. Modelul fizic al AOLSOL il constituie organe de lucru ale combinatorului conceput in cadrul unui proiect de cercetare.

Masa totala a organul de lucru cu suport (portiunea vibratoare, AOLSOL) are masa totala m= 5.388 kg. Amortizarea proprie a suportului (proprie metalului) nu se considera in acest model. Coeficientul de rigiditate se calculeaza in conformitate cu [3], dupa formula:

$$k = \frac{3EI}{l^3}, \tag{6}$$

where E is the modulus of elasticity of the support material (steel in our case, so $E = 2.1 \cdot 10^{11}$ Pa), I is the moment of inertia of the cross section of the rod holder:

in care E este modulul de elasticitate al materialului suportului (otel in cazul nostru, deci $E= 2.1 \cdot 10^{11}$ Pa), I este momentul de inertie al sectiunii transversal a barei suportului:

$$I = \frac{a_s^4}{12} \tag{7}$$

because it is considered as a square section. The edge section is set to a_s = 0025 m. The length of the support (the support to the point of attachment of the working element) is l, with the value of l = 0788 m. Obtain the spring constant of the oscillator, k = 41 902 N / m.

The purely viscous damping is characterized by c_v value according to [4] or [5], given by:

deoarece se considera o sectiune patrata cu latura as. Latura sectiunii are valoarea a_s= 0.025 m. Lungimea suportului (de la rezemare pana la punctul de fixare al organului de lucru) este l, avand valoarea l= 0.788 m. Se obtine pentru constanta de elasticitate a oscilatorului, valoarea k= 41902 N/m.

Amortizare de tip pur vascoasa este caracterizata de valoarea c_v conform [4] sau [5], data de formula:

$$c_v = 0.32\sqrt{K\rho}\,. \tag{8}$$

Considering an average soil density, ρ=1900 kg / m^3 and K = 73000 N / m^2, the damping coefficient is obtained after [4] or [5], the value c_v = 3769 kg / s.

For the above data, the oscillator shows the supercritical damping therefore oscillations are only possible due to exciter force. The natural frequency of the purely elastic system (damped null) is 14 035 Hz. If it is deemed depth a = 12 cm and the working width 8.6 cm, then the exciter force constant component has the value F = 755 N. Excitation oscillating component has an amplitude of 25% in constant force, F. Its frequency has different critical values around the corresponding

Considrand o valoare medie a densitatii solului, ρ=1900 kg/m^3 si K= 73000 N/m^2, se obtine pentru coeficientul de amortizare, dupa [4] sau [5], valoarea c_v= 3769 kg/s.

Pentru datele de mai sus, oscilatorul are amortizare supracritica, prin urmare, oscilatii sunt posibile numai datorita fortei excitatoare . Frecventa proprie a sistemului pur elastic (cu amortizare nula) este de 14.035 Hz. Daca adancimea de lucru se considera a= 12 cm si latimea de lucru 8.6 cm, atunci componenta constanta a fortei excitatoare are valoarea F= 755 N. Componenta oscilanta a excitatiei are o amplitudine de 25 % din forta

own frequency oscillator without damping system.

If the unit moves perpendicular lines plowing results of previous work, then a working width B = 25 cm and a depth equal, obtain critical speed for producing resonance value v_{cr} = 3509 m / s (12,631 km / h) .

For the numerical solution of the problem, I used an algorithm Runge Kutta type fourth order in Mathcad mathematical software. Parametric study of the working body model oscillations is based on this simulator which use the Runge Kutta algorithm.

The simulator developed in order to study oscillations of the cultivator or vibro - cultivator support and working bodies is used to:

-testing in extreme situations to which certain phenomena known;

-investigation of the use of the model to define the difference between cultivator and vibro-cultivator;

- investigation of the existence of a resonance optimal working process for the vibro-cultivator;

-investigation of the effects of parameters relative nonlinearities on the amplitude or oscillation speed of the working body of the vibro-cultivator.

The first three topics will be addressed in this article, the latter being subject to subsequent approaches.

constanta, F. Frecventa acesteia ia diferite valori in jurul celei critice care corespunde frecventei proprii a sistemului oscillator fara amortizare. Daca agregatul se deplaseaza perpendicular pe liniile de aratura rezultate din lucrarea anterioara, atunci pentru o latime de lucru B= 25 cm si o adancime egala, se obtine viteza critica pentru producerea rezonantei cu valoarea v_{cr}= 3.509 m/s (12.631 km/h). Pentru rezolvarea numerica aproblemei, am folosit un algoritm de tip Runge Kutta de ordinul al patrulea, in programul Mathcad. Studiul parametric al modelului oscilatiilor organului de lucru se face folosind simulatorul bazat pe acest algoritm numeric.

Simulatorul elaborat in scopul studiului oscilatiilor organelor de lucru cu support ale combinatorului sau vibro-combinatorului, se foloseste pentru:

-testarea in situatii limita pentru care unele fenomene se cunosc;

-investigarea folosirii modelului pentru definirea diferentei intre cultivator si vibro-cultivator;

-investigarea existentei unui regim de rezonanta optimal in functionarea de tip vibrocultivator;

-investigatii privind efectele neliniaritatilor unor parametrii in raport cu amplitudinea sau viteza de oscilatie a organului de lucru al vibrocultivatorului.

Primele trei subiecte vor fi abordate in acest articol, ultimul fiind subiectul unei abordari ulterioare.

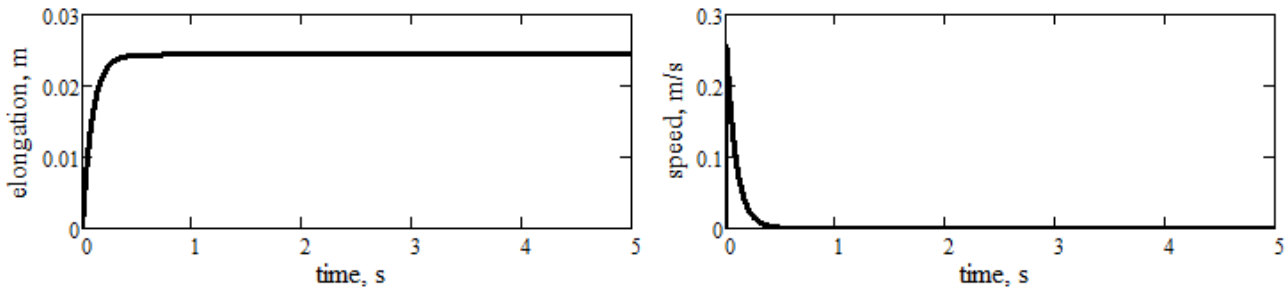

Fig. 1 - AOLSOL history elongation (left) and its rate of change (right) subjected to constant force excitation over time (no oscillatory component).

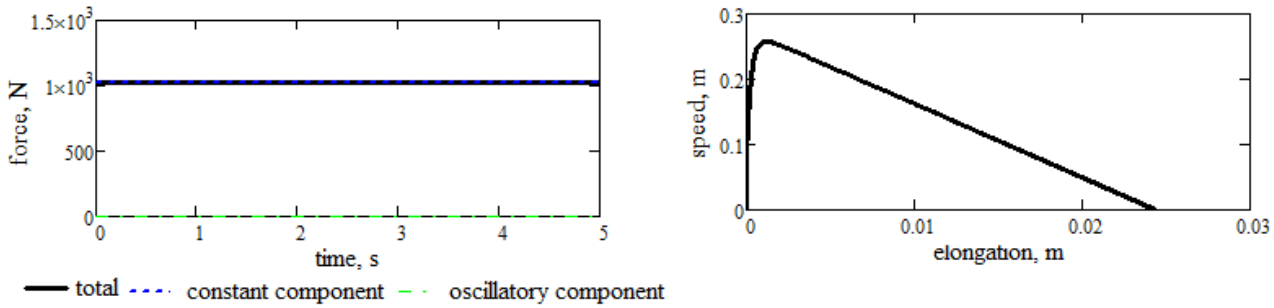

Fig. 2 - AOLSOL exciter force history and its components (left) and movement in the phase plane (right).

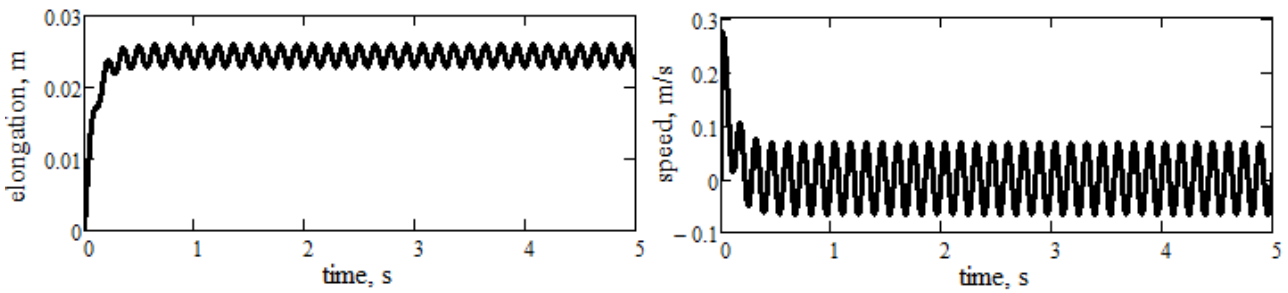

Fig. 3 - AOLSOL history elongation (left) and its rate of change (right) subjected to force excitation over time (with oscillatory component).

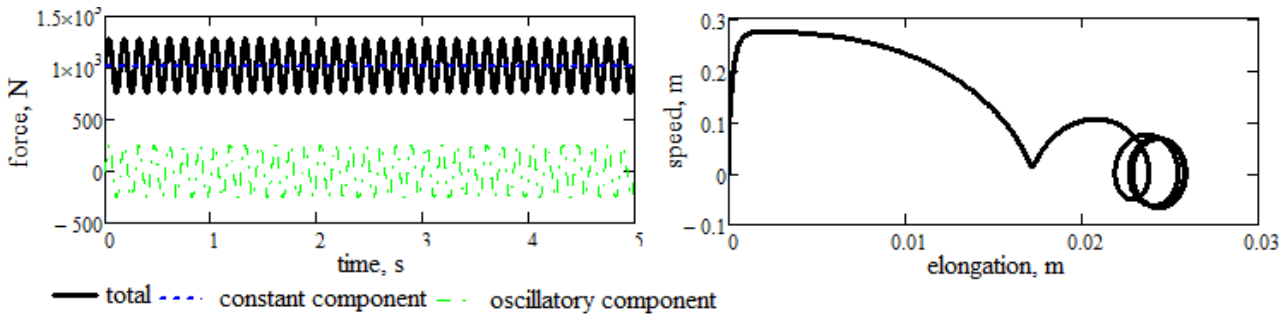

Fig. 4 - AOLSOL exciter force history and its components (left) and movement in the phase plane (right).

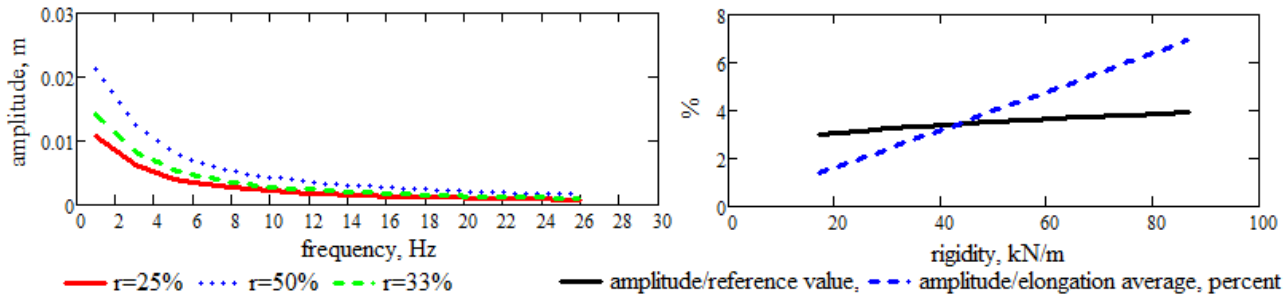

Fig. 5 - Variation of oscillator amplitude with the frequency of excitation force (left) and variation of the ratio of amplitude oscillator and relative displacement in case of the constant force exciter and of the ratio between the oscillator amplitude and the average value of its elongation (right).

In Fig. 1-5 I plotted very few results of very many that can be obtained and plotted using the model AOLSOL oscillator.

In Fig. 1 and 2 we plotted the results show AOLSOL behavior when the only constant component excitation force has non-zero, oscillating component is null. In Fig. 3 and 4 we plotted results which showing AOLSOL oscillator behavior where force has both excitatory components nonzero.

In Fig. 5 gives qualitative results of the model (simulator). In Fig. 5 (left) is represents the variation of the center of mass of the working body amplitude, depending on the frequency of the oscillator component of the excitation force, for three fixed values of the ratio between the amplitude of the oscillators component and constant component of the exciter force. In Fig. 5 (right) is represents the variation of the amplitude ratios of the center of mass of the working body and the maximum elongation when the oscillation exciter force is null or average value of elongation AOLSOL if excitation force oscillating, function on the AOLSOL stiffness.

CONCLUSIONS

Although the study of this oscillator is started, we can draw some conclusions about its usefulness and the applications in the design of vibro-cultivators.

The first conclusion is that AOLSOL can make the difference between a cultivator and a vibro-cultivator if is given a conventional limit value for the ratio of amplitude oscillatory motion and constant component elongation force produced by exciter force, for example.

It may introduce other criteria difference between cultivator and vibro-cultivator using AOLSOL oscillator model.

Another important conclusion is that the simulator AOLSOL can be used to design (depending on soil characteristics) the support with working body at a

In fig. 1 - 5 am reprezentat grafic foarte putine rezultate dintre foarte multele care se pot obtine si cerceta folosind modelul AOLSOL.

In fig. 1 si 2 am reprezentat grafic rezultate care arata comportamentul AOLSOL in cazul in care forta excitatoare are numai componenta constanta nenula, componenta oscilatorie fiind nula. In fig. 3 si 4 am reprezentat grafic rezultate care arata comportamentul AOLSOL in cazul in care forta excitatoare are ambele componente nenule.

In fig. 5 sunt date rezultate calitative ale modelului (simulatorului). In fig. 5 (stanga) se reprezinta variatia amplitudinii centrului de masa al organului de lucru, functie de frecventa componentei oscilatoare a fortei de excitatie, pentru trei valori fixate ale raportului dintre amplitudinea componentei oscilatoare si a celei constante ale fortei excitatoare. In fig. 5 (dreapta) se reprezinta variatia rapoartelor dintre amplitudinea centrului de masa al organului de lucru si valoarea maxima a elongatiei in cazul fortei excitatoare cu oscilatie nula, respectiv valoarea medie a elongatiei AOLSOL in cazul fortei excitatoare oscilante, functie de rigiditatea AOLSOL.

CONCLUZII

Desi studiul acestui oscilator este la inceput, se pot trage cateva concluzii asupra utilitatii acestuia si asupra aplicatiilor lui in proiectarea vibro-cultivatoarelor.

Prima concluzie este aceea ca AOLSOL poate face diferenta intre un cultivator si un vibro-cultivator daca se da prin conventie o valoare limita pentru raportul dintre amplitudinea miscarii oscilatorii si elongatia produsa de componenta constanta a fortei excitatoare, de exemplu.

Se pot introduce si alte criterii de diferenta intre cultivator si vibro-cultivator folosind modelul oscilatorului AOLSOL.

O alta concluzie importanta este aceea ca simulatorul AOLSOL poate fi folosit pentru a proiecta (functie si de caracteristicile solului) un suport cu organ de lucru la o

stiffness to allow him to take part of vibro-cultivator or cultivators categories.

The mathematical model that relies AL SOL simulator also allows the design of an optimal mode of operation that can be produced by oscillating force exciter component.

I found, however, that at this level, the optimized mode of operation is in conflicts with the principle of optimality required by geometry rectangular plots.

The perspective has many components, among which: the introduction of the nonlinear friction, nonlinear stiffness introducing, developing models to include the equation of motion of the unit.

Any progress in this building will require a large amount of experimental data. Either this chapter is currently difficult to guess.

From the experimental point of view, the model was built on real data of their bodies work and support of a vibro-cultivator learned in the prototype stage. The deflection caused by static exciter force constant component, the value of 24 mm, for a value of 755 N force, was a key criterion for the start of construction simulator. The value of static deflection, 24 mm to 755 N force applied to the center of mass of the body work was set on the test. The natural frequency was also a fundamental criterion for the choice of constants model to get the value measured in the laboratory 14.035 Hz.

Correlation with experimental results do next as we have this data and simulator construction progresses.

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rigiditatea care sa-i permita sa faca parte din categoria cultivatoarelor sau vibro-cultivatoare.

Modelul matematic pe care se bazeaza simulatorul AOLSOL, permite de asemenea proiectarea unui regim de lucru optimal care poate fi produs de componenta oscilanta a fortei excitatoare.

Am constatat insa ca, la acest nivel, procesul de lucru astfel optimizat intra in conflict cu principiul de optimalitate dat de geometria parcelelor dreptunghiulare.

Modelul are multe perspective de completare, printre care mentionam: introducerea frecarilor neliniare, introducerea unor rigiditati neliniare, dezvoltarea pana la modele care sa includa ecuatia de miscare a agregatului.

Orice progres in aceasta constructie va necesita un mare volum de date experimentale. Ori la acest capitol este, la ora actuala, greu de intuit.

Din punct de vedere experimental, modelul a fost construit pe date reale ale organelor de lucru si suportilor acestora ale unui vibro-cultivator aflat in etapa de prototip. Valoarea sagetii statice produse de componenta constanta a fortei excitatoare, cu valoarea de 24 mm, pentru o valoare a fortei de 755 N, a fost un criteriu de baza pentru startul constructiei simulatorului. Sageata statica de 24 mm, pentru fortei de 755 N la centrul de masa al organului de lucru, a fost stabilita pe standul de incercari. Frecventa proprie fundamentala a fost de asemenea un criteriu de alegere a constantelor de model, pentru a obtine valoarea masurata in conditii de laborator, 14.035 Hz. Corelarea cu rezultatele experimentale se face in continuare pe masura ce avem aceste date si constructia simulatorului avanseaza.

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ELEMENTARY AND COMPLEX SIMULATION OF A RIVER POLLUTION IN ORDER OF ENVIRONMENTAL TRAINING AND AWARENESS
/
SIMULAREA ELEMENTARA SI COMPLEXA A POLUARII UNUI RAU PENTRU INSTRUIRE SI CONSTIENTIZARE DE MEDIU

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Abstract: *This paper shows the role of numerical simulation of physical processes in the environmental awareness and education, emphasizing the right choice of its complexity depending on the level of depth that should or can be done exposure. The authors insist on the important role incumbent on incremental simulation (based on mathematical models simple) in environmental awareness and even higher education field. The jump to complex simulators can be done only after knowing (which means to know a model and simulator, we will try to explain in the paper) the basic models, and effective use of complex simulation is effective only in specialist teams which include at least 2 -3 or more related fields. These views are supported in simulators and work with examples of practical use in case of pollution of a river simulation.*

Keywords: *simulation, modeling, environmental, awareness, teaching, practice, pollution*

INTRODUCTION

After [1], the simulation is something that is made to look, feel, or behave like something else especially so that it can be studied or used to train people:

- a computer simulation of spaceflight
- simulations of body movements
- a simulation of the planet's surface
- computer simulation to predict weather conditions.

After [2] simulate means:

- to pretend that you have a particular feeling;
- to create particular conditions that exist in real life using computers, models, etc., usually for study or training purposes;
- to be made to look like something else;

After [2], the origin of this word is located in time in the mid of 17th century from the Latin word simulat that means copied or represented, from the verb simulare, from similis "like".

Very interesting are the definitions given by [3] for the notion of simulation. After [3], in British for the simulation are usual the next definition:

- a model of a set of problems or events that can be used to teach someone how to do something, or the process of making such a model ;
- in football, the act of pretending to have been fouled to try to win a penalty or free kick unfairly.

In American, the simulation is used after [3] preferential meaning: a model of a real activity, created for training purposes or to solve a problem.

Also [3] proposes the usual meanings in business simulation:

- a situation or event that seems real but is not real,

Rezumat: *Lucrarea prezinta rolul simulatoarelor proceselor fizice in procesul de constientizare de mediu si in invatamant, accentuand asupra alegerii potrivite a complexitatii acestuia functie de nivelul de profunzime la care trebuie sau poate fi facuta expunerea. Autorii insista asupra rolului mai important ce revine simulatoarelor elementare (bazate pe modele matematice cat mai simple), in procesele de constientizare de mediu si chiar in invatamantul superior de profil. Saltul catre simulatoarele complexe se poate face numai dupa cunoasterea (ce inseamna a cunoaste un model si un simulator, ne vom stradui sa explicam in lucrare) modelelor elementare, iar folosirea eficienta a simulatoarelor complexe este eficienta numai in echipe de lucru care include specialist in cel putin 2 -3 sau mai multe domenii conexe. Aceste opinii se sustin in lucrare cu exemple de simulatoare si utilizarea lor in cazul practice al simularii poluarii unui rau.*

Cuvinte cheie: *simulare, modelare, mediu inconjurator, constientizare, invatare, practica, poluare*

INTRODUCERE

Dupa [1], simularea este ceva facut pentru a da o imagine, o simtire sau comportament asemenea unei entitati asa incat sa poata fi utilizat pentru studiul sau instruirea oamenilor:

-un calculator care simuleaza zborul spatial

-simulaea miscarilor unui corp

-computer care simuleaza in scopul prognozei meteo. Dupa [2], simularea inseamna:

-a pretinde posesia unei simtiri particulare;

-a crea conditii particulare care exista in viata reala folosind calculatoare, modele, etc., in activitatea de studiu si invatare;

-a crea o imagine, care sa arate ca altceva;

Dupa [2], originea acestui cuvant se afla in timp undeva in mijlocul secolului 17 in cuvantul latin *simulat*, care inseamna *copiat* sau *reprezentat*, din verbul *simulare*, din *similis* „ca”.

Foarte interesante sunt definitiile din [3]pentru cuvantul simulare. Dupa [3], pentru acest cuvant sunt uzuale urmatoarele definitii:

-un model a unei multimi de probleme sau evenimente, care pot fi folosite pentru a invata pe cineva procesul de constructie a unui *model*;

-in fotbal, actul de a pretinde un fault pentru a obtine o lovitura de penalizare. In SUA simularea are , dupa [3], preferential sensul de model al unei activitati reale, creat pentru instruire sau rezolvarea unei probleme.

Tot [3], propune urmatoarele sensuri in simularea afacerilor:

- o situație sau un eveniment care pare real, dar nu

used especially in order to help people deal with such situations or events;

In [4], the simulation suggests imitation: the process of imitating a real phenomenon with a set of mathematical formulas.

In fact, as with many other words, the simulation has several meanings, acquired a vague and relative to areas where it is used. It is certainly a feature of modern language, which as you want exactly, becomes inaccurate, the more are increasingly using many words.

Consequently, by [8], a device that enable the operator to reproduce or represent under test conditions phenomena likely to occur in actual performance, is called simulator. This device can be a physical (small-scale simulation model, its electronic one - analog simulation, a computer) or theoretical (theoretical model with analytical solutions available).

A notion that can replace simulation that when this is done theoretically, is numerical experiments. In this case, the simulator is human mind or more generally, thinking, or computer. According to [1], the numerical experiment is included in what is called the experimental mathematics. By [1], experimental mathematics is a type of mathematical investigation in which computation is used to investigate mathematical structures and identify their fundamental properties and patterns. As in experimental science, experimental mathematics can be used to make mathematical predictions which can then be verified or falsified on the bases of additional computational experiments.

Borwein and Bailey (2003, pp. 2-3) use the term "experimental mathematics" to mean the methodology of doing mathematics that includes the use of computation for:

1. Gaining insight and intuition.
2. Discovering new patterns and relationships.
3. Using graphical displays to suggest underlying mathematical principles.
4. Testing and especially falsifying conjectures.
5. Exploring a possible result to see if it is worth formal proof.
6. Suggesting approaches for a formal proof.
7. Replacing lengthy hand derivations with computer-based derivations.
8. Confirming analytically derived results.

Whatever type of simulation and the simulator, it can be used with confidence only after validation. This means that between the physical quantities involved in the process must be examined, at least within certain limits, relations between same characteristic values of the real process. After validation, the simulator can be used to find new relationships, finding optimal working processes, or improvement in order to generalize.

I made a long introduction to define as precisely as instruments whose use trying to comment on the work of environmental awareness and pedagogical. We try to prioritize their work simulators by the complexity of environmental awareness and pedagogical. Below we give a few examples, and then we draw conclusions.

MATERIAL AND METHOD

We examine a particular case, a pollution of a river, but the most elementary possible, but coupled with interaction with oxygen in the river water. This will give greater scope conclusions.

este real, folosit în special în scopul de a ajuta oamenii se ocupe de astfel de situații sau evenimente

În [4], simularea sugerează imitație: procesul de a imita un fenomen real, cuajutorul unei multimi de formule matematice. De fapt, ca şi multe alte cuvinte, simularea are mai multe sensuri, capatand un sens vag şi relativ dependent de zonele în care este utilizat. Este cu siguranță o caracteristică a limbajului modern, care, după incercand sa fie cat mai exact, devine inexactă, cu atât mai mult folosesc din ce în ce mai multe cuvinte. În consecință, dupa [8], un dispozitiv care permite operatorului de a reproduce sau reprezenta fenomene care pot să apară în condiții reale de testare, este numit ***simulator***. Simulatorul poate fi fizic (model de simulare la scara redusa, simulator analogic, un calculator) sau teoretic (model teoretic cu soluții analitice disponibile).

O noțiune care poate înlocui simularea, atunci când aceasta se face teoretic, este experimentul numeric. În acest caz, simulatorul este mintea umană sau, mai general, gândirea, sau calculatorul. Potrivit [1], experimentul numeric este inclus în ceea ce se numeşte matematica experimentala. Dupa [1], matematica experimentala este un tip de investigație matematică în care calculul este utilizat pentru a investiga structurile matematice şi a identifica proprietățile lor fundamentale şi ale modelelor. Ca şi în ştiința experimentală, matematica experimentala pot fi folosita pentru a face predicții matematice, care pot fi apoi verificate sau declarate false pe baza experimentelor de calcul suplimentare. Borwein şi Bailey (2003, pp 2-3) folosesc termenul "matematica experimentala" în sensul metodologia de a face o matematică care include calculul pentru:

1. Castigul de înțelegere şi intuiție.
2. Descoperirea noi modele şi relații.
3. Folosirea reprezentarilor grafice pentru a sugera principiile care stau la baza relatiilor matematice.
4. Testarea şi în special gasirea presupunerilor false.
5. Explorarea un posibil rezultat pentru a vedea dacă acesta este o dovadă formală în valoare.
6. Sugerarea aproximari pentru un rezultat formal.
7. Trecerea calculelor lungi de mana pe calculator.
8. Confirmarea rezultatelor obținute analitic.

Indiferent de tipul de simulare, simulatorul poate fi folosit cu încredere numai după validare. Acest lucru înseamnă că între parametrii fizici implicati în procesul trebuie verificate, în anumite limite, relațiile dintre valorile caracteristice in procesul real. După validare, simulatorul poate fi folosit pentru a găsi noi relații, procese de lucru optimale, sau îmbunătățiri în vederea generalizarii.

Am făcut o introducere lungă pentru a defini cât mai precis instrumentele folosite in activitatea de conştientizare a mediului şi pedagogică. Incercam sa ierarhizam complexitatea simulatorelor functie de nivelul de constientizxare sau pedagogic. Urmeaza exemple si concluzii.

MATERIAL ŞI METODĂ

Probele utilizate în determinările experimentale ale caracteristicilor fizice ale măcinişului au fost prelevate de pe fluxul tehnologic al unității S.C. Spicul S.A., Roşiorii de Vede, Teleorman, România. Au fost determinate experimental: coeficientul de frecare static, unghiul de taluz natural, masa volumică şi densitatea particulelor

The mathematical model underlying the simulation, consist of a system of two partial differential equation, nonlinear, though simple, as the number of equations and shape, boundary condition and initial pose difficult problems to solve..

fiecărei fracții şi au fost calculate suprafața specifică şi porozitatea fracțiilor de măciniş la compartimentul C2 de sită plană aferent pasajului M1B din faza de măcinare a morii. În fig. 1 este prezentată diagrama fazei de măcinare a grişurilor la unitatea de morărit amintită.

Table 1

List of model parameters, notations, units of measurement and simulation values Neajlov River.

model parameters		**Values in model**
notation	**name (units SI)**	
L	polluted length of the river, m	>10000
D_P	pollutant dispersion coefficient on the variable direction x (m^2day^{-1})	34.56
D_X	dispersion coefficient of dissolved oxygen in the direction of the variable x (m^2day^{-1})	34.56
v	water speed in the direction of the x, m day^{-1}	21600
A	normal sectional area of the river, m^2	12.5
q	rate added pollutant along the river, kg m day^{-1}	0.06
K_1	coefficient of pollutant degradation rate at 20° C	8.27
K_2	de-airing the rate coefficient for dissolved oxygen at 20° C	44.10
k	halfsaturated concentration ratio of oxygen required to decompose the pollutant, kg m^{-3}	0.007
α	mass transfer of oxygen from air to water, m^2day^{-1}	16.5
S	oxygen saturation concentration, kg m^{-3}	0.01

The equations of the mathematical model are:

Ecuatiile modelului matematic sunt:

$$\begin{aligned}\frac{\partial(AP)}{\partial t} &= D_P\frac{\partial^2(AP)}{\partial x^2}-\frac{\partial(vAP)}{\partial x}-K_1\frac{X}{X+k}AP+qH(x),\ (x<L\le\infty,t>0)\\ \frac{\partial(AX)}{\partial t} &= D_X\frac{\partial^2(AX)}{\partial x^2}-\frac{\partial(vAX)}{\partial x}-K_2\frac{X}{X+k}AP+\alpha(S-X),\ (x<L\le\infty,t>0)\end{aligned}, \quad (1)$$

where P is the pollutant, and X is the oxygen concentration in the river water, and :

Unde P este concentratia de poluant, X este concentratia de oxigen in apa raului si:

$$H(x)=\begin{cases}0, x\le 0\\ 1, x>0\end{cases}, \quad (2)$$

is Heaviside function. Equations (1) add initial and boundary conditions that will result for a particular case. Nonlinearities make the system of equations to not be solved analytically on the initial form (system solutions are possible only in numerical form, at least currently). Basic analytical solutions can be obtained in individual cases which although possible, are generally rare in nature. However, these solutions are the first that can validate theoretical model, then opening the door to other analytical and numerical investigations.

Particular solution

According with the authors of [2], is consider only the steady-state solution in the case when dispersion can be take negligible, D_p=0, D_x=0. For this case the system (1) became:

este functia lui Heaviside. Ecuatiilor (1) li se adauga conditiile initiale si conditiile pe frontiera pentru fiecare caz particular. Neliniaritatile fac ca sistemul, in forma initiala sa nu fie rezolvabil analitic (solutia este posibila numai numeric). Solutii nalaitice fundamentale sunt posibile in cazuri particulare a caror realizare in realitate este rar intalnita. Totusi, aceste solutii sunt primele care pot valida modelul teoretic, deschizand usa altor solutii analitice si investigatiilor numerice.

Solutii particulare

Conform cu autorii [2], se considera numai solutia pentru starea de echilibru, cu dispersie neglijabila, , D_p=0, D_x=0. In aceste ipoteze, sistemul (1) devine:

$$\begin{aligned}\frac{d(vAP_s(x))}{dx} &= -K_1\frac{X_s(x)}{X_s(x)+k}AP_s(x)+q,\ (x>0)\\ \frac{d(vAX_s(x))}{dx} &= -K_2\frac{X_s(x)}{X_s(x)+k}AP_s(x)+\alpha(S-X_s(x)),\ (x>0)\end{aligned}, \quad (3)$$

with boundary conditions::

cu conditiile la limite:

$$P_s(0)=0, X_s(0)=S\,. \tag{4}$$

In addition to linearize equations is needed and hypothesis that the half-saturated oxygen demand concentration for pollutant decay is negligible (*k*=0). In these circumstances, the solution is obtained:

In plus, pentru a liniariza ecuatiile este necesara si ipoteza ca oxigenul necesar datorita degradarii concentratiei acestuia fata de concentratia de semisaturatie este neglijabila (k=0). Atunci se obtine:

$$P_s(x)=\frac{q}{K_1A}\left(1-e^{\frac{-K_1x}{v}}\right),\ X_s(x)=S-\frac{K_2q}{K_1}\left(\frac{1}{\alpha}-\frac{1}{\alpha-K_1A}e^{\frac{-K_1x}{v}}\right)-\frac{K_2qA}{\alpha(\alpha-K_1A)}e^{\frac{-\alpha x}{vA}}, \tag{5}$$

As a consequence of assumptions, the solution (5) does not depend on time and is valid only for *x*> 0 for *x* <0 with: $P_S(x)$=0 and $X_S(x)$=*S*. Asymptotic behavior of the solution is given by:

Ca o consecinta a ipotezelor: solutia (5) nu depinde de timp si este adevarata pentru orice *x*>0, iar pentru orice *x*<o: *Ps*(x)=0 si *Xs*(*x*)=0. Comportamentul asimptotic al solutiei este dat de:

$$\lim_{x\to\infty}P_s(x)=\frac{q}{K_1A},\lim_{x\to\infty}X_s(x)=S-\frac{qK_2}{\alpha K_1}, \tag{6}$$

A graphical representation of the solution to facilitate awareness

For application if I got Neajlov River, Giurgiu County. The spill occurs near the bridge over the Neajlov The settlement Calugareni. The graphical representation of the solution is given in Fig. 1. It was the first level of complexity of the pollutant transport on the river phenomenon simulator.

In [2], the authors make another through analytical results, but with a broader hypothesis, however improbable characteristics of situations in reality. Next we preferred to generalize the result to situations more likely in reality to solve numerically the problem (1) - (4).

We constructed a simulation using Mathcad software facility (can use Matlab, Mathematica, FlexPDE, COMSOL, and many other well-known software programs).

The results of this simulator can give to the one in Fig. 1 or in separate graphical representations.

This is the second level of complexity of the simulator phenomenon of pollutant transport on the river.

The third level of complexity begins with complex software programs, specialized, such as WASP, ISIS, FLO-2D and 3D SoilVision, etc.

In this article we shall merely list them and to show the difficulties of use.

O reprezentare grafica a solutiei care faciliteaza constientizarea

Ca aplicatie s-a un rau din judetul Giurgiu, raul Neajlov. Portiunea de scurgere este situata in vecinatatea podului de la Calugareni. Reprezentarea grafica a solutiei este data in fig. 1. Acesta a fost primul nivel de complexitate al simulatorului fenomenului de transport al poluantului pe rau.

In [2], autorii mai dau un rezultat obtinut pe cale analitica, dar cu ipoteze ceva mai largi, totusi caracteristici unor situatii putin probabile in realitate. In continuare am preferat, pentru generalizarea rezultatului la situatii cat mai probabile in realitate, sa rezolvam numeric problema (1) - (4). Am construit astfel un simulator folosind facilitatile programului software Mathcad (se poate folosi Matlab, Mathematica, FlexPDE COMSOL si alte multe programe software foarte cunoscute). Rezultatele acestui simulator se pot da la nivelul celui din fig. 1 sau in reprezentari grafice separate. Acesta este al doilea nivel de complexitate al simulatorului fenomenului de transport al poluantului pe riu.

Al treilea nivel de complexitate incepe cu programele software complexe, specializate, cum sunt WASP, ISIS, FLO-2D si 3D, SoilVision, etc. In acest articol ne vom margini sa le mentionam si sa aratam dificultatile de utilizare.

RESULTS

A first result obtained using the mathematical model (1) - (4) in the simplifying assumptions that allow analytical solution (5) is given in Figure 1. This result allows an awareness and education of good quality, fast and useful, but not technically accessible than only to university level.

In Figure 1 shows overlapping plots of solution component variations over river aerial photograph of the area that aims phenomenon of pollution: pollutant concentrations and dissolved oxygen. On the aerial photo of the area are marked places for distance measurement reference axis river. Marking labels appear on the horizontal axis of the graphs of variation in pollutant concentrations and dissolved oxygen. The map in Figure 1 can be used for delimitation of the river zone where certain species of animals or plants are in danger of losing his life, to determine the location where remediation might make optimal aeration for delimitation of any prohibited areas access people and animals.

REZULTATE

Un prim rezultat obtinut folosind modelul matematic (1) - (4), in ipotezele simplificatoare care permit solutia analitica (5), este dat in fig. 1. Acest rezultat permite o constientizare si instruire de buna calitate, rapida si utila, nu insa accesibila tehnic decat la nivel universitar.

In fig.1 se arata suprapunerea reprezentarilor grafice ale variatiilor componentelor solutiei peste fotografia aeriana a zonei de rau pe care se urmareste fenomenul de poluare: concentratiile poluantului si oxigenului dizolvat. Pe fotografia aeriana a zonei sunt marcate locatiile de referinta pentru masurarea distantei pe axa râului. Etichetele marcajelor apar pe axa orizontala a graficelor de variatie a concentratiei de poluant si de oxigen dizolvat. Harta din fig. 1 poate fi folosita pentru delimitarea zonelor de riu in care anumite specii de animale sau plante sunt in pericol de a-si pierde viata, pentru determinarea locatiei in care remedierea s-ar putea face optimal prin aerare, pentru delimitarea unor eventuale zone interzise accesului oamenilor si

Map of Figure 1 represents an important public awareness on how the phenomenon takes place, especially around the affected area residents can identify their homes or workplaces.

animalelor. Harta din fig. 1 reprezinta si un important mijloc de constientizare a publicului asupra modului in care se desfasoara un fenomen, mai ales ca locuitorii din jurul zonei afectate isi pot identifica locuintele sau locurile de munca.

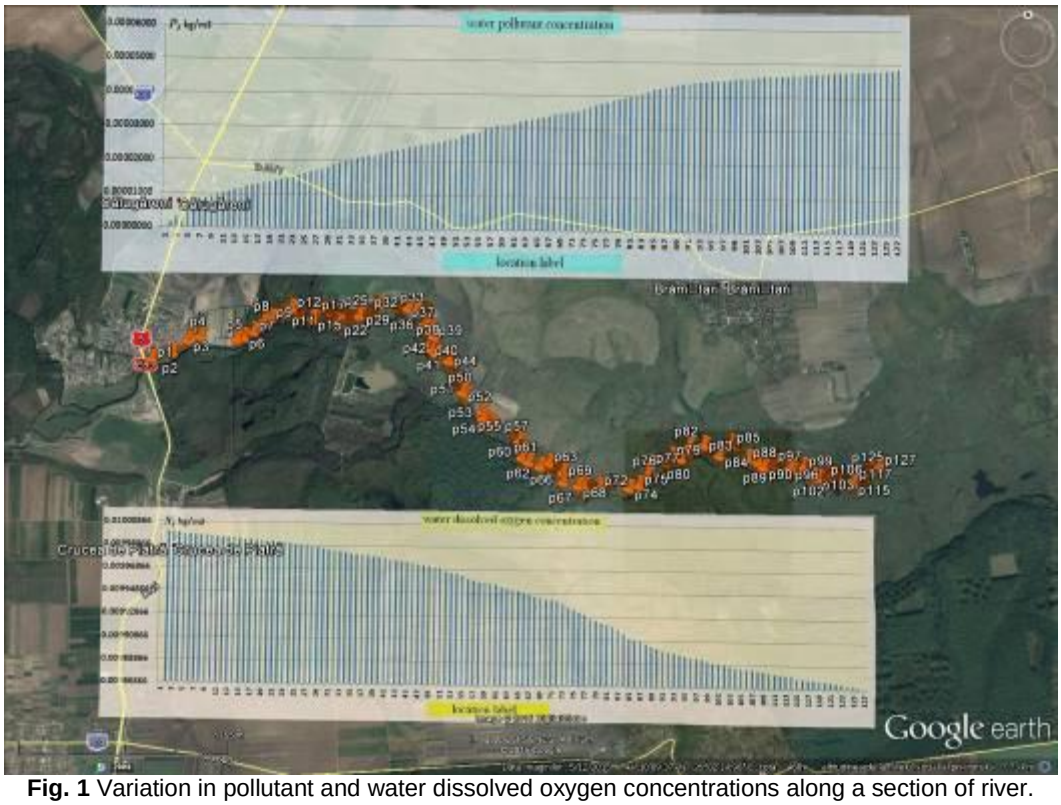

Fig. 1 Variation in pollutant and water dissolved oxygen concentrations along a section of river.

Using experimental values, presented in table 2, were drawn charts of variation of the average values for the coefficient of static friction and the angle of natural slope for the six grist fractions analyzed, using MS Excel program version 12 (fig. 2).

Values of bulk density, specific surface, porosity and mean diameter of the grist fractions analyzed are presented in table 3.

Based on the data obtained and presented in Table 3, were drawn, graphic, variations of bulk density, density, specific surface and porosity of grist intermediate products analyzed.

As can be seen from the analysis of data from table 3, and of charts in figure 3, bulk density of fractions resulted at sorting of grist in plansifter compartment C2 has a random variation, it depends such on the type of sieve frame fabric, and to the size of apertures of the working sieve, but also of the initial granulation of grist or of shell content adhesive on the semolina particles subjected to grinding.

In Fig. 2-6 simulator results are given pollutant transport phenomenon along a river, in the context of the phenomenon of aeration as a remedy.

Folosind valorile experimentale, prezentate în tabelul 2, au fost trasate graficele de variație a valorilor medii pentru coeficientul de frecare static şi pentru unghiul de taluz natural pentru cele şase fracții de măciniş analizate, utilizând programul MS Excel versiunea 12 (fig. 2).

Valorile masei volumice, densității, suprafeței specifice, porozității şi a diametrului mediu al fracțiilor de măciniş analizate sunt prezentate în tabelul 3.

Pe baza datelor obținute şi prezentate în tabelul 3, au fost trasate, grafic, variațiile masei volumice, densității, suprafeței specifice şi a porozității produselor intermediare de măciniş analizate.

După cum se observă din analiza datelor din tabelul 3, cât şi a graficelor din figura 3, masa volumică a fracțiilor rezultate la sortarea măcinişului în compartimentul de sită plană C2 are o variație aleatoare, ea depinzând, atât de tipul țesăturii ramei de sită, cât şi de dimensiunea orificiilor sitelor de lucru, dar şi de granulația inițială a măcinişului sau de conținutul de înveliş aderent pe particulele de griş supuse mărunțirii.

In fig. 2 - 6 se dau rezultate ale simulatorului fenomenuluio de transport poluant in lungul unui riu, in contextul fenomenului de aerare ca remediu.

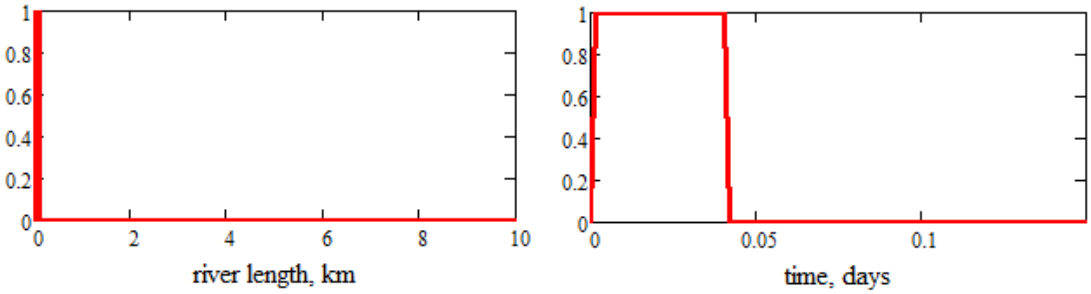

Fig. 2 Space (left) and time (right) history of the timeand space factor control (discharge function).

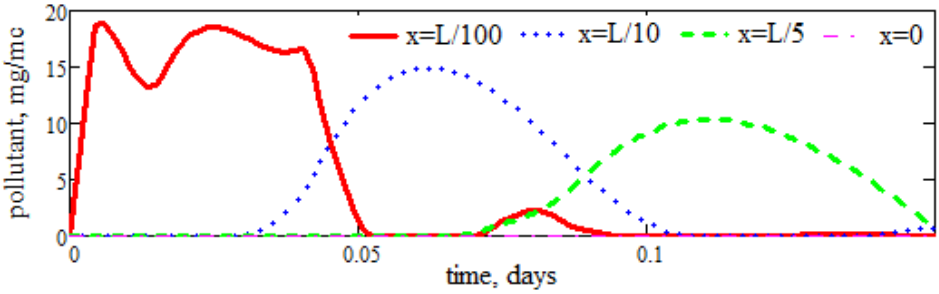

Fig. 3 Time history of the pollutant concentration in four location along the river.

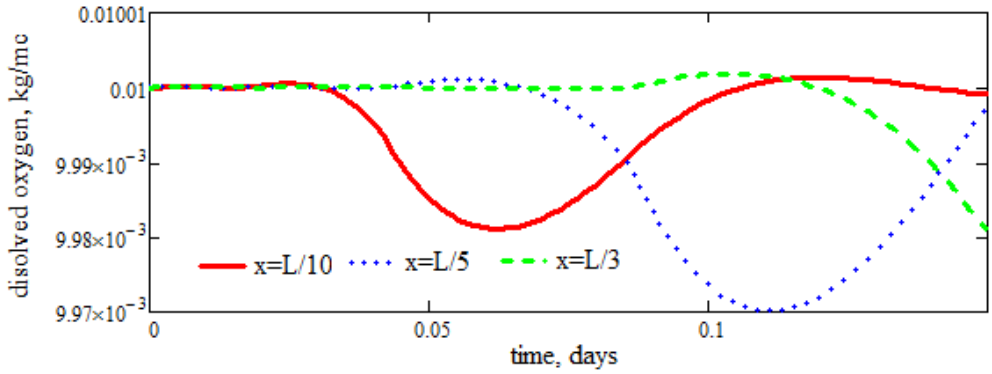

Fig. 4 Time history of the dissolved oxygen concentration in three location along the river.

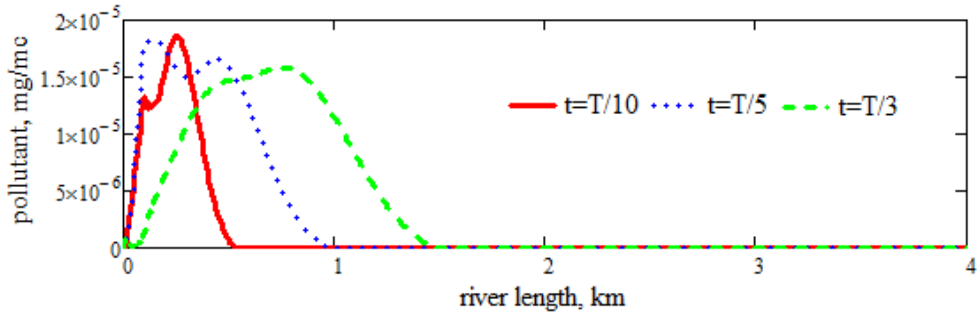

Fig. 5 Variation along the river of the pollutant concentrations at three time points.

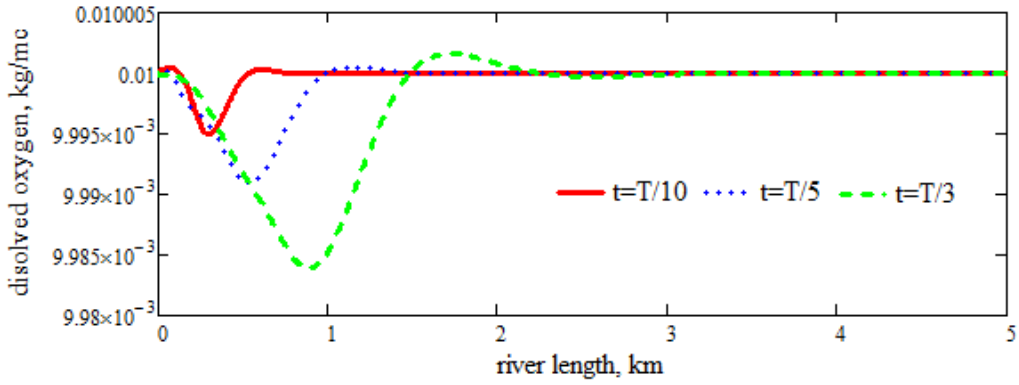

Fig. 6 Variation along the river of the dissolved oxygen concentrations at three time points.

The function of discharge shall form a constant multiplied by factors trapezoidal in time and space, factors that delimit the range of temporal and spatial discharge occurs. Temporal and spatial variation of the discharge function are given in fig. 2. Spill (pollutant discharge) occurs on a portion of length 99 m starting from 1 m elevation (center area under the bridge at Calugareni over Neajlov) for one hour at a rate q = 0.06 kg m^{-1} day^{-1}.

History of the pollutant concentration of 3.6 hours in four locations in the river (100 m, 1000 m, 2000 m and 0 m) is given in Fig. 3. History the water dissolved oxygen concentration of 3.6 hours in four locations in the river (100 m, 1000 m, 2000 m and 0 m) is given in Fig. 4.

Changes in concentrations of pollutants over the first four kilometers of river measured from the central area under the bridge at three time points, is given in Fig. 5. Varying the concentration of dissolved oxygen in the water during the first four kilometers of the river measured from the central area under the bridge at three time points, it is given in Fig. 6.

To achieve these results was considered a maximum length of riverbed observable *L* = 10 km (until the first tributary whose appearance made inoperative model). Model characteristic parameters were fixed at values in Table 1.

Calculation program has run a total of 100 temporal steps and 1500 steps in space.

There are some fine points of the solutions (right solution must be positive and after cancel remain zero until the end if other leaks do not occur) that must meet to obtain the correct solution.

CONCLUSIONS

Several conclusions can be drawn even if a description of the same level computing very complex models cannot be included in this article.

First, it is clear that at the level of awareness or learning, mathematical models and simulators based on them are more useful than the complex software programs which include among other facilities the contaminant transport simulation.

1D mathematical models are simple and easily verified by our intuition about the phenomena of dispersion and propagation of attenuated wave. The results of these models allow the assessment of the time before a dangerous pollutant concentration reaches a certain distance from the spill site. This is the time available for intervention. Some of the results are readily accepted and even obtained an audience that is not technical background. The operation of the simulator is not recommended however that public, without further instructions. In contrast, students in technical and specialized audience, we recommend using these simulators and the confrontation of the results with the intuition and reality. Doing so can see advantages and disadvantages of these models and simulators. The use of elementary models and simulators facilitates the understanding the logic of complex programs that solve such problems. Even the simple model presented in this work, it is not the easiest, because it includes parameters that characterize the flow of water, oxygen and pollutant dispersion and their interaction. Therefore, to ensure the accuracy of results is required qualifications for modeling dispersion and hydraulic phenomena in the transport of substances, and (in the least) in numerical calculation. A

Functia de deversare are forma unei constante inmultita cu factori de tip trapezoidal in timp si spatiu, factori care delimiteaza intervalul temporal si spatial in care are loc deversarea. Variatia factorilor temporal si spatial ai functiei de deversare sunt date in fig. 2. Scurgerea (descarcarea de poluant) are loc pe o portiune de lungime 99 m incepand de la cota 1 m (centru zonei de sub podul de la Calugareni peste Neajlov) timp de o ora, cu un debit q=0.06 kg m^{-1} zi^{-1}.

Istoria concentratiei de poluant in 3.6 ore in patru locatii ale riului (100 m, 1000 m, 2000 m si 0 m) este data in fig. 3.

Istoria concentratiei de oxigen dizolvat in apa in 3.6 ore in patru locatii ale riului (100 m, 1000 m, 2000 m si 0 m) este data in fig. 4.

Variatia concentratiei de poluant in lungul primilor patru km ai riului masurati de la zona centrala de sub pod, la trei momente de timp, este data in fig. 5. Variatia concentratiei de oxigen dizolvat in apa in lungul primilor patru km ai riului masurati de la zona centrala de sub pod, la trei momente de timp, este data in fig. 6.

Pentru a obtine aceste rezultate s-a considerat o lungime maxima a albiei observabile *L*= 10 km (pana la primul afluent a carui aparitie face modelul inoperant deoarece apare un debit de apa parazit care modifica relativ brusc si intr-o sectiune mica, debitul de apa si concentratiile de poluant si oxigen). Parametrii caracteristici modelului au fost fixati la valorile din tabelul 1.

Programul de calcul a rulat cu un numar de 100 de pasi temporali si 1500 de pasi in spatiu.

Exista o serie de aspecte fine ale solutiilor (solutia corecta trebuie sa fie pozitiva si dupa ce se anuleaza sa ramana nula pana la final daca alte scurgeri nu se manifesta) care trebuie satisfacute pentru a obtine o solutie corecta.

CONCLUZII

Cateva concluzii se pot extrage chiar daca o descriere a aceluiasi calcul in modele de nivel foarte complex nu pot fi incluse in acest articol.

In primul rand este clar ca la nivel de constientizare sau de invatare, modelele matematice si simulatoarele bazate pe ele sunt mult mai utile decat programele software foarte complexe care includ printre alte facilitati simularea transportului de poluanti.

Modelele matematice 1D sunt simple si usor de verificat in baza intuitiei nostre despre fenomenele de dispersie si propagare a undelor atenuate. Rezultatele acestor modele permit aprecierea timpului dupa care o concentratie periculoasa de poluant ajunge la o anumita distanta de locul scurgerii. Este timpul avut la dispozitie pentru interventie. O parte din rezultate sunt usor de acceptat si de obtinut chiar de un public care nu este de formatie tehnica. Operarea pe simulator nu se recomanda totusi acestui public, fara instructie suplimentara. In schimb, pentru studentii in domeniul tehnic si publicul de specialitate, se recomanda utilizarea acestor simulatoare si confruntarea cu intuitia si realitatea a rezultatelor obtinute. Procedand in acest fel vor putea observa avantajele si dezavantajele acestor modele si simulatoare. De asemenea, utilizarea modelelor si simulatoarelor elementare, faciliteaza intelegerea logicii programelor complexe care rezolva astfel de probleme. Chiar simplu fiind modelul prezentat in aceasta lucrare, el nu este cel mai simplu, deoarece include parametri ce caracterizeaza curgerea apei, dispersia poluantului si oxigenului si interactiunea acestora. Prin urmare, pentru a garanta corectitudinea rezultatelor este necesara pregatirea specialistului in modelarea fenomenelor de dispersie si hidraulica, in transportul de substanta, dar si (catusi de putin) in calculul numeric. Un model elementar de acest tip 1D nu poate reda o serie de aspecte importante: diferenta

basic model of the 1D cannot play a series of important aspects of pollutant concentrations difference between the central area of the riverbed and banks, concave geometric concentration in certain areas (ports, piers, river basins in communication with), etc. Other issues on which model they contain are not exposed to the influence of thermal field, the influence of atmospheric pressure, influence the quality of river fluid (density, viscosity, speed side) interaction with river tributaries, normal variation riverbed section, additional flows from rainfall, etc. To account for these phenomena, enter third level of models and simulators, namely complex software programs. These problems coupled fluid flow problem with the transport of substances and energy problem, the problem of heat transfer an biomass and contain empirical relationships between certain parameters of the model. To give a brief idea on how these programs can address demands an example of the WASP program offered for free.

Inputs include: geometry riverbed, the necessary data integration (start time and end time, minimum step, the method of integration, etc.), system polluted with their main properties, constants parts to the surface and pores data about fluid flow and how it is done downloading pollutant, boundary conditions, Time for loading and border conditions, the output. Therefore the use of this program required knowledge in different domains that consequently a number of specialists in various fields. For this reason it is not recommended to use such simulators in awareness activities and training specialists formation. These programs are recommended by specialist teams already trained in the necessary fields.

Acknowledgement

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de concentratii ale poluantului intre zona centrala a albiei riului si maluri, concentrarea in anumite zone geometrice concave (porturi, dane, bazine in comunicatie cu riul), etc. Alte aspecte pe care modelul expus nu le contine sunt influenta campului termic, influenta presiunii atmosferice, influenta calitatilor fluidului riului (densitate, viscozitate, viteza laterala) interactiunea cu afluentii riului, variatia sectiunii normale a albiei riului, debitele suplimentare de la ploi, etc. Pentru a tine seama de aceste fenomene, se introduce al treilea nivel de modele si simulatoare, anume programele software complexe. Aceste probleme cupleaza problema curgerii fluidelor cu problema transportului de substanta si energie, cu problema transferului de caldura si a biomasei si contin si relatii empirice intre anumiti parametri ai modelului. Pentru a da o idee cat de sumara asupra cerintelor acestor programe se poate aborda un exemplu dintre cele oferite gratuit de programul WASP.

Datele de intrare contin: geometria albiei riului, datele necesare integrarii (timpul de start si timpul final, pasul minim, metoda de integrare, etc.), sistemul de poluanti cu proprietatile lor principale, constantele de schimb la suprafata apei si in pori, date despre curgerea fluidului si despre modul in care se face descarcarea de poluant, conditiile pe frontiera, functii de timp pentru incarcare si conditii la frontiera, date de iesire. Prin urmare utilizarea acestui program cere cunostinte din varii domenii, in consecinta un numar de specialisti din diverse domenii. Din aceasta cauza nu se recomnada folosirea unor astfel de simulatoare in activitatile de constientizare si instruirile de formare a specialistilor. Aceste programe se recomanda echipelor cu specialisti deja formati in domeniile necesare.

Mulțumiri/Recunoştință

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PARAMETRIC MODELING OF THE IMPULSE GEARBOX IN OIL BATH FROM THE GRASSLANDS REGENERATION MACHINE
/
MODELAREA PARAMETRICĂ A CUTIEI DE VITEZE CU IMPULSURI ÎN BAIE DE ULEI DE LA MAŞINA DE REGENERAT PAJIŞTI

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Abstract: *The quality and cost of products are functions dependent on the level of the applied technologies since the conception phase. This paper presents a 3D parametric modeling of the gearbox in oil bath, part of the machine for regenerate grasslands made by S.C. MECANO FUC S.A. in partnership with INMA Bucharest.* Parametric modeling was performed using the software SolidWorks 2013. This version of software has the necessary functions allowing a three-dimensional view based on the entire components of the gearbox. By approaching this concept was achieved remarkable progress in reducing the design time and lowering the cost price at the producing company.

Keywords: *3D modelling, gear box, machine for regenerate, grasslands*

Rezumat:*. Calitatea şi costul produselor sunt funcții dependente de nivelul tehnologiilor aplicate încă din faza de concepție. Lucrarea prezintă modelarea parametrică 3D a cutiei de viteze cu impulsuri în baie de ulei, parte componentă a maşinii de regenerat pajişti realizată de S.C. MECANO FUC S.A. în parteneriat cu INMA Bucureşti. Modelarea parametrică s-a efectuat cu ajutorul software-ului SolidWorks versiunea 2013. Acest software dispune de funcțiile necesare care să permită o vizualizare tridimensională pe baza elementelor componente a întregii cutii de viteze. Prin abordarea acestui concept s-au obținut progrese remarcabile pentru reducerea timpului de proiectare, cât şi scăderea prețului de cost la societatea producătoare.*

Cuvinte cheie: *modelare 3D, cutie de viteze, maşină de regenerat, pajişti*

INTRODUCTION

Currently, CAD programs (Computer Aided Design) know a widespread in engineering applications, due to their crucial role in increasing productivity in the design of new products [5].

Through their development, they were able to be implemented the methods and means of design (design/ technological) and manufacturing the parts and subassemblies from the components of mechanical systems CAD - CAM - CAE (Computer Aided Manufacturing, Computer Aided Engineering). [9].

That's why, in the top research from this category, was aimed to increase the navigation commands, selection and to improve the functionalities of CAD modeling based on parametric feature [7].

Parametric modeling is based on the construction of a sequential model and is the working default mode of the program, so that the properties of individual elements of construction or assembly are interconnected, being able to make interactive changes in quotas or geometric properties from the entity at any time of the model realization, changes immediately reflected on components items [8].

One of 3D CAD programs for parametric geometric modeling (3D) is the SolidWorks software package produced by Dassault Systèmes SolidWorks Corp. It works under Windows environment and benefit from its graphical interface. The main advantage of the Solidworks software package (and in general from the CAD programs working natively in 3D) is that allow achievement with precision the 3D projects, both individual parts and also assemblies, as well as associative generating, based on 3D models of 2D execution and overall drawings [10].

In general, gearboxes with impulses are made up of

INTRODUCERE

În prezent, programele CAD (Computer Aided Design) cunosc o largă răspândire în aplicațiile inginereşti, datorită rolului esențial în creşterea productivității la proiectarea de noi produse [5].

Prin dezvoltarea acestora, s-au putut implementa metodele şi mijloacele de proiectare (constructivă/ tehnologică) şi fabricare a pieselor şi subansamblurilor din componenta sistemelor mecanice CAD – CAM – CAE (Computer Aided Manufacturing, Computer Aided Engineering). [9].

De aceea, în cercetările de vârf din această categorie, s-a urmărit mărirea comenzilor de navigație, selecție şi îmbunătățirea funcționalităților modelării CAD bazată pe trăsături parametrice [7].

Modelarea parametrică se bazează pe construcția unui model secvențial şi reprezintă modul implicit de lucru al programului, astfel încât proprietățile elementelor individuale de construcție sau ale ansamblului sunt interconectate, putându-se efectua modificări interactive ale cotelor sau proprietăților geometrice ale entităților în orice moment al realizării modelului, modificări reflectate imediat asupra elementelor componente [8].

Unul din programele CAD 3D de modelare geometrică parametrizată (3D) este pachetul de programe SolidWorks produs de firma Dassault Systèmes SolidWorks Corp. Acesta lucrează sub mediul Windows şi beneficiază de interfața grafică a acestuia. Principalul avantaj al pachetului de programe Solidworks (şi în general al programelor CAD care lucrează nativ în 3D) îl reprezintă faptul că permite realizarea precisă a proiectelor 3D, atât piese individuale cât şi ansambluri, precum şi generarea asociativă, pe baza modelelor 3D a desenelor 2D de execuție şi de ansamblu [10].

În general, cutiile de viteze cu impulsuri au în componență unul sau mai multe mecanisme de tip camă-

one or more cam-rocker mechanisms which transforms the uniform rotary motion of the camshaft a periodic movement, as a "pulse", of the drive shaft of the metering apparatus, with a certain degree of non-uniformity. The continues variation of transmission reports is done by adjusting the angle of rotation of the driving element, for a pulse the balance [6].

Their parametric design starts from the functional role namely the insurance of a specific frequency range that contain gear ratios covering entirely the range necessary to achieve the seeding rules according to agro-technical requirements [1].

During the stage of parametric modeling can be created new mechanical systems or templates, that are part of the product composition, by rigid and flexible representations of the parties, connected using geometric and kinematic constraints and who can be act by external and internal forces/moments [2].

Mass properties of parts and sub-assemblies can be obtained from associated solid models (3D CAD), while the vibration characteristics may result from models based on finite element (FEA-SolidWorks Simulation) [3].

The purpose of this paper is to show, by the freedom offered by the complete design of parts in the context of an overall, thus ensuring the bidirectionality changes ensemble design, the efficiency of parametric modeling method using SolidWorks software package version 2013, for being assimilated by businesses machine builders.

MATERIAL AND METHOD

Based on scientific and technical knowledge and developed practical skills, the paper's authors followed mostly, by parametric modeling, optimizing the gearbox with impulses in oil bath from the machine for regenerate grasslands, in terms of conceptual, functional, constructive, technological and economic.

The modeled gearbox consists of two mechanisms type oscillating cam-follower. To increase the uniformity of the rotation of the output shaft, they are mounted in parallel and operating out of phase by an angle whose value depends on the number of cams and the number of lobes thereof.

The type box is with mechanism to which the contact (point M) between the leading element (cam) and the follower (rocker cam) is made directly, and the oscillating tappet roller moves on a plate for limiting the stroke.

The varying rotation of the output shaft is carried out by increasing or decreasing the power stroke Ψ of the push rod (beam) (Figure 1), as a result of the action of a restriction plate [4].

balansier prin care se transformă mişcarea de rotație uniformă a arborelui cu came într-o mişcare periodică, sub formă de "impulsuri", a arborelui de antrenare a aparatelor de dozare, cu un anumit grad de neuniformitate. Variația continuă a rapoartelor de transmitere se face prin reglarea unghiului de rotație al elementului condus, pentru un impuls al balansierului [6].

Proiectarea parametrică a acestora porneşte de la rolul funcțional şi anume asigurarea unui anumit diapazon în care să fie cuprinse rapoartele de transmitere care să acopere în întregime intervalul necesar pentru realizarea normelor de semănat conform cerințelor agrotehnice [1].

În timpul etapei de modelare parametrică pot fi create sistemele mecanice noi sau tipizate, care fac parte din componența produsului, prin reprezentări rigide şi flexibile ale părților, conectate cu ajutorul unor constrângeri geometrice şi cinematice şi asupra cărora pot acționa forțe/momente externe şi interne [2].

Proprietățile masice ale reperelor şi subansamblurilor componente se pot obține din modelele solide asociate (CAD-3D), în timp ce caracteristicile vibratorii pot rezulta din modelele bazate pe element finit (FEA-SolidWorks Simulation) [3].

Scopul lucrării este de a arăta, prin libertatea oferită de proiectare completă a pieselor în contextul unui ansamblu, asigurând astfel bidirecționalitatea modificărilor ansamblu - desen de execuție, eficiența metodei de modelare parametrică cu ajutorul pachetului de programe SolidWorks versiunea 2013, pentru a fi a fi asimilată de către agenții economici constructori de maşini.

MATERIALE ŞI METODĂ

Având la bază cunoştințe ştiințifico-tehnice şi abilități practice dezvoltate, autorii lucrării au urmărit cu precădere, prin modelarea parametrică, optimizarea cutiei de viteze cu impulsuri în baie de ulei de la maşina de regenerat pajişti din punct de vedere conceptual, funcțional, constructiv, tehnologic şi economic. Cutia de viteze modelată este alcătuită din două mecanisme de tip camă-tachet oscilant. Pentru mărirea uniformității mişcării de rotație a arborelui de ieşire, acestea sunt montate în paralel şi funcționează defazat cu un anumit unghi, a cărui valoare este dependentă de numărul de came şi de numărul de lobi ai acesteia.

Tipul cutiei este cu mecanism la care contactul (punctul *M*) dintre elementul conducător (cama) şi elementul condus (tachet oscilant) se face direct, iar rola tachetului oscilant se deplasează pe o placă de limitare a cursei. Mişcarea de rotație variabilă a arborelui de ieşire este realizată prin mărirea sau micşorarea cursei active Ψ a tachetului (balansier) (fig. 1), ca urmare a acționării asupra unei plăci de limitare [4].

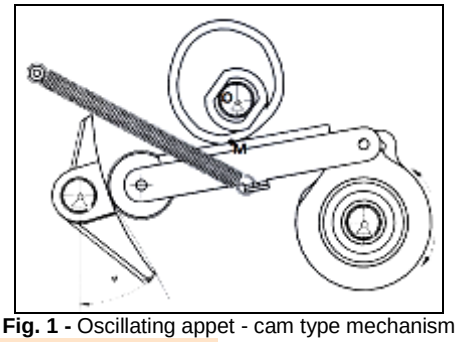

Fig. 1 - Oscillating appet - cam type mechanism

For parameterized design of the gearbox with impulses in oil bath from the machine for regenerate grasslands was used a CAD specialized system

Pentru proiectarea parametrizată a cutiei de viteze cu impulsuri în baie de ulei de la maşina de regenerat pajişti s-a utilizat un sistem CAD specializat (programul

(SolidWorks software) which, by the extensive facilities, allowed the use at the same time of geometric data and technological informations to lifelike achieve the 3D model, the restrictions and operating conditions.

Parts modeling is based on achieving the 2D sketch - which elements belong to an unique plan. SolidWorks offers a variety of tools for creating the geometric profiles, the following entities are available in the toolbar sketch: Line, Circle, CenterPoint arc, Tangent arc, 3 point arc, Ellipse, Partial Ellipse, Parabola, Spline, Polygon, Rectangle, Parallelogram, Point, Centerline. When generating the solid entity were used some of the modeling commands specific for the software, such as: Extrude Feature, Extruded Cut, Revolved Boss/Base, Swept Boss/Base, Lofted Boss/Base, Hole Wizard, Revolved Cut, Swept Cut, Lofted Cut, Fillet/Round, Chamfer, Rib, Draft, Shell etc.

Assemblies modeling and general assembly was performed through a freedom of complete design parts with *Part* module, the achievement of drawings with *Drawing* mode respecting the existing ISO standards, ISO SR, SR EN ISO, followed by the entities assembling using *Assembly* module, thus ensuring the bidirectionality of changes for whole-drawing.

The three-dimensional modeling allowed alongside the spatial visualization of the elements of composition and an ease understanding of the principle operation of the gearbox with impulses, because the components can explode in part for suggest the assembly.

Making of general assembly was done by imposing constraints that define the relationships between component sub-assemblies, following the order of assembly. The constraints imposed on each component have reduced the number of freedom degrees. The main component, which is the gearbox housing, was totally constrained or fixed by removing all degrees of freedom.

Using *Simulation* module, for each component piece, it was performed a linear static analysis, which calculates displacements, stresses, reaction forces under the effect of applied loads. The steps were: importing the module geometry, defining the material, defining the appropriate restrictions, the meshing, the analysis calculation and viewing the results. For this purpose, it was necessary to define material characteristics: elastic module *E* and the Poisson coefficient *v*. By selecting a material from the SolidWorks library, could be required the automatically assign of these properties. After defining a full study, the results have been obtained and viewed by running the analysis study.

By going through three distinct phases determined by the kinematic design, organological and linear static analysis, It has been solved by the parameterized design the following requirements: the purpose of the gearbox with impulses in oil bath in the machine for regenerate grasslands, the functional principles and execution technology.

RESULTS

Figure 2 presents the 3D geometric model of impulse gearbox in oil bath, which was developed with SolidWorks software. The components are metal structures such as: housing, shaft, cam, U profile, arc and standardized elements as screw type, spring pin, overrunning elastic clutch etc.

SolidWorks) care, prin facilitățile extinse, a permis folosirea în acelaşi timp a datelor geometrice şi a informațiilor tehnologice pentru realizarea cât mai fidelă a modelului 3D, a restricțiilor şi a condițiilor de funcționare.

Modelarea pieselor are la bază realizarea schiței 2D – ale cărei elemente aparțin unui plan unic. SolidWorks oferă o varietate de unelte pentru crearea pofilelor geometrice, următoarele entități fiind disponibile în bara de unelte sketch: Line, Circle, CenterPoint arc, Tangent arc, 3 point arc, Ellipse, Partial Ellipse, Parabola, Spline, Polygon, Rectangle, Parallelogram, Point, Centerline. La generarea entității solide s-au utilizat o parte din comenzile de modelare specifice softului, cum ar fi: Extrude Feature, Extruded Cut, Revolved Boss/Base, Swept Boss/Base, Lofted Boss/Base, Hole Wizard, Revolved Cut, Swept Cut, Lofted Cut, Fillet/Round, Chamfer, Rib, Draft, Shell etc.

Modelarea subansamblurilor şi ansamblului general s-a efectuat printr-o libertate de proiectare completă a pieselor cu modulul *Part*, realizarea desenelor de execuție cu modului *Drawing* respectându-se standardele în vigoare ISO, SR ISO, SR EN ISO, urmând apoi asamblarea entităților folosind modulul *Assembly*, asigurându-se astfel bidirecționalitatea modificărilor ansamblu–desen de execuție.

Modelarea tridimensională a permis pe lângă vizualizarea spațială a elementelor din componență şi o uşurință în înțelegerea principiului de funcționare a cutiei de viteze cu impulsuri, deoarece componentele se pot exploda în parte pentru a sugera asamblarea.

Realizarea ansamblului general s-a efectuat prin impunerea de constrângeri care definesc relațiile dintre subansamblurile componente, cu respectarea ordinii de asamblare. Constrângerile aplicate fiecărei componente au condus la reducerea numărului de grade de libertate. Principala componentă, care este carcasa cutiei de viteze, a fost total constrânsă sau fixată prin eliminarea tuturor gradelor de libertate.

Cu ajutorul modulului *Simulation,* pentru fiecare piesă componentă, s-a efectuat o analiză statică liniară, care calculează deplasări, tensiuni, forțe de reacțiune sub efectul unei sarcini aplicate. Etapele parcurse au fost următoarele: importarea geometriei modelului, definirea materialului, definirea restricțiilor adecvate, a discretizărilor, calculul de analiză şi vizualizarea rezultatelor. În acest scop, a fost necesar să se definească caracteristicile materialului: modulul de elasticitate *E* şi coeficientul lui Poisson *v*. Prin selectarea unui material din biblioteca SolidWorks, s-a putut impune atribuirea în mod automat a acestor proprietăți. După definirea unui studiu complet, rezultatele au putut fi obținute şi vizualizate prin rularea studiului de analiză.

Prin parcurgerea celor trei etape distincte determinate de proiectarea cinematică, organologică şi analiza statică liniară, s-au rezolvat prin proiectarea parametrizată următoarele cerințe: scopul cutiei de viteze cu impulsuri în baie de ulei în cadrul maşinii de regenerat pajişti, principiile funcționale şi tehnologia de execuție.

REZULTATE

În figura 2 este prezentat modelul geometric 3D al cutiei de viteze cu impulsuri în baie de ulei, care a fost realizat cu programul SolidWorks. Elementele componente sunt structuri metalice de tipul carcasă, ax, camă, profil U, arc şi elemente standardizate de tipul şurub, ştift elastic, cuplaj elastic unisens etc.

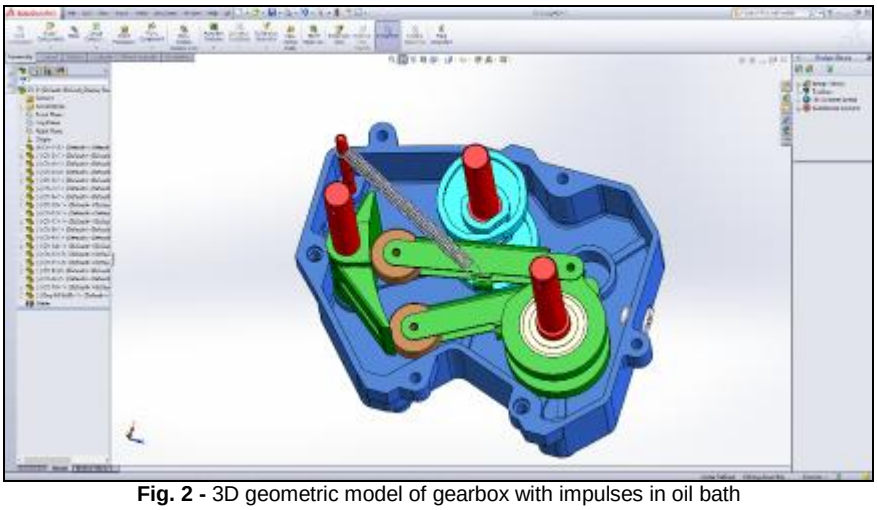

Fig. 2 - 3D geometric model of gearbox with impulses in oil bath

The following are the stages of realization o 3D geometric patterns for some of the component parts of the gearbox with impulses.

Figure 3 presents the basic outline sketch of the gearbox housing, which was formed with orientation *Normal To* plan sketching. The geometry has been completely defined (is black), because all the lines and curves of the sketch as well as their positions are governed by the dimensions and / or geometrical relationships. 3D geometric model of housing was achieved by using commands Extruded Boss / Base, Shell, and Extruded Cut Fillet / Round.

În continuare sunt prezentate etapele de realizare a modelelor geometrice 3D pentru câteva din reperele componente ale cutiei de viteze cu impulsuri.

În figura 3 este prezentată schițarea conturului de bază pentru carcasa cutiei de viteze, care a fost realizată având orientarea *Normal To* la planul de schițare. Geometria a fost complet definită (are culoarea neagră), deoarece toate liniile şi curbele din schiță precum şi pozițiile lor sunt guvernate de dimensiuni şi/sau relații geometrice. Modelul geometric 3D al carcasei a fost obținut prin utilizarea comenzilor Extruded Boss/Base, Shell, Extruded Cut şi Fillet/Round.

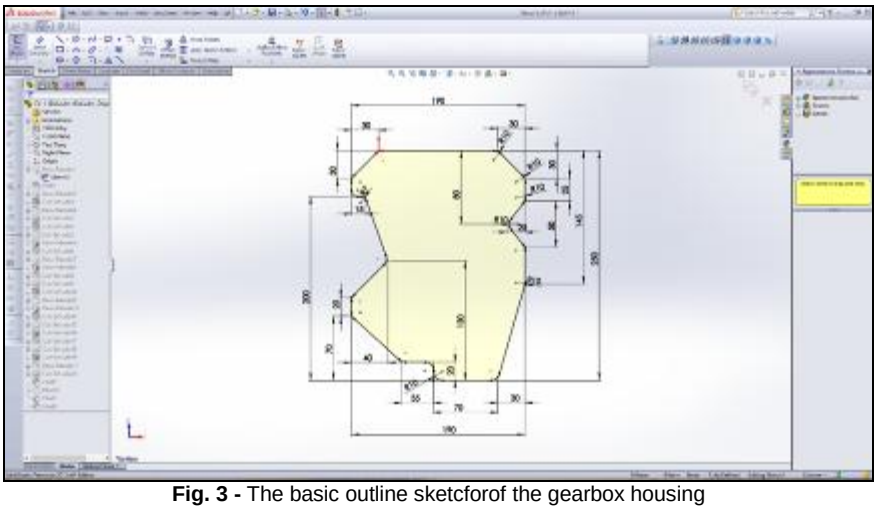

Fig. 3 - The basic outline sketcforof the gearbox housing

Figure 4 shows the 3D geometric model of the output shaft. The modeling part was done by using *Revolved Boss / Base* command, which creates a geometry by turning a sketch around an axis line (*Centerline*). Dimensioning the sketch was technological performed as the drawing can be obtained easily and without interfering too much on him by using *Model Items* command from *Drawing* module.

În figura 4 este prezentat modelul geometric 3D al axului de ieşire. Modelarea reperului s-a efectuat prin utilizarea comenzii *Revolved Boss/Base,* care creează o geometrie prin rotirea unei schițe în jurul unei linii de axa (*Centerline*). Cotarea schiței a fost realizată tehnologic pentru ca desenul de execuție cotat să se poată obține uşor şi fără a interveni prea mult asupra lui prin utilizarea comenzii *Model Items* din modul *Drawing.*

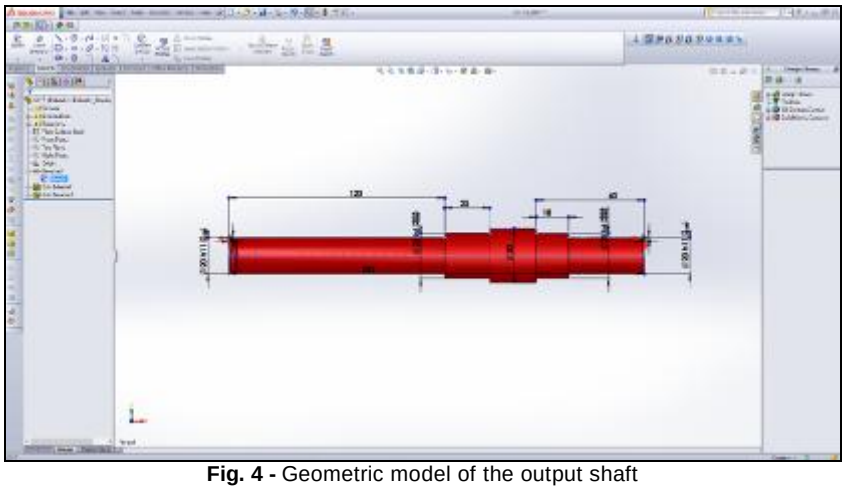

Fig. 4 - Geometric model of the output shaft

Linear Static Analysis aimed a preliminary verification of stress and elastic deformation occurring in basics of gearbox with impulses, those acquiring large requests developed during the working process. For example, for linear static analysis of the ring of averrunning clutch, which is a part of the gearbox with impulses, were the following steps:

- Was selected the material from the SolidWorks library (was assigned *Plain Carbon Steel* material, whose main alloying element is carbon concentration of 0.16 ... 0.29%. Its properties, according to the database of SolidWorks are: modulus of elasticity 2.1 × 1011 N / m2; Poisson's ratio 0.28; density of 7800 N / m3; tensile strength 399 826 × 106 N / m2; flow limit 220 594 × 106 N / m2);
- They were canceled the degrees of freedom in the direction perpendicular to contact inner cylindrical surface with the overrunning clutch;
- Was selected the charging on model from *External Loads* tab (When force is applied to a benchmark it tries to absorb its effects by developing internal forces. The effort represents the intensity of these internal forces and its unit of measurement is: force per area unit);
- Was made the mesh with high quality (resulted in a total of 81 438 knots and a number of 54 882 finite elements);
- Was run the analysis study after full definition, and the results could be viewed.

Von Mises Tension has maximum value in the hinge area with oscillating tappet body, and its distribution is shown in Figure 5.

Analiza statică liniară a avut drept scop o verificare preliminară a tensiunilor şi deformaţilor elastice care apar în elementele de bază ale cutiei de viteze cu impulsuri, cele care preiau solicitările mari dezvoltate în timpul procesului de lucru. De exemplu, pentru analiza statică liniară a inelului cuplajului unisens, care face parte din componenţa cutiei de viteze cu impulsuri, s-au parcurs următorii paşi:

- a fost selectat materialul din biblioteca SolidWorks (materialul atribuit a fost *Plain Carbon Steel,* care are ca principal element de aliere carbonul în concentraţie de 0,16…0,29 %. Proprietăţile acestuia, conform bazei de date a SolidWorks, sunt următoarele: modulul de elasticitate $2{,}1\times10^{11}$ N/m^2; coeficientul lui Poisson 0,28; densitatea 7800 N/m^3; rezistenţa la rupere $399{,}826\times10^6$ N/m^2; limita de curgere $220{,}594\times10^6$ N/m^2);
- au fost anulate gradele de libertate pe direcţia perpendiculară la suprafaţă cilindrică interioară de contact cu cuplajul unisens;
- a fost selectată încărcarea pe model din tabul *External Loads* (Când forţa este aplicată pe un reper acesta încearcă să absoarbă efectele ei dezvoltând forţe interne. Efortul reprezintă intensitatea acestor forţe interne şi are ca unitate de măsură: forţa pe unitatea de suprafaţă);
- a fost realizată discretizarea cu o calitate ridicată (au rezultat un număr de 81438 noduri şi un număr de 54882 elemente finite);
- a fost rulat studiul de analiză după definirea completă, iar rezultatele au putut fi vizualizate.

Tensiunea von Mises are valoarea maximă în zona de articulaţie cu corpul tachetului oscilant, iar distribuţia acesteia este prezentată în fig. 5.

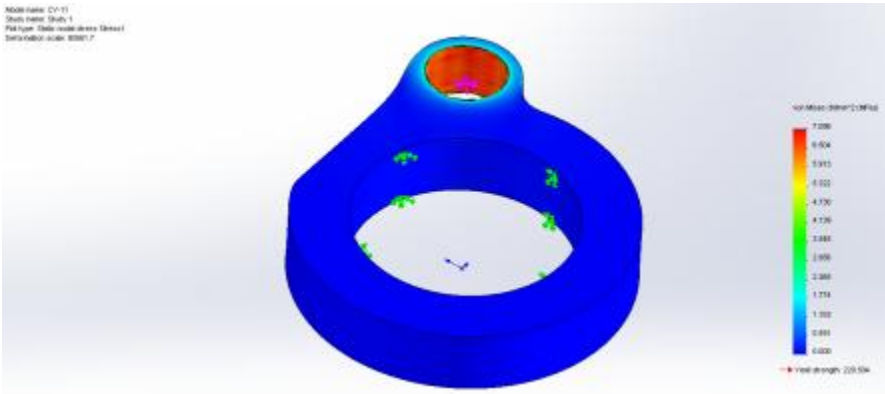

Fig. 5 - Von Mises stress distribution

The maximum value of displacement was located at the end of the articulation with the oscillant follower and

Valoarea maximă a deplasării a fost situată la extremitatea articulaţiei cu tachetul oscilant iar distribuţia

its distribution is shown in Figure 6.

acesteia este prezentată în fig. 6.

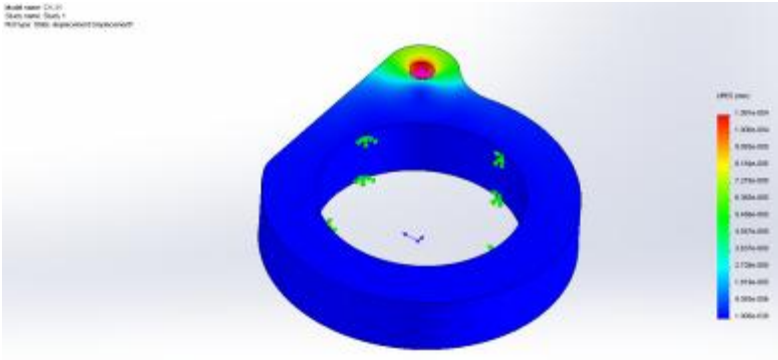

Fig. 6 - The resultant displacement distribution

CONCLUSIONS

3D modeling greatly reduce the runtime and realize important benefits;

Using 3D imaging facilitates recognition of components and the understanding of operating principle of impulses gearbox;

3D modeling leads to creation of a virtual product, whose execution can be simulated (for example: operations such as turning, milling, drilling, etc.); Calculation of stresses and strains values offers to design engineers a numerical solution to check the strength of product components in order to eliminate the faults that can occur during exploitation.

CONCLUZII

Modelarea 3D reduce foarte mult timpul de execuție realizând importante beneficii;

Utilizarea imaginii 3D facilitează recunoaşterea elementelor componente şi înțelegerea principiului de funcționare al cutiei de viteze cu impulsuri;

Modelarea 3D conduce la realizarea unui produs virtual, al cărei execuție poate fi simulată (spre exemplu: operații cum sunt: strunjirea, frezarea, găurirea etc);

Calcularea valorilor tensiunilor şi deformațiilor oferă inginerilor proiectanți o soluție numerică pentru a verifica rezistența componentelor produsului în scopul eliminării defecțiunilor care pot apărea în timpul exploatării.

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MATHEMATICAL MODELING OF THE THRESHING PROCESS MADE BY THE THRESHING SYSTEMS WITH MULTIPLE ROTORS / *MODELAREA MATEMATICĂ A PROCESULUI DE TREIER REALIZAT DE APARATELE DE TREIER CU ROTOARE MULTIPLE*

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Abstract: *The researches regarding the threshing process made by tangential threshing system of conventional combines harvester had as result the obtaining mathematical models, based on experimental datas, expressed through functions that define partial this process. Moreover, for the threshing systems with multiple rotors, the mathematical modeling of threshing process made by them it is more difficult. This paper presents a mathematical model of the threshing process made by the threshing system with multiple rotors of the Romanian combine C110ATM.The mathematical model was based on the experimental datas made by INMA Bucharest in 2001.*
Keywords: *combine harvester, tangential threshing system, threshing system with multiple rotors, threshing process, mathematical models.*

Rezumat: *Cercetările privind procesul de treier realizat de aparatul de treier tangențial al combinelor convenționale de recoltat cereale au avut ca rezultat obținerea de modele matematice pe baza datelor experimentale, exprimate prin funcții care definesc doar parțial acest proces. Cu atât mai mult, pentru aparatele de treier cu rotoare multiple modelarea matematică a procesului de treier realizat de acestea este şi mai dificilă. Lucrarea de față prezintă un model matematic al procesului de treier realizat de aparatul de treier cu mai multe rotoare al combinei româneşti C110ATM. Modelul matematic prezentat s-a bazat pe datele experimentale realizate de INMA Bucureşti în anul 2001.*
Cuvinte cheie: *combină de recoltat cereale, aparat de treier tangențial, aparat de treier cu rotoare multiple, proces de treier, modele matematice.*

INTRODUCTION

The threshing process of the conventional combine harvesters is made by the tangential threshing system and it consists in breaking the link between the seeds and plant and separation of them through concave.[7]

The tangential threshing system is the main work organ of a conventional combine harvester in terms of the seeds separation and is positioned in the technological flow of this combine between the feederhouse and the straw walkers [8]. (Fig. 1)

INTRODUCERE

Procesul de treier al combinelor convenționale de recoltat cereale este realizat de aparatul de treier tangențial şi constă în desfacerea legăturilor semințelor cu planta şi separarea acestora prin contrabătător. [7]

Aparatul de treier tangențial este cel mai important organ de lucru al unei combine convenționale de recoltat cereale din punct de vedere al separării semințelor şi este poziționat în fluxul tehnologic al acestei combine între elevatorul central şi scuturător [8]. (fig. 1)

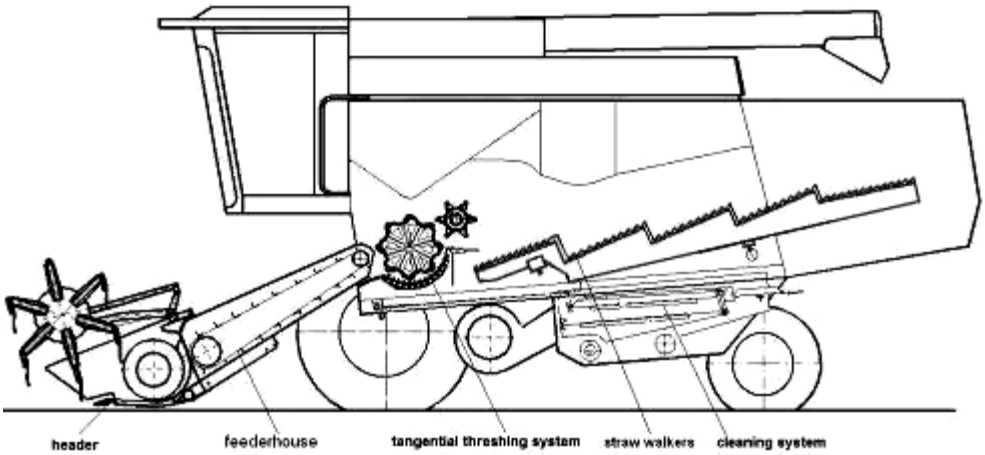


Fig. 1 – The tangential threshing system in the technological flow of a conventional combine harvester [3]

In optimal conditions, the separation of seeds in tangential threshing system can be up to 85%, falling below 50-60% in the conditions of inadequate adjustments and a culture with high humidity. [5]

The tangential threshing system must ensure a threshing process with remained seeds in heads of grain under 1%, free seeds in straw under 14% and broken seeds under 2% of the harvested production. [9]

The main components of tangential threshing system are: threshing cylinder, concave, beater and concave

În condiții optime, separarea semințelor în aparatul de treier tangențial poate fi de maxim 85%, scâzand sub 50-60% în condițiile unor reglaje necorespunzătoare şi o cultură cu umiditate ridicată. [5]

Aparatul de treier tangențial trebuie să asigure un proces de treier cu semințe netreierate şi rămase în spice sub 1%, semințe libere în paie sub 14% şi semințe vătamate sub 2% din producția recoltată. [9]

Componentele principale ale aparatului de treier tangențial sunt: bătătorul, contrabătătorul, postbătătorul şi

extension [2]. (Fig. 2)

prelungirea contrabătător [2]. (fig. 2)

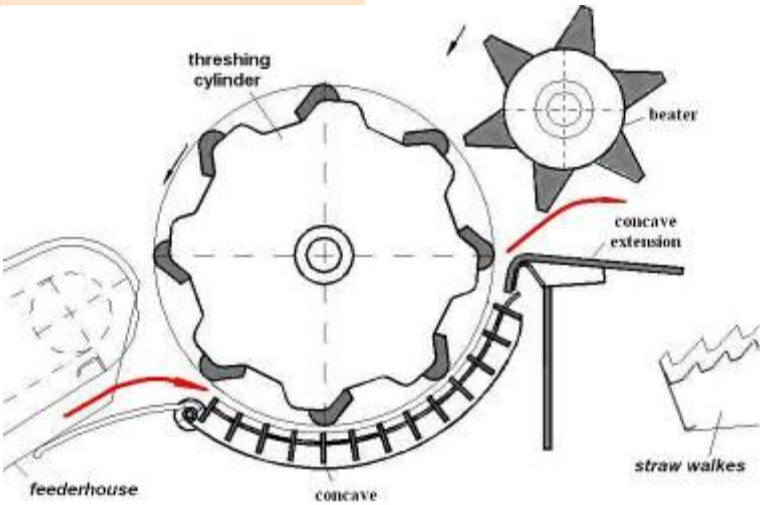
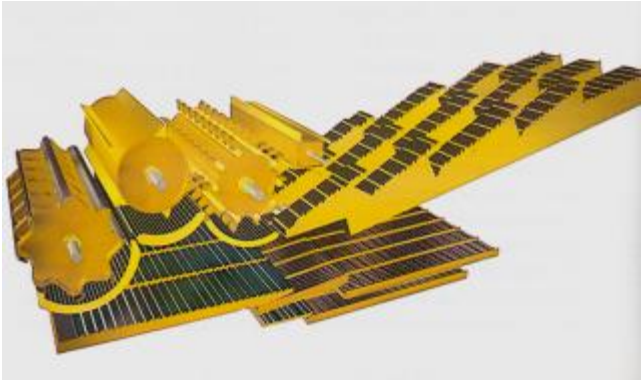


Fig. 2 – The main components of the tangential threshing system [2]

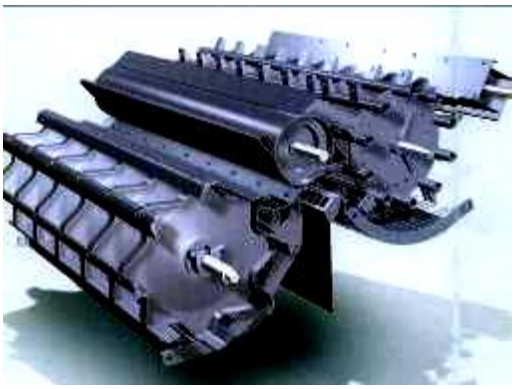
At the current combines equipped with tangential threshing system, to improve the threshing process, some firms use threshing systems with multiple rotors, who can be placed after beater (*New Holland, Laverda*) or in front of the threshing cylinder (*Claas*), Fig. 3.

La combinele actuale prevăzute cu aparat de treier tangențial, pentru a îmbunătăți procesul de treier, unele firme folosesc aparate de treier cu rotoare multiple, care pot fi amplasate după postbătător (*New Holland, Laverda*) sau în fața bătătorului (*Claas*), fig. 3.

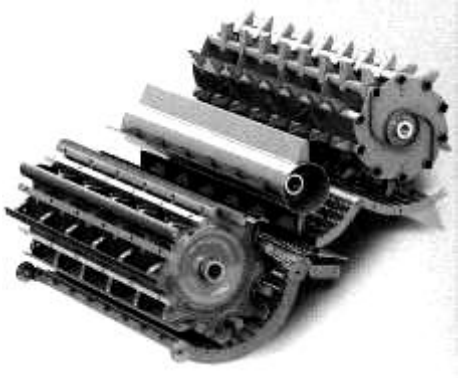


Multi-threshing system – TC, TX, CS, CX combines (New Holland)

APS System - Lexion combines (Claas)



Multi-threshing system with Optithresh concave - CS combines (New Holland)



Multi Crop Separator - LXE, M300 combines (Laverda)

Fig. 3 – The threshing systems with multiple rotors [12,13,14]

At the threshing system with multiple rotors, the separation surface of seeds increases by 65-75%, the index of seeds separation is 90-95%.[5]

The flow rate of a combine with threshing system with multiple rotors is higher by 14-20% than that of a conventional combine. [5]

Romanian combine C110ATM has in component a threshing system with multiple rotors, its location in the technological flow of the combine is shown in Fig. 4.

La aparatele de treier cu rotoare multiple, suprafața de separare a semințelor se mareşte cu 65-75%, indicele total de separare a semințelor fiind de 90-95%. [5]

Debitul unei combine cu aparat de treier cu rotoare multiple este mai mare cu 14-20% decât al unei combine convenționale. [5]

Combina românească C110ATM are în componeță un aparat de treier cu rotoare multiple, amplasarea acestuia în fluxul tehnologic al combinei este prezentată în fig. 4.

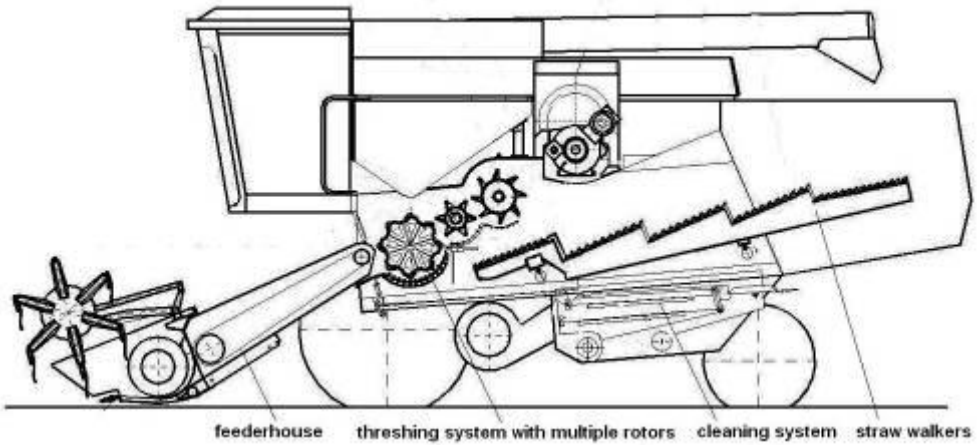


Fig. 4 – Location of the threshing system with multiple rotors at C110ATM combine [1]

MATERIAL AND METHOD

The threshing process takes place in the threshing space, positioned between threshing cylinder and concave, the characteristic dimensions of this being the concave radius R_c, the concave winding angle α and the distances d_i and d_e between threshing cylinder and concave. (Fig. 5)

MATERIAL ŞI METODĂ

Procesul de treier are loc în spațiul de treier, poziționat între bătător şi contrabătător, dimensiunile caracteristice ale acestuia fiind raza R_c a contrabătătorului, unghiul α de înfăşurare a contrabătătorului şi distanțele d_i şi d_e între bătător şi contrabătător. (fig. 5)

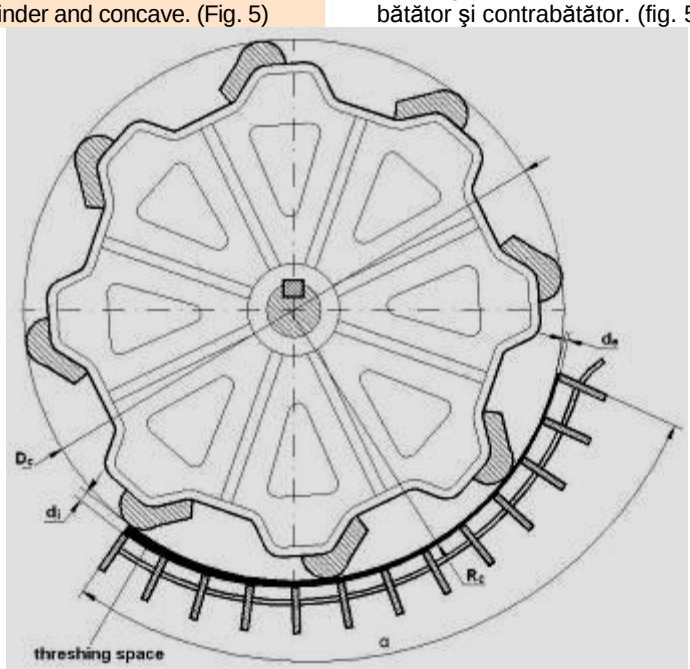


Fig. 5 – The threshing space of the tangential threshing system [1]

The threshing space length of the tangential threshing system can be calculated with relationship 1. [5]

Lungimea spațiului de treier al aparatului de treier tangențial se poate calcula cu relația 1. [5]

$$s = \pi R_c \frac{\alpha}{180^0}, \text{[m]} \quad (1)$$

where s is length of the threshing space; R_c – radius of the concave; α - winding angle of the concave.

The researches regarding the threshing process in the tangential threshing system had as a result the obtaining of mathematical models based on experimental data, expressed by functions who define partial the threshing process, the method used being the linear mathematical regression, nonlinear or multiple. [5]

We present below the most important mathematical models concerning the percentage of seeds separated by concave depending on the length of threshing space at the conventional combines. [4,6]

unde s este lungimea spațiului de treier; R_c - raza contrabătătorului; α - unghiul de înfăşurare al contrabătătorului.

Cercetările privind procesul de treier în aparatul de treier tangențial au avut ca rezultat obținerea de modele matematice pe baza datelor experimentale, exprimate prin funcții care definesc doar parțial procesul de treier, metoda folosită fiind regresia matematică liniară, neliniară sau multiplă. [5]

În continuare prezentăm cele mai importante modelele matematice privind procentul semințelor separate prin contrabătător în funcție de lungimea spațiului de treier la combinele convenționale. [4,6]

Table 1

Mathematical models of the threshing process at the conventional combines [4,6]

Model	Structure	Notations
Casper (1973)	$\xi_s(s) = 100\left(1 - e^{-\left(k_1 s + k_2 s^2 + k_3 s^3\right)}\right)\%$	where $\xi_s(s)$ is the percentage of seeds separated by concave depending on the length of threshing space; s – length of the threshing space, in m; k_1, k_2, k_3 – threshing coefficients (experimental).
Rusanov A.J. (1976)	$\xi_s(s) = 100\left(1 - e^{-\mu s^{\alpha}}\right)\%$	α – winding angle of the concave, in radians; μ – threshing coefficient (experimental).
Trollope J.R. (1982)	$\xi_s(s) = 100\left[1 + \frac{ce^{-kP_0\psi} - kP_0 e^{-c\psi}}{kP_0 - c}\right]\%$	k, c – experimental coefficients; Ψ – geometric function on the winding angle.
Miu Petre (1995)	$\xi_s(s) = \frac{100}{a-b}\left[a\left(1 - e^{-bs}\right) - b\left(1 - e^{-as}\right)\right]\%$	s – length of the threshing space, in m; a, b – threshing coefficients (experimental).
Klenin N.I. and Lomakin S.G. (1972)	$\frac{d\xi_s(s)}{ds} = 100\left[1 - \frac{A}{k_2\mu}\left(k_2 e^{\mu s} - e^{k_2 s}\right) - (1-A)e^{\mu s}\right]\%$	s – length of the threshing space , in m; A, k_2, μ – threshing coefficients (experimental).
Alferov S.A and Braginec V.S. (1972)	$\xi_s(s) = 100\left[1 - e^{-k_1 s} - A\frac{e^{-k_0 s} - e^{-k_1 s}}{k_1 - k_0}\right]\%$	s – length of the threshing space , in m; A, k_0, k_1 – threshing coefficients (experimental).

Koen Maertens and *Josse De Baerdemaeker* have published in 2003 the results of experiments performed at stationary on the tangential threshing system of a New Holland combine harvester for feed rates of 25-45 t/h (6.94-12.5 kg/s) 15.5-15.9% seeds humidity, 12-13% straw humidity, comparing with the 6 mathematical models shown in Table 1, the best results being achieved by mathematical models Rusanov, Caspers and Alferov-Braginec, in that order. [4]

C110 combine harvester of the company Semănătoarea (Romania) went into production in 1994. [16] After 2000 were made at INMA Bucharest researches to increase the working capacity of this combine, by introducing a threshing system with multiple rotors (ATM), yielding a increase of the seeds separation surface at the level of threshing system with 84%.[11]

The constructive scheme of the threshing system with multiple rotors at C110ATM combine is presented in Figure 5. [1]

Koen Maertens şi *Josse De Baerdemaeker* au publicat în 2003 rezultatele experimentelor efectuate la staționar pe aparatul de treier tangențial al unei combine *New Holland*, pentru debite de alimentare de 25-45 t/h (6,94-12,5 kg/s), umiditatea semințelor 15,5-15,9%, umiditatea paielor 12-13%, comparându-se cu cele 6 modele matematice prezentate în tabelul 1, rezultatele cele mai bune fiind obținute de modelele matematice Rusanov, Caspers şi Alferov-Braginec, în aceasta ordine. [4]

Combina *C110* a firmei *Semănătoarea* (România) a intrat în fabricație în 1994. [16] Dupa anul 2000 s-au făcut la INMA Bucureşti cercetări în vederea măririi capacității de lucru a acestei combine, prin introducerea unui aparat de treier cu rotoare multiple (ATM), obținându-se o mărire a suprafeței de separare a semințelor la nivelul aparatului de treier cu 84%. [11]

Schema constructivă a sistemului de treier cu rotoare multiple al combinei C110ATM este prezentată în figura 5. [1]

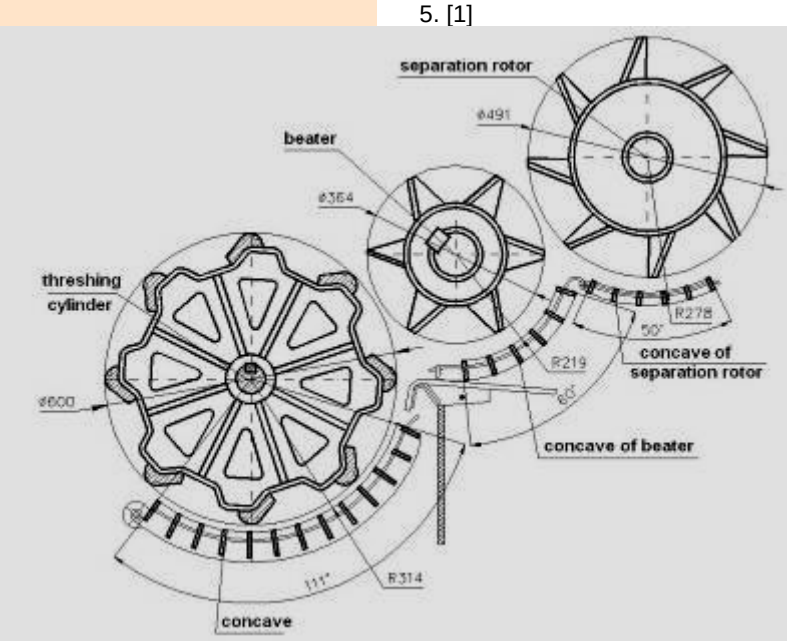


Fig. 5 - The constructive scheme of the threshing system with multiple rotors at C110ATM combine [1]

Characteristic for ATM is possibility to rotate the last

Caracteristic ATM-ului este posibilitatea de rotire a ultimelor două contrabătătoare (numite în continuare

two concaves (hereinafter called separation concaves), their threshing function canceling, the rotor separation just having the role of transport and directing the straw. The canceling of this function is made if the harvesting exceeds the optimum period, because in this case there is an excessive shredded of the straw, with negative effects on shaking and cleaning processes. [11]

Technical features of the threshing system with multiple rotors at C110ATM combine harvester are presented in Table 2. [11]

contrabătătoare de separare), funcția de treier a acestora anulându-se, rotorul de separare având doar rolul de transport şi direcționare a paielor. Anularea acestei funcții se face dacă recoltarea depăşeşte perioada optimă, deoarece în acest caz are loc o marunțire excesivă a paielor, cu efecte negative asupra proceselor de scuturare şi curățire. [11]

Caracteristicile tehnice ale sistemului de treier cu rotoare multiple al combinei C110ATM sunt prezentate în Tabelul 2. [11]

Table 2

Technical features of the threshing system with multiple rotors at C110ATM combine harvester

Threshing cylinder	diameter [mm]	600
	length [mm]	1080
	number of bars	8
	RPM [rot/min]	460-1200
Concave	number of bars	13
	surface [m^2]	0.67
	winding angle	111°
Beater	diameter [mm]	360
	RPM [rot/min]	760
Separation rotor	diameter [mm]	491
	RPM [rot/min]	920
Beater concave	number of bars	7
	winding angle	60°
	surface [m^2]	0.303
	fixed distance between beater and concave [mm]	25
Separation rotor concave	number of bars	6
	winding angle	50°
	surface [m^2]	0.253
	fixed distance between rotor and concave [mm]	25

The mathematical model of the threshing process made by the threshing system with multiple rotors ATM, which we propose, is based on the mathematical model Rusanov, considered by researchers Koen Maertens and Josse De Baerdemaeker as the mathematical model wich best describes the separation seeds in the tangential threshing system.[1]

Thus, the percentage of seeds separated by the concaves ATM, depending on the length of threshing spaces and the winding angles size of the concaves is given by relationship 2. [1]

Modelul matematic al procesului de treier realizat de aparatul de treier cu rotoare multiple ATM, pe care îl propunem, are la bază modelul matematic Rusanov, considerat de cercetătorii Koen Maertens şi Josse De Baerdemaeker ca fiind modelul matematic care defineşte cel mai bine procesul de separare al semințelor în aparatul de treier tangențial.[1]

Astfel, procentul semințelor separate prin contrabătătoare ATM-ului în funcție de lungimea spațiilor de treier şi mărimea unghiurilor de înfăşurare ale contrabătătoarelor este dat de relația 2. [1]

$$\xi_{s_{ATM}}(s)=100\left[1-e^{-\left(\mu_1 s_1^{\alpha_1}+\mu_2 s_2^{\alpha_2}+\mu_3 s_3^{\alpha_3}\right)}\right], [\%] \quad (2)$$

where $\xi_{sATM}(s)$ is the percentage of seeds separation in ATM; s_1 – the threshing space length of the concave; s_2 – the threshing space length of the beater concave; s_3 – the threshing space length of the separation rotor concave; α_1 – the winding angle of the concave; α_2 – the winding angle of the beater concave; α_3 – the winding angle of the separation rotor concave; μ_1 – the threshing coefficient for seeds separation through concave; μ_2 – the threshing coefficient for seeds separation through beater concave; μ_3 – the threshing coefficient for seeds separation through separation rotor concave.

The threshing space length of ATM concave is calculated with the relationship 3.

unde $\xi_{sATM}(s)$ este procentul semințelor separate în ATM; s_1 - lungimea spațiului de treier al contrabătătorului; s_2 - lungimea spațiului de treier al contrabătătorului postbătătorului; s_3 - lungimea spațiului de treier al contrabătătorului rotorului de separare; α_1 - unghiul de înfăşurare al contrabătătorului; α_2 - unghiul de înfăşurare al contrabătătorului postbătătorului; α_3 - unghiul de înfăşurare al contrabătătorului rotorului de separare; μ_1 - coeficient de treier pentru separarea semințelor prin contrabătător; μ_2 - coeficient de treier pentru separarea semințelor prin contrabătătorul postbătătorului; μ_3 - coeficient de treier pentru separarea semințelor prin contrabătătorul rotorului de separare.

Lungimea spațiului de treier al contrabătătorului ATM-ului se calculează cu relația 3.

$$s_1 = \pi R_{c1}\frac{\alpha_1}{180^0}, [m] \quad (3)$$

where s_1 is the threshing space length of ATM concave; R_{c1} – radius of the concave; α_1 – the winding

unde s_1 este lungimea spațiului de treier al contrabătătorului ATM-ului; R_{c1} – raza contrabătătorului;

angle of the concave.

The threshing space length of beater concave is calculated with the relationship 4. [1]

α_1 – unghiul de înfăşurare al contrabătătorului.

Lungimea spațiului de treier al contrabătătorului postbătătorului se calculează cu relația 4. [1]

$$s_2 = \pi R_{c2} \frac{\alpha_2}{180^0}, \text{ [m]} \quad (4)$$

where s_2 is the threshing space length of beater concave; R_{c2} – radius of the beater concave; α_2 – the winding angle of the beater concave.

The threshing space length of separation rotor concave is calculated with the relationship 5. [1]

unde s_2 este lungimea spațiului de treier al contrabătătorului postbătătorului; R_{c2} - raza contrabătătorului postbătătorului; α_2 - unghiul de înfăşurare al contrabătătorului postbătătorului.

Lungimea spațiului de treier al contrabătătorului rotorului de separare se calculează cu relația 5. [1]

$$s_3 = \pi R_{c3} \frac{\alpha_3}{180^0}, \text{ [m]} \quad (5)$$

where s_3 is the threshing space length of the separation rotor concave; R_{c3} – radius of the separation rotor concave; α_3 – the winding angle of separation rotor concave.

The sum consists of the percentage of free seeds remaining in straw and the percentage of seeds no threshing of the bale caming from the threshing cylinder of ATM (the separation concaves are out of the threshing flow) is given by relationship 6. [1]

unde s_3 este lungimea spațiului de treier al contrabătătorului rotorului de separare; R_{c3} – raza contrabătătorului rotorului de separare; α_3 – unghiul de infăşurare al contrabătătorului rotorului de separare.

Suma formată din procentul semințelor libere rămase în paie şi procentul semințelor netreierate ale vrafului provenit de la bătătorul ATM-ului (contrabătătoarele de separare fiind scoase din fluxul de treier) este dată de relația 6. [1]

$$\xi_l(s) + \xi_n(s) = 100 e^{-\mu_1 s_1^{\alpha_1}}, \text{[\%]} \quad (6)$$

where $\xi_l(s)$ is the the percentage of free seeds remaining in straw found at the exit from the threshing space located between threshing cylinder and concave; $\xi_n(s)$ - the percentage of seeds no threshing at the exit from the threshing space located between threshing cylinder and concave; μ_1 - the threshing coefficient for seeds separation through concave; s_1 - the threshing space length of the concave; α_1 - the winding angle of concave.

The sum consists of the percentage of free seeds remaining in straw and the percentage of seeds no threshing of the bale caming from all rotors of ATM is given by the relationship 6. [1]

unde $\xi_l(s)$ este procentul semințelor libere rămase în paie la ieşirea din spațiul de treier aflat între bătător şi contrabătător; $\xi_n(s)$ - procentul semințelor netreierate la ieşirea din spațiul de treier aflat între bătător şi contrabătător; μ_1 - coeficient de treier pentru separarea semințelor prin contrabătător; s_1 - lungimea spațiului de treier al contrabătătorului; α_1 - unghiul de înfăşurare al contrabătătorului.

Suma formată din procentul semințelor libere rămase în paie şi procentul semințelor netreierate ale vrafului provenit de la toate rotoarele ATM-ului este dată de relația 7. [1]

$$\xi_{lATM}(s) + \xi_{nATM}(s) = 100 e^{-\left(\mu_1 s_1^{\alpha_1} + \mu_2 s_2^{\alpha_2} + \mu_3 s_3^{\alpha_3}\right)}, \text{[\%]} \quad (7)$$

where $\xi_{lATM}(s)$ is the percentage of free seeds remaining in straw found at the exit from ATM; $\xi_{nATM}(s)$ - the percentage of no threshing seeds at the exit from ATM; μ_1 - the threshing coefficient for seeds separation through concave; μ_2 - the threshing coefficient for seeds separation through beater concave; μ_3 - the threshing coefficient for seeds separation through separation rotor concave; s_1 - the threshing space length of concave; s_2 - the threshing space length of beater concave; s_3 - the threshing space length of separation rotor concave; α_1 - the winding angle of concave; α_2 - the winding angle of beater concave; α_3 - the winding angle of separation rotor concave.

The relations 6 and 7 represent processes the threshing losses made by ATM, to which the separation concaves were taken out of the flow of material (similarly the threshing system of conventional combine C110) and ATM at which the separation concaves were introduce in the threshing flow.

The report of the relations 7 and 6 represents the loss report of the two types of the threshing systems (of the combines C110ATM and C110), according to the

unde $\xi_{lATM}(s)$ este procentul semințelor libere rămase în paie la ieşirea din ATM; $\xi_{nATM}(s)$ - procentul semințelor netreierate la ieşirea din ATM; μ_1 - coeficient de treier pentru separarea semințelor prin contrabătător; μ_2 - coeficient de treier pentru separarea semințelor prin contrabătătorul postbătătorului; μ_3 - coeficient de treier pentru separarea semințelor prin contrabatatorul rotorului de separare; s_1 - lungimea spațiului de treier al contrabătătorului; s_2 - lungimea spațiului de treier al contrabătătorului postbătătorului; s_3 - lungimea spațiului de treier al contrabătătorului rotorului de separare; α_1 - unghiul de înfăşurare al contrabătătorului; α_2 - unghiul de înfăşurare al contrabătătorului postătătorului; α_3 - unghiul de înfăşurare al contrabătătorului rotorului de separare.

Relațiile 6 şi 7 reprezintă pierderile pentru procesele de treier realizate de ATM, la care contrabătătoarele de separare au fost scoase din fluxul de material (similar aparatului de treier al combinei convenționale C110) şi ATM la care contrabătătoarele de separare au fost introduse în fluxul de material.

Raportul relațiilor 7 şi 6, reprezintă raportul pierderilor celor doua tipuri de aparate de treier (ale

relationship 8. [1]

combinelor C110ATM şi C110), conform relației 8. [1]

$$\frac{\xi_{lATM}(s)+\xi_{nATM}(s)}{\xi_l(s)+\xi_n(s)}=e^{-\left(\mu_2 s_2^{\alpha_2}+\mu_3 s_3^{\alpha_3}\right)} \quad (8)$$

The losses report of the two types threshing systems equals with the report of total losses to straw walkers of combine C110ATM.

The separation concaves, having the same configuration, μ_1 and μ_2 threshing coefficients can be considered equal and having μ_{ATM} value, resulting the relationship 9. [1]

Raportul pierderilor celor doua tipuri de aparate de treier este egal cu raportul pierderilor totale la scuturătorul combinei C110ATM.

Contrabătătoarele de separare având aceaşi configurație, coeficienții de treier μ_1 şi μ_2 se pot considera egali şi având valoarea μ_{ATM}, rezultând relația 9. [1]

$$\frac{\xi_{lATM}(s)+\xi_{nATM}(s)}{\xi_l(s)+\xi_n(s)}=e^{-\mu_{ATM}\left(s_2^{\alpha_2}+s_3^{\alpha_3}\right)}=k \quad (9)$$

where μ_{ATM} is the threshing coefficients of the separation concaves of ATM; k – the losses report value of the two types threshing systems.

Knowing the losses report value of the two threshing systems types, results the threshing coefficient value μATM of the separation concaves of ATM, according to the relationship 10. [1]

unde μ_{ATM} este coeficientul de treier al contrabătătoarelor de separare ale ATM-ului; k - valoarea raportului pierderilor celor doua tipuri de aparate de treier.

Cunoscând valoarea raportului pierderilor celor două tipuri de aparate de treier, rezultă valoarea coeficientului de treier μ_{ATM} al contrabătătoarelor de separare ale ATM-ului, conform relației 10.[1]

$$\mu_{ATM}=-\frac{\ln k}{s_2^{\alpha_2}+s_3^{\alpha}} \quad (10)$$

where μ_{ATM} is the threshing coefficients of the separation concaves of ATM; k – the losses report value of the two types threshing systems; s_2 - the threshing space length of beater concave; s_3 - the threshing space length of separation rotor concave; α_2 - the winding angle of beater concave; α_3 - the winding angle of separation rotor concave.

The intensification value of the threshing process made by the ATM threshing system with multiple rotors reported to the threshing process made by the threshing system of the conventional combine C110, is given by relationship 11. [1]

unde μ_{ATM} este coeficientului de treier al contrabătătoarelor de separare; k - valoarea raportului pierderilor celor doua tipuri de aparate de treier; s_2 - lungimea spatiului de treier al contrabatatorului postbătătorului; s_3 - lungimea spatiului de treier al contrabătătorului rotorului de separare; α_2 - unghiul de înfăşurare al contrabătătorului posbătătorului; α_3 - unghiul de înfăşurare al contrabătătorului rotorului de separare.

Valoarea intensificării procesului de treier, realizat de aparatul de treier cu rotoare multiple ATM raportată la procesul de treier realizat aparatul de treier al combinei convenționale C110, este dată de relația 11. [1]

$$I_{ATM}=100\frac{\xi_l(s)+\xi_n(s)}{\xi_{lATM}(s)+\xi_{nATM}(s)},[\%] \quad (11)$$

where I_{ATM} is intensification of threshing process made by the threshing system with multiple rotors ATM, reported to the threshing process of the conventional combine C110; $\xi_l(s)$ - the percentage of free seeds remaining in straw at the exit from the threshing system of C110 combine; $\xi_n(s)$ - the percentage of no threshing seeds at the exit from the threshing system of C110 combine; $\xi_{lATM}(s)$ - the percentage of free seeds remaining in straw at the exit from ATM; $\xi_{nATM}(s)$ - the percentage of no threshing seeds at the exit from ATM.

unde I_{ATM} este intensificarea procesului de treier realizat de aparatul de treier cu rotoare multiple ATM, raportat la procesul de treier al combinei convenționale C110; $\xi_l(s)$ - procentul semințelor libere rămase în paie la ieşirea din aparatul de treier al combinei C110; $\xi_n(s)$ - procentul semințelor netreierate la ieşirea din aparatul de treier al combinei C110; $\xi_{lATM}(s)$ - procentul semințelor libere rămase în paie la ieşirea din ATM; $\xi_{nATM}(s)$ - procentul semințelor netreierate la iesirea din ATM.

RESULTS

The laboratory tests of the C110ATM combine harvester were conducted in June 2001 by DITRMA-INMA Bucharest Laboratory and the field tests were conducted in July 2001 in Dor Mărunt locality, Călăraşi County. [11]

In Table 3 are presented the values of the working regime and working quality indices for the tests with the separation concaves of ATM introduced into the material flow. [11].

REZULTATE

Încercările de laborator ale combinei de recoltat C110ATM au fost efectuate în iunie 2001 de către Laboratorul DITRMA-INMA Bucureşti, iar încercările în câmp au fost efectuate în iulie 2001 în zona localității Dor Mărunt, județul Calaraşi. [11]

În tabelul 3 sunt prezentate valorile regimului de lucru şi a indicilor calitativi de lucru pentru încercările efectuate cu contrabătătoarele de separare ale ATM-ului introduse în fluxul de material. [11]

Table 3

The working regime and working quality indices for the tests with the separation concaves of ATM introduced into the vegetal mass flow

Nr.crt	Indice	M.U.	Value determined	
WORKING REGIM				
1	Working speed	km/h	3.789	6.426
2	Flow rate combine	kg/s	**4.299**	**6.027**
3	Working width	m	4.1	
4	Cutting height	m	0.16	0.17
WORKING QUALITY INDICES				
1	Total losses per hectare at header: - seeds in uncut ears - seeds in cut ears - free seeds on the ground	%	0.2958 0.1472 0.1205 0.0281	0.3735 0.1872 0.1426 0.0437
2	Total losses at threshing machine: - total losses at straw walkers - seeds in no threshing ears - free seeds in straw - total losses at clining system	%	1.2314 **0.0785** 0.0032 0.0753 1.1529	1.3124 **0.0839** 0.0027 0.0812 1.2285
3	Total losses at combine	%	1.5272	1.6859
4	Broken seeds	%	1.64	1.78
5	The purity of the material collected in bunker	%	99.59	99.41

In Table 3 are presented the values of the working regime and working quality indices for the tests with the separation concaves of ATM remove from the material flow. [11].

În tabelul 4 sunt prezentate valorile regimului de lucru şi a indicilor calitativi de lucru pentru încercările efectuate cu contrabătătoarele de separare ale ATM-ului scoase din fluxul de material. [11]

Table 4

The working regime and working quality indices for the tests with the separation concaves of ATM removed from the material flow

Nr.crt	Indice	M.U.	Value determined	
WORKING REGIM				
1	Working speed	km/h	3.747	6.286
2	Flow rate combine	kg/s	**4.186**	**5.988**
3	Working width	m	4.1	
4	Cutting height	m	0.15	0.19
WORKING QUALITY INDICES				
1	Total losses per hectare at header: - seeds in uncut ears - seeds in cut ears - free seeds on the ground	%	0.3167 0.1272 0.1523 0.0372	0.3683 0.1659 0.1626 0.0398
2	Total losses at threshing machine: - total losses at straw walkers - seeds in no threshing ears - free seeds in straw - total losses at clining system	%	1.7594 **0.3501** 0.0663 0.2838 1.4093	2.0556 **0.4292** 0.0807 0.3485 1.6264
3	Total losses at combine	%	2.0761	2.4239
4	Broken seeds	%	1.69	1.73
5	The purity of the material collected in bunker	%	99.72	99.45

By entering into the relationship 10 the test report data for the combine C110ATM, the total loss obtained at the straw walkers for the two positions of the separation concaves (similar to the two threshing system of C110 and C110ATM combines), is calculated the threshing coefficient values μ_{ATM} of the separation concoves and the intensification of threshing process I_{ATM} of ATM, according to Table 5.

Introducând în relația 10 datele din raportul de încercări al combinei C110ATM pentru valorile pierderilor totale la scuturător obținute la cele două poziții ale contrabătătoarelor de separare (similare celor doua aparate de treier ale combinelor C110 şi C110ATM), se calculează valorile coeficientului de treier μ_{ATM} ale contrabătătoare de separare şi intensificarea procesului de treier I_{ATM} al ATM-ului, conform tabelului 5.

Table 5

The threshing coefficient values of the separation concoves and the intensification of threshing process of ATM [1,10]

Nr. crt	Indice	M.U.	Value determined			
			C110	C110ATM	C110	C110ATM
WORKING REGIM						
1	Flow rate combine	kg/s	4.2*		6.0*	
2	Total losses at straw walkers	%	0.3501	0.0785	0.4292	0.0839
WORKING QUALITY INDICES						

1	Threshing coefficient μ_{ATM}	-	2.963	3.235
2	Intensification of threshing process I_{ATM}	%	51.15	44.60

***** The flow rate combines have been rounded to the first decimal

Analyzing the values presented in Table 5 result:

- The threshing coefficient, specific ATM, has a variable value, increasing specific of the flow rate value;
- ATM intensifies considerably the threshing process, the intensify value being variable, decreasing depending on the flow rate value;
- The small values of total losses of C110ATM combine harvester, it would require the experimentation of combine at flow rates bigger.

CONCLUSIONS

1. The threshing systems with multiple rotors have the separation surface bigger with 65-75%, relative to the separating surface of the tangential threshing system, which would allow the decreasing of straw walkers length;
2. The threshing systems with multiple rotors produces an intensification of the threshing process relative to the tangential threshing system, but that does not mean that the flow rate to increase with equal percentage value. This explains why the flow rate of a combine with threshing system with multiple rotors is bigger only 14-20% relative to the flow rate of a conventional combine harvester. [5]
3. The increase of threshing space length at the threshing system with multiple rotor lead to shredding the straw, being necessary changes of the straw walkers and the cleaning system. It also increases the specific energy consumption;
4. Combines with threshing system with multiple rotors are less universal, these beiing only effective for certain crops, the crops with large seeds (maize) or the crops with seeds more susceptible to harvest with cereal combine harvester (sunflower, soybeans, beans , peas etc.) can not be harvested with these combines;
5. The combines harvester with threshing systems with multiple rotors are more complex, more expensive, harder to maintain and more easily clogged at crops with weeds and with high humidity;
6. The combines harvester with threshing systems with multiple rotors are recommended for the cereals harvesting, provided that the investment and modifications to the conventional combines to be relatively low.

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Analizând valorile prezentate în tabelul 5, rezultă:

- Coeficientul de treier specific ATM-ului are o valoarea variabilă, crescătoare în funcție de valoarea debitului de alimentare;
- ATM-ul intensifică considerabil procesul de treier, valoarea intensificării fiind variabilă, descrescătoare în funcție de valoarea debitului de alimentare;
- Valorile mici ale pierderilor totale ale combinei C110ATM ar fi cerut experimentarea combinei şi la debite de alimetare mai mari. [1]

CONCLUZII

1. Aparatele de treier cu rotoare multiple au suprafața de separare mai mare cu 65-75%, raportată la suprafața de separare a unui aparat de treier tangențial, ceea ce ar permite micşorarea lungimii scuturătorului;
2. Aparatul de treier cu rotoare multiple produce o intensificare a procesului de treier față de aparatul de treier tangențial, dar asta nu presupune ca şi debitul de alimentare să crească procentual cu aceeaşi valoare. Astfel se explică de ce debitul de alimentare al unei combine cu aparat de treier cu rotoare multiple este mai mare doar cu 14-20% raportat la debitul de alimentare al unei combine conventionale; [5]
3. Creşterea lungimii spațiului de treier la aparatele de treier cu rotoare multiple conduce la mărunțirea paielor, fiind necesare modificări ale scuturătorului şi sistemului de curățire. De asemenea, creşte consumul energetic specific;
4. Combinele cu aparatele de treier cu rotoare multiple sunt mai puțin universale, fiind eficiente doar pentru anumite culturi, culturile cu semințe mari (porumbul) sau culturile cu semințe mai sensibile la recoltatul cu combina de recoltat cereale (floarea-soarelui, soia, fasolea, mazărea etc) neputând fi recoltate cu aceste combine;
5. Combinele cu aparatele de treier cu rotoare multiple sunt mai complexe, mai costisitoare, mai greu de intreținut şi se înfundă mai uşor la culturi îmburuienate şi cu umiditate mare;
6. Combinele cu aparate de treier cu rotoare multiple sunt recomandate pentru recoltarea cerealelor păioase, în condițiile în care investiția şi intervenția asupra combinelor cu aparat de treier tangențial sunt relativ reduse.

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STUDY OF THE VIBRATIONS OF A PLOW BLADE
/
STUDIUL VIBRAȚIILOR UNEI LAME DE PLUG

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Abstract: *The paper analyses the bending vibrations of a plow blade, modeled as a variable cross-section beam, clamped at one end and free at the other. The study is performed by using the discretization method, while the differential equations of the free vibrations are deduced by means of the influence coefficients method.*

Keywords: *bending vibrations, variable cross-section, discretization, influence coefficient.*

Rezumat: *Lucrarea analizează vibrațiile de încovoiere ale unei lame de plug, modelată ca o bara de secțiune variabilă, încastrată la un capăt şi liberă la celălalt. Studiul vibrațiilor se efectuează prin metoda discretizării, iar ecuațiile diferențiale ale vibrațiilor se deduc cu ajutorul metodei coeficienților de influență.*

Cuvinte cheie: *vibrații de încovoiere, secțiune variabilă, discretizare, coeficient de influență.*

INTRODUCTION

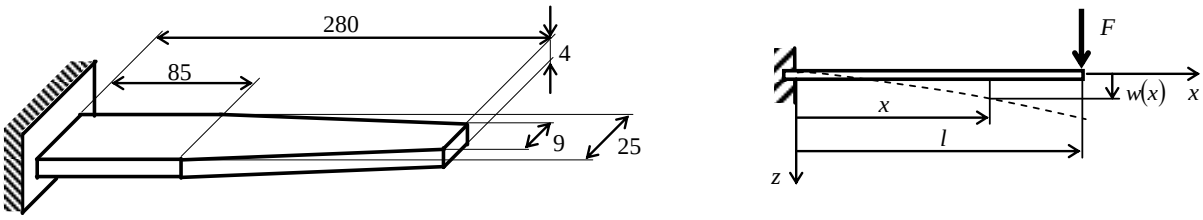
In order to study the vibrations of an arbitrary blade with variable section, the model of a rectangular cross-section beam is adopted, with variable width. The beam is clamped at one end and free at the other (Fig. 1 a).

The beam performs bending vibrations, in the longitudinal plane (vertical in the figure).

INTRODUCERE

Pentru studiul vibrațiilor unui cuțit oarecare, cu secțiune variabilă, se adoptă modelul unei bare de secțiune dreptunghiulară, de lățime variabilă, încastrată la una dintre extremități şi liberă la cealaltă (fig. 1 a).

Bara efectuează oscilații de încovoiere în plan longitudinal (vertical pe figură).



a) b)

Fig. 1 - Beam with variable cross-section

The width of the beam varies with abscissa x according to the law

Lățimea barei variază cu abscisa x după legea

$$b(x)=\begin{cases}0.025\text{m} & \text{if / } dacă \quad 0\le x\le 0.085\text{m}\\ 0.03197436-0.08205x & \text{if / } dacă \quad 0.085\text{m}<x\le 0.280\text{m}.\end{cases} \tag{1}$$

MATHEMATICAL MODEL

It is known from the strength of materials [11] that the deflection w of the neutral fiber of the beam acted by a force F in static regime (Fig. 1 b) results from the equation

MODEL MATEMATIC

Se cunoaşte din rezistența materialelor [11] că deplasarea pe direcție transversală, w, a fibrei medii a barei acționate în regim static de o forță F (fig. 1 b) rezultă din ecuația

$$w''(x)=-\frac{M_z(x)}{EI_y(x)}, \tag{2}$$

where

în care

$$M_z(x)=-F(l-x), \tag{3}$$

is the bending moment produced by the force in the section defined by abscissa x,

este momentul încovoietor produs de forță în secțiunea definită de abscisa x,

$$I_y(x)=\frac{b(x)h^3}{12}. \tag{4}$$

is the geometrical moment of inertia of the section, while E is the Young's modulus of the material of the beam.

By integrating two times equality (2), the equation of the neutral fiber in static regime is obtained:

este momentul de inerție geometric al secțiunii, iar E este modulul lui Young al materialului barei.

Integrând de două ori egalitatea (2), rezultă ecuația fibrei medii deformate, în regim static:

$$w(x)=\int_0^x\left(\int_0^x \frac{M_z(x)}{EI_y(x)}\,\mathrm{d}x\right)\mathrm{d}x=\frac{12F}{Eh^3}\int_0^x\left(\int_0^x \frac{l-x}{b(x)}\,\mathrm{d}x\right)\mathrm{d}x\,. \tag{5}$$

It is known from the literature [6, 7, 8, 9] that the bending vibrations of the beam are governed by the partial derivative differential equation

Se cunoaşte din literatură [6, 7, 8, 9] că vibrațiile de încovoiere ale barei sunt guvernate de ecuația diferențială cu derivate parțiale

$$\frac{\partial^2}{\partial x^2}\left[EI_y(x)\frac{\partial^2 w}{\partial x^2}\right]=-\rho A(x)\frac{\partial^2 w}{\partial t^2}\,, \tag{6}$$

where $A(x)$ is the area of the cross-section of the beam, while ρ is the density of the material of the beam.

However, the differential equation (6) cannot be integrated analytically in the general case, i.e. for arbitrary functions $I_y(x)$ and $A(x)$, respectively. Therefore, in the present paper, the study is performed numerically, by means of the discretization method, which was presented and successfully used in papers [1, 2, 3, 4, 5], for the study of the free and forced bending oscillations, respectively, of homogeneous beams with or without a number of attached concentrated masses.

The method consists in replacing the distributed mass system by a discrete one, made of a relatively high number n of material points, of masses

unde $A(x)$ este aria secțiunii barei, iar ρ este densitatea materialului barei.

Ecuația diferențială (6) este, însă, imposibil de integrat analitic în cazul general, adică în cazul unor funcții oarecare $I_y(x)$, respectiv $A(x)$. Ca urmare, în lucrarea de față, studiul este efectuat numeric, cu ajutorul metodei discretizării, prezentată şi utilizată cu succes în lucrările [1, 2, 3, 4, 5], pentru studiul oscilațiilor de încovoiere libere şi forțate, ale unor bare omogene, unele dintre acestea având ataşate un număr de mase concentrate.

Metoda constă în înlocuirea sistemului continuu printr-unul discret, alcătuit dintr-un număr n, relativ mare, de puncte materiale, de mase

$$m_i=\rho b(x_i)h\cdot(x_i-x_{i-1})\quad (i=1,2,\ldots,n)\,, \tag{7}$$

which are attached to a beam with negligible mass (fig. 2).

ataşate unei bare de masă neglijabilă (fig. 2).

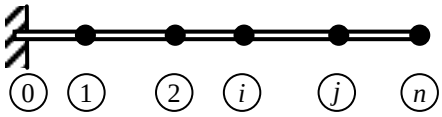


Fig. 2 - Discretized beam

The differential equations of the free small oscillations can be obtained by means of the method of the influence coefficients [8, 10]. The influence coefficient δ_{ij} represents the deflection of the neutral fiber in section i, produced by a unit force, applied statically in section j (fig. 2).

For the analyzed beam,

Ecuațiile diferențiale ale micilor oscilații libere se pot obține cu ajutorul metodei coeficienților de influență [8, 10]. Coeficientul de influență δ_{ij} reprezintă deplasarea fibrei medii în secțiunea i, produsă de o forță egală cu unitatea, aplicată static în secțiunea j (fig. 2).

În cazul barei analizate,

$$\delta_{ij}=\delta_{ji}=\frac{12}{Eh^3}\int_0^{x_j}\left(\int_0^x \frac{x_j-x}{b(x)}\,\mathrm{d}x\right)\mathrm{d}x\quad (i,j=1,2,\ldots,n)\quad \text{if}\quad x_i\le x_j\,. \tag{8}$$

In the present paper, integrals in formula (8) were computed numerically.

By defining the matrix of the influence coefficients, the mass matrix and the dynamic matrix, respectively,

In lucrarea de față, integralele din formula (8) au fost calculate numeric.

Construind matricea coeficienților de influență, matricea maselor, respectiv matricea dinamică,

$$[\delta]=[\delta_{ij}],\qquad [m]=[m_{ij}],\qquad [D]=[\delta][m], \tag{9}$$

it is shown in the cited works that the circular eigenfrequencies are

se arată în lucrările citate că pulsațiile proprii ale sistemului sunt

$$\omega_i=\frac{1}{\sqrt{\lambda_i}}\quad (i=1,2,\ldots,n)\,, \tag{10}$$

where λ_i represent the eigenvalues of matrix $[D]$, while the eigenmodes are equal with the corresponding eigenvectors of the same matrix.

în care λ_i reprezintă valorile proprii ale matricei $[D]$, iar modurile proprii sunt egale cu vectorii proprii corespunzători ai aceleiaşi matrice.

NUMERICAL STUDY

The numerical study of the vibrations of the beam in Figure 1 a was performed based of the following values:

STUDIU NUMERIC

Studiul numeric al vibrațiilor barei din figura 1 a s-a efectuat considerând următoarele valori:

$$E = 210 \text{x} 10^9 \text{ N/m}^2, \qquad \rho = 7850 \text{kg/m}^3, \qquad n = 40 .$$

The first 10 circular eigenfrequencies and the corresponding eigenfrequencies are presented in Table 1.

Primele 10 pulsații proprii obținute şi frecvențele proprii corespunzătoare sunt prezentate in tabelul 1.

Table 1

Values of the first 10 circular eigenfrequencies and the corresponding eigenfrequencies

i	1	2	3	4	5	6	7	8	9	10
ω_i [s^{-1}]	263.41	1534.18	4409.33	8921.36	15035.13	22669.89	31656.21	41724.28	52766.81	65273.29
f_i [Hz]	41.92	244.17	701.77	1419.88	2392.92	3608.03	5038.24	6640.63	8398.1	10388.57

The first three vibration eigenshapes are illustrated in Figure 3.

Primele trei forme proprii de vibrație sunt ilustrate în figura 3.

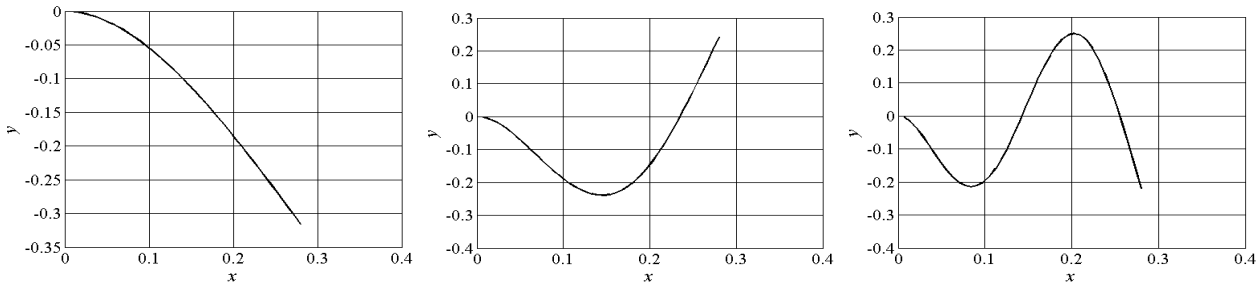


Fig. 3 - First three eigenshapes

EXPERIMENTAL STUDY

The experimental study of the system was performed on the measuring stand shown in Figures 4-6.

STUDIUL EXPERIMENTAL

Studiul experimental al sistemului s-a efectuat cu ajutorul bancului de probă prezentat în figurile 4-6.

Fig. 4 - Measuring Stand

Fig. 5 - Accelerometer layout

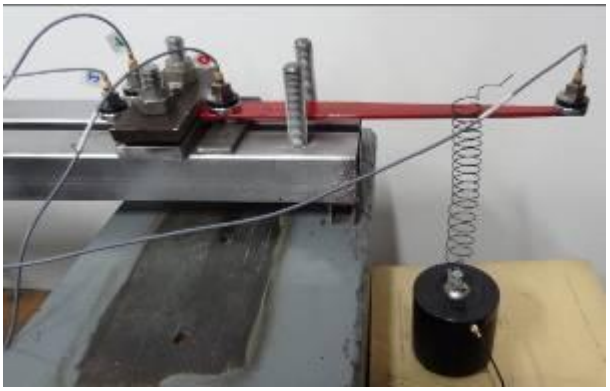


Fig. 6 - Excitation system

A measuring chain was used, with four accelerometers, counted from 0 to 3.

Accelerometer 3 was positioned at the free end of the beam, while accelerometer 0 on the beam, near the fixing system. Accelerometers 1 and 2 were placed on the fixing system.

Free vibrations produced by applying percussions

S-a utilizat un lanț de măsură cu patru accelerometre, numerotate de la 0 la 3.

Accelerometrul 3 a fost amplasat în capul liber al barei, iar accelerometru 0 pe bară, lângă încastrare. Accelerometrele 1 şi 2 au fost plasate pe sistemul de prindere.

S-au studiat vibrații libere, produse prin aplicare

on the beam were studied, as well as forced vibrations, produced by the excitation system in Figure 6, with white signal.

The obtained date were processed with LabVIEW program, resulting the spectra in Figures 7-8.

unor percuții pe bară, precum şi vibrațiile forțate, produse de sistemul de excitație din figura 6, cu semnal alb.

Datele au fost prelucrate cu ajutorul programului LabVIEW, obținându-se spectrele din figurile 7-8.

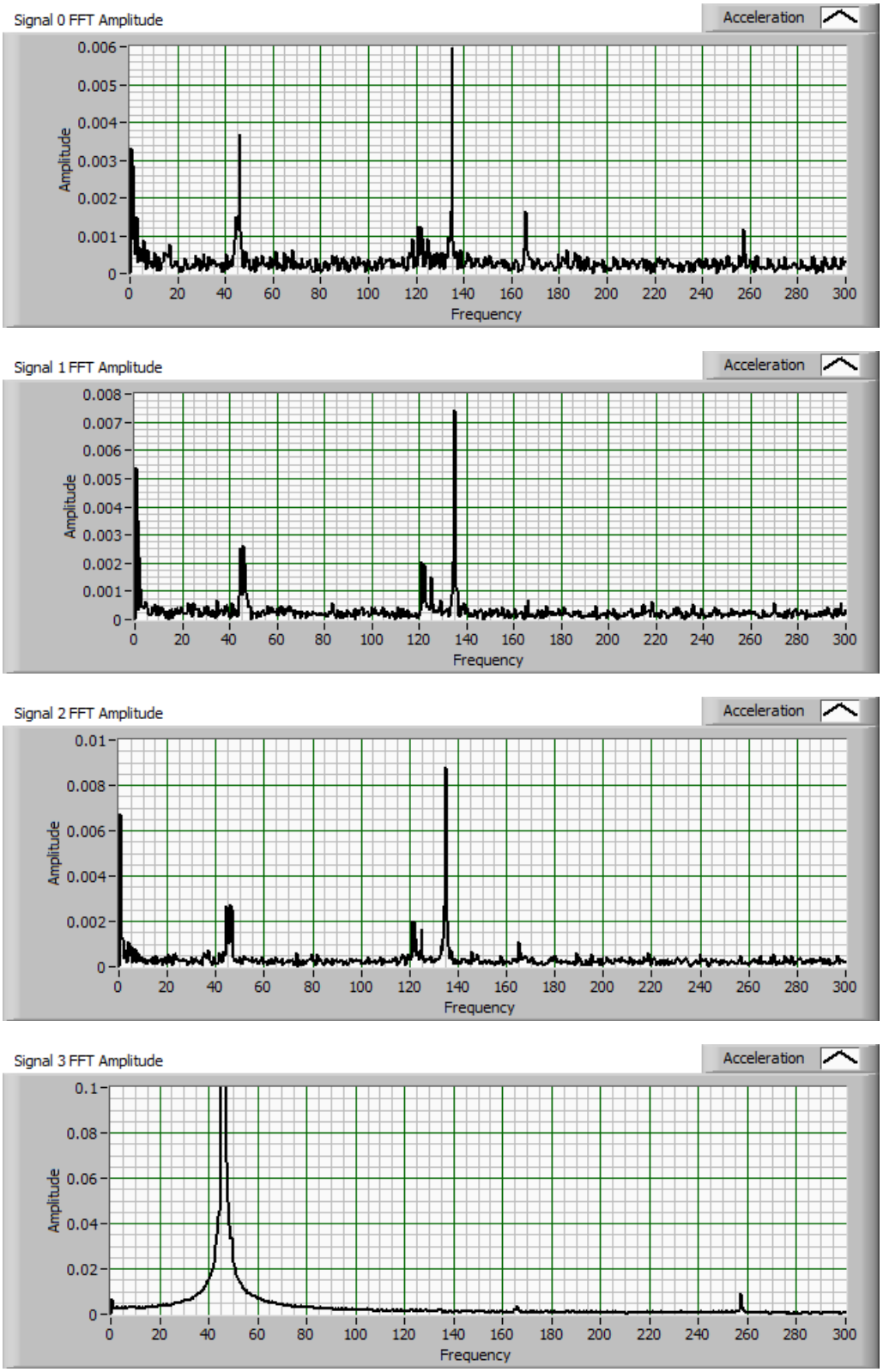


Fig. 7 - Free vibrations spectra

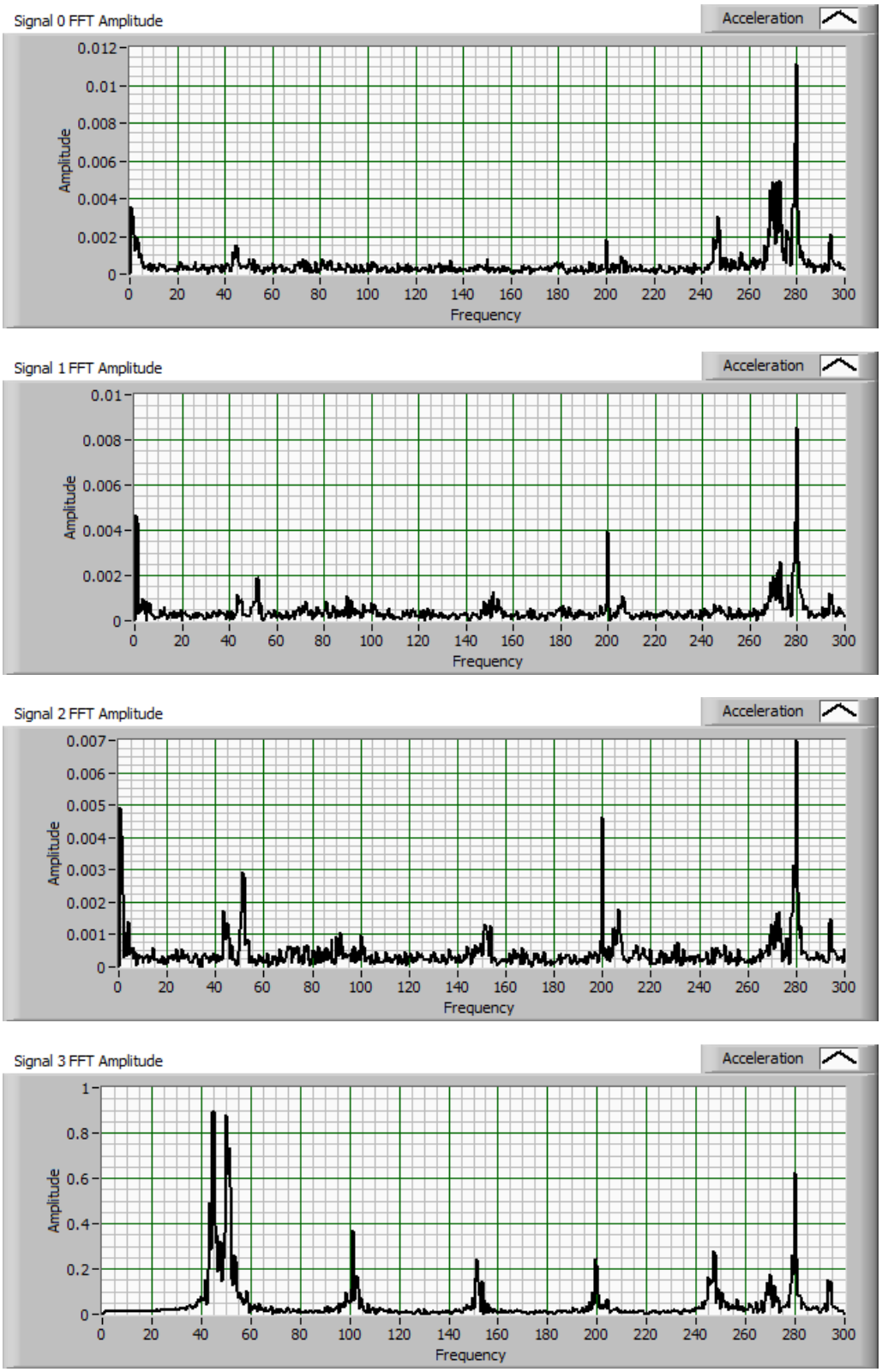


Fig. 8 - Forced vibrations spectra - white signal

CONCLUSIONS

Based on a simple model, the paper analyzed the vibrations of an arbitrary blade with variable section, which can represent a plow coulter.

The spectra obtained by processing the experimental data from free vibrations present a pronounced pick at a frequency close to the first computed eigenfrequency.

CONCLUZII

Lucrarea a analizat pe baza unui model simplu vibrațiile unei lame oarecare de secțiune variabilă, ce poate reprezenta un cuțit lung de plug.

Spectrele obținute prin prelucrarea datelor experimentale în cazul vibrațiilor libere prezintă un vârf accentuat la o frecvență apropiată de prima frecvență proprie calculată.

The spectrum of the signal measured by accelerometer 3, placed at the free end of the beam, shows a lower pick close to the second computed eigenfrequency.

The first three accelerometers, placed close to the fixing system and on the fixing system, respectively, exhibit supplementary picks, due to the stand vibrations.

The spectra obtained from forced vibrations confirm the first two components, but in this case the signal captured by accelerometer 3 presents also some components multiple of 50 Hz, due to the excitation system which is placed close to this accelerometer.

The numerical method used in the paper provided results in agreement with the experiments.

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Spectrul semnalului măsurat de accelerometrul 3, plasat în capătul liber al barei prezintă un vârf mai redus în apropierea celei de a doua frecvențe proprii calculate.

Primele trei accelerometre, plasate în apropierea sistemului de prindere, respectiv pe acesta, prezintă vârfuri suplimentare, datorate vibrațiilor bancului.

Spectrele obținute în cazul vibrațiilor forțate confirmă prezența primelor două componente, dar în acest caz semnalul captat de accelerometrul 3 prezintă, de asemenea, componente în apropierea unor frecvențe multiplu de 50 Hz, datorate sistemului de excitație, plasat în apropierea acestui accelerometru.

Metoda numerică utilizată a condus la rezultate în acord cu experimentele.

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THE INFLUENCE OF THE CONDITIONING SYSTEM ON SEED QUALITY
/
ÍNFLUENŢA SÍSTEMULUI DE CONDÍŢÍONARE ASUPRA VALORÍÍ CULTURALE A SEMÍNŢEÍ

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Abstract: *The paper presents researches concerning the manner in which different conditioning systems influence the quality of seeds prepared for sowing by optimization of the preparation process for increasing quality and decreasing specific energy consumption as well as of the cost per ha. The results processed and interpreted with well known statistical methods exhibit significant differences between the studied conditioning systems and their influence on quality indices which indicate the cultural value of seeds.*

Keywords: *seed, sprout, conditioning*

INTRODUCTION

After to the harvesting, the converging point of all the actions of the agricultural producer, conditioning, storage and preservation of products are the compulsory processes, in order to ensure continuously the major food source for humans and animals.

For the optimal management of these processes a complex study is necessary concerning the physico-mechanical properties of seeds, the physiologic processes and micro-organic activities that take place inside the seed and the cinematic regime of the machinery, in order to preserve the integrity of seeds during processing.

As it is well known, the final product obtained through harvesting consists of a mixture composed of the seeds of the main crop, weed seeds, different mineral or organic impurities (dust, straw, husk). Besides these one must take into consideration the fact that even the seeds of the main crop are of different size and weight some of them being broken, stunted or damaged.

When harvesting, grains are not totally physiological mature. The broken and shriveled grains and weed seeds present a higher humidity than the rest of the components, increased breathing (3-5 times higher than normal) which rises the environmental temperature and in humid conditions finally leads to the development of certain undesirable processes in seeds as: rot, sprouting etc [1]. Under these circumstances microorganisms as bacteria, mildew, fungi existent in huge quantities in seeds enhance their activity producing carbon dioxide, alcohols, toxins and favorable conditions are created for propagation of different pests. All these circumstances lead to a significant decrease of viability and poor preservation capacity of seeds. Microorganisms penetrate in the cracked seeds, degrade them by destroying their enzymatic system inducing low sprouting capacity and abnormal sprouts.

In this respect, the conditioning process come to understood as the process of bringing the harvested seeds to a certain humidity, temperature, purity levels which allows the preservation off all the initial characteristics for a longer period of time..

The quality of the seeds is defined by their biologic

Rezumat: *Lucrarea prezintă rezultatele cercetării, privind influența diferitelor sisteme de condiționare asupra calității semintei destinate însămânțării, în contextul optimizarii procesului de pregatire a seminței, în sensul cresterii calitătii si scăderii consumului specific de energie si a costului semintei pe unitatea de suprafată. Valorificarea rezultatelor si interpretarea lor, cu tehnicile statistice cunoscute, au evidențiat diferențe semnificative intre variantele de condiționare si influențe diferite ale acestora, asupra tuturor indicilor de calitate, ce caracterizează valoarea culturală a seminței.*

Cuvinte cheie: *sămânță, germinație, condiționare*

INTRODUCERE

După recoltare, punctul de convergenţă a tuturor acţiunilor producătorului agricol, condiţionarea, depozitarea si conservarea produselor sunt procesele obligatorii pentru a putea asigura în mod continuu sursa majoră de hrană pentru om si animale.

Pentru controlul şi dirijarea acestor procese complexe se impune studierea lor nedisociată, fiind necesare cunoştinţe temeinice in ce priveşte, proprietăţile fizico-mecanice ale seminţelor, cunoaşterea proceselor fiziologice şi a activităţii microorganismelor din masa de seminţe şi nu în ultimul rând a regimurilor cinematice ale maşinilor şi utilajelor, pentru a menţine integritatea boabelor după prelucrare.

După cum se ştie,produsul final obţinut în urma recoltării este un amestec format din boabele culturii principale, seminţe de buruieni şi diferite impurităţi de natură minerală sau organică (praf,paie,pleavă). In afară de acestea,insăşi seminţele culturii de bază au dimensiuni şi greutăţi diferite, unele fiind şiştave, vătămate sau sparte.

La recoltare, boabele nu sunt complet maturizate fiziologic, seminţele sparte, şiştave şi seminţele de buruieni au o umiditate mai ridicată decât restul componentelor, respiratie marită de (3-5ori) fata de cele normale iar efectul este cresterea temperaturii, care in prezenta umidităţii, vor favoriza dezvoltarea unor procese in masa de seminte ca: incingerea, incoltirea etc Microorganismele pătrund în interiorul seminţei microfisurate, distrug sistemul enzimatic, având drept urmare degradarea seminţei, provocând germeni anormali şi facultate germinativă redusă. [1]. În acest sens prin condiţionare se întelege, aducerea produsului recoltat la o anumita stare de umiditate, de temperatură, puritate, etc. care să-i asigure păstrarea în timp a însuşirilor iniţiale, forma şi integritatea boabelor, îndeplinind în acelaşi timp o serie de cerinţe agrotehnice.

Calitatea seminţei este definită de însuşirile ei biologice valoarea culturală asigurată prin condiţionare şi păstrare

characters and its cultural value guaranteed by preservation, storage and conditioning in proper conditions.

MATERIAL AND METHOD

The technological process of conditioning might be simple or complex according to: destination of seeds, requirements, various machinery used. The most common equipment must cover purification and assortment of seeds by their aerodynamic properties, size, specific form and weight.

Fig. 1 presents a scheme of processing seeds for sowing.

ı condiţii optime.

MATERIAL ŞI METODĂ

Fluxul tehnologic de condiţionare poate fi mai simplu sau mai complex în funcţie de multitudinea de condiţii: destinaţia seminţei, cerinţe, gama foarte variată de maşini şi organe de lucru, dar nu poate fi conceput fără un minim de utilaje care să asigure curăţirea şi sortarea după proprietăţile lor aerodinamice, după principiul dimensional şi după cel al diferenţei ca formă si greutate specifică.

În **Fig. 1** se prezintă o schemă a tehnologiei de prelucrare a seminţelor în vederea semănatului.

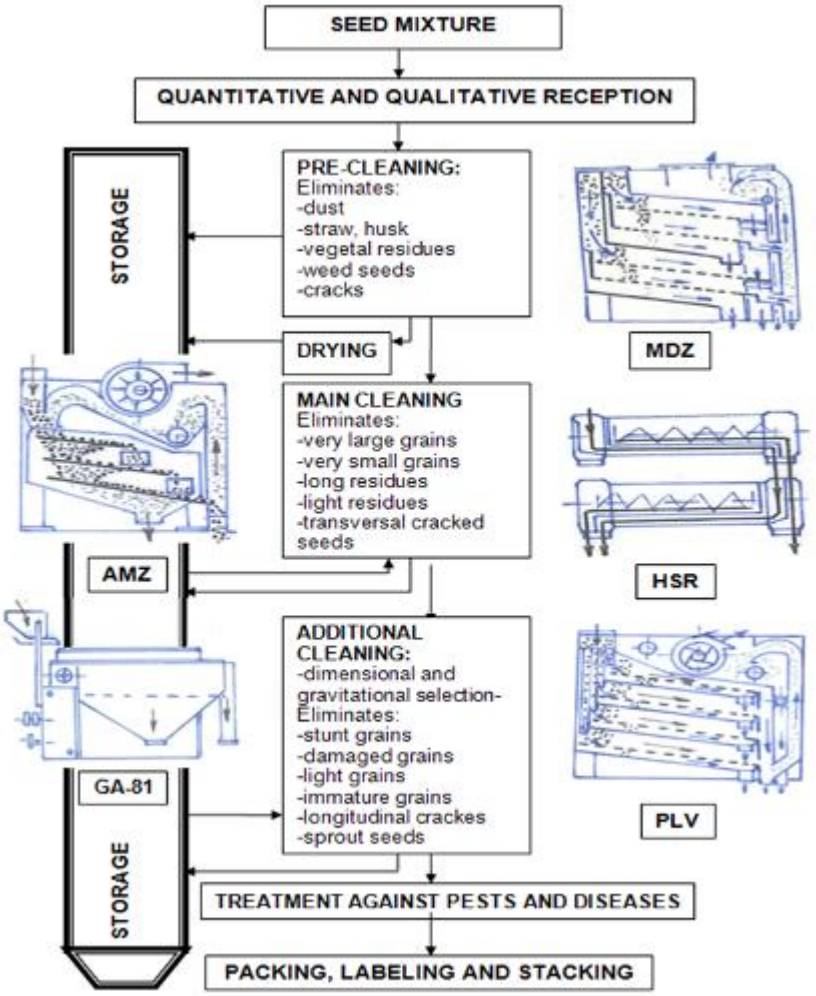

Fig.1 - Conditioning technology for crop seeds (SCDA **Turda)**

The high dependence of crops on the pedoclimatic conditions and the necessity to achieve increasing productions, in order to guarantee the food security require seeds with high genetic and production value. The high production value is represented by seeds with a certain purity, good germination capacity and phytosanitary condition imposed by certain standards (Law 266/2002).

Due to the varied physico-mechanical characteristics of the seeds derived from different species, the processing machineries are very diversified. The working process is developed stationary, but the cinematic regime

Dependenţa foarte ridicată a plantelor de cultură faţă de condiţiile de sol şi mediu şi nevoia de a realiza producţii ridicate, pentru a asigura securitatea alimentară, a impus necesitatea folosirii la însămânţare a unui material biologic cu o valoare genetică şi culturală ridicată. Valoare culturală înaltă înseamnă în primul rând o sămânţă cu puritate fizică, germinaţie, componentă botanică, stare fitosanitară conform standardelor în vigoare.(Legii seminţei 266/2002).

Ca urmare a caracteristicilor fizico-mecanice ale seminţelor provenite din diferite specii, se remarcă o diversitate constructivă a maşinilor pentru prelucrarea seminţei .Procesul de lucru al acestor maşini se

of certain machine parts is one of the main factors that mark the quality of the biologic matter.

The working parts of the equipment must operate smoothly to maintain the shape and integrity of grains thereby to reduce the infestation with pests and diseases. The processing flux of seeds is very complex, with a well defined sequence of purifying phases as pre-cleaning, basic cleaning, dimensional and gravitational selection, treatment against pests and diseases,packing, all created to avoid impurification of the seeding material [2].

The percentage of each category *Xi*: pure seed impurities etc are computed with the formula:

desfăşoară la staţionar, dar alegerea regimurilor cinematice la diferite organe de lucru, este unul dintre principalii factori care concură la asigurarea unui material biologic de calitate.

Organele de lucru ale maşinilor, trebuie să nu fie agresive, prin acţiunea lor să menţină forma şi integritatea seminţelor pentru a nu-i reduce rezistenţa la boli şi dăunători şi să scadă vigoarea seminţelor

Procesul de prelucrare a seminţei, componentă esenţială a tehnonogiei de cultură, este complex, seminţele trebuie să urmeze un flux tehnologic în care diversele operaţiuni: precurăţire, curăţire de bază, sortarea dimensională şi gravitaţională, tratarea, ambalarea au o succesiune bine stabilită, cu trasee sigure, pentru a evita posibilitatea de impurificare [2].

Conţinutul procentual *Xi* al fiecărei categorii: sămânţă pură, impurităţi etc. se calculează cu formula

$$x_i = \frac{m_i \cdot 100}{\sum m_i} K[\%] \qquad (1)$$

Where m_i is seed mass of *„i"* category of impurities, in g

$\sum m_i$ - sum of all components on the analyzed, in g

K - correction coefficient (if is necessary)

The technologic effect is represented by the impurity percentage eliminated from the grain quantity passed through the selector, determined by the relation:

unde: m_i - masa categoriei **„i"** de impurităţi, în g

$\sum m_i$–suma tuturor componentelor din proba de analizat, în g

K - coeficientul de corecţie (dacă este cazul)

Efectul tehnologic reprezintă procentul de impurităţi,corpuri străine etc. eliminate din masa de seminţe la o trecerea a produsului prin selector, se determină cu relaţia:

$$\eta_t = \frac{\left[Q_{ii} - Q_{ie} \right] \times 100}{Q_{ii}} \qquad (2)$$

where: Q_{ii} is total input impurity quantity, in %

Q_{ie} – total output impurity quantity, in %

Working capacity and specific consumption

Specific grain quantity is determined as**:**

unde: - Q_{ii}- conţinutul de impurităţi totale la intrare în maşină, în %

-Q_{ie} – conţinutul de impurităţi la evacuare din utilaj , în %

Capacitatea de lucru şi consumul specific

Cantitatea de material condiţionat se determină în general, cu relaţia

$$Q = \frac{M}{t} [kg / h] \qquad \textbf{(3)}$$

where*: M* - seed-mass of the material passed through the selector in *"t"* time

The energy consumed for processing is expressed by the formula:

în care M- masa materialului trecut prin selector în timpul t.

Energia consumată pentru prelucrare se calculează cu formula

$$E = \frac{W}{q \cdot \eta} [kWh/ kg], [\%] \qquad (3)$$

W- is energy consumption at a certain electric,(with an autput, *η*)

High separation speed leads to increased working capacity but decreases the efficiency of the process.

For increasing seed quality and reducing energy consumption by using combined equipments it is necessary to carry out more elaborated theoretical and experimental studies concerning the selection process. Our researches were organized at SCDA-Turda, in a specialized processing center, where by means of the existent technical equipment there have been developed new combined systems for separation of the impurities from seeds.

To optimize the proposed objectives there has been

unde: **W**- energia consumată de maşină la un randament electric, *η*

Viteza mare de separare duce la creşterea capacităţii de lucru dar determină scăderea randamentului de separare.

Pentru creşterea calităţii condiţionării produselor destinate însămânţării şi reducerea consumului de energie, prin folosirea combinată de echipamente tehnice, apare ca necesară şi oportună aprofundarea cercetărilor teoretice şi experimentale asupra proceselor combinate de selectare a seminţelor.

Realizarea cercetărilor teoretice si experimentale s-au efectuat în centrul specializat de prelucrare a seminţelor al SCDA - Turda unde prin dotarea tehnică existentă s-au putut elabora sisteme combinate de separare a

quantified the technologic effect of each machinery as well as the cumulative one, in order to choose the variant that provides high purity grains with proper parameters and agro-technical requirements at a minimum specific energy consumption.

The main objective of our researches was the influence of the processing systems on seed quality indices: germination, purity, phytosanitary condition, physical properties of seeds resulted from a wheat field. There has been studied a wheat plot of Arieşan variety obtained in the conditions of the year 2015..

The characteristics of the wheat crop after pre-cleaning (it is forbidden to store without pre-cleaning) are presented in the following table (Table 1).

impurităţilor din seminţe.

Pentru optimizare,în sensul creşterii calităţii şi scăderii costului energetic s-a cuantificat efectul tehnologic al fiecărui utilaj precum şi cel cumulativ, în vederea alegerii variantei care asigură sămânţa finală la parametrii şi cerinţele agrotehnice cerute, la un consum specific de energie minim.

În cazul de faţă obiectul principal al cercetării este influenţa sistemelor de condiţionare asupra indicilor de calitate: germinaţie, puritate fizică, stare fito-sanitară, însuşiri fizice ale seminţei rezultate dintr-un lot de grâu. A fost luat în studiu un lot de grâu din soiul ARIEŞAN, produs în condiţiile anului 2015.

Caracteristicile de stare ale lotului de grâu după precurăţire sunt date în tabelul de mai jos (Tabelul 1).

Table 1

Analysis sheet of the crop

Sample no.	Humidity [%]	Hectolitric weight [kg]	Classification of components				
			-small cracks -main cult.scraps, minerals [%]	-large scraps -pinched [%]	shriveled grains [%]	small grains [%]	medium and large grains [%]
1	13.5	80.2	2.60	0.7	7.8	1.9	87.00
2	13.1	78.0	4.10	1.1	9.7	2.4	82.70
3	12.8	78.5	3.4	0.9	8.6	2.3	84.80
Mean			**3.37**	**0.90**	**8.70**	**2.2**	**84.83**

The sowing **(550 bg/m²)** was performed at the beginning of October 2014 after a precursory leguminous crop (soybean) with concomitant administration of 300 kg/ha chemical fertilizer (20:20:0). The soil humidity provided a good sprouting and tillering meeting the winter period with 2-3 leaves. An additional nitrogen fertilization was applied in March with 150 kg/ha and in mid-April with another 150 kg/ha.

It is well known that in Transylvania the climatic conditions are highly unforeseeable, in this respect May was excessively rainy favoring a good valorification of the nitrogen fertilizer. The heavy storms „laid down" most of the crop. At the end of May and beginning of June the atmospheric drought is installed exactly in the period of grain filling and maturation, producing a large number of shriveled grains in the harvested crop.

Experimental design

A monofactorial experimental design was carried out with six conditioning variants**(V_1, V_2, V_3, V_4, V_5, V_6)**

V_1 -conditioning with: **AMZ** (bolter device) and **HSR** (double selector); V_4- conditioning with: **AMZ, PLV** and **GA-81 (**gravitator)

V_2- conditioning with: **AMZ** and **PLV** (bolter device)

V_3-conditioning with: **AMZ, PLV** and **HSR**

V_4- conditioning with: **AMZ, PLV** and **GA-81 (**gravitator)

V_5- conditioning with: **AMZ, HSR** and **GA-81**

V_6- conditioning with: **AMZ, PLV,HSR** and **GA-81**

The influence of these conditioning systems on seed quality was studied, quantifying the shriveled grains remained in the output, the percentage of small grains and large cracks – components considered as being accepted as part of the pure seeds in conformity with **SR7713/1999** standards. The level of these components was determined in samples taken from the technologic

Semănatul (550 bg/m²) s-a efectuat la începutul lunii octombrie 2014 având premergătoare leguminoasă (soia), administrându-se deodată şi îngrăşământ complex in cantitate: 300kg/ha, (20.20.0) . Umiditatea din sol a asigurat o bună răsărire şi înfrăţire intrând în iarnă în stadiul de 2-3 frunze. Fertilizarea fazială cu azot în primăvară s-a efectuat în luna martie (150 kg/ha). şi mijlocul lunii aprilie (150 kg/ha).

Se ştie că în Transilvania condiţiile climatice sunt caracterizate printr-o imprevizibilitate mare, astfel luna mai a fost excesiv de ploioasă, favorizând valorificarea foarte bine a îngrăşămintelor cu azot. Furtunile repetate a „culcat" în mare parte cultura. La sfârşitul lunii mai şi începutul lunii iunie se instalează seceta atmosferică perioada, ce coincide, cu fenofaza umplerii bobului şi atingerea fazei de coacere. Aceste deziderate explică prezenţa procentului mare de boabe şiştave în masa produsului recoltat.

Metodica experimentală

Pentru efectuarea cercetărilor s-a implementat o experienţă monofactorială cu şase variante **(V1,V2,V3,V4,V5,V6)** de condiţionare:

Pentru efectuarea cercetărilor s-a implementat o experienţă monofactorială cu şase variante **(V1,V2,V3,V4,V5,V6)** de condiţionare:

V_1 -condiţionare cu: **AMZ**(masina cu site) şi **HSR**(trior dublu)

V_4 --condiţionare cu:**AMZ, PLV şi GA-81(**gravitator

V_2 -condiţionare cu: **AMZşi PLV**(masina cu site)

V_5 condiţionare cu:**AMZ, HSR şi GA-81**

V_3 **--**condiţionare cu: **AMZ, PLV şi HSR**

V_6 -condiţionare cu:**AMZ, PLV,HSR şi GA-81**

S-a urmărit influenţa acestor sisteme de condiţionare asupra calităţii seminţei rezultate, cuantificându-se în primul rând procentul de **boabe şiştave** rămase în sămânţa finală, procentul de **boabe mici,** si procentul de **spartura mare**, componente considerate ca facind parte din saminta pura conform

flux in four replications. The mean value of shriveled grains, small grains in the four replications and the output purity are presented in table 2.

Cinematic parameters of the devices and filling debit were adjusted to guarantee the purity level of seeds according to the present standards.

RESULTS AND DISCUSSION

. Results concerning the influence of conditioning systems on shriveled grain level

standard **SR7713 /1999.** Aceste componente au fost determinate din probele ridicate pe flux în patru repetiţii. Valorea medie a repetitiilor a acestor componente precum şi a puritatii pe variante sunt redate în tabelul 2.

Parametrii cinematici ai maşinilor, debitul de alimentare, au fost reglaţi astfel încât să se asigure puritatea necesară seminţei conform STAS-ului în vigoare după care s-au ridicat probele experimentale.

REZULTATE ŞI DISCUŢII

Rezultatele cercetării privind influenţa sistemului de condiţionare asupra procentului de boabe şiştave.

Table 2

Results concerning the influence of the conditioning system on the shriveled

No of variant	Conditioning variant	Shriveled grains [%]	Difference	Significance	Purity [%]	Small grains [%]
1.	**AMZ+HSR**	6.20	-	Control	99,15	1.40
2.	**AMZ+PLV**	4.70	-1.50	o	98.90	0.90
3.	**AMZ+PLV+HSR**	4.10	-2.10	oo	99.50	0.30
4.	**AMZ+PLV+GA-81**	0.70	-5.50	ooo	99.76	0.60
5.	**AMZ+HSR+GA-81**	1.10	-5.10	ooo	99.62	0.70
6.	**AMZ+PLV+HSR+GA-81**	0.30	-5.90	ooo	99.87	0.30

DL 5% 1.33 Effect level Association degree

DL 1% 1.83 f = 2.1 ω^2=0.85

DL 0.1% 2.49

The conditioning system influences definitely the quality indices of seeds.

The classic combination formed by **selecting device + trior** (**AMZ+HSR)** has been considered as control, as far as it is widely used by farmers. The only difference vs. the most common conditioning system is represented by two trior batteries disposed in cascade not parallel. There can be noticed that the influence of this conditioning variant on the percentage of shriveled and small grains is lower than all the other studied variants.

High purity obtained by this variant is due to the efficiency of the trior in eliminating the transversal cracks. The combination **AMZ+PLV** is more efficient in eliminating the shriveled and small grains by the combined action of air pressure and dimensional selection made by **PLV**. The V_1 and V_2 variants accomplish the proper purities for certified categories but they reach the lowest level of basic and pre-basic categories **(Law 266/2002)**.

Once **GA-81** device (gravitator) is connected, a considerable improvement of all quality indices can be observed with a remarkably low effect on soundly small grains. Comparing variants V_4 and V_5 it is obvious that the technologic effect of the gravitator depends on the cumulative effect of the upstream devices.

Extrapolating the indices accomplished by the control variant (V_1 – classic) to a quantity of 1000 T_0 output material of a lot, in conformity with the Analysis sheet of crop (table 1), there could be commercialized for seeding 62.000 kg shriveled seeds and 14.000 kg small grains existent in the output material. With the same reasoning, in the combined conditioning variant (V_6) the quantity of these components is significantly reduced: 3.000 kg shriveled and 3.000 kg small grains.

Each component of the output material was analyzed concerning their performance (table 3).

Sistemul de condiţionare influenţeaza indiscutabil indicii de calitate finali ai seminţei.

S-a luat ca martor varianta clasică:**maşina de selectat + trior**,(**AMZ+HSR**) practicată în general de producătorii agricoli cu excepţia faptului că aici avem 2 baterii de trior, dispuse în cascadă şi nu în paralel.Se poate observa că acţiunea acestei variante de condiţionare asupra procentului de boabe şiştave şi boabe mici este mai redusă decât în oricare variantă.

Puritatea mai ridicată in aceasta varianta se datorează eficacităţii acţiunii triorului în eliminarea spărturilor transversale ale seminţei. Combinaţia **AMZ+PLV** este mult mai eficace în eliminarea boabelor şiştave şi a boabelor mici, prin acţiunea combinată a aerului şi sortarea dimensională făcută de **PLV.** Variantele de conditionare V1 şi V2 realizează puritităţile necesare în ce priveşte categoriile de sămânţă certificată dar sunt la limita inferioară a realizării, în cazul categoriilor bază şi prebază, conform **Legii seminţei(266/2002).** Odată cu introducerea în lucru a maşinii **GA-81** (gravitatorul) se poate observa îmbunătăţirea considerabilă a tuturor indicilor de calitate,remarcând efectul mai redus asupra boabelor mici şi sănătoase. Comparind variantele de conditionare,V4 şi V5 reiese clar faptul, ca efectul tehnologic al gravitatorului depinde de efectul cumulativ a celor din amonte.

Extrapolând indicii realizati de **varianta martor, (V_1)** (clasica) la o cantitate de **1000** T_0 sămânţa finala, rezultata dintr-o partidă cu o fişă de analiză conform tabelului 2, s-ar comercializa spre insamintare, cantitatea de 62.000kg boabe şiştave şi 14.000 kg boabe mici aflate in produsul final. Urmind acelasi rationament si pentru varianta de conditionare combinata**(V_6)**cantitatile acestor componente sunt foarte reduse: 3.000 kg boabe şiştave şi 3.000 kg boabe mici.

Din probele finale, s-au analizat fiecare componenta in parte, în ce priveşte performanţa lor (tabelul3).

Rezultate privind analiza de germinaţie a

Results concerning the germinative capacity of the shriveled, small grains and large cracks

The analyzed components present in different percentage in the final product, as a result of the different conditioning systems applied, that matched the standard category of pure seeds, influence negatively the obtaining of a high quality seed that guarantees a good and sound crop.

The cracked and shriveled grains present low resistance to diseases and pests, especially toxic fungus and their presence in the output material reduces its quality, increasing the sowing rate (germinative seeds/m^2), finally spreading the diseases to healthy grains.

Small grains might be affected by the technological process. Usually in soils with great humidity, small grains germinate earlier than the normal ones, due to the sawing depth fixed for the large grains, these small ones bring disadvantaged. Small seeds produce weak plants, most of them perishing during the vegetation period or presenting a low yielding capacity. After a few years storage period their germination capacity is much reduced as compared to the larger grains.

componentelor de natura boabe şiştave,boabe mici, spărturi mari.

Componentele analizate prezente în diferite procente în produsul final, ca urmare a sistemului de condiţionare aplicat, încadrabile de altfel în STAS-ul seminţei pure, contribuie negative la obţinerea unei seminţe de calitate, garanţia unor recolte mari şi sănătoase.

Boabele sparte, şiştave au o rezistenţă redusă la boli şi dăunători, în special la ciuperci toxigene, iar prezenţa lor în sămânţa finală, contribuie la reducerea calităţii seminţei, creşterea normei de semănat **[boabe germinative/ m²]**şi în final contribuie la răspândirea bolilor prin amestec cu seminţele sănătoase ce urmeaza a fi introduse în pământ.

Pentru boabele mai mici există un risc mai mare de a fi afectate de procesul tehnologic.În general, seminţele mici germinează mai repede decât cele mari, în solurile umede datorită adâncimii de semănat reglată pentru cele de măsură normală, seminţele mici sunt dezavantajate.

Seminţele mici dau plante slabe, din care foarte multe pier pe parcurs, iar plantele respective au un potenţial de producţie scăzut.

În păstrare, după câţiva anis-a dovedit că au o germinaţie mai slabă decât cele normale

Table 3

Quality indices of the components

Grain types	Quality indices		
	Germination	**Abnormal germs**	**Dead seeds**
Shriveled wheat grains	Mean value	Mean value	Mean value
	49%	**33%**	**18%**
Large grain cracks	Mean value	Mean value	Mean value
	7%	**8%**	**85%**
Small wheat grains	Mean value	Mean value	Mean value
	86%	**9%**	**5%**

Results concerning the influence of the conditioning system on germination

The homogeneity, normality and additivity of variants $(S_1^2, S_2^2, S_3^2, S_4^2, S_5^2, S_6^2)$ being accomplished, the „t" test may be applied without any correction therefore this will be taken in consideration in determining the limit differences and multiple comparisons.

Rezultatele cercetării privind influenţa sistemului de condiţionare asupra germinaţiei

Îndeplinindu-se condiţiile de omogenitate, normalitate şi aditivitate a variantelor $(S_1^2, S_2^2, S_3^2, S_4^2, S_5^2, S_6^2)$, testul „t" se poate aplica direct fără corecţie,datele nu trebuiesc transformate, prin faptul că efectul repetiţiilor este nesemnificativ, demonstrându-se combinarea aditivă cu variantele.

Table 4

Results concerning the influence of conditioning systems on germination

Variantă	Conditioning variants	Mean of germination [%]	Confidence interval of means $\bar{G}_m \pm t_{5\%} S_{\bar{G}}$	Coefficient of variability C_v [%]	Difference	Significance
1.	**AMZ+HSR**	**88.25**	**84.7- 91.8**	**2.51**	**-**	**Control**
2.	**AMZ+PLV**	**90.50**	**87.7- 93.3**	**1.91**	**+ 2.25**	**-**
3.	**AMZ+PLV+HSR**	**91.00**	**88.1- 93.9**	**2.01**	**+ 2.75**	*****
4.	**AMZ+PLV+GA-81**	**96.00**	**93.7- 98.3**	**1.47**	**+ 7.75**	*******
5.	**AMZ+HSR+GA-81**	**94.25**	**93.6- 96.6**	**1.60**	**+ 6.00**	*******
6.	**AMZ+PLV+HSR+GA-81**	**97.00**	**95.2- 98.8**	**1.20**	**+ 8.75**	*******

DL 5%	**2.48**	Power of the test	Effect level	Association degree
DL 1%	3.41	**β =0.64**	**f = 1.8**	ω^2**=0.76**
DL 0.1%	4.64			

The results indicate a high value of the effect level (**f**) as well as of the association degree. The mean value of the statistic test is generally **0.46,** in our case being **0.64** (due to the low rate of observations in the different variants and lesser to the errors in observations) the test was capable to detect the effects

Differences between means in a number of $C_n^m = \frac{n(n-m+1)}{1 \cdot 2 \cdot m!} = 15$, is compared with the smallest significance ranks **(cmmrs).** The smallest significance ranks are computed as multiplication of the error of means with the value of the correspondent ranks of different distances between variants (***Isaic and Voda,2006***).

Rezultatele indică o valoare mare a mărimii efectului (f) precum şi a gradului de asociere.Valoarea medie a puterii statistice este in general de 0.46, in cazul de fata avem o valoarea de 0.64, (datorita volumului redus de observatii pe variante si mai putin erorilor de masurare) testul a fost capabil sa detecteze efectele.

Diferenţele dintre medii, în număr de $C_n^m = \frac{n(n-m+1)}{1 \cdot 2 \cdot m!} = 15$, se compară cu cele mai mici ranguri semnificative**(cmmrs)**. Cmmrs se calculează, înmulţind eroarea mediei cu valorile rangurilor corespunzătoare diferitelor depărtări dintre variante.(*Isaic si Voda,2006*)

Table 5

Comparison of means with the smallest significance ranks

No. of variants	Differences between means	Confidence interval of differences between means $\mu_{dif} = m_{dif} \pm t_c\, S_{dif}$	cmmrs	Significance of differences
6 - 1	97 - 88.25=8.75	5.68 ÷ 11.8	2.78	Significant
6 - 2	97 - 90.5=6.5	3.96 ÷ 9.04	2.74	Significant
6 - 3	97 - 91=6	3.36 ÷ 8.64	2.69	Significant
6 - 4	97 - 96=1	-1.23 ÷ 2.23	2.49	***Insignificant***
6 - 5	97 - 94.25=2.75	0.45 ÷ 5.05	2.62	Significant
5 - 1	94.25 – 88.75=6	2.72 ÷ 9.28	2.69	Significant
5 - 2	94.25 – 90.5=3.75	0.96 ÷ 6.54	2.62	Significant
5 - 3	94.25 - 91=3.25	0.36 ÷ 6.14	2.49	Significant
4 - 5	96- 94.25 = 1.75	-4.27 ÷ 0.77	2.49	***Insignificant***
4 - 1	96 – 88.25=7.75	4.53 ÷ 10.9	2.74	Significant
4 - 2	96 – 90.5=6.5	3.77 ÷ 9.23	2.69	Significant
4 - 3	96 - 91=5	2.18 ÷ 7.82	2.62	Significant
3 - 1	91 – 88.25=2.75	-0.76 ÷ 6.26	2.62	Significant
3 - 2	91 – 90.5=1.5	-1.32 ÷ 4.32	2.49	***Insignificant***
2 - 1	90.5 – 88.25=2.25	-1.19 ÷ 5.69	2.49	***Insignificant***

Considering the germination capacity, in all variants there have been obtained an output material fit in the standards of seed law (minimum 85%). Even if in variant V_2 (AMZ+PLV) there is obtained a lower purity (98.90%) vs. control variant V_1 (AMZ+HSR) the output seed germination is better due to the fact that in V_2 seed are more sound, the ratio of shriveled, small grains and of longitudinal cracks is lower. In variants V_1, V_2, V_3 due to a large amount of the components, there is a great variability of germination in the studied replications.

There can be observed that as the shriveled grains and other impurities are eliminated from the output material by applying advanced conditioning systems, the germination capacity increases significantly, even more than 8%, which is a very appreciate gain not only in the output material but also in the necessary seed quantity per hectare which reduces seeding costs.

Analyzing the germination capacity of the variants there have been recorded significant differences between coleoptile length (5-42 mm), height of seedlings as well as in the root system (0-5 roots). This considerable differences are obvious in the variants in which shriveled and small grain rate is high.

Din punct de vedere al valorii germinaţiei în toate variantele se realizează germinaţie,încadrabila în Normele legii seminţei (minim 85%).Chiar dacă in varianta:AMZ+PLV,(V_2) se realizeaza o puritate mai slaba (98.90%) fata de varianta martor (clasica) AMZ+HSR, (V_1) germinatia finala este mai mare si acesta datorita faptului ca in varinta (V_2)saminta finala este mai sanatoasa, procentul de boabe sistave, boabe mici si spaturãlongitudinala este mult redus. In variantele:V_1,V_2,V_3datoritã prezentei intr-un procent mai mare a componentelor de mai sus, se iregistrează o mai mare variabilitate a germinatiei pe repetitii. Se poate observa că pe măsura eliminării din proba finală a boabelor şiştave şi a creşterii purităţii, ca urmare a sistemelor de condiţionare, facultatea germinativă creşte considerabil, realizându-se diferenţe de peste 8%, ceea ce înseamnă foarte mult, nu numai în calitatea finală aseminţei ci şi în cantitate de sămânţă necesara pe hectar şi în final în costurile culturii înfiinţate.

Analizind probele de germinatie pe variante, la momentul desfintarii, prin masurare,s-a constatat diferente mari intre lungimea coleoptilului de la 5mm (s-au lipsa) pina la 42 mm, precum si intre lungimea plantulelor. Sistem radicular variat, de la lipsa radacinii, pinã la un numar de 4-5 radacini. Acest lucru este foarte

CONCLUSIONS

The results of our research work interpreted by well known statistical tests emphasized certain technical aspects of the conditioning systems with a significant influence on all the quality indices of the seeding material. For obtaining vigorous plants with uniform sprouting there must be produced and commercialized very high quality seeds. The embryo of medium and large grains is well developed producing plants with high yielding capacity **(**Bucurescu et al,1992**).**

Therefore conditioning and dimensional selection of seeds is an essential link in crop technology.

Applying an additional cleaning, results in an output material with superior indices that meets the present standards. Shriveled, damaged, dehusked and small grains existent in the output material, though considered as pure enough for the base category, still deteriorate it significantly. Yielding capacity of these seeds, especially of the shriveled ones, is very low, therefore these grains should be avoided when seeding.

Our experiments concerning the influence of different conditioning systems on the rate of shriveled seeds remained in the output material and the germinative capacity showed a „break" in the cumulative effect of the machinery once the GA-81 gravitator device has been connected.

The most important role in obtaining a standard output is assigned to the **PLV** device and the **GA-81** gravitator even though their cumulative action is recommended, these two devices eliminating the most part of the shriveled, diseased and small grains.

The significant differences observed between the studied conditioning variants concerning shriveled grain ratio remained in the output material (almost 6% in the case of V_1 - V_6 variants), as well as differences concerning germination capacity (over 8%) needs a very serious analysis when seeding material is commercialized. For obtaining a standard seeding material the seed conditioning process must take place in specialized centers with high performance machinery and well trained personnel.

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evident, în variantele în care procentul de boabe mici si sistave este mare.

CONCLUZII

Valorificarea rezultatelor obţinute în urma experimentului efectuat, cu tehnicile statistice cunoscute au surprins o serie de aspecte tehnice ale sistemelor de condiţionare cu influenţe deosebite asupra tuturor indicilor de calitate, ce definesc valoarea culturală a unui material biologic ce urmează a fi însămânţat. Actualmente se vorbeşte de dinamica seminţelor, de uniformitate de germinaţie, de viteza de creştere a tinerei plante, garanţii potenţiale realizării de plante riguroase, uniform răsărite capabile să asigure recolte mari.

De aceea,condiţionarea şi sortarea dimensională este o verigă(componentă) esenţialã întehnologia culturii.In comparaţie cu seminţele mici, seminţele mijlocii si mari au un embrion mai bine dezvoltat,dau plantule cu vitezã de crestere sporitã si prin aceasta o dezvoltare rapidã a aparatului vegetativ..(Bucurescu et al,1992)

Prin curăţire suplimentară se obţine o sămânţă cu indici superiori celor obţinuţi încadrabil de altfel în STAS-ul seminţei.Seminţele şiştave, deteriorate,descojite, mici rămase în proba finală, deşi sunt considerate pure, ca facind parte din categoria seminţei de bază, au totuşi defecte, experimentul de fatã a demonstrat performantele slabe a acestor componente. Potentialul de productie al acestor seminte in special al celor sistave este foarte scazut, cea ce le face necorespunzătoare insămîntarii. Cercetările practice au demostrat relatia directa care exista intre nivelul productiilor obţinute si mărimea seminţelor,uniformitatea si starea de sănatate a acestora.

Din datele rezultate, privind influienta sistemelor de conditionare asupra procentului de boabe sistave ramase in proba finala, facultatea germinativã, se constata o „rupere" a efectului cumulativ al utilajelor odatã cu intrarea in lucru a gravitatorului(GA-81),cea ce inseamna un efect singular mare al acestei masini.

Rolul important în fineţea pregătirii seminţei îl are maşina **PLV** şi gravitatorul **GA-81**, chiar dacă se poate observa efectul cumulativ al fiecărui utilaj. Aceste două utilaje îşi aduc cel mai mare aport în eliminarea boabelor şiştave, bolnave şi mici. Sămânţa finală, cu endosperm bine dezvoltat, boabe pline şi sănătoase va determina valoarea culturală a lotului ce urmează a fi analizat.

Diferenţele semnificative ce se înregistrează între variantele de condiţionare în ce priveşte procentul de boabe şiştave rămase în produsul final,aproape 6%(în cazul variantelor:V_1-V_6) precum şi diferenţe în ce priveşte germinaţia, de peste 8%,deziderate ce contribuie la reducerea calităţii seminţei, creşterea normei de semănat, răspândirea bolilor odată cu semănatul, obligă ca pregătirea seminţei, să se facă în centre specializate, ce au o dotare tehnică corespunzătoare si personal specializat.

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THEORETIC CONSIDERATION REGARDING THE PNEUMATIC TRANSPORT SYSTEM DESIGN MEANT FOR SMALL AND VERY SMALL SEEDS ALVEOLAR PNEUMATIC SOWING EQUIPMENT
/
CONSIDERAȚII TEORETICE PRIVIND PROIECTAREA INSTALAȚIEI PNEUMATICE DE TRANSPORT UTILIZATĂ DE UN ECHIPAMENT PNEUMATIC DE SEMANAT ALVEOLAR A SEMINTELOR MICI SI FOARTE MICI

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Abstract: *In this paper is treated the pneumatic transport phenomenon, from the theoretic point of view, of vegetable seeds ,namely small and very small seeds, which are handled by dedicated sowing equipment in order to be seeds in plug trays and nourishing layer. The working principles of those equipments combine two important sub domains of the pneumatic actuation systems, the low pressure field (pressures up to 10 bar) and the vacuum field, and for each line in part must be used specific equipments that must meet the designer technical requirements. Therefore, it is required that in the design/optimization process to take into account the seeds morphological properties that have a direct impact on transport and positioning process. Thus, the factors that influence the technological process shall be treated in this paper from a theoretical perspective.*

Keywords: *seeding equipment, pneumatic system, pneumatic transport, small seeds and plug tray.*

Rezumat: *În acest articol se tratează fenomenul de transportul pneumatic, din punct de vedere teoretic, al materialului semincer legumicol cu dimensiuni reduse, respectiv semințe mici şi foarte mici, ce este manipulat de echipamentele de semănat speciale pentru a fi plantat în suport alveolar şi start nutritiv. Principiile de funcționare ale acestor echipamente combină două subdomenii importante din cadrul acționărilor pneumatice, domeniul presiunilor mici - de până la 10 bar şi cel al vacuumului, iar pentru fiecare ramură în parte se utilizează echipamente specifice ce trebuie să răspundă cerințelor tehnice ale proiectantului. Din aceste considerente este necesar ca în procesul de proiectare/optimizare să se țină cont de proprietățile morfologice ale semințelor ce au impact direct asupra procesului de transport şi poziționare. Astfel, factorii care influențează procesul tehnologic sunt tratați în această lucrare din punct de vedere teoretic.*

Cuvinte cheie: *echipament de semănat, instalație pneumatică, transport pneumatic, semințe mici, tavă alveolară.*

INTRODUCTION

The technologic process of pneumatic transportation of granulated and seeding material is used in agriculture (sowing, harvesting, conditioning and storage) in cereal and seed pre-processing and post post-processing. Those technologies uses air flow in order to maintain the integrity of harvested materials, to cause damage to grain or seed harvested, to make a separation of the impurities and insects, and also to realise an accurate dosage in bags or other transport containers. [2, 5, 7, 9, 12]

Also, on this principle works the most performant pneumatic seeders, as field seeders, greenhouses sowing equipments and now, more recently in alveolar structures. [3, 4, 8, 11]

Taking in to consideration the fact that the most important crops with the greatest impact is the vegetable crop, and due to the fact that the climate change has a great impact on it, the demand of seedlings was increased. In order to meet this requirement, were developed and manufactured seeds superior capitalization technologies, for all categories of farmers and growers, so they can adapt to the environmental conditions. [3, 4, 8]

In vegetable and flower growing is prevailing seeds with small and very small dimensions (Table.1), with regulate or less regular geometric shapes (Fig. 2) and for this reasons the most seedlings producers used manual sowing method on a fairly large area. But due to competition for resources, in particular nutrients, only a

INTRODUCERE

Procesul tehnologic de transportul pneumatic al materialului semincer sau granulat, este utilizat cu precădere în agricultură (semănare, recoltare, transport, condiționare şi depozitare), în tehnologiile de preprocesare şi postprocesare cereale şi semințe. Aceste tehnologii utilizează curenții de aer pentru a păstra integritatea materialelor recoltate, pentru a nu deteriora bobul sau sămânța recoltată, pentru a realiza o separarea impurităților şi a insectelor, precum şi o dozare precisă în saci sau alte recipiente de transport. [2, 5, 7, 9, 12]

Tot pe acest principiu funcționează şi cele mai performante semănători pneumatice, fie ele în câmp fie ele în solarii, şi acum mai nou în structuri alveolare. [3, 4, 8, 11]

Datorită faptului că, una dintre cele mai importante culturi este cea legumicolă, şi datorită faptului că schimbările climaterice au un impact ridicat asupra acestor culturi, s-a mărit cererea de răsaduri. Pentru a satisface această necesitate s-au realizat tehnologii de valorificare superioară a materialului semincer pentru toate categoriile de fermieri şi cultivatorii, pentru a se putea adapta la condițiile de mediu. [3, 4, 8]

În legumicultură şi floricultură, predomină semințele cu dimensiuni mici şi chiar foarte mici (Tabelul 1), cu forme geometrice regulate sau mai puțin regulate, (Fig. 2) şi din aceste cauze majoritatea producătorilor de răsaduri utilizau metode de semănat manuale pentru

small number of seeds where able to germinate and develop properly and then to be transplanted in pots.

Therefore at international level, were made and promoted a wide range of pneumatic seeding equipment for small and very small seeds in cellular systems so that each seed to have optimum development conditions. [3, 4, 8, 10]

semănarea acestora pe o suprafață destul de mare. Dar datorită competiției pentru resurse, în deosebi substanțe nutritive, numai un număr redus de semințe puteau germina şi dezvolta în normale, pentru ca apoi să fie transplantate în ghivece. Din aceste considerente la nivel internațional, au fost realizate şi promovate o gamă variată de echipamente pneumatice de semănat semințe mici şi foarte mici în sisteme alveolare, astfel încât fiecare sămânță să aibă condiții optime de dezvoltare. [3, 4, 8, 10]

Table 1.

The peculiarities of leguminous seeds.

Species	Length [mm]	Wide [mm]	Thickness [mm]	MMB [g]	Seed no. /[g]	Weight [hl]
Tarhon	1-1,2	0,4-0,5	0,4-0,5	0,25	4000	-
Celery	1-1,5	0,6-0,9	0,6-1	0,3-0,5	2700-3500	53-55
Savory	1,1-1,8	0,8-1,3	0,6-0,7	0,5-0,8	1250-2000	-
Salad	2,7-3,8	1,2-1,7	0,5-0,8	1-1,2	800-1000	44-46
Carrot	2-4	1,1-1,8	0,6-1,2	1,1-1,9	550-850	11-35
Parsley	2,2-3,2	1-1,7	0,8-1,3	1,2-1,8	560-820	52-60
Dill	3,0-4,6	2-3,2	0,6-0,8	1,2-2	500-820	38-40
Steve	2,2-4	1,5-2	1,5-2	1,6-3	350-600	-
leek	2,1-3,2	1,5-2	1-1,7	2,3-3,6	270-420	40-54
Tomato	3-4	2,2-3	0,5-1	2,7-3,4	300-370	-
Onion	2,4-3,2	1,2-2	0,8-1,6	2,7-5	200-360	40-52
Loboda	6-10	5-7	1,2-2	3,6-6	170-280	-
White cabbage	1,5-1,4	1,3-2,4	1,1-1,3	3,2-4,2	240-300	67-69
Peppers	2,3-4	2-3,6	0,6-1,1	4,5-8	125-200	48-50
Radishes	2,9-3,9	2-3	1,2-3	6-10	80-135	60-72
Asparagus	3-3,8	30-32	2-2,2	17-20	50-60	-
Cucumber	8-12	3,2-4	1-1,6	28-40	25-45	48-50
Melon	7-11	3-3,8	1,3-2	30-50	20-35	47-51
Watermelon	7-12	3-8	2-3	30-150	7-35	40-50
Artichokes	6-8	3-5	2-3	44-51	19-23	
Bame	3,5-6	3,5-6	3,4-6	65-85	12-15	-
Noggin	10-19	2,8-12	1,5-4	80-250	5-12	50-55
Spinach	2-5	2,3-3,5	1,8-2,1	7-12/9-14	-	35-40
Lovage	4,7-7,5	2,1-3,7	1-1,5	-	-	-

Peppers Okra Cucumber Parsley Tomatoes Beet

Fig. 1 - Small vegetable seeds physiological properties. [10]

MATERIAL AND METHOD

An important factor in pneumatic conveying systems is the concentration of material in air, respectively the report between the material weight and the air weight. [1, 6]

In the case of small and very small seeds can be applied vertically transported particle theory, due to their very small dimensions; in order to pick them up alveolar tray, a depression is generated to the upper body, forming a current of air which aspires the seed or the particle in the tray.

The phenomenon of vertical transportation of solid particles and keeping them suspended occurs when air speed is equal or greater against the floating speed.

In this case, the speed of the rising particles v_r is equal with the airflow speed v_a minus the particle flotation

MATERIAL ŞI METODĂ

Un factor important în cadrul sistemelor de transport pneumatic este concentrația amestecului de material în aer, respectiv raportul dintre greutatea materialului şi greutatea aerului. [1, 6]

În cazul semințelor mici şi foarte mici se poate aplica teoria particulelor de transport pe verticală, datortită faptului că dimeniunile acestora sunt foarte mici, iar pentru a le ridica din tava alveolară se generează o depresiunie în partea superioară a corpului, cea ce formează un curent de aer ce aspiră sămânța din tava de alimentare, respectiv particula.

Fenomenul de transport pe verticală a particulelor solide şi menținerea acestora suspendate se realizează atunci când viteza aerului să fie mai mare au egală cu viteza de plutire.

În acest caz, viteza cu care particulele se ridică v_r este egală cu viteza curentului de aer v_a minus viteza de

speed v_m.

plutire a particulei v_m.

$$v_r = v_a - v_m \text{ (m/s)} \quad (1)$$

The slip factor namely S can be expressed in the equation (2).

Factorul de alunecare, respectiv S,are expresia din ecuația (2).

$$S = 1 - \frac{v_m}{v_a} \quad (2)$$

In practice, the particles carried by air currents usually have different shapes and sizes, which are included in specific limits. This relative sliding of the material is the average particle glide.

In the limiting case, when the air speed v_a is equal to the speed of floating v_p, the relative speed v_r is equal with the air velocity v_a and S is equal 1 and the vertical transport of material ceases.

If v_a>v_p, the gliding factor is subunitary and material transportation occurs. Because the solid material transported to do not cause an increasement of mixture concentration, the gliding factor must reach lower values, around 0.5 - for small grains and 0.2 - for grains.

For each type of material, it is an optimal energy regime, respectively the minimal energy consumption for transporting a material unit.

The particle floating speed, in conclusion, has an important role and therefore this phenomenon will be studied because it is applied to small and very small seeds.

The particles flotation rate, when they are in position and the air flow is upward, is influenced by the forces equilibrium, respectively by the relative speed of the air from the external environment.

In Fig. 3, illustrates an isolated spherical particle in an air stream, where v_a is the air velocity and this must be chosen as a particle to be in a state of rest to a designated location.

În practică, particulele transportate cu ajutorul curenților de aer, au de obicei, diferite forme şi mărimi, ce sunt cuprinse în anumite limite. Astfel alunecarea relativă a materialului, reprezintă alunecarea medie a particulelor.

În cazul limită, când viteza aerului va este egală cu viteza de plutire v_p, viteza relativă v_r este egală cu viteza aerului v_a şi *S* este egal cu *1*, iar transportul de material pe verticală încetează.

În cazul în care v_a>v_p, factorul de alunecare este subunitar şi transportul materialului are loc. Pentru ca materialul solid transportat să nu producă o creştere a concentrației amestecului, factorul de alunecare trebuie să ajungă la valori mai mici, înjur de 0,5 - pentru granule mari şi 0,2 - pentru granule.

Pentru fiecare tip de material în pare, există un regim energetic optim, respectiv consumul minim de energie pentru transportul unei unității de material.

Viteza de plutire a particulelor, in concluzie, are un rol important şi din acest motiv, în continuare se va studia acest fenomen aplicat la semințe de dimensiuni mici şi foarte mici.

Viteza de plutire a particulelor pentru cazul în care acestea stau pe loc şi curentul de aer este ascendent, este influențată de echilibru de forțe, respectiv de viteza relativă a aerul din mediul extern.

În fig. 3, este prezentată o particulă izolată de formă sferică într-un curent de aer, unde: v_a reprezintă viteza aerului şi trebui astfel aleasă pentru ca particula să se găsească în stare de repaus față de un reper fix.

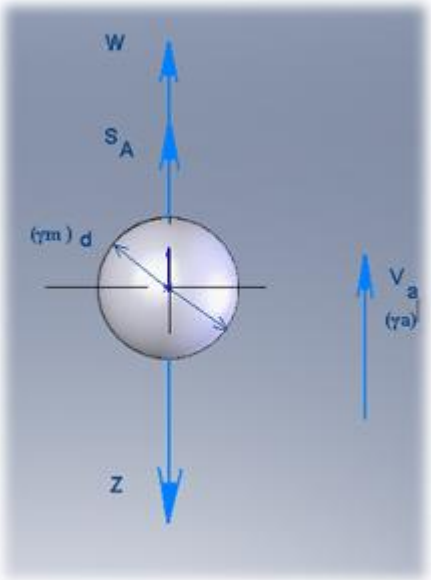

Fig. 2 Balance of particle in upward air current.

From equilibrium eq. (3), it is noted that on the particle acts, the particle weight *Z* and the upward forces acting, respectively the airflow pressure *W* and the Archimedes force S_A.

Din ecuația de echilibru (3) se observa ca asupra particulei acționează, greutatea particulei *Z* şi forțele ascendente, respectiv presiunea curentului de aer *W* şi forța lui Arhimede S_A.

$$W + S_A = Z \quad (3)$$

The particle weight is shown in eq. (4), where: *d* is the particle diameter (m) and γ_m is the specific material weight (kgf/m^3).

Greutatea particulei este exprimată cu ec. (4) unde: *d* este diametrul particulei (m) şi γ_m este greutatea specifică a materialului (kgf/m^3).

$$Z = \frac{\pi * d^3}{6} * \gamma_m \quad (4)$$

Archimedes force is equivalent to the particle air displaced weight, eq.5, where γ_a is the specific weight of air (kgf/m^3) at a certain temperature.

Forța lui Arhimede este echivalentă cu greutatea aerului dislocat de particulă, ec.5, unde γ_a este greutatea specifică a aerului (kgf/m^3) la o anumită temperatură.

$$S_A = \frac{\pi * d^3}{6} * \gamma_a \quad (5)$$

The bearing force is the force generated by the air flow, eq. 4, and depends: by γ_a - the air specific weight (kg/m^3), by *g* – the gravitational acceleration (m/s^2) and ψ – the coefficient of pressure.

.

Forța portantă, reprezintă forța generată de presiunea curentului de aer, ec. (6), şi depinde: de γ_a - greutatea specifică a aerului (kgf/m^3), de *g* - accelerația gravitațională (m/s^2) şi de ψ - coeficientul de presiune.

$$W = \psi * \frac{\pi * d^2}{4} * \frac{v_a^2 * \gamma_a}{2 * g} \quad (6)$$

In most cases the $\gamma_m \gg \gamma_a$ and for this reason the Archimedes force is neglected, and equilibrium condition becomes *W* = *Z*. Replacing forces with their expressions and we obtain the equation (7). [1]

În majoritatea cazurilor $\gamma_m \gg \gamma_a$ şi din aceste considerente se neglijează forța lui Arhimede, iar condiția de echilibru devine $W = Z$. Înlocuind forțele cu expresiile lor se obține ecuația (7).[1]

$$v_a = \sqrt{\frac{4 * g * d * \gamma_m}{3 * \psi * \gamma_a}} \quad (7)$$

With the above expression, can be determined the floating speed $v_p = v_a$, which at the moment is an equation with two unknowns, since ψ is dependent on the Reynolds number, which is determined, in its turn, by the air speed v_a.

Next, a certain value is chosen for v_a., from which is determined the Reynolds number using eq.(8).

Cu ajutorul expresiei de mai sus se poate determina viteza de plutire $v_p = v_a$, care în acest moment este o ecuație cu două necunoscute, deoarece ψ este dependent de numărul Reynolds, care la rândul lui este determinat de viteza aerului v_a.

În continuare, se alege o anumită valoare pentru v_a din care se determină numărul Reynolds cu ajutorul ec.(8).

$$Re = \frac{v_a * D}{\nu} \quad (8)$$

The kinematic viscosity *v* has the value 0.145*10^{-4} m/s, only when the air has the temperature of *θ*=15 °C, *p*=760 mmHg and γ_a=1,2 kgf/m^3. Knowing *Re*, the coefficient *ψ* can be determined and it is check if v_a was correctly chosen, whether that condition $v_a \approx v_p$ is respected.

It should be noted that the pipe floating speed is slmaller than the speed in space, but also the fact that the mathematical model is applicable only to particles with spherical shape.

For the irregularly shaped particles, it is taken into account the equivalent sphere diameter d_{ech} and the form factor K_f

If the particle with varied shape has a volume *V*, then the diameter of the equivalent sphere can be determined by applying eq. (9).

Vâscozitatea cinematică *v,* are valoarea de 0,145*10^{-4} m/s, atunci când aerul are temperatura *θ*=15 °C, *p*= 760 mmHg şi γ_a=1,2 kgf/m^3. Cunoscând *Re* se poate determina coeficientul *ψ* şi se verifică dacă v_a a fost bine aleasă, respectiv dacă se respectă condiția $v_a \approx v_p$.

Trebuie luat în considerare faptul că viteza de plutire în conductă este mai redusă decât viteza în spațiul liber, dar şi faptul că, modelul matematic este aplicabil numai pentru particulele cu formă sferică.

Pentru particule cu forme neregulate se ia în considerare diametrul sferei echivalente d_{ech} şi noțiunea factorului de formă K_f.

Dacă particula, cu formă oarecare, are volumul *V*, atunci diametrul sferei echivalente pate fi determinat aplicând ec. (9).

$$d_{ech} = \sqrt[3]{\frac{6 * V}{\pi}} \quad (9)$$

The form factor influences the air pressure coefficient on the particle *ψ*, and the equation floating speed in this case is shown as in eq.(10).[1].

Factorul de formă influențează coeficientul de presiune a aerului asupra particulei *ψ,* iar ecuația vitezei de plutire în acest caz are forma prezentată în ec.(10).[1]

$$v'_p = \sqrt{\frac{4 \cdot g \cdot d \cdot \gamma_m}{3 \cdot \psi \cdot \gamma_a}} \cdot \frac{1}{\sqrt{K_f}} \cdot \left[1 - \left(\frac{d_{ech}}{D}\right)^2\right] \quad (8)$$

The value for K_f parameter and the report C between the floating speed of equivalent sphere v'_p and the spherical particle floating rate v_p, can be chosen according to Table 4.

Valoarea parametrului K_f şi raportul C dintre viteza de plutire a sferei echivalente v'_p şi viteza de plutire a particulei sferice v_p, pot fi alese conform Tabelului 4.

Table 4.

Values of shape factor K_f and C for bodies with different shapes. [1]

Body's shape	The form factor K_f	Coefficient C
Sphere	1	1
The rounded shape with irregular surface	2,5	0,64
Elongated body	3	0,57
Board	5	0,45

Table 5.

Experimental data on the dynamic characteristics of seeds. [1, 10]

Seed type	Volumetric weight γ_m (kgf/m^3)	Floating speed v'_p (m/s)	Observations
Lin	660	5,2	Technical plant with small seed
Cotton	600	9,5	Textile plant with small seed
Poppy	590	2,5 – 4,3	Vegetable species with very small seeds
Chicory	390	11,9 – 13,2	Vegetable species with very small seeds

The speed of floating bodies, usually is determined for individual particles or if the solid material concentration in the air is very low, because from the experimental work it is demonstrated that, along with increasing concentration of material, floating rate increases.

From the viewpoint of seeding technology of small and very small seeds, such calculation methods are suitable, because the speed of the float is specific to materials with reduced concentration, respectively to seed absorbtion, using a nozzle or needles connected to the vacuum system, see Fig. 6-11.

Viteza de plutire a corpurilor, de obicei este determinată pentru particule individuale sau pentru cazul în care concentrația materialului solid în aer este foarte redusă, deoarece din activitățile experimentale s-a demonstrat că o dată cu creşterea concentrației de material, viteza de plutire se măreşte.

Din punct de vedere al tehnologii de semănare a semințelor mici şi foarte mici aceste metode de calcul sunt adecvate, deoarece viteza de plutire este specifică materialelor cu concentrație reduse, respectiv de absorbție a unei semințe cu ajutorul unei duze sau ace conectate la instalația de vacuum, vezi Fig. 6-11.

Fig.6. Seed interchangeable nozzles for plug trays - MOSA.

Fig.7 Seed needles aspiration/evacuation units –MOSA.

Fig.8 Seed metal nozzles aspiration/evacuation units – HAMILTON.

Fig.9 Seed rubber nozzles aspiration/evacuation units – BLACKMORE.

Fig.10 Type of needles for small seeds multiple sowing - AGRITEH.

Fig.11 Bent needles for GS1seeder – SEEDERMAN.

To dimension the pneumatic transport system, respectively alveolar pneutronic seed drill for small and medium seeds, it is very important to know the quantity of transported product, which is directly reflected on machine productivity. [6]

Depending on this, it can be determined functional and technical parameters of conveying such as: mixing coefficient, air flow, diameter of transmission pipelines (nozzles and needles) nozzles, diameter for main power line and others. [6]

An important parameter is the ***mixing coefficient*** μ that usually it is framed between 1.5 ÷ 3 and represents the ratio between the product transported quantities G_m (kg/min) and the air quantity needed during this process G_a (kg/min), eq.9. [6]

Pentru dimensionarea instalației de transport pneumatic, respectiv al semănătorii alveolare pneutronice pentru semințe mici şi mijlocii, este foarte important a se cunoaşte cantitatea de produs transportată, care se reflectă direct asupra productivității maşini. [6]

În funcție de aceasta, se pot determina parametrii tehnico-funcționali ai instalației de transport precum: coeficientul de amestec, debitul de aer, diametrul conductelor de transport (duze şi ace), diametrul liniei principale de alimentare şi alții.[6]

Un parametru important este coeficientul de amestec μ, care de obicei se încadrează între 1,5 şi 3, şi reprezintă raportul dintre cantitatea de produs transportată G_m (kg/min) şi cantitatea de aer necesară acestui proces G_a (kg/min), eq.9.[6]

$$\mu = \frac{G_m}{G_a} \tag{9}$$

Where G_a is the product of the specific mass of 1 m^3 of air flow γ_a specific to the working environment and the debit Q_a..

Unde G_a este produsul dintre masa specifică a 1 m^3 de aer $\gamma_a$specifică mediului de lucru şi debitul Q_a.

$$G_a = \gamma_a * G_a \tag{10}$$

The airflow needed a transport line q is determined using the eq. (11). [4]

Debitul de aer necesar unei linii de transport q se stabileşte utilizând formula din ec. (11).[4]

$$q = \frac{G_m}{\gamma * \mu * 60} \tag{11}$$

The determination of the required flow for a power lines / pipeline Q_t can be used eq. (12).

Pentru a determina debitul necesar unei linii de alimentare/magistrale Q_t se utilizeaza ec. (12).

$$Q_t = (q_1 + q_2 + \cdots . + q_n) * c_a \tag{12}$$

Where c_a is the amplification factor to cover unexpected losses or consumption.

Diameter of transmission lines d_t is calculated using eq. (13).

Unde c_a este coeficientul de amplificare pentru acoperirea unor pierderi sau consumuri neprevăzute.

Diametrul conductelor de transport d_t se calculează cu folosind ec. (13).

$$d_t = 0{,}133 * \sqrt{\frac{G_m}{\mu * v_p * 60}} \tag{13}$$

Where: d_t is the diameter of the pipeline (m), G_m is the quantity of transport´ product (kg/h), μ is mixture coefficient and v is the air velocity in the pipeline (m/s).

The diameter of main supply line or main pipe D, on which are connected to the transport lines, is calculated according to eq. (14).

Unde: d_t este diametrul conductei (m), G_m cantitatea de produs de transport (kg/h), μ este coeficientul de amestec şi v este viteza aerului pe conductă (m/s).

Diametrul conductei principale de alimentare sau a magistralei D, la care sunt racordate liniei de transport, se calculează conform ec. (14).

$$D = \sqrt{\frac{4 * Q_t}{\pi * v_p}} \tag{14}$$

In the scientific literature, the particles transported by an air current have a rotation movement, whether the transport is on horizontal or vertical, because it has an asymmetrical geometry and the gravity center varies. Rarely the result of bearing force passes through the particle gravity center and the resultant force isn't positioned in center of gravity and then is produced a rotation moment.

CONCLUSIONS

The working principles of sowing small and very small seeds in plug trays has an interdisciplinary character as it combines two important subdomains of the pneumatic actuation systems, the low pressure field (pressures up to 10 bar) and the vacuum field, and for each line in part, must be used specific equipments that must meet the technical requirements.

Therefore, it is required that in the design/optimization process to take into consideration the seeds morphological properties that have a direct impact on transport and positioning process.

Besides factors presented in this paper the process is influenced by the seed friction force with feeder, in order to reduce the contact area. For this reason, the seed it has a hopping motion due to a vibrating system or, which is set according to the morphological characteristics (such as: size, the specific weight and particles form), Properties which are also important for the pneumatic vertical transport, namely the gliding factor.

This aspect was not treated from the theoretical standpoint in this paper, but will be subject to other scientific papers that will expand the theoretical basis that can be applied to these types of equipment.

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[10] Vişan A.L., Bogdanof G.C., Milea D., Mircea

În literatura de specialitate particulele transportate de un curent de aer se rotesc, indiferent dacă transportul se face pe orizontală sau pe verticală, deoarece acestea sunt asimetrice iar centru lor de greutate variază. Rareori rezultanta forței portante trece prin centru de greutate a corpului şi atunci forța rezultantă nu este poziționată în centru de greutate şi se produce un moment de rotație.

CONCLUZII

Principiile de funcționare ale echipamentelor de semănat semințe mici şi foarte mic în tăvi alveolare are un caracter interdisciplinar, deoarece combină două subdomenii importante din cadrul acționărilor pneumatice, domeniul presiunilor mici - de până la 10 bar şi cel al vacuumului, iar pentru fiecare ramură în parte se utilizează echipamente specifice ce trebuie să răspundă cerințelor tehnice.

Din aceste considerente procesul de proiectare/optimizare trebuie ia in considerare proprietățile morfologice ale semințelor ce au impact direct asupra procesului de transport şi poziționare.

În afara de factorii prezentați în această lucrare procesul tehnologic mai este influențat şi de forța de frecare a seminței cu tava de alimentare, pentru a micşora suprafața de contact. Din acest motiv, sămânța este săltată datorită unui sistem vibrator care este reglat în funcție de caracteristicile morfologice (precum: dimensiunea, greutatea specifică şi forma particulelor). Carcateristici care de asemenea sunt importante şi pentru transportul penumatic pe verticală.

Acest aspect nu a fost tratat din punct de vedere teoretic în această lucrare, dar va fi subiectul unei alte lucrari stiintifice pentru a complecta baza teoretică ce poate fi aplicată acestor tipuri de echipamente.

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TRACTOR TRAILED WINDROWER FOR FODDER PLANTS, DESIGNED TO HARVEST, CONDITIONING (STALKS CRUSHING, BREAKING OR DEFIBRATION) AND LEAVING SWATHS OF FODDER PLANTS
/
VINDROVER TRACTAT PENTRU RECOLTAREA COMBINATĂ CU CONDIȚIONAREA PLANTELOR COSITE (STRIVIREA, FRÂNGEREA SAU DEFIBRAREA TULPINILOR) ŞI LĂSAREA ÎN BRAZDE

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Abstract: *An important requirement in animal feed is the quality of hay obtained from forage harvesting process. The paper presents experimental research of prototype of windrower trailed who performed in a single pass mowing and conditioning operations (crushing, breaking or defibration stalks) and left swaths of fodder plants. The results will constitute the basis of promoting the exploitation of a competitive product, which, by the work process performed, helps to accelerate the drying of hay on the soil, thus improving its nutritional quality.*

Keywords: *trailed windrower, harvesting, crushing, breaking, defibration, swaths, fodder*

INTRODUCTION

Hay plays an essential role in animal nutrition in winter. In winter should be used as feed hay first of all, followed by the first meed of concentrate fodder [1].

The hay is a food of a dairy cow that cannot be relinquished. It supports the motor functions of the bellows, i.e. muscle activity of the digestive system and ruminants, activities crucial for proper decomposition of food.

Therefore, the yield of dairy cows is influenced by genetic potential generally around 20%, about 30% of accommodation and care and feeding 50% [6].

This relationship is dependent on the harvest - conservation – rationing of feeding. Harvesting plants on permanent pasture and crop land is common from spring until late fall to ensure daily needs of food animals [2].

The quantity and quality of fodder depend on various factors forced the speed of growth of the plants, weather conditions, mechanization and the way storage [3].

One of meteorological factors influencing the quality of hay is rain, which darkens and depreciates them [4].

S.C. MECANO FUC S.A. in partnership with INMA Bucharest has found the solution to this problem by applying a harvest technologies leading to hasten drying hay on the ground. Thus they were conducted experimental research to promote in this new technology a windrower, which is designed to perform mowing operations (crushing, breaking or defibration stalks) and left swaths forage grasses for drying natural [5].

Lamination (crushing) plant plays by rollers has an important role in the harvesting technology because this operation hastens the water evaporation. At the same time, by crushing the humidity of leaflets and stems are unified, ensuring their identical drying conditions and also be

Rezumat: *O cerință importantă în furajarea animalelor este calitatea fânului obținut în urma procesului de recoltare a plantelor furajere. În lucrare sunt prezentate cercetările experimentale efectuate cu prototipul de vindrover tractat, care la o singură trecere realizează operațiile de cosire (strivirea, frângerea sau defibrarea tulpinilor) şi lăsatul în brazde a plantelor furajere. Rezultatele obținute vor sta la baza promovării în exploatare a unui produs competitiv, care prin procesul de lucru realizat ajută la grăbirea uscării fanului pe sol, îmbunătățindu-i astfel calitatea nutritivă.*

Cuvinte cheie: *vindrover tractat, recoltat, strivire, frângere, defibrarea, brazde, furaje*

INTRODUCERE

Fânul joacă un rol esențial în alimentația de iarnă a animalelor. Iarna trebuie administrat fânul prima dată ca furaj, după care urmează primul tain de nutrețuri concentrate [1].

Fânul este un aliment al unei vaci de lapte la care nu se poate renunța. El sprijină funcțiile motorii ale burdufului, adică activitatea musculară a sistemului digestiv, şi rumegatul, activitate indispensabilă pentru o descompunere corespunzătoare a hranei. De aceea, randamentul unei vaci de lapte este influențat de potențialul genetic în general cca.20%, cca.30% de condițiile de cazare şi îngrijire şi 50% de furajare [6].

Acest lucru este dependent de relația recoltare - conservare - furajare rațională. Recoltarea plantelor pe păşunile permanente şi terenurile cultivate este des întâlnită începând de primăvara şi până toamna târziu în scopul asigurării necesarului zilnic de hrană la animale [2]. Cantitatea şi calitatea furajelor depind de diverşi factori impuşi de ritmul de vegetație al plantelor, condițiile atmosferice, mecanizarea lucrărilor şi felul de depozitare [3]. Unul din factorii meteorologici care influențează calitatea fânului este ploaia, care îl înnegreşte şi depreciază [4]. S.C. MECANO FUC S.A. în parteneriat cu INMA Bucureşti a găsit soluția pentru rezolvarea acestei probleme, prin aplicarea unei tehnologii de recoltare care să conducă la grăbirea uscării fanului pe sol. Astfel, au fost efectuate cercetări experimentale în scopul promovării în cadrul acestei tehnologii a unui vindrover tractat, care este destinat să efectueze operațiile de cosire (strivirea, frângerea sau defibrarea tulpinilor) şi lăsatul în brazde a plantelor furajere ierboase, în vederea uscării naturale [5].

Laminarea(strivirea) plantelor de către valțuri are un rol important în cadrul tehnologiei de recoltare deoarece prin această operație se grăbeşte evaporarea apei. În acelaşi timp, prin strivire se uniformizează umiditatea dintre frunzulițe şi tulpini, asigurând acestora condiții identice de

eliminated or reduced work rummage, thus reducing the losses in leaflets by shaking. All these advantages lead in the end to obtain high quality fodder.

MATERIAL AND METHOD

Experimental research in laboratory and exploitation conditions, which are presented in this paper, were performed on experimental fields of SCD Pajişti Vaslui, according to the testing procedures developed by INMA Bucharest, with the prototype of a windrower trailed by a 47.8 kW Romanian manufacturing wheel tractor (fig.1).

This was coupled to the tractor drawbar and working bodies were driven to the power via a shaft. Trailed windrower, while working, by submitting in fodder plant field, bends plants with a front bar, cut them with a cutter knife and fingers and directs them by the elastic fingers of a folded towards two crushing rollers. Plant laminating by rolling rollers plays an important role in obtaining high quality fodder, as speeds up the evaporation of water, equalizing the humidity of the leaflets and stalks, in order to reduce the loss of leaflets by shaking.

Working indices determined under laboratory conditions:
- Effective working width, cm
- After cutting swath width, cm
- Cutting height (stubble) cm

Parameters determined in operating conditions:
- Average speed of working, m/s
- Effective torque to the PTO, Nm
- Effective power consumption, kW
- Noise, dB
- The amount of vegetal mass per hectare, t/ha of green mass

However, in the testing research in operating conditions intended to establish how move in work the aggregate windrower VF + 47.8 kW wheel tractor, to diminish the time of returns at the end of the plot and avoid traveling unladen,

uscare şi totodată se elimină sau se reduc lucrările de răvăşire, reducând astfel pierderile de frunzulițe prin scuturare. Toate aceste avantaje conduc în final la obținerea unor furaje de calitate.

MATERIALE ŞI METODĂ

Cercetările experimentale în condiții de laborator şi exploatare, care sunt prezentate în lucrare, au fost efectuate pe terenurile experimentale ale SCD Pajişti Vaslui, în conformitate cu procedura de încercări elaborată de INMA Bucureşti, cu prototipul de vindrover tractat în agregat cu tractorul de 47,8 kW pe roți de fabricație românească (fig.1). Acesta a fost cuplat la bara de tracțiune a tractorului, iar organele de lucru au fost acționate de la priza de putere prin intermediul unei transmisii cardanice. Vindroverul tractat, în procesul de lucru, prin înaintarea în lan, apleacă plantele cu ajutorul unei bare frontale, le taie cu un aparat de tăiere cu degete şi cuțit şi le dirijează cu nişte degete elastice ale unui rabator spre două valțuri de strivire. La ieşirea dintre valțuri, plantele cosite sunt lăsate pe sol în brazde a căror lățime poate fi variată cu ajutorul unor deflectoare reglabile, în funcție de cantitatea de material şi de lățimea de lucru a echipamentelor de strâns plantele uscate.

Indicii de lucru determinați în condiții de laborator:
- Lățimea efectivă de lucru, cm
- Lățimea brazdei după tăiere, cm
- Înălțimea de tăiere (miriştea), cm

Parametri determinați în condiții de exploatare:
- Viteza medie de lucru, m/s
- Momentul real la priza de putere, Nm
- Puterea reală consumată, kW
- Nivelul de zgomot, dB
- Cantitatea de masă vegetală la hectar, t/ha masă verde

Totodată, în cadrul cercetărilor în condiții de exploatare s-a urmărit stabilirea modului de deplasare în lucru a agregatului vindrover VF + tractor de 47,8 kW, în vederea diminuării timpului afectat întoarcerilor la capătul parcelei şi evitării deplasării în gol.

Fig. 1 -Trailed windrower prototype in aggregate with the 47.8 kW wheel tractor

Table 1

The conditions under which the tests were performed

Specification	Harvesting culture: SAINFOIN
Year of vegetation	First year
Growing stages	55 % blooming
The average height of grass field, mm	540
Average plant height, mm	620
Plant moisture at harvesting,%	56.8
The number of plants per m^2, pcs.	246
The average amount per hectare of the vegetal mass, t/ha	22.7
Botanical composition of the harvester grass field,% - sainfoin - other plants	 68 32
Tractor in aggregate, CP - Engine speed, rev / min - PTO speed, rev / min	65 1800 540

Specification	Harvesting culture: SAINFOIN
Load on the skates of the windrower, kg	40

The apparatus used in experiments

- Measuring the forces of connection between the tractor and the trailed windrower (tensile strength *Ft*) was performed using transducers drawbar.
- Effective torque to the PTO measured with a torque transducer (model T4WA-S3 / 2kN).
- To record the acquired data directly to a computer Toshiba has used a package of specialized programs.
- Stopwatch
- Metallic frame of 1 m2
- Measuring tape 50 m;
- Weigher.
- Tensile strength was calculated based on driving speed v_l of the aggregate and average tensile strength F_t previously determined with the relationship:

Aparatura utilizată la experimentări

- Măsurarea forțelor de legătură dintre tractor şi vindroverul tractat (forța de rezistență la tracțiune F_t) s-a realizat folosind traductoare cu bară de tracțiune.
- Momentul real la priza de putere s-a măsurat cu un traductor de moment de torsiune (model T4WA-S3/2kN).
- Pentru înregistrarea datelor achiziționate direct pe un computer Toshiba s-a utilizat un pachet de programe specializate.
- Cronometru
- Ramă metalică de 1 m^2
- Ruletă de 50m;
- Cântar
- Puterea de tracțiune s-a calculat, pe baza vitezei de deplasare v_l a agregatului şi a forței medii de tracțiune F_t determinate anterior, cu ajutorul relației:

$$P_t = \frac{F_t \times v_l}{1000}, \text{ kW} \quad (1)$$

where F_t is the average tensile strength in N and v_l - average working speed in m/s.

unde F_t este forța medie de tracțiune, în N iar v_l - viteza medie de lucru, în m/s.

RESULTS

Table 2 presents the average values of indices obtained in laboratory tests.

Analysis of the data presented in Table 3 shows that trailed windrower in aggregate with 47.8 kW wheel tractor, has performed, in accordance with the effective settings, a working width of 2100 mm and an average cutting height of 62 mm. Following experimental research in laboratory conditions it was found that the width and thickness aspect of furrows made by trailed windrower is uniform and can be collected by balers, loading wagons, fodder combines whose harvesting equipment have working widths of 1.5 ... 1.8 m.

Operational tests were made in different working driving and working conditions according to the INMA Bucharest test procedures. Table 3 presents the average indices values obtained from energetic tests in operating conditions.

REZULTATE

În tabelul 2 sunt prezentate valorile medii ale indicilor obținuți la încercările în condiții de laborator.

Analiza datelor prezentate în tabelul 3 arătă că vindroverul tractat în agregat cu tractorul de 47,8 kW pe roți a realizat, în conformitate cu reglajele efectuate, o lățime medie efectivă de lucru de 2100 mm şi o înălțime medie de tăiere de 62 mm. În urma cercetărilor experimentale în condiții de laborator s-a constatat că aspectul lățimii şi grosimii brazdele realizate de vindroverul tractat este uniform şi pot fi adunate de presele de balotat, remorcile autoîncărcătoare, combinele de furaje al căror echipament de adunat au lățimi de lucru de 1,5…1,8 m.

Încercările de exploatare s-au efectuat în diverse condiții de deplasare şi de lucru, în conformitate cu procedura de încercări INMA Bucureşti. În tabelul 3 sunt prezentate valorile medii ale indicilor energetici obținuți la încercările în condiții de exploatare.

Table 2

Indices obtained in laboratory testing conditions

Name of Indices	M.U.	Measured value
Average effective working width	mm	2100
Average width of the swath after cutting (the first stage adjustment)	mm	1500
Average width of the swath after cutting (the second stage adjustment)	mm	1100
Cutting average height (stubble)	mm	62

Table 3

Energetic indices obtained from tests under operational conditions

The measurement carried out	MU	Average speed of working, m/s			
		1.27	1.41	1.57	1.72
The average engine speed	rev/min.	1853	1856	1850	1813
Average speed of PTO	rev/min	556	557	555	544
Effective average torque of PTO	N m	26.92	28.62	30.48	32.56
Effective average consumed power	kW	16.5	18.3	20.4	22.3
Average Noise Level	dB	85			
The average amount of vegetal mass per hectar	t/ha	22.7			

Within operational tests intended to establish the mode

În cadrul încercărilor de exploatare s-a urmărit stabilirea

of displacement in work of the windrower, VF, in aggregate with 47.8 kW wheel tractor, to diminish the time of returns at the end of the field and avoid unloaded movement.

Moving around from the outside towards the center of the field is the most recommended because time returns is very small and is recommended for harvesting fields of 200 ... 250 m sides, possibly square shape.

The lateral displacement, on the right side return at the end of the parcels, is recommended for fields, grater width of 250 m and length of approx. 50 ... 100 m. In this situation, to safely return, requiring a space width of 6 ... 8 m at the ends of the parcel, obtained by mowing or harvesting plants with forage harvesting.

Figure 3 shows the aggregate of 47.8 kW wheel tractor + trailed windrower while turns at the end of the parcel.

modului de deplasare în lucru a agregatului vindrover VF-tractor de 47,8 kW, în vederea diminuării timpului afectat întoarcerilor la capătul parcelei şi evitării deplasării în gol.

Deplasarea de jur împrejur, de la exterior către centru parcelei, este cea mai recomandată deoarece timpul afectat întoarcerilor este foarte mic, fiind recomandată pentru recoltarea parcelelor cu laturile de 200…250 m, pe cât posibil de formă pătrată.

Deplasarea laterală, cu întoarcere pe partea dreaptă la capetele parcelelor, este recomandată pentru parcele cu lățimea mai mare de 250 m şi lungimea de cca. 50…100 m. În această situație este necesar ca la capetele parcelei să existe un spațiu necesar pentru întoarcerea agregatului cu lățimea de 6…8 m, care se obține prin cosirea plantelor cu cositori sau recoltarea cu combine de furaje.

În figura 3 este prezentat agregatul tractor de 47,8 kW + vindrover tractat în timpul efectuării întoarcerilor la capătul parcelei.

Fig. 3 - Picture of 47.8 kW wheel tractor + trailed windrower while returns

CONCLUSIONS

Following the observations made during experimental research showed that:

- trailed windrower respected major quality assessment indices and operating parameters for mowing (crushing, breaking or shredding stalks) and leaving swaths of fodder plants;
- through the work conducted by tested trailed windrower the drying time of mowed plants became shorter and ensured also drying of the stems and leaves.

The results will form the basis of assimilation into operation of the trailed windrower so that the risk caused by prolonged remaining on the ground of the fodder to be harvested is much lower, thus improving its qualities.

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CONCLUZII

În urma observațiilor efectuate în timpul cercetărilor experimentale a rezultat că:

- Vindroverul tractat a respectat indicii principali de apreciere a calității şi parametrii de exploatare pentru lucrarea de cosire (strivirea, frângerea sau defibrarea tulpinilor) şi lăsatul în brazde a plantelor furajere;
- Prin procesul de lucru realizat de vindroverul tractat s-a scurtat timpul necesar uscării plantelor şi s-a asigurat uscarea în acelaşi timp a tulpinilor şi frunzelor.

Rezultatele obținute vor sta la baza asimilării în exploatare a vindroverului tractat, astfel încât riscul provocat de rămânerea prelungită a furajului recoltat pe teren să fie este mult diminuat, îmbunătățindu-i-se astfel calitățile.

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EXPERIMENTAL RESEARCH ON CHOPPING OF MEDICINAL PLANTS / *CERCETARI EXPERIMENTALE PRIVIND TOCAREA PLANTELOR MEDICINALE*

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Abstract:. *Medicinal plants represent natural resources of bioactive principles, as the active compounds are concentrated in the whole plant or in its different organs, the so-called useful parts.*

After gathering, the vegetal matter can be subject to conditioning or mincing operations. Diminishing the medicinal plants dimensions is required by the market demands, or represents an intermediary phase/operation within the technological processes of obtaining the relevant products.

The paper presents the experimental results regarding the quality of chopping the Milfoil herb (Achillea millefolium L.), as well as St John's wort (Hypericum perforatum L.), for different adjustments of cutting system. The aim was to determine the possibilities of utilization of vegetal matter resulted for specific end products (tablets, tea, extracts etc.)

Keywords: *process quality, dimensional reduction, herbs.*

Rezumat:

Plantele medicinale constituie resurse naturale de principii bioactive, deoarece concentreaza compusi activi in totalitatea plantei sau in diverse organe ale acesteia, denumite parti utile.

Dupa colectare, materialul vegetal poate fi supus unor operatii de conditionare sau maruntire. Reducerea dimensionala a plantelor medicinale se aplica ca urmare a cerintelor pietei, sau ca faza/operatie intermediara in cadrul proceselor tehnologice de obtinere a produselor de profil.

Lucrarea prezinta rezultatele experimentale referitoare la calitatea procesului de tocare a herbei de coada soricelului (Achillea millefolium L.), precum si a herbei de sunatoare (Hypericum perforatum L.), pentru diferite reglaje ale sistemului de taiere. S-au urmarit posibilitatile de utilizare a materiei vegetale rezultate, pentru produse finite specifice (comprimate, ceaiuri, extracte etc.)

Cuvinte cheie: *calitate proces, reducere dimensionala, herba.*

INTRODUCTION

Reduction of medicinal herb size is achieved by means of mechanical forces, similarly to mincing process for any type of raw material. [5], [8]

Cutting/chopping is one of most used methods for mechanically reducing medicinal herbs' useful part size(folium, herb, radix, cortex etc). As a general rule, the operation is performed after conditioning, which comprises sorting and/or drying [4] The most efficient cutting of fresh or dried medicinal plants is performed by shearing between two cutting blades, after having compressed the material, previously. The material cutting begins when the knife pressure surpasses the plants shearing resistance. The latest depends both on plants natural features and technical and technological factors (geometrical and kinematic characteristics of cutting parts, material flow characteristics etc.) [2], [5], [6]

Herbs represent the medicinal plant aerial organs, respectively the stem with leaves and flowers. Thus, Milfoil*(Achillea millefolium L)* (fig.1) and St John's wort *(Hypericum perforatum L),* (fig.2) are harvested as such, being ones of the most natural remedies used in traditional human and veterinary therapy.

Milfoil *(Achillea millefolium L)* is a perennial plant of spontaneous flora or crop. Flowers contain an essential oil rich in azulene, cineol, achilleine etc., which are mostly lost by drying. Herb also contains monocycles triterpenic compounds, salicylic acid, formic acid, ascorbic acid, micro and macroelements(Fe, Cu, Mn, Ni, Zn, Si), fat oil, etc. Green or dried plant, as infusion or decoction is used in human therapy, as stomachic, eupeptic, astringent, tonic, fighting against digestive, kidney, nervous diseases, being also a hemostatic, colagog, hypotensive and antiseptic factor.[4]

INTRODUCERE

Reducerea dimensiunilor in cazul plantelor medicinale se realizeaza datorita actiunii unor forte mecanice, asa cum se realizeaza in general maruntirea pentru orice tip de materie prima sau material. [5], [8]

Taierea/tocarea reprezinta unul din procedeele utilizate pentru reducerea mecanica a dimensiunilor partilor utile ale plantelor medicinale (folium, herba, radix, cortex etc). Aceasta se executa de obicei dupa conditionare, constituita de obicei din operatii de sortare si/sau uscare [4] Taierea cea mai eficienta a plantelor medicinale in stare proaspata sau uscata se realizeaza prin forfecare, intre doua lame taietoare, dupa ce materialul a fost comprimat in prealabil. Sectionarea materialului incepe atunci cand forta de apasare a cutitului depăseste rezistenta la forfecare a plantelor. Aceasta depinde atat de caracteristicile naturale ale plantelor, cat si de factori tehnici si tehnologici (caracteristicile geometrice si cinematice ale organelor de taiere, caracteristicile fluxului de material etc.) [2], [5], [6]

Herba reprezinta in cazul plantelor medicinale organele aeriene ale acestora, respectiv tulpina cu frunze si flori. Astfel, sub aceasta forma se recolteaza Coada soricelului *(Achillea millefolium L)* (fig.1) si Sunatoarea *(Hypericum perforatum L),* (fig.2) unele dintre cele mai cunoscute si utilizate remedii naturale, utilizate in terapia umana traditionala cat si in cea veterinara.

Coada soricelului *(Achillea millefolium L)* este o planta perena din flora spontana sau din cultura. Florile contin un ulei volatil bogat in azulene, cineol, achilleina etc. care se pierde in mare masura prin uscare. Herba mai contine: compusi triterpenici monociclici, acid salicilic, acid formic, acid ascorbic, micro si macroelemente (Fe, Cu, Mn, Ni, Zn, Si), ulei gras, etc. Planta verde sau uscata, sub forma de infuzie sau decoct se intrebuinteaza in terapia umana ca tonic stomahic, eupeptic, astringent, combatand afectiunile digestive, renale, nervoase si fiind hemostatic, colagog,

St John's wort *(Hypericum perforatum L)* is a perennial plant from spontaneous flora or crop, that is harvested when the inflorescence has still buds (months VI-VIII). Conditioning of vegetal matter is preformed by drying. It contains essential oil 1%, hypericin, 12% tannin, resins, flavonoids, saponins, ascorbic acid, nicotinic acid and valerianic acid, as well as, mineral salts. In popular medicine, St John's wort is used as infusion or macerate, as a remedy for ulcer disease, chronic hepatic liver affections and biliary motility disorders, as having colagog, choleretic, diuretic, anti-inflammatory, vasodilator, cicatrizing effect.[4]

hipotensiv, antiseptic.[4]

Sunatoarea *(Hypericum perforatum L)* este o planta perena din flora spontana sau din cultura, care se recolteaza cand inflorescenta mai are boboci (lunile VI-VIII). Conditionarea materialului vegetal se face prin uscare. Contine ulei volatil 1%, hipericina, 12% tanin, rezine, flavonozide, saponine, acid ascorbic, nicotinic si valerianic, saruri minerale. In medicina populara sunatoare este utilizata sub forma de infuzie sau macerat, in medicina populara ca remediu antiulceros, in tulburarile hepatice cronice si motilitatea cailor biliare,cu rol colagog, coleretic si diuretic, antiinflamator, vasodilatator, cicatrizant.[4]

Fig.1 Milfoil (Achillea Millefolium) 1]

Fig. 2 St. John's wort *(Hypericum perforatum L 1}*

Phytotherapeutic products, designed to treatment of the above disorders have imposed to reduce the size of the two plants herb. Thus, they may used :

- native plants: as a whole, fragments, powder or infusion or decoction, or macerate;
- Pharmaceutical/phyto-pharmaceutical preparations (extracts, tinctures, syrups) in which the active principles are more concentrated, easy to administrate and not very expensive [3], [10]

Individual monographs of vegetal products or substances from *Farmacopeea Romana* offer details on size of medicinal plants fragments used.[9]

By using an accuarate cutting system, differently adjusted, conclusions on correlation between the adjustments type and products for which the vegetal matter will be especially used, have been drawn.

MATERIALS AND METHOD

Vegetal material used in tests was made of herb of Milfoil *(Achillea millefolium L)* and herb of St John's wort *(Hypericum perforatum L),* coming from spontaneous flora. Plants were naturally dried, in the shadow, in well aerated chambers until they reached the storing humidity desired.[7] When herb of Milfoil *(Achillea millefolium L) was* chopped, it had 10.21% humidity and St John's wort herb had 7.89% humidity. This reduced humidity is explained by high temperatures during July-August months, when tests were performed.

Vegetal matter has been reduced in size by means of a chopper for medicinal plants endowed with a gate shear type knife, that during the working process, has a plan-parallel movement, being one of the elements of a quadrangle mechanism (fig.3) One of its bars, that controls the movement of knife fixed by another pair working beam, is united to a balancer, on which axle one link may move, being driven by the button of a crank mechanism. This is situated on one of outlets of worm reducer-spiral wheel, driven by

Produsele fitoterapeutice, destinate tratarii afectiunilor amintite anterior, impun reducerea dimensionala a herbei celor doua plante medicinale. Astfel ele pot fi folosite:

- in stare naturala: intregi, fragmente, pulbere sau sub forma de influzie, decoct, macerat;
- preparate farmaceutice/fitofarmaceutice (extracte, tincturi, siropuri) in care principiile active sunt mai concentrate, mai usor de administrat si nu foarte costisitoare [3], [10]

Monografiilor individuale de produse vegetale sau substante din *Farmacopeea Romana* dau detalii cu privire la dimensiunea fragmentelor plantelor medicinale utilizate.[9]

Utilizandu-se un sistem de taiere exacta, reglat diferit, s-au emis concluzii referitoare la corelatia intre reglaje si tipurile de produse la care va putea fi folosit cu precadere materialul vegetal rezultat.

MATERIALE ŞI METODA

Materialul vegetal utilizat la experimentari a fost constituit din herba de Coada soricelului *(Achillea millefolium L)* si herba de Sunatoarea *(Hypericum perforatum L),* provenite din flora spontana. Plantele au fost uscate in mod natural, la umbra, in incaperi bine aerisite pana cand au atins umiditatile de depozitare prescrise.[7] In momentul tocarii herba de coada soricelului a avut o umiditate de 10,21% iar cea de sunatoare a avut o umiditate de 7,89%. Aceasta umiditate scazuta se datoreaza temperaturilor foarte ridicate din perioada (iulie-august a.c.) in care s-au efectuat experimentarile.

Materialul vegetal a fost redus dimensional cu ajutorul unei tocatori pentru plante medicinale, echipata cu un cutit tip ghilotina, care in timpul procesului de lucru are o miscare plan paralela, fiind unul din elementele unui mecanism patrulater. (fig.3) Una dintre barele acestuia, ce controleaza miscarea cutitului ancorat de inca un balansier pereche, este solidara cu un balansier, pe axa caruia se misca o culisa, purtata de butonul de manivela al unui mecanism manivela. Acesta se afla pe una din iesirile reductorului melc roata melcata actionat de motorul electric. La cealalta iesire se afla alta manivela cu raza reglabila, al carui

electric engine. At the other outlet, there is another crank with adjustable radius, whose crankpin slides along a balancer that commands the forward movement of conveying bands. The driving drums of the two conveying belts are coupled between them by a gear train. One of the wheels is intermitently driven by a unisense cylindrical coupling and a system of articulated levers, that transforms the balancer alternative movement into rotating oscillation of unisense coupling. The size of forward pace of conveying belts is set by adjusting the radius of crankpin handle. (fig.4)

maneton culiseaza de-alungul unui balansier care comanda miscarea de avans intermitenta a benzilor transportoare. Tamburii de antrenare a celor doua benzi transportoare sunt cuplati intre ei printr-un tren de roti dintate. Una dintre acestea este antrenata intermitent prin intermediul unui cuplaj cilindric unisens si al unui sistem de parghii articulate, care transforma miscarea alternativa a balansierului in miscare oscilanta de rotatie a cuplajului unisens. Prin reglarea razei manivelei manetonului se regleaza marimea pasului de inaintare al benzilor transportoare. (fig.4)

Fig.3 Mobile knife and driving system

Fig. 4 Bolt that modifies the handle radius

In order to operate the chopper of medicinal and aromatic plants, it is necessary to perform the following:

-check and set the extent of conveying belt;

-check the rolls and the extent of upper belt assuring the material compression;

-check the integrity of covers and protection guards

Medicinal plants (namely the dried ones), to be cut, have to be previously cleaned of foreign bodies (inorganic materials or other plants), as well as of damaged or infested parts.

First, the material feeding is set, then the plants are manually put on the band, so that the stems be oriented to belt movement direction. If possible, it is advised to use bunches of plants for a better handling and a more efficient cut. The chopped material is shown in fig 5. In fig 5a is shown Milfoil and in fig 5b is presented St. John's wort.

In fig. 6 are shown some aspects during the tests.

In vederea punerii in functiune a masinii de tocat plante medicinale si aromatice este necesar sa se efectueze:

-verificarea si reglarea întinderii benzii transportoare;

-verificarea rolelor si intinderea benzii superioare ce asigura presarea materialului;

-verificarea integritatii capacelor şi apărătorilor de protecție.

Plantele medicinale (in cazul nostru uscate), ce urmeaza a fi taiate, trebuie curatate în prealabil de corpurile străine (materiale anorganice sau alte plante), precum şi de părțile vătămate sau infestate conținute.

Se stabileste avansul materialului, apoi plantele sunt asezate manual pe banda, astfel incat tulpinile sa fie orientate pe directia de miscare a acesteia. Daca este posibil este indicat ca plantele sa fie sub forma de manunchiuri, pentru a fi manevrate mai usor si pentru realizarea unei taieri eficiente. Materialul ce a fost supus tocarii este prezentat in fig 5. In fig 5a este prezentata coada soricelului, iar in fig 5b este prezentata sunatoarea.

In fig. 6 sunt prezentate aspecte din timpul experimentarilor.

a) b)

Fig. 5- a) Dried Milfoil
b) Dried St. John's wort

Fig. 6- Aspects during the experiments

Determination of *quality of material mincing* aims to evaluate the mincing degree of medicinal plants and is performed at each theoretical cutting length, initially set.

Experiments have been made for a minimum advance of the band, similar to theoretical chopping length, namely of: 2mm, 4mm, 6.5mm, 8mm. 3 samples of 120 g each were collected out of material minced, appropriate for

Determinarea *calității maruntirii materialului* are ca scop evaluarea gradului de mărunțire a plantelor medicinale şi se efectuează la fiecare lungime teoretică de tăiere, reglată inițial.

Experimentarile au fost realizate pentru un avans al benzii, identic cu lungimea teoretica de tocare de: 2mm, 4mm, 6.5mm, 8mm. Din materialul mărunțit, pentru

each species and adjustment of conveying band pace. In order to determine the distribution of fractions obtained for the three adjustments of the machine, each sample was separated in fractions using the *Screening system Retsch of AS 200basic type.* Dimensions of sieve mesh are chosen according to band feeding. Therefore, for the sieves of screening system, the following dimensions have been chosen: 0.5 mm. 1.6mm, 2mm, 4mm, 6.3mm, 8mm, 10mm. For each plant, the separation time was of 6 min, and amplitude of screening vibrations was of 40mm for St. John's wort and 60mm for Milfoil.

RESULTS AND CONCLUSIONS

For every species and according to feeding, each of the three samples was introduced in the screening system, thus obtaining 8 fractions. They were weighed, masses average and shares being calculated..

The distribution of sorts of the two chopped plants is shown in table 1. Table values represent the average of the three samples collected from the chopped material obtained for each feeding adjustment, according to methodology.

fiecare specie si corespunzător fiecaruia dintre reglajele pasului benzii transportoare s-au colectează 3 probe a cate 120 g. Pentru a se determina distributia fractiilor obtinute pentru cele trei reglaje ale masinii, fiecare proba a fost separata in fractii utilizandu-se *Sistemul de sitare Retsch tip AS 200basic.* Dimensiunile ochiului sitelor se aleg in functie de valorile avansului benzii. Astfel pentru sitele sistemului de sitare s-au ales dimensiunile: 0,5 mm. 1,6mm, 2mm, 4mm, 6.3mm, 8mm, 10mm. Pentru fiecare planta timpul de separare a fost de 6 min, iar amplitudinea vibratiilor sitemului de sitare a fost de 40mm pentru sunatoare si 60mm pentru coada soricelului.

REZULTATE SI CONCLUZII

Pentru fiecare specie, corespunzator fiecarui avans, fiecare din cele trei probe a fost introdusa in sistemul de sitare, obtinandu-se 8 fractii. Acestea au fost cantarite, calculandu-se media maselor si ponderea.

In tabelul 1 se prezinta distributia sorturilor celor doua plante tocate. Valorile din tabel reprezinta media celor trei probe colectate din materialul tocat obtinut pentru fiecare reglaj al avansului, conform metodologiei.

Table 1

Distribution of chopped plant sorts

Den. No.	Length of material advance [mm]	Sieve mesh size [mm]	Sort	St. John's wort herb		Milfoil herb	
				Masa [g]	Share [%]	Mass [g]	Share [%]
1.	2	-	Sort 1 ≤0.5	8.41	7.01	11.9	9.92
2.		0.5	0.5<Sort 2 ≤16	31.20	25.99	30.01	25.01
3.		1.6	1.6<Sort 3≤2	3.93	3.27	8.26	6.88
4.		2	2<Sort 4≤4	57.55	47.95	44.68	37.23
5.		4	4<Sort 5≤6	13.95	11.62	14.79	12.32
6.		6.3	6<Sort 6≤8	1.55	1.3	2.24	1.87
7		8	8<Sort 7≤10	0.86	0.72	1.73	1.44
8.		10	10<Sort 8	2.57	2.14	6.4	5.33
9.	**Total**			120,02	100	120.01	100
10.	4	-	Sort 1 ≤0,5	7.09	5.91	11.03	9.19
11.		0.5	0,5<Sort 2 ≤1,6	30,1	25.08	29.14	24.27
12.		1.6	1,6<Sort 3≤2	3.19	2.65	5.01	4.17
13.		2	2<Sort 4≤4	8.89	7.41	18.39	15.32
14.		4	4<Sort 5≤6	59,86	49,88	47.68	39.72
15.		6.3	6<Sort 6≤8	1.45	1.21	2.37	1.98
16.		8	8<Sort 7≤10	0.85	0.71	1.86	1.55
17.		10	10<Sort 8	8.58	7.15	4.55	3.8
18.	**Total**			120,01	100	120.03	100
19.	6.5	-	Sort 1 ≤0,5	10.67	8.89	9.71	8.09
20.		0.5	0.5<Sort 2 ≤1,6	28.48	23.73	28.82	24.01
21.		1.6	1.6<Sort 3≤2	3.37	2.81	8.91	7.42
22.		2	2<Sort 4≤4	1.31	1.09	4.37	3.64
23.		4	4<Sort 5≤6	8.89	7.41	8.58	7.15
24.		6.3	6<Sort 6≤8	63.12	52.59	51.04	42.53
25.		8	8<Sort 7≤10	1.33	1.11	2.94	2.45
26.		10	10<Sort 8	2.85	2.37	5.64	4.71
27.	**Total**			120,02	100	120.01	100
28.	8	-	Sort 1 ≤0,5	7.02	5.85	11.12	9.26
29.		0.5	0,5<Sort 2 ≤1,6	26.01	21.67	24.48	20.4
30.		1.6	1,6<Sort 3≤2	2.81	2.34	6.37	5.3
31.		2	2<Sort 4≤4	1.04	0.87	1.51	1.26
32.		4	4<Sort 5≤6	6.48	5.40	11.62	9.68
33.		6.3	6<Sort 6≤8	1.41	1.17	1.79	1.49
34.		8	8<Sort 7≤10	63.83	53.18	54.99	45.82
35.		10	10<Sort 8	11.42	9.52	8.15	6.79
36.	**Total**			120,02	100	120.03	100

In figures 7,8,9,10 are comparatively presented the sorts distributions of the two chopped plants, for each theoretical cutting length for which the adjustment was

In figurile 7,8,9,10 sunt prezentate comparativ distributiile sorturilor celor doua plante obtinute prin tocare, pentru fiecare lungime teoretica de taiere, pentru care s-a facut

performed. The share of every sort represents the plant mincing degree.

reglajul. Ponderea fiecarui sort reprezinta gradul de maruntire al plantei.

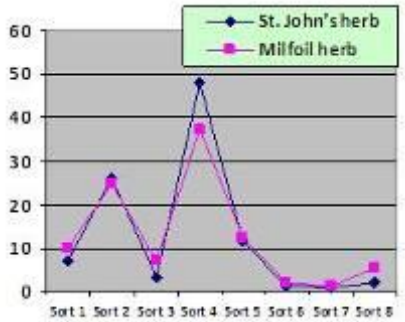

Fig. 7- Distribution of chopped plant sorts for an advance of 2mm

Fig. 8 - Distribution of chopped plant sorts for an advance of 4mm

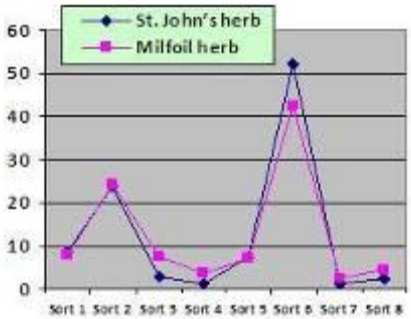

Fig.9 - Distribution of chopped plant sorts for a feeding advance of 6.5mm

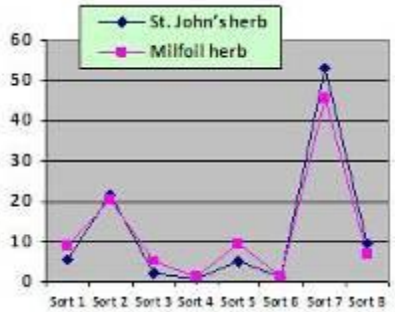

Fig. 10 - Distribution of chopped plant sorts for a feeding advance of 8mm

After reducing the herb size of the two medicinal plants chosen - Milfoil *(Achillea millefolium L)* and St. John's wort *(Hypericum perforatum L)* it was noticed that the share appropriate to adjustment of cutting length (advance length of feeding band) has increased. At the same time, sort 2 share is high irrespective of the advance length set. We consider this fact as a consequence of high temperature (38^0C-39^0C in the shadow) recorded during the tests performing, the medicinal plants humidity being very much reduced, thus increasing the crushing tendency. Sort 2 share decreases easily along with increment of theoretical cutting length.

In all the cases analyzed, the share of sort suitable to length of advance set is of approx. 50%, therefore it results that the cutting process has been appropriately achieved.

We should mention that in case of fractions of medicinal plants constituted in a homogenous mixture, the distribution mostly differs from seeds or grist distribution which have a uniform aspect. The sieving system was used with a higher vibration amplitude for Milfoil, due to presence of long and thin little hair on stem and leaves, that hampered the separation process.

In current case, the factors that have influenced the chopped material quality, were:

- plant morphology
- harvesting method (from St John's wort, has been harvested from the upper part 1/3 from stem, the flowers being mostly subject to shaking and crushinging; Milfoil has been harvested with stem longer than over 2/3);
- humidity of dried plants subject to chopping and atmospheric conditions;
- non-uniformity of material's thickness when feeding, having in view the different sizes of bundles.

In urma reducerii dimensionale a herbei celor doua plante medicinale alese - Coada soricelului *(Achillea millefolium L)* si Sunatoarea *(Hypericum perforatum L)* s-a observat cresterea ponderii sortului corespunzator reglajului lungimii teoretice de taiere (lungimii de avans a benzii de alimentare). De asemenea s-a observat ca ponderea sortului 2 este ridicata indiferent de lungimea de avans reglata. Consideram acest fapt ca o consecinta a temperaturile atmosferice foarte ridicate (38^0C-39^0C la umbra) inregistrate in perioada efectuarii experimentarilor, umiditatea plantelor medicinale a scazut foarte mult, sporind tendinta de sfaramare. Ponderea sortului 2 scade usor cu cresterea lungimii teoretice de taiere.

In toate cazurile analizate ponderea sortului corespunzator lungimii avansului reglat este de aprox. 50%, rezulta ca procesul de taiere s-a realizat corect.

Mentionam ca in cazul fractiilor plantelor medicinale ce se constituie intr-un amestec eterogen, distributia este mult diferita de cea a semintelor sau macinisurilor, care au un aspect uniform. Sistemul de sitare a fost utilizat cu o amplitudine mai mare a vibratiilor la herba de coada soricelului, datorita prezentei perisorilor lungi si fini de pe tulpina si frunze, care impiedicau realizarea procesului de separare.

In cazul de fata factorii care au influentat calitatea materialului obtinut la tocare au fost:

- morfologia plantei;
- modul de recoltare (de la sunatoare s-a recoltat din partea superioara 1/3 din tulpina, florile avand tendinta de scuturare sfaramare ridicata; coada soricelului s-a recoltat cu tulpina mai lunga peste 2/3);
- umiditatea plantelor uscate supuse tocarii si conditiile atmosferice;
- neuniformitatea grosimii stratului de material la alimentare, datorita dimensiunilor diferite ale

(Plants have to be introduced in the machine as they were dried. Bundles separation determines excessive crushing and shaking, before chopping).

Following the experimental results obtained when chopping Milfoil herb *(Achillea millefolium L)* and St. John's herb *(Hypericum perforatum L)* we recommend:

- advance length= 2mm for chopped vegetal material use in order to obtain pharmaceutical tablets;
- advance length =4mm and 6.5mm for chopped vegetal material use in order to obtain teabags and extracts;
- advance length=8mm for chopped vegetal material use in order to obtain bulk tea.

Different sorts obtained after chopping are explained by the utilization of vegetal matter for preparing different phytotherapeutic products according to *Farmacopeea Romana.*

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manunchiurilor. (Plantele trebuie introduse in masina asa cum au fost uscate. Separarea manunchiurilor provoaca sfaramarea si scuturarea excesiva, inainte de tocare).

In urma rezultatelor experimentale obtinute la tocare a herbei de Coada soricelului *(Achillea millefolium L)* si Sunatoarea *(Hypericum perforatum L)* recomandam:

- lungime avans= 2mm pentru utilizarea materialului vegetal tocat pentru obtinerea de comprimate;
- lungime avans=4mm si 6,5mm pentru utilizarea materialului vegetal tocat pentru ceaiuri plic si obtinerea de extracte;
- lungime avans=8mm pentru utilizarea materialului vegetal tocat pentru ceaiuri vrac.

Sorturile diferite obtinute in urma tocarii sunt justificate de utilizarea materialului vegetal pentru prepararea diverselor produse fitoterapeutice conf. *Farmacopeea Romana.*

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NUMERICAL METHOD FOR DETERMINING THE INERTIA PROPERTIES OF AN ARBITRARY SHAPED PLATE

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METODĂ NUMERICĂ PENTRU DETERMINAREA PROPRIETĂȚILOR INERȚIALE ALE UNEI PLĂCI DE FORMĂ ARBITRARĂ

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Abstract: *The paper presents a numerical method to determine the inertial characteristics (coordinates of the mass center, mechanical and geometrical moments and products of inertia) of a homogeneous arbitrary shaped plane plate. This method is based on some reduction theorems presented in published papers. The results are general and can be applied to a large variety of bodies. In the final part, two applications are presented, in order to illustrate the use of the proposed method and the results are compared with the results obtained by the analytical method.*

Keywords: *mass center, moment of inertia, product of inertia, geometric moment of inertia, homogenous plate.*

INTRODUCTION

In reference [5] a calculation method is presented for the inertial characteristics of some simple bodies, considered elementary. The method consists in finding discrete systems of material points, with equivalent inertia properties.

In references [4, 5, 7], it is shown that for a homogenous triangular plate, of mass m, an equivalent system can be found, composed of three points of mass $\frac{m}{12}$ placed in the corners and one of mass $\frac{3m}{4}$ placed in the mass center.

The reduction of bodies to discrete systems of material points can simplify calculations, as shown in [2, 5, 6, 8], since the proposed models have a reduced complexity and are adequate to processing with spreadsheet software applications, such as Excel.

In the present paper, the method is extended in order to determine approximately the inertial characteristics of arbitrary shaped homogeneous plates.

CALCULATION OF THE INERTIAL QUANTITIES OF A HOMOGENEOUS, SIMPLY CONNECTED PLATE

First the case of a homogeneous, simply connected, arbitrary shaped plate is considered, i.e. of a plate without cavities.

The curved contour of such a plate can be approximated by a large number of points. It follows that the plate can be divided into a large number of small triangles, which can be reduced to discrete material points, according to the above-mentioned method.

Even though the method is general, a particular case is considered, of plane plates defined by the points A_i (i=1,2,…,n) on the contour, for which a point O exists inside the plate or on its contour, so that all segments OA_i are contained by the surface of the plate (Fig. 9a).

The choice of the point O is not restrictive, but, if the plate has a symmetry plane, axis or point, the point O should lay on the symmetry element.

An orthogonal reference system Oxy is considered, with the origin in the point O chosen according to the above

Rezumat: *Lucrarea prezintă o metodă de calcul numeric a proprietăților inerțiale (coordonatele centrului de masă,i momente şi produse de inerție mecanice şi geometrice) ale unei plăci omogene plane de formă oarecare. Această metodă are la bază câteva teoreme de reducere prezentate în lucrări publicate. Rezultatele sunt generale şi pot fi aplicate pentru o varietate largă corpuri. În încheiere sunt prezentate două aplicații care ilustrează modul de utilizare a metodei propuse, rezultatele fiind comparate cu cele obținute prin metoda analitică.*

Cuvinte cheie: *centru de masă, moment de inerție, produs de inerție, moment de inerție geometric, placă omogenă.*

INTRODUCERE

În lucrarea [5] este prezentată o metodă de calcul a caracteristicilor inerțiale ale unor corpuri simple, considerate elementare. Metoda constă în găsirea unor sisteme discrete de puncte materiale care au proprietăți inerțiale echivalente.

În referințele [4, 5, 7] se arată că pentru o placă triunghiulară omogenă, de masă m, se poate găsi un sistemul echivalent, compus din trei puncte de masă $\frac{m}{12}$, plasate în colțuri şi unul de masă $\frac{3m}{4}$, plasat în centrul de masă.

Reducerea unor corpuri la sisteme discrete de puncte materiale poate conduce la simplificarea calculelor, aşa cum se arată în [2, 5, 6, 8], deoarece modele rezultate au o complexitate redusă şi sunt adecvate prelucrării cu programe de calcul tabelar, precum Excel.

În lucrarea de față, metoda este extinsă pentru determinarea aproximativă a caracteristicilor inerțiale ale unor plăci omogene de formă arbitrară.

CALCULUL MĂRIMILOR INERȚIALE ÎN CAZUL UNEI PLĂCII OMOGENE PLANE, SIMPLU CONEXE

Se consideră, pentru început, cazul unei plăcii omogene de formă arbitrară, simplu conexă, adică al unei plăci fără goluri interioare.

Conturul curb al unei astfel de plăci poate fi aproximat printr-un număr mare de puncte. Rezultă că placă poate fi împărțită într-un număr mare de triunghiuri mici, care pot fi reduse la sisteme discrete puncte materiale, conform metodei menționate.

Deşi metoda este generală, se va considera cazul plăcilor plane definite de punctele de pe contur A_i (i=1,2,…,n), pentru care există un punct O, în interiorul plăcii sau pe contur, astfel încât toate segmentele OA_i să fie conținute de suprafața plăcii (fig. 9a).

Alegerea punctului O nu este restrictivă, dar, dacă placa are un plan, o axă sau un punct de simetrie, este preferabil ca punctul O să se afle pe elementul de simetrie.

Se consideră un sistem de referință ortogonal Oxy, cu originea în punctul O ales în conformitate cu

assumption.
In order to determine numerically the approximate values of the inertial quantities of the homogeneous plates, the coordinates of the vertices of the rectilinear edges, the theoretical curve or the coordinates of a large enough number of points on these curves must be known. For the plates defined only by rectilinear edges, the proposed method leads to the exact values of the inertial quantities, as shown in reference [7].

presupunerea de mai sus.
Pentru a determina numeric valorile aproximative ale mărimilor inerțiale ale plăcilor omogene, este necesar să se cunoască coordonatele punctelor din capătul muchiilor drepte, curba teoretică sau coordonatele unui număr suficient de mare de puncte de pe aceste curbe. Pentru plăci având doar muchii drepte, metoda propusă conduce la determinarea exactă a mărimilor ce măsoară inerția plăcii, aşa cum se arată în lucrarea [7].

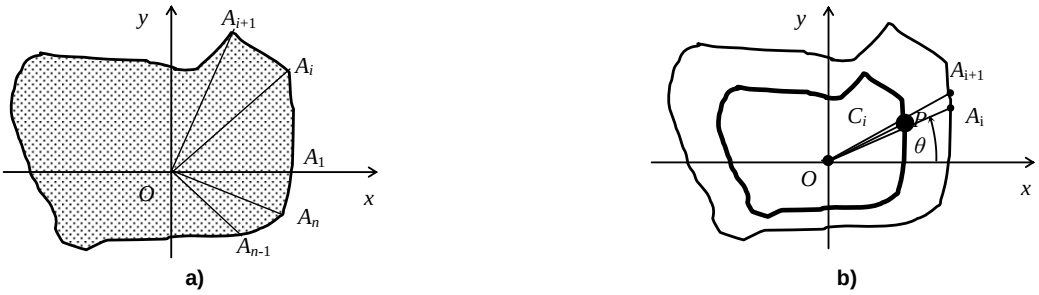

Fig. 9 – Arbitrary shaped homogeneous plan plate

The method presented in this paper is more general than the method in reference [7]. The presence of curved edges introduces approximations with precision dependent on the number of points used to define the edge. The way in which the reducing of an arbitrary shaped plate to a discrete system of material points can be made is shown in Figure 9b. Two successive points A_i and A_{i+1} on the edges of the plate form, together with point O, define the elementary triangular plate OA_iA_{i+1}, whose area can be calculated by means of the vector product,

Metoda prezentată în lucrarea de față are un caracter mai general decât cea din referința [7]. Prezența muchiilor curbe introduce aproximări a căror precizie depinde de numărul de puncte considerate pentru definirea muchiei. În figura 9b, este arătat modul în care se poate face reducerea unei plăci de formă oarecare la un sistem de puncte materiale. Două puncte consecutive A_i şi A_{i+1} de pe muchiile plăcii formează, împreună cu punctul O, placa triunghiulară elementară OA_iA_{i+1}, a cărei arie poate fi calculată cu ajutorul produsului vectorial,

$$\Delta S_i = \frac{1}{2}\left|\overrightarrow{OA_i} \times \overrightarrow{OA_{i+1}}\right| = \frac{1}{2}\left|\vec{r}_i\right|\left|\vec{r}_{i+1}\right|\sin\Delta\theta_i = \frac{1}{2} r_i r_{i+1} \sin\Delta\theta_i \quad \left(i = 1,2,\ldots,n, \qquad \vec{r}_{n+1} = \vec{r}_1\right), \tag{11}$$

where $\Delta\theta_i$ represents the angle between position vectors $\vec{r}_i$ and $\vec{r}_{i+1}$.
If the plate is homogeneous, its superficial density is constant and has the expression

unde $\Delta\theta_i$ reprezintă unghiul dintre vectorii de poziție $\vec{r}_i$ şi $\vec{r}_{i+1}$.
Dacă placa este omogenă, densitatea superficială a acesteia este constantă şi are expresia

$$\rho_s = \frac{m}{S} = \frac{\Delta m_i}{\Delta S_i} \quad \left(i = 1,2,\ldots,n\right). \tag{12}$$

According to the theorem presented in [3], it follows that a homogeneous plate with the masses of the triangular elements

Conform teoremei prezentate in [3], rezultă că o placă omogenă cu masele elementelor triunghiulare

$$\Delta m_i = \rho_S \Delta S_i \tag{13}$$

can be reduced to a system of material points with the following masses (Fig. 9 b): $O\left(\frac{m}{12}\right)$, $A_1\left(\frac{\Delta m_n + \Delta m_1}{12}\right)$, $A_2\left(\frac{\Delta m_1 + \Delta m_2}{12}\right)$, $\ldots$, $A_n\left(\frac{\Delta m_{n-1} + \Delta m_n}{12}\right)$, $C_1\left(\frac{3\Delta m_1}{4}\right)$, $C_2\left(\frac{3\Delta m_2}{4}\right), \ldots, C_n\left(\frac{3\Delta m_n}{4}\right)$.
The coordinates of the mass centers can be determined from the vector expression

poate fi redusă la un sistem de puncte materiale cu următoarele mase (fig. 9 b): $O\left(\frac{m}{12}\right)$, $A_1\left(\frac{\Delta m_n + \Delta m_1}{12}\right)$, $A_2\left(\frac{\Delta m_1 + \Delta m_2}{12}\right)$, $\ldots$, $A_n\left(\frac{\Delta m_{n-1} + \Delta m_n}{12}\right)$, $C_1\left(\frac{3\Delta m_1}{4}\right)$, $C_2\left(\frac{3\Delta m_2}{4}\right), \ldots, C_n\left(\frac{3\Delta m_n}{4}\right)$.
Coordonatele centrelor de masă pot fi determinate din expresia vectorială

$$\vec{r}_{C_i} = \frac{\vec{r}_i + \vec{r}_{i+1}}{3} \quad \left(i = 1,2,\ldots,n, \qquad \vec{r}_{n+1} = \vec{r}_1\right). \tag{14}$$

If the positions of the points A_i in polar coordinates, i.e. through equations of the form $r_i = r(\theta_i)$ $(i = 1,2,\ldots,n)$, are known, then the plate area between two consecutive

Dacă se cunosc pozițiile punctelor A_i în coordonate polare, adică prin ecuații de forma $r_i = r(\theta_i)$ $(i = 1,2,\ldots,n)$, atunci aria plăcii cuprinsă între două puncte consecutive A_i, A_{i+1},

points A_i, A_{i+1}, can be approximated by relationship (11) and the plate can be reduced to a material point, O, with the mass equal to 1/6 of the whole mass of the body and two curves: one is defined by the contour of the plate and the other by the vectors $\frac{2}{3}\overrightarrow{OA_i}$ (fig. 9b).

Obviously, as shown in [4], if these curves are considered continuous, they are non-homogeneous, with the linear density depending on the distances between O and the points on the contour:

poate fi aproximată cu relația (11), iar placa poate fi redusă la un punct material, O, cu masa egală cu 1/6 din întreaga masă a corpului şi două curbe: una definită de conturul plăcii, iar alta de vectorii $\frac{2}{3}\overrightarrow{OA_i}$ (fig. 9b).

Evident, aşa cum este arătat şi în [4], dacă aceste curbe sunt considerate continue, ele sunt neomogene, cu densitatea liniară dependentă de distanțele dintre O şi punctele situate pe contur:

$$\rho_l = \lambda \frac{\Delta m_i}{\Delta s_i} = \frac{\lambda \rho_S r_i r_{i+1}}{2\sqrt{r_i^2 + r_{i+1}^2 - 2 r_i r_{i+1} \cos\Delta\theta_i}}, \qquad \lambda = \begin{cases} 1/2 & \text{for the inner curve / pentru curba interioară} \\ 1/6 & \text{for the outer curve / pentru curba exterioară.} \end{cases} \tag{15}$$

The position of the center of mass of the plate is calculated by the vector expression

Poziția centrului de masă al plăcii se calculează cu expresia vectorială

$$\vec{r}_C = \frac{1}{m}\left(\sum_{i=1}^{n}\frac{\Delta m_i}{12}\vec{r}_i + \sum_{i=1}^{n}\frac{\Delta m_i}{12}\vec{r}_{i+1} + \sum_{i=1}^{n}\frac{3\Delta m_i}{4}\frac{\vec{r}_i + \vec{r}_{i+1}}{3}\right) = \frac{1}{3m}\sum_{i=1}^{n}\Delta m_i\left(\vec{r}_i + \vec{r}_{i+1}\right) =$$
$$= \frac{1}{6S}\sum_{i=1}^{n} r_i r_{i+1}(\vec{r}_i + \vec{r}_{i+1})\sin\Delta\theta_i \qquad \left(i = 1,2,\ldots,n, \qquad \vec{r}_{n+1} = \vec{r}_1\right), \tag{16}$$

where S is the total area of the plate:

în care S este aria totală a plăcii:

$$S = \sum_{i=1}^{n}\Delta S_i = \frac{1}{2}\sum_{i=1}^{n} r_i r_{i+1}\sin\Delta\theta_i\ . \tag{17}$$

The expressions of the moments and products of inertia can be determined from the definition relations for discrete systems of material points [3]:

Expresiile momentelor de inerție se pot determina din relațiile de definiție pentru sisteme discrete de puncte materiale [3]:

$$\begin{cases} J_x = \frac{1}{12}\sum_{i=1}^{n}\Delta m_i\left[y_i^2 + y_{i+1}^2 + (y_i + y_{i+1})^2\right], \quad J_y = \frac{1}{12}\sum_{i=1}^{n}\Delta m_i\left[x_i^2 + x_{i+1}^2 + (x_i + x_{i+1})^2\right], \quad J_z = J_x + J_y \\ J_{xy} = \frac{1}{12}\sum_{i=1}^{n}\Delta m_i\left(2x_i y_i + 2x_{i+1}y_{i+1} + x_i y_{i+1} + x_{i+1}y_i\right), \quad J_{yz} = 0, \quad J_{zx} = 0. \end{cases} \tag{18}$$

Substituting elementary masses (13) in relations (18) and dividing by the density, the formulas of the geometrical moments and product of inertia are obtained:

Înlocuind masele elementare (13) în relațiile (18) şi împărțind la densitate, se obțin formulele momentelor şi produsului de inerție geometrice:

$$\begin{cases} I_x = \frac{1}{12}\sum_{i=1}^{n} r_i r_{i+1}\cdot(y_i^2 + y_{i+1}^2 + y_i y_{i+1})\sin\Delta\theta_i, \quad I_y = \frac{1}{12}\sum_{i=1}^{n} r_i r_{i+1}\cdot(x_i^2 + x_{i+1}^2 + x_i x_{i+1})\sin\Delta\theta_i \\ I_z = I_x + I_y = \frac{1}{12}\sum_{i=1}^{n} r_i r_{i+1}\cdot(r_i^2 + r_{i+1}^2 + x_i x_{i+1} + y_i y_{i+1})\sin\Delta\theta_i, \quad I_{xy} = \frac{1}{24}\sum_{i=1}^{n} r_i r_{i+1}(2x_i y_i + 2x_{i+1}y_{i+1} + x_i y_{i+1} + x_{i+1}y_i)\sin\Delta\theta_i. \end{cases} \tag{19}$$

If the edges are rectilinear, the points A_i are chosen in the vertices, as shown in [7]. If the plate has curved edges with high radial variations with respect to O, the points A_i should be chosen so that parameters $\Delta\theta_i$ are low.

If the point A_1 is chosen at the intersection of the contour with axis Ox, then $\theta_1 = 0$ and

În cazul muchiilor drepte, punctele A_i se aleg în vârfurile acestor muchii, aşa cum a fost demonstrat în [7]. Dacă placa are muchii curbe cu variații radiale mari în raport cu O, atunci punctele A_i se aleg astfel încât parametrii $\Delta\theta_i$ sa fie mici.

Dacă se alege punctul A_1 la intersecția conturului cu axa Ox, atunci $\theta_1 = 0$ şi

$$x_i = r_i\cos\theta_i, \qquad y_i = r_i\sin\theta_i, \qquad \theta_i = \sum_{j=1}^{i}\Delta\theta_j \quad (i = 1,2,\ldots,n). \tag{20}$$

CALCULATION OF THE INERTIAL QUANTITIES OF A HOMOGENEOUS, MULTIPLY CONNECTED PLATE

If the plate is homogeneous, but double connected, i.e. it contains a cavity, the calculation method can be applied in the same manner, by using, were the case, Steiner's Theorem and by considering negative values for the inertial quantities of the extracted part:

CALCULUL MĂRIMILOR INERȚIALE ÎN CAZUL UNEI PLĂCII OMOGENE, MULTIPLU CONEXE

Dacă placa este omogenă, dar dublu conexă, adică prezintă un gol interior, metoda de calcul prezentată poate fi aplicată în acelaşi mod, utilizând, unde este cazul, teorema lui Steiner şi considerând valori negative pentru mărimile inerțiale ale porțiunii extrase:

$$I_\Theta = I_\Theta^1 - I_\Theta^2, \tag{21}$$

where superscript 1 denotes the complete plate (without

unde indicele superior 1 denotă placa considerată plină

cavity), while superscript 2 denotes the cavity.
If the cavity is arbitrary shaped, the approximate inertia properties will be determined using the above method.
If the plate is multiply connected, i.e. it presents N cavities, the calculation described at the double connected case is applied repeatedly.

(fără gol), iar indicele superior 2 denotă golul.
În cazul în care golul interior are formă arbitrară, se va proceda în aproximarea proprietăților de inerție prin metoda de mai sus.
Dacă placa este multiplu conexă, adică prezintă N goluri interioare, se aplică în mod repetat calculul descris în cazul dublu conex.

APPLICATION 1

General relations determined above find an immediate use for any homogeneous plane plate, if it meets the mentioned geometric condition, that point O is chosen inside the plate or on its contour, so that no segment OA_i (i=1,2,…,n) intersects any edge of the polygon:
In order to verify the correctness and accuracy of the proposed method, first an elliptical shaped, homogeneous pane plate is considered (fig. 10a), with the semiaxes $a = 1\,\mathrm{m}$ and $b = 2\,\mathrm{m}$. The points A_i (i=1,2,…,n) on the contour, necessary for the approximate calculation (Fig. 10b), are chosen so that the successive radii OA_i and OA_{i+1}, form the equal angles

APLICAȚIA 1

Relațiile generale determinate mai sus îşi găsesc o utilizare imediată pentru orice placă plană omogenă, dacă se respectă condiția geometrică menționată, ca punctul O să fi ales în interiorul plăcii sau pe contur, astfel încât niciun segment OA_i (i=1,2,…,n) să nu intersecteze vreo muchie a poligonului.
Pentru a verifica corectitudinea şi precizia metodei propuse, se consideră mai întâi o placă plană omogenă, de formă eliptică (fig. 10a), cu semiaxele $a = 1\,\mathrm{m}$ şi $b = 2\,\mathrm{m}$. Punctele de pe contur A_i (i=1,2,…,n), necesare pentru calculul aproximativ (fig. 10b), sunt alese astfel încât razele succesive, OA_i şi OA_{i+1}, să formeze între ele unghiurile egale

$$\Delta\theta_i = \frac{2\pi}{n}. \tag{22}$$

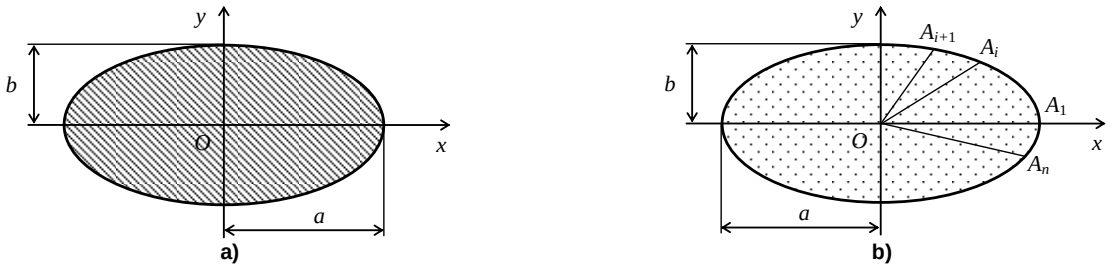

Fig. 10 – An elliptical homogenous plane plate

Analytical formulas are known for this plate [1],

Pentru această placă se cunosc formulele [1]

$$S = \pi ab, \tag{23}$$

$$I_x = \frac{\pi ab^3}{4}, \quad I_y = \frac{\pi a^3 b}{4}, \quad I_z = I_x + I_y = \frac{\pi ab\left(a^2 + b^2\right)}{4}, \quad I_{xy} = 0. \tag{24}$$

With these formulas, the exact values are obtained:

Cu aceste formule, se obțin valorile exacte

$$S = 6.2832\,\mathrm{m}^2, \quad I_x = 1.5708\,\mathrm{m}^4, \quad I_y = 6.2832\,\mathrm{m}^4. \tag{25}$$

The approximate values obtained with the proposed method, as well as the corresponding relative errors are shown in Table 2, for several values of the discretization parameter n.

Valorile aproximative obținute cu metoda propusă, precum şi erorile relative corespunzătoare, sunt afişate în tabelul 2, pentru diferite valori ale parametrului de discretizare n.

Table 2

Approximate results for the elliptical plate

n	$\tilde{S}$	$\tilde{I}_x$	$\tilde{I}_y$	ε_S [%]	ε_{Ix} [%]	ε_{Iy} [%]
10	5.6382	1.3839	4.6583	-10.266	-11.899	-25.861
20	6.0998	1.5248	5.7528	-2.918	-2.927	-8.441
50	6.2529	1.5633	6.1924	-0.482	-0.475	-1.445
100	6.2756	1.5689	6.2603	-0.121	-0.119	-0.365
200	6.2813	1.5703	6.2774	-0.03	-0.03	-0.091

APPLICATION 2

A plate whose inertial properties can be determined exactly is presented in Figure 11a. The points chosen for the approximation are shown in Figure 11 b.
The calculation data are included in Table 3.

APLICAȚIA 2

În figura 11a este prezentată o placă pentru care se pot determina exact proprietățile de inerție. Punctele alese pentru aproximare sunt arătate în figura 11b.
Datele de calcul sunt incluse în tabelul 3.

Table 3

Calculation data /
Datele de calcul

Point / *Punct*	1	2	3	4	5	6	7	8
$r_i / a = OA_i / a$	5	5.831	5.198	5.071	5.198	5.831	5	0
$\Delta\theta_i$ [rad]	0.5404	0,1134	0.1393	0.1393	0,1134	0.5404	0	-

a) b)

Fig. 11 - A homogenous plate

1. Determination of the exact value
The area of the plate calculated exactly is:

1. Determinarea valorilor exacte
Aria plăcii calculată exact este:

$$S = \sum_{i=1}^{2} S_i = 25a^2 \cdot 2.5a - \pi a^2 = 21.8584a^2 \,. \tag{26}$$

The coordinates of the mass center have the following exact expressions:

Coordonatele centrului de masă au următoarele expresii exacte:

$$x_C = y_C = \frac{1}{S}\sum_{i=1}^{2} S_i x_i = \frac{25a^2 \cdot 2.5a - \pi a^2\left(5a - \frac{8a}{3\pi}\right)}{25\,a^2 - \pi a^2} = \frac{49.459a^3}{21.858a^2} = 2.2627a \,. \tag{27}$$

The exact geometric moments of de inertia are:

Momentele de inerție geometrice exacte sunt:

$$I_x = I_y = I_x^{C1} - I_x^{C2} = \frac{625a^4}{3} - \left[\frac{\pi a^2 \cdot 4a^2}{4} - \pi a^2 \cdot \left(\frac{8a}{3\pi}\right)^2 + \pi a^2 \cdot \left(5a - \frac{8a}{3\pi}\right)^2\right] = 153.318a^4 \tag{28}$$

The exact geometric product of de inertia is:

Produsul de inerție geometric exact este:

$$I_{xy} = I_{xy}^{C1} - I_{xy}^{C2} = \frac{625a^4}{4} - \left[2a^4 - \pi a^2 \cdot \left(\frac{8a}{3\pi}\right)^2 + \pi a^2 \cdot \left(5a - \frac{8a}{3\pi}\right)^2\right] = 102.376a^4 \,. \tag{29}$$

2. Determination of the approximate values
The approximate area of the plate is

2. Determinarea valorilor aproximative
Aria plăcii aproximativă este

$$\tilde{S} = \sum_{i=1}^{6} S_i = \frac{1}{2}\sum_{i=1}^{6} r_i r_{i+1} \sin\Delta\theta_i = 22.085a^2 \,. \tag{30}$$

The coordinates of the mass center have the following approximate values:

Coordonatele centrului de masă au următoarele valori aproximative:

$$\tilde{x}_C = \tilde{y}_C = \frac{1}{3S}\sum_{i=1}^{6} S_i (x_i + x_{i+1}) = 2.2634a \,. \tag{31}$$

The approximate geometric moments and product of inertia calculated with relations (19) are

Momentele şi produsul de inerție geometrice aproximative calculate cu relațiile (19) sunt:

$$\tilde{I}_x = \tilde{I}_y = \frac{1}{6}\sum_{1}^{n-1} \tilde{S}_i \cdot (y_i^2 + y_{i+1}^2 + y_i y_{i+1}) = 154.797a^4, \qquad \tilde{I}_{xy} = \frac{1}{12}\sum_{i=1}^{n-1} \tilde{S}_i (2x_i y_i + 2x_{i+1}y_{i+1} + x_i y_{i+1} + x_{i+1} y_i) = 103.843a^4. \tag{32}$$

3. Determination of the errors of the proposed method
By comparing the values obtained by the proposed method with the exact ones, the following errors result:

3. Determinarea erorilor metodei propuse
Comparând valorile obținute prin metoda propusă, cu cele exacte, rezultă următoarele erori:

- for the calculation of the area,

- pentru calculul ariei,

$$\varepsilon_S = 1.04\%; \quad (33)$$

- for the calculation of the moments and products of inertia, respectively,

- pentru calculul momentelor, respectiv al produsului de inerție,

$$\varepsilon_{Ix} = \varepsilon_{Iy} = \frac{154.797 - 153.31}{153.31} \cdot 100 = 0.97\%, \quad \varepsilon_{Ixy} = \frac{103.84 - 102.37}{102.37} \cdot 100 = 1.47\%. \quad (34)$$

From the obtained results, it follows that the proposed calculation method is correct and is highly accurate, as shown by errors (34), even if for the curved contour only a few points were chosen.

Din rezultatele obținute rezultă că metoda de calcul propusă este corectă şi că are un grad de precizie ridicat, aşa cum arată erorile (34), chiar în condițiile în care pentru conturul curb a fost ales un număr mic de puncte.

CONCLUSIONS

The proposed method for calculating the properties of inertia of a homogeneous arbitrary shaped plane plate allows for a quick calculation, with high accuracy, if it is associated with a spreadsheet software application.
The method can be used for the calculation of the inertia properties of any plane profile used in a mechanism.
Also, the method can determine the properties of inertia for plates of arbitrary shape, even for those with internal cavities.
Together with a tool for measuring the polar coordinates of a finite number of points located on the contour of a plate, the method can be used for teaching, as well as in industrial deign, without the need to represent the plate in a CAD software.

CONCLUZII

Metoda propusă pentru calculul proprietăților de inerție pentru o placă plană omogenă de formă arbitrară permite un calcul rapid şi de precizie ridicată, dacă este asociată cu un program de calcul tabelar.
Metoda poate fi utilizată pentru calcul proprietăților de inerție pentru orice tip de profil plan utilizat într-un mecanism.
De asemenea, prin această metodă se pot determina proprietățile de inerție pentru plăci de orice formă, chiar şi pentru cele care au goluri interioare.
Împreună cu un instrument care să permită măsurarea coordonatelor polare ale unui număr finit de puncte, situate pe conturul unei plăci, metoda poate fi utilizată în scop didactic, precum şi în proiectare, fără a necesita ca placa să fie desenată în programe de tip CAD.

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RESEARCHES REGARDING THE INTRINSIC VALUES OF ROTATING DISKS SUBJECTED TO CHANGING TEMPERATURE ALONG THE RADIUS AND THICKNESS
/
CERCETĂRI TEORETICE CU PRIVIRE LA VALORILE PROPRII ALE DISCURILOR ÎN MIŞCARE DE ROTAȚIE, SUPUSE LA TEMPERATURI VARIABILE PE RAZĂ ŞI GROSIME

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Abstract: The present paper presents the research regarding the stability of rotating disks, subjected to changing temperature along the radius and thickness.

The stability calculations comply with the hypothesis of the external and internal forces equilibrium of the structure, at a given moment. It is accepted that within certain limits, a minor change of the load will not lead to a disproportionate increase of the state of stress and strain.

The calculation of the plates' thermo-elastic stresses is extremely complex, being related to the solution of some non-linear equations within variable coefficients. In case of the temperature's change along the disk's radius and thickness, temperature gradients arise. In this situation the bending stresses arise too, simultaneous with the membrane stresses (changing temperature on radius and rotation).

The establishment of the buckling critical temperature is intended. The stability loss is achieved through axially-symmetric modes (nodal circles modes), but also through asymmetric modes (nodal diameter modes). Practice shows that especially the intrinsic modes with zero nodal circles are of interest. Under these circumstances the lowest critical stresses and intrinsic frequencies are obtained, respectively.

The disk's rotation under constant angular velocity ω lead to a membrane stress field, namely traction stresses. This field exerts a great influence upon the field given by the temperature inequality along the radius and the significant influence upon the loss of the disk's elastic stability has been established. The above mentioned influence is emphasized by the theory exposed in the first part of the paper, meaning intrinsic values issues.

Keywords: Stability, disk, intrinsic values problems, membrane stresses, critical stresses.

Rezumat: Lucrarea de față prezintă cercetările teoretice cu privire la stabilitatea discurilor aflate în mişcare de rotație uniformă, supuse la temperaturi variabile pe rază şi grosime. Calculele de stabilitate sunt acceptate în ipoteza necesității unui echilibru între sarcinile externe şi eforturile interioare din structură, la un moment dat. Se acceptă că, în anumite limite, o uşoară modificare a sarcinilor nu va produce o creştere disproporționată a stării de tensiune şi de deformație. Calculul tensiunilor termoelastice în plăci este foarte complex, acesta fiind legat de rezolvarea unor ecuații neliniare cu coeficienți variabili. În cazul în care temperatura variază atât pe raza discului, dar şi pe grosime, iau naştere gradienți de temperatură; în acest caz, concomitent cu tensiunile de membrană (temperatură variabilă pe rază şi mişcare de rotație), iau naştere şi tensiuni de încovoiere. Se urmăreşte determinarea temperaturii critice de flambaj. Pierderea stabilității se face prin moduri axial-simetrice (moduri cu cercuri nodale), dar şi prin moduri nesimetrice (moduri cu diametre nodale). S-a constatat că în practică interesează mai ales modurile proprii cu zero cercuri nodale; în aceste situații se obțin tensiunile critice cele mai mici, respectiv frecvențele proprii minime.

Mişcarea de rotație a unui disc cu viteza unghiulară constantă ω, dă naştere unui câmp de tensiuni de membrană, tensiuni de tracțiune. Acest câmp introduce o mare influență asupra câmpului dat de diferența de temperatură pe rază şi s-a constatat că are implicații apreciabile asupra fenomenului de pierdere a stabilității elastice a discurilor. Influența amintită se arată prin teoria expusă în prima parte a acestui articol, cu referire la probleme de valori proprii.

Cuvinte cheie: *Stabilitate, probleme de valori proprii, tensiuni membranare, tensiuni critice.*

INTRODUCTION

The rotation of a disk with constant angular velocity ω leads to a membrane stresses field; traction stresses which can be solved with the equations below [4]:

INTRODUCERE

Rotația unui disc cu viteză unghiulară constantă ω, produce un camp de tensiuni membranare, tensiuni de tracțiune, care poate fi rezolvat cu ajutorul ecuațiilor:

$$\begin{cases} \sigma_r = \dfrac{EA}{1-\nu} - \dfrac{EB}{r^2(1+\nu)} - \dfrac{3+\nu}{8}\cdot\dfrac{\gamma}{g}\cdot\omega^2 r^2; \\ \sigma_\theta = \dfrac{EA}{1-\nu} + \dfrac{EB}{r^2(1+\nu)} - \dfrac{1+3\nu}{8}\cdot\dfrac{\gamma}{g}\cdot\omega^2 r^2, \end{cases} \tag{1}$$

where the constant values A and B are determined as a function depending on the imposed support condition, for each case partly;

- E represents the material's longitudinal modulus of elasticity;
- ν - is Poisson's ratio;
- $\frac{\gamma}{g}$ - is the specific mass of the disk's material;

The authors use within the present paper the

unde constantele A şi B se determină în funcție de condițiile de legătură impuse discurilor, pentru fiecare caz în parte.

- E – reprezintâ modulul de elasticitate longitudinal;
- ν - coeficientul lui Poisson;
- $\frac{\gamma}{g}$ - reprezintă masa specifică a materialului discului.

Autorii au utilizat în lucrarea de față următoarele legi

following law for the temperature's distribution along the disk radius:

de distribuție a temperaturii în funcție de raza discului:

$$T = T_0\left(\frac{r}{b}\right)^{\gamma} \text{ or } T_0 = \frac{\Delta T}{1-\left(\frac{a}{b}\right)^{\gamma}}, \tag{2}$$

where γ = 1/3, ½, 1, 2 … 30, *a* and *b* represent the inner and the outer radius of the disk, respectively.

în care γ = 1/3, ½, 1, 2 … 30, *a* şi *b* reprezentând raza interioară, respectiv exterioară a discului.

MATERIAL AND METHOD

One tackles the case where the approach of the plates subjected to static or dynamic bending, is made in the presence of a membrane stresses field, of rotation, and of a field of temperature whose distribution along the radius is variable. It starts with the equation presented below:

MATERIAL ŞI METODĂ

Se consideră cazul în care studiul plăcilor plane supuse la încovoiere static sau dinamică se efectuează în prezența câmpului de tensiuni membranare, de rotație şi a câmpului de temperature variabile în lungul razei.

Se porneşte de la următoarea ecuație:

$$D\Delta^2 w + G(\varphi, w) + \rho h\frac{\partial^2 w}{\partial t^2} = q \tag{3}$$

where ρ is the density of the material, the other values being mentioned in the above sections of the present paper.

FEM is applied to the above equation and the partial derivatives equation is replaced by a linear system of equations:

relație în care ρ reprezintă densitatea materialului, ceilalți termeni fiind specificați în paragraful anterior al prezentei lucrări.

MEF se aplică ecuației anterioare, iar ecuația cu derivate parțiale este înlocuită cu un system de ecuații liniare:

$$([K]+[K_G])\{u\}+[M]\{\ddot{u}\}=\{P\} \tag{4}$$

The decomposition of the displacement vector {u} in the eigenvectors space is effected and it obtains the solution of the problem given by the equation (4).

Two intrinsic values issues are formulated:

Se efectuează descompunerea vectorului deplasare {u} în spațiul vectorilor proprii, obținându-se soluția problemei dată de ecuația (4).

Sunt formulate două probleme de valori proprii:

$$([K]+\lambda[K_G])\{u\}=0 \tag{5}$$

which lead to the critical value of the membrane stresses, for which the loss of stability because of fork occurrence.

care conduc la valori critice ale tensiunilor membranare, pentru care aparare pierderea stabilității din cauza bifurcării:

$$[K]-\omega^2[M]\{u\}=0 \tag{6}$$

The above equation leads to the frequencies and the natural modes of vibration of the plates.

Finally, the solution of the intrinsic values problem (4) is written as follows:

Ecuația conduce la determinarea frecvențelor şi a modurilor proprii de vibrație ale plăcilor.

În final, soluția problemei de valori proprii (4) se scrie, după cum urmează:

$$([K]+\lambda[K_G]-\omega^2[M])\{u\}=0 \tag{7}$$

Other aspects concerning the concrete results as well as diagrams plotting will be treated in a future paper.

Alte aspecte privind rezultatele concrete obținute, precum şi trasarea diagramelor, vor fi tratate ulterior.

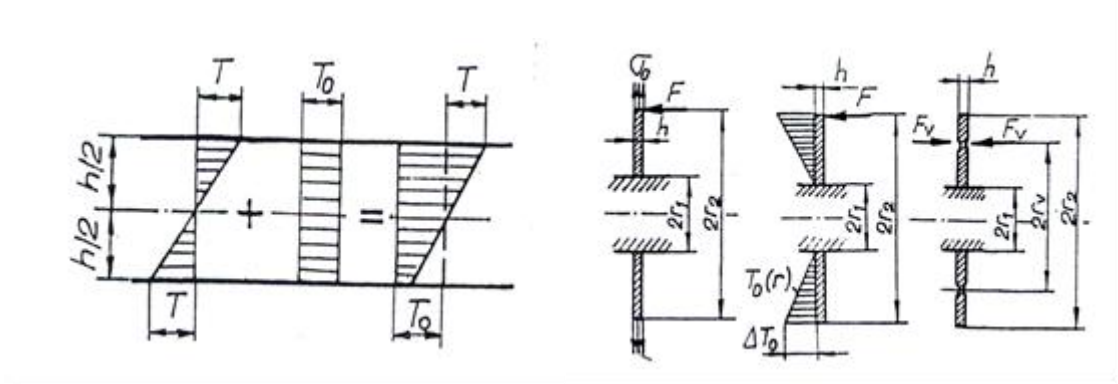
RESULTS

This stresses field introduces a great influence upon the membrane stresses field given by the change of temperature along the radius and it is established that its implication on the appearance of elastic stability loss at disks is very important.

The above mentioned influence is put on evidence on basis of the exposed theory, meaning equations (4) and (5), which are intrinsic values issues leading to the determination of critical membrane stresses, where the stability loss may occur and to the determination of vibration intrinsic frequencies and intrinsic modes, respectively.

REZULTATE

Acest câmp de tensiuni introduce o mare influență asupra câmpului tensiunilor membranare, date de variația temperaturii pe rază şi s-a stabilit importanța pe care o are în ceea ce priveşte pierderea stabilității elastice a discurilor. Această influență este pusă în evidență pe baza teoriei expuse, a ecuațiilor (4) şi (5), care reprezintă probleme de valori proprii, conducând la determinarea tensiunilor de membrană critice, când poate apărea pierderea stabilității, a frecvențelor vibrațiilor proprii şi a modurilor proprii



a b

Fig. 1. Temperature distribution – a.- on thickness, b. – along the radius

The parabolic dependence between the intrinsic values Ω_i and ω_i was established and it is put into evidence that in the case of more existing membrane stresses fields which work simultaneously, the elastic loss of stability at disks occurs when the following equation is accomplished:

A fost stabilită dependența parabolică a valorilor proprii Ω_I de ω_I şi s-a pus în evidență faptul că în prezența mai multor câmpuri de tensiuni membrane simultane, pierderea stabilității elastice apare atunci când este îndeplinită următoarea relație

$$\sum \frac{\lambda^n}{\lambda_i^n} = 1 \tag{8}$$

It is assumed that the critical stresses given by the two studied membrane stresses fields are known (rotational motion and temperature).

It is emphasized the linear dependence of the critical fields mentioned above, given by equation:

Se presupune că tensiunile critice, date de cele două câmpuri membranare studiate, sunt cunoscute (mişcare de rotație şi temperatură).

Este pusă în evidență dependența liniară a câmpurilor critice menționate anterior, dată de relația:

$$\frac{\lambda^T}{\lambda_{cr}^T} + \frac{\lambda^R}{\lambda_{cr}^R} = 1 \tag{9}$$

where λ^T represents the intrinsic values due to the membrane stresses field given by the change of temperature along the radius; λ^R – represents the intrinsic values due to the membrane stresses field given by the rotational motion.

Following replacements are performed in eq.9, as presented below:

în care λ^T reprezintă valorile proprii date de câmpul de tensiuni membranare generate de variația temperaturii pe rază; λ^R – reprezintă valorile proprii datorate câmpului de tensiuni membranare, generat de mişcarea de rotație.

Se înlocuiesc următoarele expresii în ecuația (9), după cum urmează:

$$T_{cr} = \lambda_{cr}^T \cdot T_0 ,$$
$$\omega_{cr}^2 = \lambda_{cr}^2 \cdot \omega_0^2 ,$$

obtaining:

obținându-se:

$$\frac{\lambda^T \cdot T_0}{T_{cr}} + \frac{\lambda^R \cdot \omega_0^2}{\omega_{cr}^2} = 1 \tag{10}$$

If the intrinsic values comply the expression $\lambda^T \cong \lambda^R \cong \lambda$, from equation (10) ensues:

Dacă valorile proprii îndeplinesc condiția $\lambda^T \cong \lambda^R \cong \lambda$, din ecuația (10) rezultă:

$$\lambda = \frac{1}{\frac{T_0}{T_{cr}} + \frac{\omega_0^2}{\omega_{cr}^2}} \tag{11}$$

It reaches to a very important conclusion, that $\lambda = 1$ at the superposition of the effects of the two membrane stresses fields only if the following condition, given by

Se ajunge la o concluzie foarte importantă, şi anume, $\lambda = 1$, în cazul suprapunerii efectelor a două câmpuri de tensiuni membranare, doar dacă este îndeplinită

eq.(12), is accomplished:

următoarea condiție, dată de ecuația (12):

$$\frac{T_0}{T_{cr}} + \frac{\omega_0^2}{\omega_{cr}^2} = 1 \tag{12}$$

getting finally the equation :

Obținându-se, în final, ecuația:

$$T_0 = \left(1 - \frac{\omega_0^2}{\omega_{cr}^2}\right) T_{cr} \tag{13}$$

where T_0 represents the change of temperature along the radius due to which the elastic stability loss by the disk branching off (buckling) occurs, in the presence of the two membrane stresses fields .

Fig. 2 shows the change of critical temperatures for stability loss as a function of the disk radius ratio, for different combinations of the number of nodal diameters and nodal circles.

În care T_0 reprezintă variația temperaturii pe rază, datorită căreia pierderea stabilității elastice a discului se produce datorită flambajului prin bifurcare, în prezența a două câmpuri de tensiuni membranare.

În figura 2 este redată variația temperaturilor critice de pierdere a stabilității în funcție de raportul razelor, pentru diferite combinații a numărului diametrelor nodale şi a cercurilor nodale.

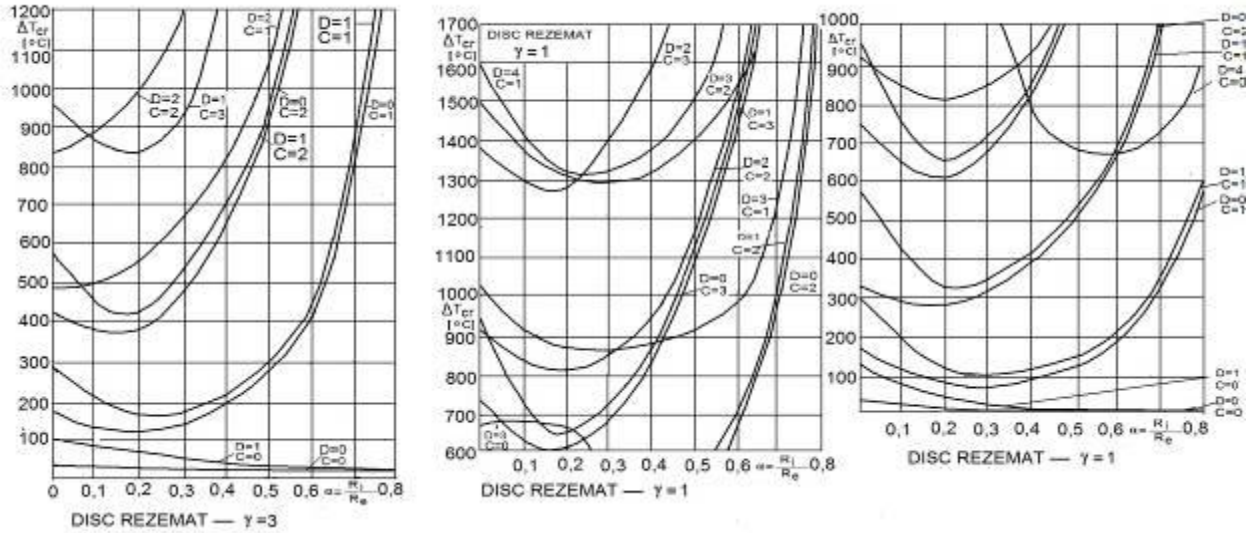


Fig. 2. – Critical temepratures dependence on disks radius ratio and different nodal diameters and nodal circles

Based on the conclusions ensued from equation (9) the values T_{cr}, ω_{cr}^2 and T_0 are calculated, the results being tabular presented.

It is mentioned that in calculations the authors considered more ratios $\alpha = \frac{a}{b}$, and also more types of loss of stability occurrence, which is put in practice by: zero or more nodal circles joined with zero or more modal diameters.

The solutions of the elastic loss of stability at disks subjected to different combinations based on computational methods, put in evidence that the condition $\lambda = 1$ is accomplished not only for zero nodal circles and zero nodal diameters but for other situations too. One enumerates some of them:

Pe baza concluziilor rezultate din ecuația (9), se calculează valorile . T_{cr}, ω_{cr}^2 şi T_0, rezultatele fiind prezentate tabelar. Se menționează faptul că în calcule autorii au luat în considerare mai multe rapoarte $\alpha = \frac{a}{b}$ şi de asemenea, mai multe moduri de pierdere a stabilității, care sunt puse în practică prin zero sau mai multe cercuri nodale correlate cu zero sau mai multe diameter nodale.

Soluțiile pierderii stabilității elastice a discurilor supuse la diferite combinații, bazate pe metode numerice, pun în evidență faptul că relația $\lambda = 1$ este îndeplinită nu este îndeplinită numai pentru zero cercuri nodale şi zero diameter nodale, dar şi pentru alte situații. Se enumeră o parte din acestea:

$$\begin{cases} i = 0 \\ n = 1, \end{cases} \begin{cases} i = 1 \\ n = 0, \end{cases} \begin{cases} i = 1 \\ n = 1, \end{cases} \begin{cases} i = 2 \\ n = 1, \end{cases} \begin{cases} i = 2 \\ n = 0. \end{cases}$$

The other studied situations are not for practical importance because it increase very much the temperature difference and these cases are not met in practice.

By *i* and *n* are denoted the number of nodal circles

Alte situații studiate nu sunt de importanță practică, deoarece conduc la creşterea excesivă a diferenței de temperatură, ceea ce nu se întâmplă în realitate.

Prin *i* şi *n* sunt notate numărul cercurilor nodale, respectiv numărul diametrelor nodale.

and of nodal diameters, respectively.

In the tables 1, 2, 3 and 4 there are presented the critical temperatures of stability loss, and also the interdependence of the membrane stresses fields.

În tabelele 1, 2, 3, şi 4, care urmează, sunt prezentate temperaturile critice de pierdere a stabilității şi, de asemenea, interdependența câmpurilor tensiunilor membranare.

Table 1

Critical temperatures. Nodal diameters ($\gamma = 30$)(disk in mandrel)

	Nr. diametre nodale / Nr. cercuri nodale	d = 0	d = 1	d = 2	d = 3	d = 4
$\frac{R_i}{R_e} = 0$	C = 0	37,92	41,552	79,99	127,118	184,61
	C = 1	90,22	147,78	219,78	300	392,156
	C = 2	227,70	311,688	422,535	533,33	659,34
	C = 3	427,04	533,333	685,714	833,33	991,73
	C = 4	689,655	810,81	1016,949	1188,118	1384,08
$\frac{R_i}{R_e} = 0,2$	C = 0	42,44	63,707	89,55	134,378	194,174
	C = 1	62,49	82,19	247,933	318,302	410,95
	C = 2	192,926	209,05	483,87	571,42	693,64
	C = 3	413,793	431,65	799,99	902,25	1043,47
	C = 4	727,27	745,34	1212,12	1307,189	1458,08
$\frac{R_i}{R_e} = 0,4$	C = 0	66,2	70,28	118,8	162,16	224,71
	C = 1	86,33	95,23	363,63	416,66	493,827
	C = 2	322,58	332,4	759,49	821,91	902,25
	C = 3	714,28	727,27	1318,68	1372,99	1463,41
	C = 4	1263,157	1276,59	2023,6	2205,88	2185,79
$\frac{R_i}{R_e} = 0,6$	C = 0	78,9	128,7	226,41	269,05	332,409
	C = 1	193,86	202,02	794,7	851,06	923,076
	C = 2	754,716	764,33	1726,61	1788,37	1877,934
	C = 3	1678,32	1690,14	3030,3	3092,78	3199,99
	C = 4	2970,29	2985,07	4743,08	4780,87	4897,95
$\frac{R_i}{R_e} = 0,8$	C = 0	160,8	260,52	307,9	1034,48	1142,85
	C = 1	916,03	930,23	967,74	3703,7	3870,96
	C = 2	3519,06	3539,82	3603,6	8003,69	8275,86
	C = 3	7843,13	7843,13	7947,01	14051,52	14302,74
	C = 4	13793,103	13808,97	13904,98	21857,92	22140,22

Table 2

Critical temperatures. Nodal circles (C=0)(disk in mandrel

C = 0	DIAMETRE NODALE	$T_{cr} = \frac{\Delta T}{\lambda}$	$\omega_{cr}^2 = -\frac{1}{\lambda} \cdot 10^5$	T_0 (calculat)
$\frac{R_i}{R_e} = 0$	d = 0	35,211	+ 13,03 · 10^6	59,531
	d = 1	112,032	+ 35,001 · 10^6	140,84
	d = 2	316,555	+ 6,706 · 10^6	741,39
	d = 3	683,15	+ 20,66 · 10^6	980,789
	d = 4	1154,25	+ 41,684 · 10^6	1403,464
$\frac{R_i}{R_e} = 0,2$	d = 0	25,846	+ 11,38 · 10^6	46,286
	d = 1	92,592	+ 4,325 · 10^6	285,268
	d = 2	301,93	+ 6,958 · 10^6	692,468
	d = 3	467,726	+ 18,69 · 10^6	692,955
	d = 4	672,992	+ 37,03 · 10^6	836,560
$\frac{R_i}{R_e} = 0,4$	d = 0	23,207	+ 12,007 · 10^6	40,602
	d = 1	70,62	+ 7,209 · 10^6	158,784
	d = 2	526,31	+ 8,598 · 10^6	1077,22
	d = 3	633,71	+ 16,44 · 10^6	980,63
	d = 4	739,86	+ 28,97 · 10^6	969,709
$\frac{R_i}{R_e} = 0,6$	d = 0	27,247	+ 18,737 · 10^6	40,33
	d = 1	74,294	+ 14,93 · 10^6	119,079
	d = 2	1594,13	+ 15,535 · 10^6	2517,46
	d = 3	1714,97	+ 20,53 · 10^6	2466,78
	d = 4	1772,04	+ 28,571 · 10^6	2330,24
$\frac{R_i}{R_e} = 0,8$	d = 0	46,772	+ 56,915 · 10^6	54,168
	d = 1	120,26	+ 55,61 · 10^6	139,723
	d = 2	1312,33	+ 56,18 · 10^6	1522,56
	d = 3	13073,94	+ 60,42 · 10^6	15021,398
	d = 4	13087,29	+ 65,832 · 10^6	14876,47

Table 3

Critical temperatures. Nodal diameters ($\gamma = 1$)(disk in mandrel)

C = 1	DIAMETRE NODALE	$T_{cr}\left(\frac{10}{\lambda}\right)$	$\omega_{cr}^2 = -\frac{1}{\lambda}\cdot 10^8$	T_0 (calculat)
$\frac{R_1}{R_e} = 0$	d = 0	169,692	+ 69,252 · 10^8	191,745
	d = 1	300,12	+ 110,399 · 10^8	324,586
	d = 2	559,28	+ 66,44 · 10^8	635,04
	d = 3	1025,85	+ 20,66 · 10^8	1114,31
	d = 4	1593,168	+ 104,36 · 10^8	1689,026
$\frac{R_1}{R_e} = 0,2$	d = 0	187,65	+ 85,105 · 10^8	207,494
	d = 1	266,637	+ 70,323 · 10^8	300,874
	d = 2	680,272	+ 77,579 · 10^8	759,19
	d = 3	1018,433	+ 100,59 · 10^8	1109,55
	d = 4	1395,089	+ 134,84 · 10^8	1488,34
$\frac{R_1}{R_e} = 0,4$	d = 0	437,828	+ 227,324 · 10^8	455,162
	d = 1	492,125	+ 181,06 · 10^8	516,587
	d = 2	1489,86	+ 156,10 · 10^8	1575,75
	d = 3	1830,59	+ 151,80 · 10^8	1939,28
	d = 4	2380,95	+ 159,31 · 10^8	2515,45
$\frac{R_1}{R_e} = 0,6$	d = 0	1602,564	+ 1093 · 10^8	1615,759
	d = 1	1663,89	+ 835,42 · 10^8	1681,835
	d = 2	5162,62	+ 616,52 · 10^8	5237,98
	d = 3	5577,24	+ 485,67 · 10^8	5680,59
	d = 4	6426,735	+ 410,34 · 10^8	6567,69
$\frac{R_1}{R_e} = 0,8$	d = 0	1879,78	+ 61625,28 · 10^8	14136,33
	d = 1	14240,95	+ 12881,6 · 10^8	14250,89
	d = 2	16186,46	+ 8733,6 · 10^8	16203,14
	d = 3	45269,35	+ 6013,23 · 10^8	45337,10
	d = 4	46685,34	+ 4336,5 · 10^8	46782,23

Table 4

Critical temperatures. Nodal circles (C=2)(disk in mandrel)

C = 0	DIAMETRE NODALE	$T_{cr} = \frac{\Delta T}{\lambda}$	$\omega_{cr}^2 = -\frac{1}{\lambda}\cdot 10^8$	T_0 (calculat)
$\frac{R_1}{R_e} = 0$	d = 0	405,56	+ 168,01 · 10^8	427,253
	d = 1	576,76	+ 224,87 · 10^8	599,843
	d = 2	913,24	+ 165,43 · 10^8	962,923
	d = 3	1485,35	+ 224,06 · 10^8	1545,013
	d = 4	2182,92	+ 290,52 · 10^8	2250,544
$\frac{R_1}{R_e} = 0,2$	d = 0	571,42	+ 258,131 · 10^8	591,343
	d = 1	640,61	+ 232,34 · 10^8	865,424
	d = 2	1271,61	+ 230,62 · 10^8	1321,234
	d = 3	1650,16	+ 249,31 · 10^8	1709,73
	d = 4	2209,94	+ 284,33 · 10^8	2279,89
$\frac{R_1}{R_e} = 0,4$	d = 0	1491,84	+ 774,59 · 10^8	1509,173
	d = 1	1542,02	+ 687,28 · 10^8	1562,2129
	d = 2	3132,83	+ 607,53 · 10^8	3179,24
	d = 3	3460,20	+ 550,66 · 10^8	3516,75
	d = 4	4338,39	+ 516,25 · 10^8	4414,02
$\frac{R_1}{R_e} = 0,6$	d = 0	5656,10	+ 3866,97 · 10^8	5678,28
	d = 1	5714,28	+ 3414,13 · 10^8	5729,343
	d = 2	11539,349	+ 2873,56 · 10^8	11545,49
	d = 3	11900,51	+ 2388,34 · 10^8	11945,344
	d = 4	12841,91	+ 1997,80 · 10^8	12899,769
$\frac{R_1}{R_e} = 0,8$	d = 0	50607,28	+ 61652,28 · 10^8	50614,667
	d = 1	50709,93	+ 54555,37 · 10^8	50718,296
	d = 2	58761,31	+ 44923,62 · 10^8	58773,082
	d = 3	102880,65	+ 35893,76 · 10^8	102906,446
	d = 4		+ 28344,67 · 10^8	

Based on the exposed theory and on the FEM study the way of stability loss for different combinations of nodal diameters and nodal circles is shown in Fig. 3. It is established that the condition λ = 1 is accomplished and so the solutions are in concordance with the theory.

The study presented in this paper allows a rapid analysis of the second order bending calculations of any plate generally and of the annular plates particularly, subjected to any membrane stress field or to any combination of different fields acting at the time. It is possible to obtain new interesting information by decomposing the plate bending solution on buckling intrinsic functions.

If for a certain membrane stresses all buckling intrinsic values have the same sign, it is possible to obtain a very simple formula.

The diagrams in Fig. 4 and Fig.5 may be utilized for any bending loading, a concentrated force being an extreme case.

Pe baza teoriei expuse şi a studiului cu ajutorul MEF modurile de pierdere a stabilității pentru diferite combinații de diamtere nodale şi cercuri nodale sunt prezentate în figura 3. S- a stabilit faptul că relația λ = 1este îndeplinită şi astfel, soluțiile sunt în concordanță cu teoria. Studiul prezentat în cadrul acestei lucrări permite o analiză rapidă a încovoierii cu calcule de ordinal doi, pentru orice placă, în general, dar şi pentru plăci inelare, în mod particular, supuse oricărui camp de tensiuni membranare sau oricărei combinații de câmpuri care acționează simultan. Este posibilă obținerea de noi informații interesante, desconpunând soluțiaprivind încovoierea plăcii în funcții proprii de flambaj. Dacă pentru anumite tensiuni membranare toate valorile proprii de flambaj au acelați semn, este posibil să se obțină o formulă foarte simplă.

Diagramele prezentate în figurile 4 şi 5 pot fi utilizate pentru orice sarcină de încovoiere, o singură forță concentrată fiind un caz extrem.

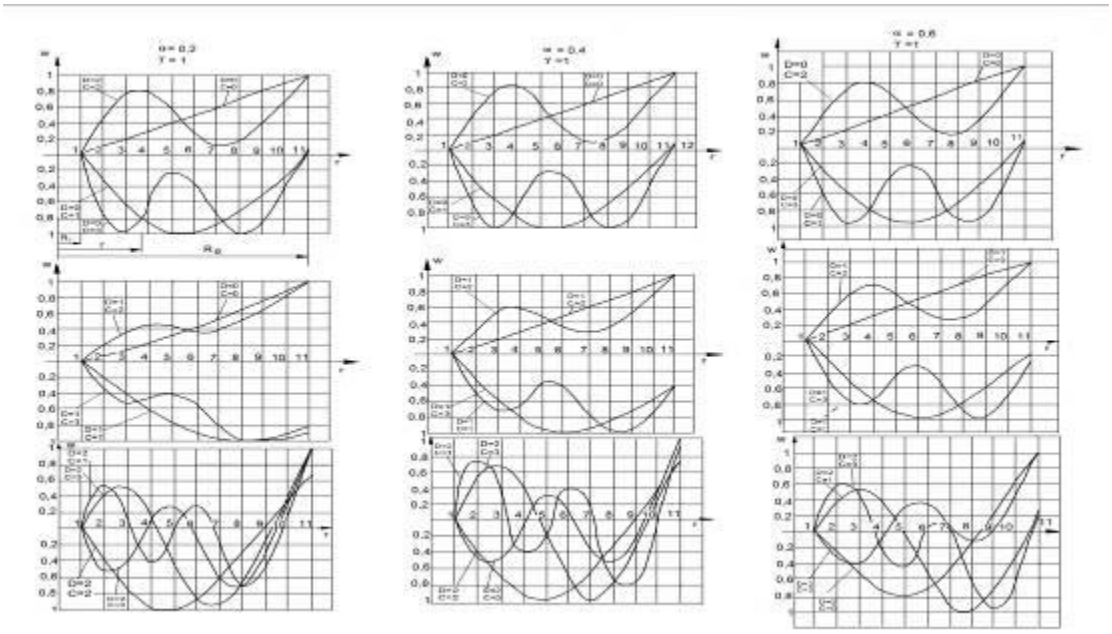


Fig. 3. – Loss of stability for different combination of nodal diameters and nodal circles

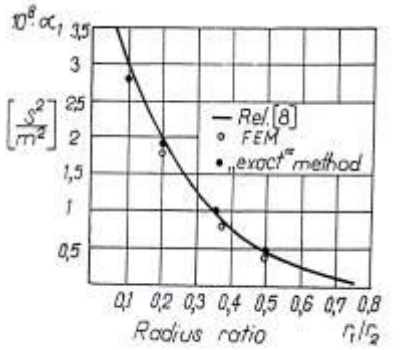


Fig. 4 – Analytical solution for any bending load

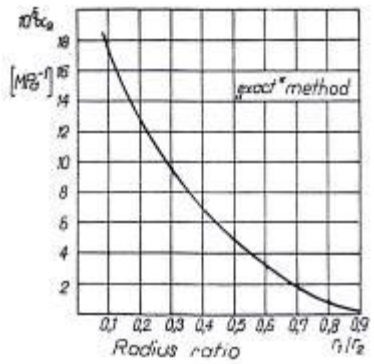


Fig. 5. – Analytical solution for any bending load

Based on the exposed theory and on the FEM study the way of stability loss for different combinations of nodal diameters and nodal circles is shown in Fig. 3. It is established that the condition $\lambda = 1$ is accomplished and so the solutions are in concordance with the theory.

The study presented in this paper allows a rapid analysis of the second order bending calculations of any plate generally and of the annular plates particularly, subjected to any membrane stress field or to any combination of different fields acting at the time. It is possible to obtain new interesting information by decomposing the plate bending solution on buckling intrinsic functions.

If for a certain membrane stresses all buckling intrinsic values have the same sign, it is possible to obtain a very simple formula.

The diagrams in Fig. 4 and Fig.5 may be utilized for any bending loading, a concentrated force being an extreme case.

Figures 6 and 7 show the bending stresses (linear temperature on thickness) and membrane stresses (linear temperature on radius), for a disk on mandrel, respectively.

Pe baza teoriei expuse şi a studiului cu ajutorul MEF modurile de pierdere a stabilității pentru diferite combinații de diamtere nodale şi cercuri nodale sunt prezentate în figura 3. S- a stabilit faptul că relația λ = 1este îndeplinită şi astfel, soluțiile sunt în concordanță cu teoria. Studiul prezentat în cadrul acestei lucrări permite o analiză rapidă a încovoierii cu calcule de ordinal doi, pentru orice placă, în general, dar şi pentru plăci inelare, în mod particular, supuse oricărui camp de tensiuni membranare sau oricărei combinații de câmpuri care acționează simultan. Este posibilă obținerea de noi informații interesante, desconpunând soluțiaprivind încovoierea plăcii în funcții proprii de flambaj. Dacă pentru anumite tensiuni membranare toate valorile proprii de flambaj au acelați semn, este posibil să se obțină o formulă foarte simplă.

Diagramele prezentate în figurile 4 şi 5 pot fi utilizate pentru orice sarcină de încovoiere, o singură forță concentrată fiind un caz extrem.

În figurile 6 şi 7 sunt reprezentate tensiunile de încovoiere (temperature liniară pe grosime), respectiv tensiunile membranare (temperatură liniară păe rază), pentru disc în mandrină.

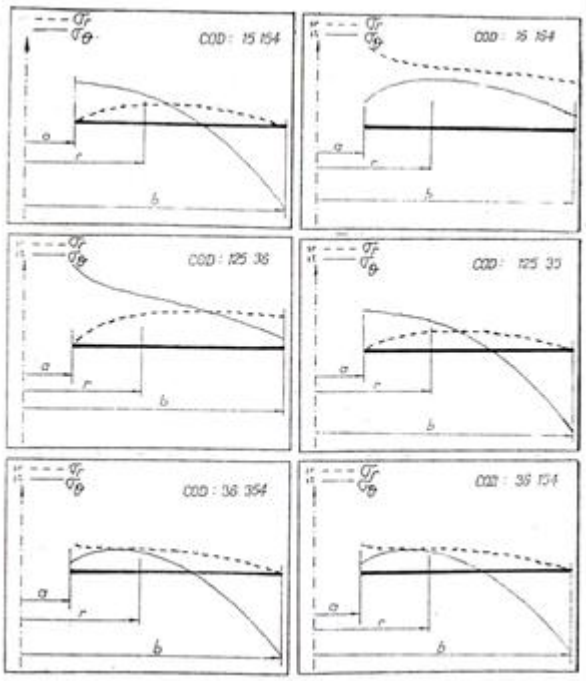


Fig. 6 – Bending stresses

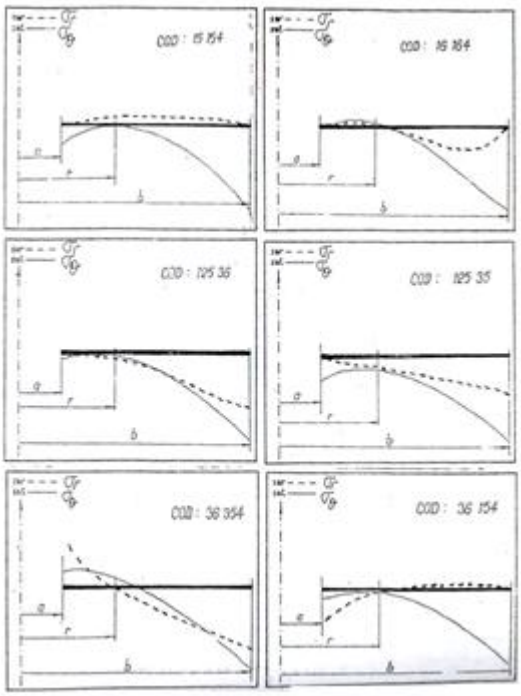


Fig. 7 – Membrane stresses

CONCLUSIONS

The authors emphasized that concerning the elastic stability calculations the minimum critical value is asserted, value denoted by λ_k. It is established that for the critical value of the membrane stresses, from equation number k it results $\Omega_i^2 = 0$, so the final conclusion: the closer the membrane stresses to the critical value are, the intrinsic frequencies decrease, tending to null. It is settled that the loss of stability at circular plates, for the zero nodal circles mode, takes place when equation (8) is accomplished, where λ^n represent the magnitude of the stresses field, denoted by k , reported at the solution of the intrinsic value issue, λ_i being the intrinsic value accordingly to the mode *i* taken into account. Equation (9) emphasized the critical values linear dependence of the membrane stresses (temperature and rotation).

An important conclusion: for $\lambda = 1$, for the overlapping effects of the two membrane stresses field, the condition imposed by equation (9) is accomplished, which states the change of temperature on radius, responsible for the loss of the elastic stability of the disk. The ways of stability loss have been studied for different combinations of nodal circles and nodal diameters, mentioning the critical temperatures (tabular or graphical represented).

The theoretical results have been completed by experimental research.

The intrinsic modes of stability loss have been determined for different ratios of the disk radius, thickness and temperatures distribution laws. These are partially presented in the present paper.

As a final conclusion: the weight of the instability calculations is at least the same as the strength calculations. These are needed within the optimization process, which impose the increase of the structures slenderness.

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CONCLUZII

Autorii subliniază faptul că în calculele de stabilitate elastic se reține, în primul rând, cea mai mică valoare critic, valoare notată cu λ_k.

S-a constatat că dacă tensiunile de membrană ating valoarea critic, atunci, din ecuația cu numărul k rezultă $\Omega_i^2 = 0$, de unde concluzia: cu cât tensiunile de membrană cresc şi se apropie de valoarea critică, frecvențele proprii scad şi se apropie de zero. S-a constatat că pierderea stabilității plăcilor circulare, pentru moduri cu zero cercuri nodale, are loc când este realizată relația (8), unde λ^n este mărimea câmpului de tensiuni, notat cu k, raportat la valoarea cu care s-a rezolvat problema de valori proprii, λ_i fiind valoarea proprie corespunzătoare modului i considerat. Relația (9) arată o dependență liniară între valorile critice ale câmpurilor de tensiuni de membrană (ex. temperatură şi rotație).

O concluzie importantă – pentru $\lambda = 1$, la suprapunerea efectelor celor două câmpuri de tensiuni de membrană se realizează condiția dată de relația (12), pe baza căreia se stabileşte diferența de temperatură pe rază, datorită căreia are loc pierderea stabilității elastic a discului. S-au studiat modurile de pierdere a stabilității în diferite combinații de cercuri şi diametre nodale, cu precizarea temperaturilor critice (redate tabelar sau grafic). S-au efectuat şi determinări experimentale.

Pentru diferite rapoarte ale razelor discului, grosimii acestuia şi a legilor de distribuție a temperaturii, s-au determinat moduri de pierdere a stabilității, prezentate parțial în lucrarea de față.

Ca o concluzie finală: dacă până acum ponderea calculului au avut-o în mare măsură calculele de rezistență, de acum, calculele de instabilitate au cel puțin aceeaşi pondere. Acestea sunt necesare în procesul de optimizare, proces ce impune creşterea zveltației structurilor.

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A REVIEW OF LOW-GRADE HEAT RECOVERY USING ORGANIC RANKINE CYCLE / *O ANALIZĂ PRIVIND RECUPERAREA CĂLDURII DE JOASĂ TEMPERATURĂ FOLOSIND CICLUL RANKINE ORGANIC*

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Abstract: *Many industrial processes and conventional fossil fuel energy production systems used in small-medium industries, such as internal combustion engines and gas turbines, provide low or medium temperature (i.e., 200–500 ^{0}C) heat fluxes as a by-product, which are typically wasted in the environment. The possibility of recovery wasted heat from internal combustion engines using organic Rankine cycle, is investigated in this article.*

Keywords: *internal combustion engine, waste heat recovery, organic Rankine cycle, configurations*

INTRODUCTION

In recent years, there has been a great deal of waste heat energy being released into the environment, such as exhaust gases from turbines and engines and waste heat from industrial plants, which lead to serious environmental pollution. In addition, there are also abundant geothermal resources and solar energy available in the world. These heat sources are classified as low grade heat sources. Therefore, more and more attention has been paid to the utilization of low grade waste heat nowadays for its potential in reducing fossil fuel consumption and alleviating environmental problems.

Since conventional steam power cycles cannot give a better performance to recover low grade waste heat, the organic Rankine cycle (ORC) is proposed to recover low grade waste heat. There are several advantages in using an ORC to recover low grade waste heat, including economical utilization of energy resources, smaller systems and reduced emissions of CO, CO2, NOx and other atmospheric pollutants. The main advantage of the ORC is its superior performance in recovering waste heat with a low temperature.

Besides the ORC, researchers have proposed various thermodynamic cycles, such as Kalina cycle, Goswami cycle, and trilateral flash cycle, to convert this low-grade heat sources into electricity. Although there is more power output for the same heat input with Kalina cycles compared to ORCs, the ORC syetem is much less complex and needs less maintenance.

ORGANIC RANKINE CYCLE

The ORC system represents a simple Rankine cycle in which the water is replaced by organic mediums that boil at low temperatures . The layout of an ORC simple cycle layout and typical T–s diagrams of both subcritical and transcritical cycles are reported in Figure 1. Over the years, the ORC systems have gained a moderate level of maturity and reliability, allowing heat recovery from different sources.

One of the main challenges of the ORC is represented by the choice of the appropriate working fluid, in order to achieve the maximum efficiency for given hot and cold sources. Many analyses of the influence of the working fluids on system efficiency have been reported in the literature, as for instance [8,10]. However,

Rezumat: *Multe procese industriale şi sisteme convenţionale de producere a energiei din combustibili fosili utilizate în industriile mici şi mijlocii, cum ar fi motoarele cu ardere internă şi turbinele cu gaze, furnizează ca şi subprodus energie termică de joasă temperatură (de exemplu, 200-500 ^{0}C), care de obicei este irosită în mediul înconjurător. Posibilitatea de recuperare a căldurii reziduale produsă de motoarele cu ardere internă utilizând ciclul Rankine organic, este cercetată în acest articol.*

Cuvinte cheie: *motoare cu ardere internă, recuperarea căldurii reziduale, ciclul Rankine organic, configuratii*

INTRODUCERE

În ultimii ani, a existat o mare cantitate de căldură reziduală eliberată în mediul înconjurător, cum ar fi gazele de evacuare de la turbine şi motoare cu ardere internă, căldura reziduală din instalațiile industriale, care conduc la poluarea mediului. În plus, există, de asemenea, resurse abundente de energie solară si geotermală. Aceste surse de căldură sunt clasificate ca energie termică la temperatură joasă. Prin urmare, din ce în ce mai multă atenție a fost acordată utilizării căldurii reziduale pentru potențialul său în reducerea consumului de combustibili fosili şi atenuarea problemelor de mediu.

Deoarece ciclurile convenționale cu abur nu pot da o performanță mai bună pentru a recupera căldura reziduală, ciclul Rankine organic (ORC), este propus pentru recuperarea energiei termice la temperatură joasă. Există mai multe avantaje în utilizarea unui ORC pentru recuperarea căldurii reziduale, inclusiv utilizarea economică a resurselor energetice, sisteme mai mici şi emisii reduse de CO, CO2, NOx şi alți poluanți atmosferici. Principalul avantaj al ciclului ORC sunt performanțele sale superioare în recuperarea căldurii reziduale cu o temperatură scăzută.

Pe lângă ORC, cercetătorii au propus diferite cicluri termodinamice, cum ar fi ciclul Kalina, ciclu Goswami, pentru a converti căldura reziduală în energie electrică. Deşi pentru aceeaşi cantitate de căldură cu ciclul Kalina se obține mai multă putere decât cu ciclul ORC, ciclul Rankine organic (ORC) este mult mai puțin complex şi necesită mai puțină întreținere.

CICLUL RANKINE ORGANIC

Sistemul ORC reprezintă un simplu ciclu Rankine în care apa este înlocuită cu un fluid organic care fierbe la temperaturi scăzute. Schema unui ciclu ORC precum şi diagramele tipice T – s , atât pentru cicluri subcritice cât şi supercritice sunt reprezentate în Figura 1. De-a lungul anilor, sistemele ORC au câştigat un nivel moderat de maturitate şi fiabilitate, care să permită recuperarea căldurii din diferite surse de caldură.

Una dintre principalele provocări ale ciclului ORC este reprezentată de alegerea corespunzătoare a fluidului de lucru, în vederea realizării eficienței maxime

the selection of the optimal working fluid is considered not fully addressed. In fact, recent research works focus on analyzing multi- component mixtures of working fluids in order to better match the heat sources.

pentru sursa de căldură considerată. Multe analize ale influenței fluidelor de lucru privind eficiența sistemului au fost ilustrare în literatura de specialitate, ca de exemplu [8,10]. Cu toate acestea, alegerea fluidului de lucru optim este dificil de realizat. De fapt, cercetările recente se concentrează pe analiza amestecurilor de fluide de lucru, în scopul de a se potrivi mai bine cu sursa de căldură.

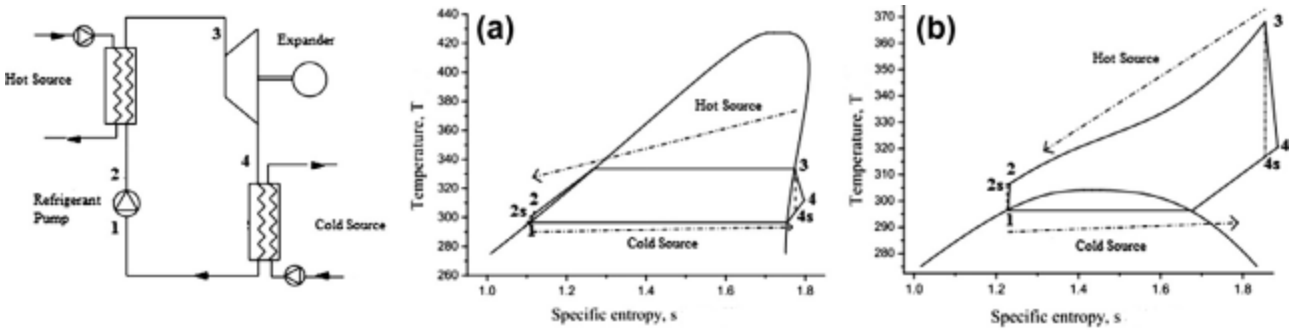

Fig. 1 – ORC simple cycle layout and T–s diagrams of subcritical (a) and transcritical (b) cycles [13]

The technical feasibility of ORC applications for LGTE recovery has already been investigated and validated [3,9]. In fact, ORC cycles are successfully used in several applications, such as geothermal resources, waste thermal energy recovery from gas turbines or internal combustion engines [15] and biomass-based CHP plants.

Although ORCs are characterized by rather low efficiencies (8–12 %) [11], they are particularly viable for small-scale power generation systems. Absence of fuel cost, improved reliability and low maintenance may also contribute to making ORCs commercially attractive.

Fezabilitatea tehnică a ciclurilor ORC de recuperare a LGTE a fost deja investigată şi validată [3,9]. Ciclurile ORC sunt utilizate cu succes în mai multe aplicații, cum ar fi resursele geotermale, recuperarea căldurii reziduale de la turbinele cu gaze sau motoarele cu ardere internă [15] şi centralele de cogenerare pe bază de biomasă.

Deşi ciclurile ORC sunt caracterizate prin eficiență destul de redusă (8 – 12 %) [11], ele sunt deosebit de viabile pentru sistemele de putere mică. Absența costului combustibilului, fiabilitatea mare şi întreținerea redusă pot contribui pentru a face ciclul ORC atractiv comercial .

ENGINE WASTE HEAT EVALUATION

Huge amounts of energy are consumed by internal combustion engines in all types of vehicles, but much of this energy is wasted through the exhaust and the cooling system. Exacerbating this problem is the fact that these combustion products also cause serious environmental issues. Engine waste-heat recovery could improve the fuel thermal efficiency, minimize fuel consumption, and reduce engine emissions. Using an organic Rankine cycle (ORC) to recover the low-grade wasted heat from these systems is the technology that is the closest to being suitable for mass production.

The efficiency of an internal combustion engine refers to the percentage of the energy resulting from the combustion that actually is applied to moving the car or running the accessories. For current ICEs, the proportion of fuel energy converted into effective work at medium and high loads is about 30% - 45% for the diesel engine or 20% - 30% for the gasoline engine, and the rest is mainly brought into the environment by the exhaust gas and cooling system.

EVALUAREA CĂLDURII REZIDUALE A MOTORULUI

Cantități uriaşe de energie sunt consumate de motoarele cu ardere internă în toate tipurile de vehicule, însă o mare parte din această energie este irosită prin gazele de evacuare şi circuitul de răcire. Gravitatea acestei probleme este faptul că aceste produse de ardere, provocă probleme serioase de mediu. Recuperarea căldurii reziduale a motorului ar putea îmbunătăți eficiența termică, minimiza consumul de combustibil şi reduce emisiile. Ciclul ORC pare a fi tehnologia cea mai potrivit pentru recuperarea acestei energii termice de joasă temperatură.

Eficiența unui motor cu ardere internă se referă la procentul de energie rezultată prin arderea combustibilului care este folosită pentru deplasarea autovehiculului sau antrenarea accesoriilor. Pentru motoarele actuale, proporția energiei din combustibili transformată în putere la sarcini mari şi medii este de aproximativ 30% - 45% pentru motoarele diesel şi 20% - 30% pentru motoarele pe benzină, iar restul este cedată în mediul înconjurător în principal prin gazele de evacuare şi circuitul de răcire.

Fig. 2 - Energy losses in gasoline engine and effective power [1]

To design a reasonable ORC system to utilize various waste heats from the diesel engine with high efficiency, studying the energy distribution in the running process of the diesel engine is necessary. When an engine is running, the energy and exergy quantities of the exhaust and the coolant are significantly different. Because of this, it is very difficult to design a system that can comprehensively recover waste heat from both the exhaust and the coolant of that system. A six-cylinder in-line diesel engine is used as the object of analysis. The main technical performance parameters are listed in Table 1

Pentru a proiecta un sistem cu eficiență ridicată pentru recuperarea căldurii reziduale a unui motor cu ardere internă, un studiu privind distribuția energiei atunci când motorul rulează este necesar. Când un motor rulează, cantitatea de energie şi exergia din gazele de evacuare şi sistemul de răcire diferă în mod semnificativ. Din această cauză, este foarte dificil de a proiecta un sistem care poate recupera căldura reziduală de la ambele surse de căldură (gazele de evacuare şi sistemul de răcire). Un motor diesel cu 4 cilindrii în linie este folosit pentru această analiză. Principalele caracteristici tehnice ale motorului sunt prezentate în tabelul 1.

Table 1

The main technical performance parameters of the diesel engine

Items	Parameters	Units
Model	Diesel	[-]
Cylinder number	4	[-]
Stroke and cylinder bore	80.5x76	[mm]
Displacement	1461	[cm^3]
Compression ratio	15.7:1	[-]
Air intake type	Turbocharged and Intercooled	[-]
Fuel injection system	High pressure common rail	[-]
Rated power	80	[kW]
Rated speed	4000	[rpm]
Maximum torque	240	[Nm]
Speed at maximum torque	1750	[rpm]

When a vehicle is running, the engine speed and load can vary through a wide range. Therefore, the engine performance test was conducted in an engine test cell in order to obtain the thermodynamic parameters of the exhaust and coolant systems overall possible engine operating regions as defined by the engine speed and output torque. For our measurements, the minimal and maximal engine speeds were set to 1000 rot/min and 4500 rot/min, respectively. The intermediate speeds were selected using a step increment of 250 rot/min, starting from the minimum engine speed. At each selected engine speed, different load values were selected, ranging from a 100% load to a minimal stable load value. The values for the output torque, the output power, the engine speed, the mass flowrate of the intake air, the injected fuel quantity, the exhaust gas temperature, and the coolant temperatures at the outlet of the engine's water jacket were all recorded for each load and speed configuration.

Atunci când un vehicul rulează, turația şi sarcina motorului pot varia într-o gamă largă în funcție de cuplu motor şi viteza vehiculului. Prin urmare, testul de performanță al motorului a fost efectuat într-un banc de testare, cu scopul de a determina parametrii termodinamici ai sistemului de evacuare şi sistemului de răcire la diverse regimuri de funcționare ale motorului. Pentru măsurătorile noastre, turația minimă şi maximă a motorului a fost stabilită la 1000 rot/min şi respectiv, 4500 rot/min. Vitezele intermediare au fost selectate folosind un increment de 250 rot/min, pornind de la viteza minimă a motorului. Pentru fiecare punct de turație stabilit am variat sarcina motorului de la valoarea de 100% până la o valoare minimă stabilă pentru încercare. Valorile pentru cuplul motor, puterea motorului, turația motorului, debitul de aer admis, cantitatea de combustibil injectat, temperatura gazelor de evacuare, precum şi temperatura lichidului de răcire la intrarea şi ieşirea din motor au fost toate înregistrate pentru fiecare punct de sarcină şi turație stabilit.

ALTERNATIVES FOR HEAT RECOVERY USING AN ORGANIC RANKINE CYCLE

In this study, three alternatives were considered for the heat recovery from an internal combustion engine:

- Exhaust gases: It utilizes the waste heat that leaves the engine whit exhaust gases.
- Combined Exhaust gases and Engine Coolant System: The engine coolant system is used to preheat the heat-transfer fluid that also captures energy form the exhaust gases.
- Combined Engine and Exhaust gases: This system replaces the engine coolant system and utilizes the heat-transfer fluid as the engine coolant.

The total heat recovered from the exhaust is carried by the working fluid into the heat power cycle. The configuration of the power cycle and the total heat recovered from the exhaust are used to calculate the mass flow rate of working fluid needed in the cycle.

ALTERNATIVE PENTRU RECUPERAREA CĂLDURII FOLOSIND CICLUL RANKINE ORGANIC

În acest studiu, sunt prezentate trei scheme pentru recuperarea căldurii de la un motor cu ardere internă:

- Recuperarea căldurii din gazele de evacuare: Utilizează căldura reziduală care iese din motorul împreună cu gazele de evacuare.
- Recuperarea căldurii din gazele de evacuare şi sistemul de răcire al motorului: Sistemul de răcire al motorului este folosit pentru preîncălzirea fluidului de lucru, care preia, de asemenea, şi energia din gazele de evacuare.
- Recuperarea căldurii din gazele de evacuare şi blocul motor: Acest sistem înlocuieşte sistemul de răcire al motorului şi utilizează fluidul de lucru ca lichid de răcire al motorului.

Toată căldura recuperată din gazele de evacuare este dusă de către fluidul de lucru în ciclul energetic termic. Configurația ciclului de putere şi căldura totală recuperată de la gazele de evacuare sunt utilizate pentru a calcula debitul masic de fluid de lucru necesar în ciclu.

The energy recovery system proposed in Figure 3 here is based on the implementation of a heat-power cycle using the exhaust gases as the heat source.

Sistemul de recuperare a energiei propus în figura 3 se bazează pe punerea în aplicare a unui ciclu de căldură - putere folosind gazele de evacuare ca sursă de căldură.

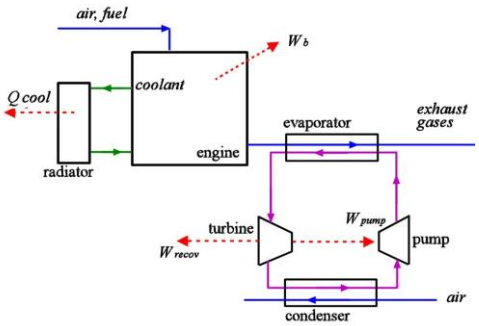

Fig. 3 - Heat recovery system from the exhaust gases [2]

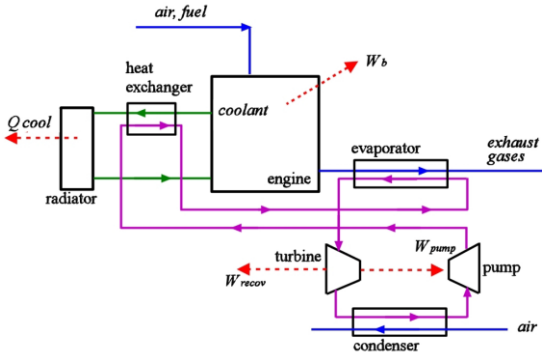

Fig. 4 - Heat recovery from the combined exhaust gases and engine coolant system [2]

Figure 4 shows the proposed system that recovers heat from the exhaust gases and the engine coolant system. This system uses the same parts of the energy recovery system from the exhaust gases and an additional heat exchanger with the engine coolant system. The objective of this heat exchanger is to pre-heat the working fluid before it enters the evaporator. By doing this, it is possible to recover some waste heat from the engine cooling system. There are many parameters that must be known for the incorporation of this heat exchanger in the engine cooling system: the amount of heat that is rejected by the engine through the engine cooling system, as well as the coolant mass flow rate and coolant temperature.

Figura 4 prezintă sistemul propus pentru recuperarea căldurii din gazele de evacuare şi sistemul de răcire al motorului. Acest sistem utilizează aceleaşi componente ale sistemului de recuperare a energiei din gazele de evacuare şi un schimbător de căldură suplimentar pentru recuperarea căldurii din circuitul de răcire al motorului. Rolul acestui schimbător de căldură este de a preîncălzi fluidul de lucru înainte de a intra în vaporizator. Făcând acest lucru, putem recupera o parte din căldura reziduală de la sistemul de răcire al motorului. Există mai mulți parametrii care trebuie cunoscuți pentru includerea acestui schimbător de căldură în sistemul de răcire al motorului: cantitatea de căldură care este cedată de către motor prin sistemul de răcire, precum şi debitul masic de lichid de răcire dar şi temperatura acestuia.

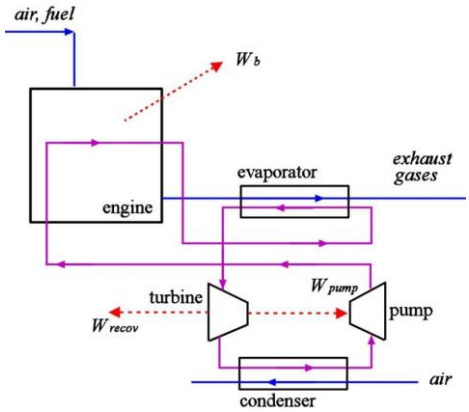

Fig. 5 - Heat recovery from the engine waste heat and exhaust gases [2]

A third system, shown in Figure 5, was proposed to take advantage of both the engine waste heat and the

Al treilea sistem, prezentat în figura 5, a fost propus pentru a profita atât de căldura reziduală a motorului cat

exhaust gases. In this system, the conventional engine coolant system was eliminated and as a replacement, the engine block was used as the heat exchanger for the Rankine cycle. This strategy has the advantage of using the waste heat from the engine at a higher temperature than the one that would be achievable by using the conventional engine coolant system. The engine block is used to raise the temperature of the working fluid. The exhaust gases are used to complete the boiling process and then to superheat the vapor.

RESULTS

One common way to present the operating characteristics of an internal combustion engine over its full load and speed range is to plot brake specific fuel consumption contours on a graph of brake mean effective pressure (or engine torque) versus engine speed. The measured engine performance map is displayed in Figure 6.

The lowest brake specific fuel consumption (b.s.f.c.) zone is situated at the high duty range between 1500 rot/min and 3000 rot/min and the minimum b.s.f.c. value is less than 210 g/kWh.

The effective thermal efficiency is defined as the ratio of the output torque at the flywheel end to the fuel combustion energy, and the results are given in figure 7. The effective thermal efficiency reaches a peak of greater than 40% in the low b.s.f.c. region.

şi a gazelor de evacuare. În această schemă, sistemul convențional de răcire al motorului a fost eliminat şi, ca un înlocuitor, blocul motor a fost folosit ca schimbător de căldură pentru ciclul Rankine. Această strategie are avantajul de a folosi căldura reziduală a motorului la o temperatură mai ridicată decât cea care ar putea fi atinsă prin utilizarea sistemului convențional de răcire al motorului. Blocul motor este utilizat pentru a creşte temperatura fluidului de lucru. Gazele de evacuare sunt utilizate pentru a finaliza procesul de evaporare şi apoi de a supraîncălzii vaporii.

REZULTATE

O modalitate comună de a prezenta caracteristicile de performanță ale unui motor cu ardere internă pe toată plaja sa de funcționare este de a trasa grafic consumul specific de combustibil în funcție de presiunea medie efectivă (sau cuplul motor) şi turația motorului. Diagrama de performanță a motorului, măsurată la bancul motor, este afişată în figura 6.

Cel mai scăzut consum de combustibil se înregistrează în zona de turații cuprinsă între 1500 rot/min şi 3000 rot/min, iar valoarea minima a consumului de combustibil este mai mică de 210 g/kWh.

Eficiența termică efectivă este definită ca raportul dintre cuplul de ieşire la capătul volantului şi energia obținută prin arderea combustibilului, iar rezultatele sunt prezentate în figura 7. Eficiența termică efectivă este puțin mai mare de 40% în regiunea cu consumul specific de combustibil cel mai scăzut.

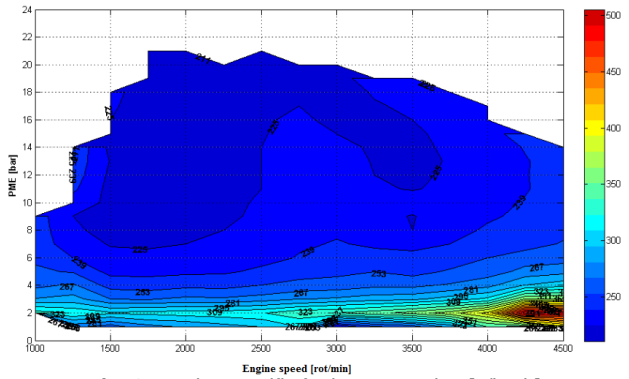

Fig. 6 - Brake specific fuel consumption [g/kWh]

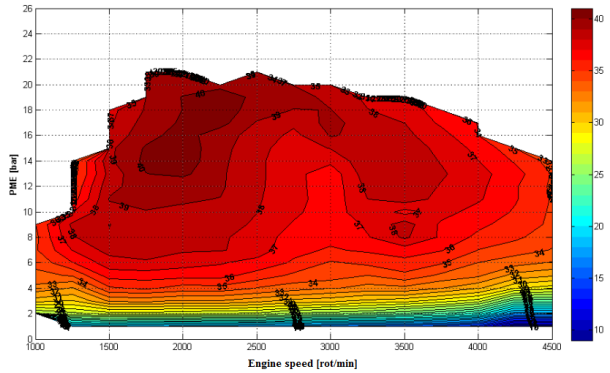

Fig. 7 - Engine effective thermal efficiency [%]

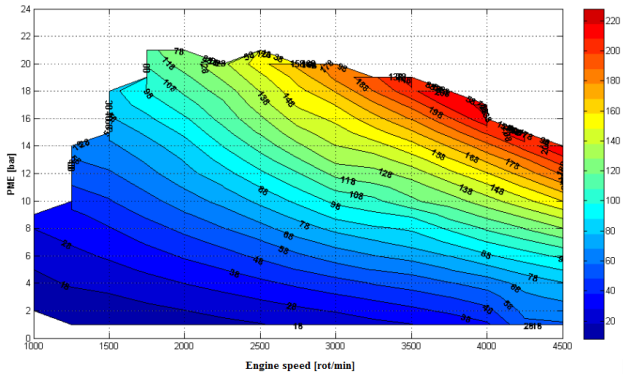

Fig. 8 - Fuel combustion energy [kW]

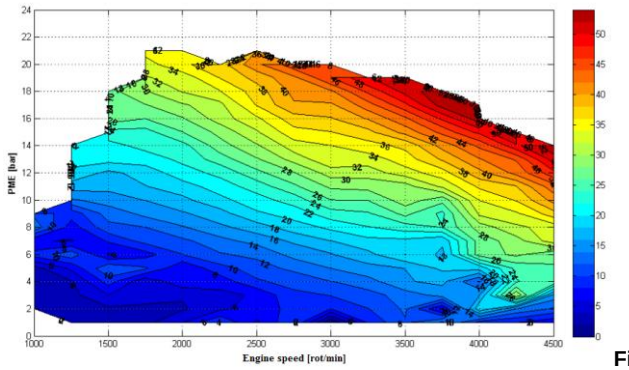

Fig. 9 - Energy part of cooling system [kW]

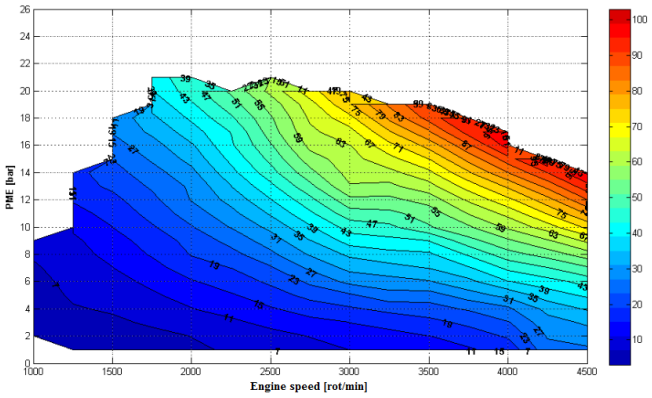

Fig. 10 - Energy part of exhaust [kW]

The distribution of fuel energy released by combustion under a certain operating condition of the diesel engine is depicted using the first law of thermodynamics, which is:

Distribuția energiei eliberată prin arderea combustibililor la diverse regimuri de funcționare ale motorului diesel este determinată folosind primul principiu al termodinamicii, care este:

$$\dot{Q}_{cb} = P + \dot{Q}_r + \dot{Q}_g + \dot{Q}_{rest}\ [kW] \quad (1)$$

Where: $\dot{Q}_{cb}$ is the heat flux received through fuel combustion; P is the amount of mechanical power produced; $\dot{Q}_r$ is the heat flux rejected through the water cooling system; $\dot{Q}_g$ is the heat rejected through the exhaust gases and $\dot{Q}_{rest}$ is the heat flux rejected through radiation and incomplete combustion that cannot be directly determined in this stage.

The fuel energy released by combustion is shown in Figure 8. As the engine speed and engine load increases, the fuel energy released by combustion increases gradually. Such phenomenon is primarily caused by the increase in fuel consumption and intake air mass. The combustion energy increases almost linearly with the engine output power, achieving 220 kW at the rated power point. Note that the waste heat quantities of the exhaust and the coolant vary in a similar fashion. The variation of the waste heat quantity carried by the coolant system and exhaust gases over the whole operating range, is shown in figures 9 and 10.

Unde: $\dot{Q}_{cb}$ este fluxul de energie termică obținut prin arderea combustibilului (energia disponibilă); P este energia termică transformată în energie mecanică efectivă (lucru mecanic efectiv); $\dot{Q}_r$ este fluxul termic cedat fluidului de răcire; $\dot{Q}_g$este fluxul termic pierdut prin gazele evacuate din motor; $\dot{Q}_{rest}$ este fluxul termic pierdut pe alte căi (convecție, radiație, ardere incompletă).

Energia eliberată prin arderea combustibilului este prezentată în figura 8. Pe măsură ce creşte turația şi sarcina motorului, energia eliberată prin arderea combustibil creşte şi ea treptat. Acest fenomen este cauzat în primul rând de creşterea consumului de combustibil şi a debitului de aer de admisie. Fluxul termic obținut prin arderea combustibilului creşte aproape liniar cu puterea motorului, atingând valoarea de 220 kW la puterea nominală de funcționare. Rețineți că, cantitatea de căldură pierdută prin gazele de evacuare şi agentul de răcire variază într-un mod similar. Variația cantității de căldură reziduală din gazele de evacuare şi sistemul de răcire pe întreg domeniul de funcționare al motorului este prezentată în figurile 9 şi 10.

CONCLUSIONS AND FUTURE RESEARCH

It can be concluded that, of the overall energy generated from the fuel combustion, only a relatively small proportion is used to produce useful work output, a large proportion of the energy is wasted, and the fuel energy released by combustion is far more than the effective power output of the diesel engine.

Exhaust gas and coolants of vehicles can be used to generate power by ORC. For normal cars in cruising speed this will produce 10% more power and can be used to improve its overall efficiency. In light duty cars depending on type this can cause between 5-30% reductions in fuel consumption. BMW, Honda and Researchers at Loughborough University and the University of Sussex, UK are examples of researchers in this field. Their researches shows that 62 miles/h speed of driving; using ORC will improved the thermal efficiency of the engine by 3.8%.

So far, most researches on waste heat recovery of the engine using ORC are theoretical researches and simulations [4,5,14], and only a few experiments are developed, especially in engine field [6,7]. What's more, most simulations are based on simple thermodynamic

CONCLUZII SI DIRECȚII VIITOARE

Se poate concluziona că, din energia totală generată prin arderea combustibililor, doar un procent relativ mic este folosit pentru a produce energie mecanică utilă, o mare parte din energie este irosită, iar energia eliberată prin arderea combustibililor este semnificativ mai mare decât puterea efectivă a motorului diesel.

Căldura din gazele de evacuare şi sistemul de răcire al unui vehicul pot fi folosite pentru a genera energie folosind ORC. La funcționare normală a unui autovehicul aceasta va produce cu 10% mai multă putere care poate fi folosită pentru a îmbunătăți eficiența globală. În cazul autovehiculelor se poate obține o reducere a consumului de combustibil între 5-30%. BMW, Honda, Universitatea Loughborough şi Universitatea din Sussex, Marea Britanie au facut cercetări în acest domeniu. Studiile lor arată că la o viteză constantă de 100km/h, folosind ORC, eficiența termică a motorului va fi îmbunătățită cu 3,8%.

Până în prezent, cele mai multe cercetări privind recuperarea căldurii reziduale a motorului, folosind ORC sunt cercetări teoretice şi simulări [4,5,13], şi doar câteva experimente sunt dezvoltate, mai ales în domeniul motoarelor cu ardere internă [6,7]. Mai mult decât atât,

models, i.e., ignoring detailed structures and operating characteristics of system components including heat exchangers and expanders. So models like that are too ideal to precisely reflect the real performance of the ORC. To optimize the performance of ORC systems flexible and reliable simulation models are required.

Future developments could involve using an exergetic analysis to show the ability of the ORC to generate electricity from the recovered heat. An efficiency improvement and lower fuel consumption of the overall system is expected.

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cele mai multe simulări sunt bazate pe modele termodinamice simple, de exemplu, ignorând structurile detaliate şi caracteristicile de funcționare ale componentelor sistemului, inclusiv schimbătoarele de căldură şi turbina. Astfel de modele sunt prea ideale pentru a reflecta cu precizie performanța reală a ORC. Pentru a optimiza performanța sistemelor ORC sunt necesare modele flexibile şi fiabile de simulare.

Activitățile viitoare pot implica o analiză exergetică pentru a arăta capacitatea sistemelor ORC de a genera electricitate din căldura recuperată. Este de aşteptat o îmbunătățire a eficienței şi reducerea consumului de combustibil al sistemului.

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EXPERIMENTAL RESEARCH ON WORKING PROCESS OF THE AGGREGATE TILLER M7.5 – REVERSIBLE PLOW PR1
/
CERCETĂRI EXPERIMENTALE PRIVIND PROCESUL DE LUCRU AL AGREGATULUI MOTOCULTOR M7,5 - PLUG REVERSIBIL PR1

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Abstract: *An important requirement for achieving the optimal conditions for the cultivation of plants, generally speaking and vegetables in particular, in small farms and individual households, is the implementation of a good quality basic work of the soil. The object of this paper consists in testing the equipment made up of a M7.5 tiller and a reversible plow PR1 in order to determine the operational parameters which will form the basis of the market promotion of the mentioned equipment*

Keywords: tiller, reversible plow, small agricultural exploitation

INTRODUCTION

In the context of the current structure of agriculture, according to the 2010 Statistical Yearbook of Romania, in which are centralized data from year 2007, was identified a number of 2,485,566 agricultural exploitations and individual households with land areas ranging between 0.1 ... 2 hectares the total area utilized by them being of 2,342,686 ha, representing approx. 17% of the total agricultural area utilized of Romania

These holdings represent the major potential users of agricultural machinery of small size and reduced work ability of tiller type which, in aggregate with technical equipment for different works, can be the ideal solution to meet the needs of small farmers.

Given the aforementioned, it appeared the need to develop new innovative products that have to meet the market requirements, according to the new vision of the people holding small land areas, regarding their cultivation and mechanized maintenance, for which purchasing large capacity equipment is not justified; this is explained by the big financial efforts, that are overwhelming and hard to recover in reasonable time periods, the equipment tender being very varied.

In this context, S.C. RURIS COM LLC together with INMA Bucharest performed and tested in laboratory and exploitation a multifunctional machine which consists in a 7.5 hp tiller, symbolized M7.5 and a reversible plow , PR1.

Romanian and world markets are well represented by such equipment, the technical tenders and price offer being most different, but for 7-10 H.P. class, the plow options are rather small, because the small farmers use less tiller-plow aggregate than motor-hoes.

The major shortcoming when using motor hoes is the reduced working depth in soil with high processing resistance that does not surpass 8-10 cm, fact that determines the creation of a beaten layer at root growing level of cultivated plants, thus diminishing the soil production capacity.

At the same time, soil work with motor hoes performs a very fine mincing, that in time could worsen the production

Rezumat: *O cerință importantă pentru realizarea unor condiții optime de cultivarea a plantelor în general şi a legumelor în special, în fermele mici şi în gospodăriile individuale, o constituie realizarea unei lucrări de bază a solului, de bună calitate. Obiectul lucrării de față îl constituie experimentarea utilajului alcătuit din motocultor M7,5 si plug reversibil PR1, în vederea determinării parametrilor funcționali care vor constitui baza promovării pe piață a utilajului menționat.*

Cuvinte cheie: *motocultor, plug reversibil, exploatații agricole mici.*

INTRODUCERE

In contextul structurii actuale a agriculturii, conform Anuarului statistic al României din 2010, în care sunt centralizate date la nivelul anului 2007, s-a identificat un număr de 2.485.566 exploatații agricole si gospodării individuale cu suprafețe de teren cuprinse intre 0,1… 2 hectare, totalul suprafeței utilizate de acestea fiind de 2.342.686 ha, care reprezintă cca. 17% din suprafața agricolă totală utilizată a României.

Aceste exploatații reprezintă posibilii utilizatori principali ai utilajelor agricole de dimensiuni si capacități de lucru mici de tip motocultor care, în agregat cu echipamente tehnice de lucru aferente diferitelor lucrări, pot fi soluția ideală pentru satisfacerea nevoilor micilor producători agricoli.

Din considerentele menționate s-a născut necesitatea dezvoltării de noi produse inovative care să satisfacă cerința de piață, in concordanță cu noua gândire a populației care deține suprafețe mici de teren, în ceea ce priveşte cultivarea si întreținerea mecanizată a acestora, pentru care nu se justifică achiziționarea de utilaje de capacități mari de lucru, pentru care oferta de piața este foarte variată dar necesită eforturi financiare mari greu de suportat şi recuperat în perioade rezonabile de timp.

În acest context, S.C. RURIS IMPEX S.R.L. împreună cu INMA Bucureşti au realizat şi experimentat în condiții de laborator şi exploatare un utilajul multifuncțional alcătuit dintr-un motocultor de 7,5 CP, simbolizat M7,5 si un plug reversibil cu o trupiță, PR1.

Piața românească şi mondială sunt bine reprezentate de astfel de echipamente, ofertele tehnice şi de preț fiind dintre cele mai diferite, dar la categoria de putere 7-10 CP, oferta de pluguri este mai slabă acest fapt şi din considerentul că în general micii agricultori utilizează mai puțin motocultorul+plug în detrimentul motosapelor.

Dezavantajul major în cazul utilizării motosapelor, este acela al adâncimii de lucru reduse pe soluri cu rezistență mare la prelucrare, care nu depăşeşte 8-10 cm, fapt ce conduce în timp, la formarea a unui strat bătătorit la nivelul adâncimii de dezvoltare a rădăcinilor plantelor cultivate, aceasta fiind una din cauzele scăderii capacității de producție a solului.

De asemenea lucrarea solului cu motosapele realizează o mărunțire mult prea fina a solului, fapt ce in

quality and state of respective soil.

Therefore, the ploughing operation should be alternatively performed, which means a previous testing of tiller-plow aggregate.

By testing the tiller M7.5 and PR1, the functional parameters in laboratory and in field, which will represent the promotion background of this aggregate to market, will be determined.

MATERIAL AND METHOD

Basic destination of the aggregate made of tiller M7.5+ reversible plow PR1, is to perform soil ploughing, the tiller representing the energetic component, and the plow-the proper ploughing equipment.

Reversible plow PR1 works in aggregate with tiller of 7.5 HP and is aimed only to soils that are constantly maintained all the year long. Before ploughing, the soil is previously checked by means of rotating hoes for knowing the soil settlement stage.

The energetic parameter which establishes the traction possibilities of tiller-plow aggregate is traction force, F_{tr}.

Theoretical traction force of the tiller is found out starting from the moment available at spur , M_r, that is determined with relation(1), where:

- M_m = 16.4Nm – nominal moment of tiller M7.5 thermal engine ;
- i_1 ;i_2 ;i_3 = 2.86; 4.3; 3.6 – Gear ratio of the three mating gears, i_1 ;i_2 from the gear box and i_3 from the reductor. These gear ratios correspond to first movement speed, respectively 5km/h.
- η_1 ;η_2 ;η_3 = 0.98; 0.99; 0.99 – gear ratio yields[1, pg.8].

Traction force F_{tr} is determined with relation, (2) where:

- r_r = 0.2m –radius of spur wheel of the tiller M7.

On the other hand, the traction force allowable at tiller wheels, F_{trd} is limited by the wheels adherence force with soil, F_a that, when skidding is not taken into consideration, is determined with the relation (3), where:

- φ = 1.0 – maximum adherence coefficient for wheels of caterpillar type (tiller wheels are metallic with spur and are similar to metallic caterpillar) [4];
- G_m = 120daN – tiller working weight.

For achieving the ploughing with plow PR1, force F_{trd} has to overcome the soil resistance to ploughing, R_a which is determined with relation (4) and running resistance F_r , which is determined with relation (5), where:

- k_a – specific resistance to ploughing (dN/cm^2). This is chosen from specialty literaure, according to type and state of soil;
- a = 12 cm – furrow depth, in case of plow PR1;
- b = 12cm – plow PR1 working width;
- f = 0.075 – coefficient of resistance to running[4];

For the user it would be easier to know the specific maximum resistance to ploughing of soil in which it works. Therefore, knowing the soil resistance value to ploughing R_a that is equal to available traction force limited by adherence F_{trd}, out of which the running resistance determined by relation (5) is subtracted, and replacing in relation (4) we can determine the maximum specific resistance of soil k_a in which the aggregate M7.5+PR1 can normally work, according to relation (6).

timp poate duce la înrăutățirea calităților de producție si a stării solurilor respective

Din aceste considerente a apărut necesitatea efectuării, alternativ a lucrării de arat, ceea ce presupune însă testarea agregatului motocultor+plug.

Prin experimentarea utilajului motocultor M7,5 si PR1, care face obiectul lucrării de față, se vor determina parametrii funcționali de laborator şi de exploatare care vor constitui baza promovării pe piață a utilajului menționat.

MATERIALE ŞI METODE

Destinația de bază a utilajului alcătuit din motocultor M7,5+ plug reversibil PR1, este de a realiza lucrarea de arat a solului, motocultorul fiind componenta energetică iar plugul echipamentul de arat efectiv.

Plugul reversibil PR1 lucrează în agregat cu motocultorul de 7,5 CP şi se utilizează numai pentru soluri întreținute pe tot parcursul anului. Înainte de lucrarea de arat, se verifică în prealabil solul cu ajutorul sapelor rotative pentru a observa starea de tasare a acestuia.

Parametrul energetic care stabileşte posibilitățile de tracțiune ale utilajului motocultor+plug este forța de tracțiune, F_{tr}.

Forța de tracțiune teoretică a motocultorului se determină plecând de la momentul disponibil la roțile cu pinteni, M_r, care se determină cu relația(1), în care:

- M_m = 16,4Nm - momentul nominal al motorului termic al motocultorului M7,5 ;
- i_1 ;i_2 ;i_3 = 2,86; 4,3; 3,6 – rapoartele de transmitere ale celor trei angrenaje cu roți dințate, i_1 ;i_2 din cutia de viteze şi i_3 din reductor. Aceste rapoarte de transmitere corespund vitezei intai de deplasare, respectiv de 5km/h.
- η_1 ;η_2 ;η_3 = 0,98; 0,99; 0,99 - randamentele transmisiilor cu roți dințate[1, pg.8].

Forța de tracțiune, F_{tr} se determină cu relația (2) în care:

- r_r = 0,2m –raza roții cu pinteni a motocultorului M7.

Pe de altă parte forța de tracțiune disponibilă la roțile motocultorului, F_{trd} este limitată de forța de aderență a roților cu solul, F_a care, în condițiile în care nu ținem seama de patinare, se determină cu relația(3), în care:

- φ = 1,0 – coeficientul de aderență maxim pe mirişte pentru roți tip şenilă(roțile motocultorului sunt metalice cu pinteni şi sunt asimilate şenilelor metalice) [4];
- G_m = 120daN – greutatea de lucru a motocultorului.

Pentru realizarea lucrării de arat cu plugul PR1, forța F_{trd} trebuie să învingă rezistența solului la arat, R_a care se determină cu relația (4) si rezistenta la rulare F_r care se determină cu relația (5), în care:

- k_a – rezistența specifică la arat (dN/cm^2). Aceasta se alege din literatura de specialitate în funcție de tipul şi starea solului;
- a = 12 cm - adâncimea brazdei, în cazul plugului PR1;
- b = 12cm – lățimea de lucru a plugului PR1;
- f = 0,075 – coeficientul de rezistenta la rulare[4];

Pentru utilizator, ar fi mai uşor să cunoască rezistența specifică maximă la arat a solurilor pe care poate lucra. Pentru aceasta, considerând valoarea rezistenței solului la arat R_a care este egală cu forța de tracțiune disponibilă limitata de aderenta F_{trd}, din care se scade rezistenta la rulare determinata cu relația (5) si înlocuind în relația (4), putem determina rezistența specifică maxima a solului k_a în care poate lucra agregatul M7,5+PR1 în condiții normale, conform relației (6).

$$M_r = M_m \cdot i_1 \cdot i_2 \cdot i_3 \cdot \eta_1 \cdot \eta_2 \cdot \eta_3 \text{ Nm} \quad (1)$$

Replacing values in relation(1), it results: M_r = 697.4Nm

Înlocuid valorile în relația(1), rezultă: M_r = 697,4Nm (69,74daN)

(69.74daN

$$F_{tr} = M_r / r_r = 348{,}7daN \quad (2)$$

$$F_{trd} = F_a = \varphi \cdot G_m = 120daN \quad (3)$$

$$R_a = k_a \cdot a \cdot b \quad (4)$$

$$F_r = G_m \cdot f = 9daN \quad (5)$$

$$k_a = R_a / a \cdot b = 0{,}77daN/cm^2 \quad (6)$$

Comparing the values determined in relations (2; 3), it can be noticed that the tiller M7.5 can develop a theoretical traction force at wheels, much bigger than the available one, limited by adherence, respectively of about three times bigger.

This represents an advantage when the tiller M7.5 works in aggregate with the rotating hoes, because it can use completely the available moment at wheels, but not the same thing happens when using trailed equipment, such as the plow.

In these cases, the traction force is limited by the working surface adherence, which leads to an important reduction of the available moment at tiller's wheels, thus, traction force diminishing.

Experimental researches for determining the functional and working parameters of tiller M7.5 during the work with reversible plow with one body, PR1, were performed in INMA Bucharest experimental fields.

Apparata used in experiments :

- weighing apparatus with non-automated function 0-150 kg;
- gauge tape 0-60 m;
- chronometer 0-30 min.;
- dynamometer (load cell) 0- 2KN ;
- peg, furrow meter.

RESULTS

In the given conditions, working tests were performed with the aggregate M7.5+PR1, and measurements of parameters of furrow obtained in 6 points, at every 2 meters, are shown in table 1.

Although, theoretically, the aggregate would have a traction force able to achieve the furrow parameters, established since the project stage, respectively a=12cm and b=12cm, when the soil category is known(average soil with ka =0.8dan/cm2), results have not been confirmed, the working depth being much smaller than the initial established one, according to values from table 1.

In this situation, the only possible cause would be that the state of soil(compression degree, humidity) be able to determine a resistance specific to ploughing bigger than the estimated one. For confirming or invalidating this hypothesis, we tested the effective resistance to ploughing in respective soil, by using a 50HP tractor, towing the aggregate M7.5 with the engine stopped+PR1 between which one dynamometer measuring the traction force, was interposed, fig. 1.

Measurement values are presented in table 2, from where it is noticed that when achieving furrow parameters very close to those required (a=12cm and b=12cm), and average traction forces of 158.33 daN, the average specific resistance to ploughing calculated with data from table 2 was of 1.155daN/cm2 , so, much bigger than that estimated for respective soil.

The simplest solution of achieving the average traction of 158.33 daN was to increase the tiller adherent weight and implicitly the adherent force, at a similar value to the required one, respectively of about 160daN. Therefore, two load units of 20 daN each, totally 40 daN, were placed on

Comparând valorile determinate în relațiile(2; 3), se observă că motocultorul M7,5 poate dezvolta o forță de tracțiune teoretică la roți, mult superioară celei disponibile, limitată de aderență, respectiv de cca. trei ori.

Acest lucru constituie un avantaj pentru situația când motocultorul M7,5 lucrează în agregat cu sapa rotativă deoarece poate utiliza în totalitate momentul disponibil la roți, însă nu acelaşi lucru se întâmplă în cazul utilizării echipamentelor de lucru tractate, precum plugul.

In aceste cazuri forța de tracțiune este limitată de aderența suprafeței de lucru acest aspect conducând la o scădere apreciabil de mare a momentului disponibil la rotile motocultorului si implicit a forței de tracțiune.

Cercetările experimentale pentru determinarea parametrilor funcționali si de lucru ai motocultorului M7,5 în lucru efectiv cu plugul reversibil cu o trupiță, PR1, au fost efectuate pe terenurile experimentale ale INMA Bucureşti.

Aparatura utilizată la experimentări

- aparat de cântărit cu funcție neautomată 0-150 kg;
- ruletă de măsură 0-60 m;
- cronometru 0-30 min.;
- dinamometru (celula de sarcină) 0- 2KN ;
- jaloane, brazdometru.

REZULTATE

In aceste condiții date, s-au efectuat probe de lucru cu agregatul M7,5+PR1, iar măsurătorile parametrilor brazdei obținute in 6 puncte din doi in doi metri sunt prezentate in tabelul 1.

Deşi teoretic agregatul ar fi avut o forța de tracțiune suficienta sa realizeze parametrii brazdei stabiliți încă din faza de proiect, respectiv a=12cm si b=12cm, in condițiile unui sol cunoscut(sol mijlociu cu ka =0,8dan/cm2), rezultatele nu au fost confirmate, adâncimea de lucru fiind mult mai mica decât cea stabilita inițial, conform valorilor din tabelul 1.

In aceasta situație, singura posibila cauza ar fi fost ca solul sa fi avut o astfel de stare(grad de tasare, umiditate) care sa fi determinat o rezistenta specifica la arat mai mare decât cea estimata. Pentru confirmarea sau infirmarea acestei ipoteze, am realizat probe pentru determinarea efectiva a rezistentei la arat efectiva pe solul in cauza. Pentru aceasta s-a utilizat un tractor de 50CP care a tractat agregatul M7,5 cu motorul oprit+PR1 intre care s-a intercalat un dinamometru care sa măsoare forța efectiva de tracțiune, fig. 1.

Valorile măsurătorilor sunt prezentate in tabelul 2 din care se observa ca, in condițiile realizării unor parametri ai brazdei foarte apropiați de cei impuşi(a=12cm si b=12cm), si a unor forte de tracțiune medii de 158,33 daN, rezistenta specifica la arat medie calculata cu datele din tabelul 2 a fost de 1,155daN/cm2 , mult superioara celei estimate pentru solul respectiv.

Cea mai simpla soluție de realizare a unei forte de tracțiune medii de 158,33 daN a fost sa mărim greutatea aderenta a motocultorului si implicit forța aderentă, la o valoare apropiata de cea necesara, respectiv in jurul valorii de 160daN. Acest lucru a fost realizat prin amplasarea pe

tiller guards, thus, the adherent weight being increased by approx. 33%,

Tests were repeated in the same conditions with loaded aggregate M7.5 +PR1, fig. 1, and values of measurements performed for furrow parameters are shown in table 3.

apărătorile de protecție ale motocultorului, a doua cutii de lestare de 20 daN fiecare, in total 40 daN, reuşindu-se astfel creşterea greutății aderente cu cca.33%,

Probele au fost repetate in aceleaşi condiții cu agregatul M7,5 lestat+PR1, fig. 1, iar valorile măsurătorilor efectuate pentru parametrii brazdei sunt prezentate in tabelul 3.

Table 1

Furrow parameters determined with M7.5+PR1

No. of sample	1	2	3	4	5	6	Average
Working depth, a(cm)	8	8.5	8	7.5	8	9	8.2
Working width, b(cm)	12	11	11.5	12	11.5	10.5	11.42

Fig. 1- Aspects during the test of aggregate M 7.5 +PR1

Table 2

Specific resistance to ploughing

No. of sample	1	2	3	4	5	6	Average
Resistance to ploughing ,R_a (daN)	155	162	158	160	165	150	158.33
Working depth , a(cm)	11.5	12.3	12.5	11	12.3	11.5	11.85
Working width , b(cm)	12.2	11.5	11	11.5	11.8	11.4	11.57
Specific resistance to ploughing , k_a (daN/cm^2)	1.1	1.14	1.15	1.26	1.14	1.14	11.55

Table 3

Furrow parameters determined with M7.5+PR1 loaded

No.of sample	1	2	3	4	5	6	Media
Working depth, a(cm)	11.3	12.2	10.8	11.8	11.5	12.0	11.6
Working width, b(cm)	11.5	11.8	11.8	12.0	11.5	11.5	11.68

CONCLUSIONS

- tiller unit M7.5+PR1 can achieve the ploughing at parameters designed, respectively a=12cm and b=12cm, only in fields which specific resistance to ploughing is smaller than 0.77daN/cm^2 , namely in light and average soils, according to literature.
- as, at least in Romania, most of soils are average and heavy, it is recommended that ploughing equipment, including the relevant equipment in this paper, could perform this operation in all types of existing soils, thus making the possible users more confident.

As the unit in its initial form can not meet all the above requirements, it has been decided to enlarge the equipment utilization area by increasing the adherent weight with load units.

- by adding loads to tiller, there were created the conditions necessary to balance the soil different parameters, taking into account not only the soil type, but also the soil state influenced by humidity, soil compression.

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CONCLUZII

- utilajul motocultor M7,5+PR1 poate realiza lucrarea de arat, la parametrii proiectați, respectiv a=12cm si b=12cm, numai pe terenuri a căror rezistența specifica la arat este mai mica de 0,77daN/cm^2 , aceasta corespunzând, conform literaturii de specialitate, solurilor uşoare si mijlocii.
- cum, cel puțin in Romania, majoritatea solurilor sunt mijlocii si grele, este de recomandat ca utilajele utilizate la arat, implicit cel care face obiectul lucrării de față, sa poată realiza aceasta lucrare in toate categoriile de soluri existente, dând astfel încredere sporită utilizatorilor posibili ai utilajului.
- întrucât utilajul de fata, aşa cum a fost el realizat inițial, nu poate satisface toate cerințele menționate la paragraful anterior, s-a luat măsura constructiva de a mari aria de utilizare a acestuia prin mărirea greutății aderente utilizând cutii de lestare.
- prin lestarea motocultorului, s-au creat şi condițiile de compenseze a influențelor parametrilor diferiți ai solurilor, ținând seama nu numai de categoria solurilor, dar si de starea acestora determinata de umiditate si starea de tasare sau compactare.

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SUPERIOR CAPITALIZATION OF LAVENDER BY OBTAINING VOLATILE OILS APPLYING THE STEAM DISTILLATION METHOD
/
VALORIFICAREA SUPERIOARA A LAVANDEI PRIN OBTINEREA DE ULEIURI VOLATILE APLICAND METODA DISTILARII CU VAPORI DE APA

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Abstract: *This paper aims to provide a rich and updated information on certain aspects regarding the necessity of establishing of lavender crops, to highlight the large palette of use the products which can be obtained from this plant and not least, the material benefits. The paper is addressed to specialists, farmers and to the family associations, highlighting the most important aspects to obtain quality products and under favorable economic conditions.*

Keywords: *lavender, technology, volatile oil, distillation floral water*

Rezumat: *Prezenta lucrare îşi propune să ofere o informație cât mai bogată şi actualizată asupra unor aspecte privind necesitatea infiintarii culturilor de lavanda, sa evidentieze paleta larga a utilizarii produselor care se pot obtine din aceasta planta si nu in ultimul rand beneficiile materiale. Lucrarea se adresează atât specialiştilor, fermierilor, cât şi asociatiilor familiale, evidențiind aspectele cele mai importante pentru obținerea unor produse de calitate şi în condiții economice avantajoase.*

Cuvinte cheie: *lavanda, tehnologie, ulei volatil, distilare, apa florala*

INTRODUCTION

Considered as small shrub, Lavender is a perennial plant, having leaves even in winter. Usually the leaves are silvery green, but there are also varieties with green or silvery leaves. The culture of lavender reaches maturity in 2-5 years, and it can be operated without problems for 30-40 years. Lavanda (Lavandula) are mai multe specii, printre care: officinalis, latifolia, stoechas etc.

In Romania the most common variety of lavender is that with narrow leafs, which have a width of 3-4 mm and a length of 30 - 40 mm called *Lavandula angustifolia*. To achieve a lavender plantation over an area of 1ha, are necessary about 18,000 to 19,000 seedlings reaching maturity after 3 years, and the production may reach 4000-4500 kg/ha of green flower (fresh). If the harvesting from summer is properly done, it can also carry out and and a second crop in autumn, from which it might still get 1000-1500 kg of lavender flowers.

Among the plants whose chemical composition can generate a significant amount of volatile oils and flower water, the lavender occupies a leading position. From chemical point of view, the volatile oils are complex mixtures of aliphatic and aromatic hydrocarbons, aldehydes, alcohols, esters and other constituents, being predominant the compounds of the terpenoids class. In the past, these oils were called etheric oils, essential oils or aromatic essences.

The extraction of a flavor from its natural environment is not an easy operation. This must be isolated or concentrated with a minimum of losses, modifications of composition and without the introduction of some impurities. Volatile oils can be extracted from various parts of the plant: flowers, seeds, leaves, stems, peels, roots, rhizomes, tubers, floral buds etc.

Although they are called oils, these substances do not contain fatty materials: a drop of essential oil placed on a paper sheet will not leave any trace, as opposed to one of vegetal oil. However, the essential oils properties must not be confused with those of the leaves or flowers of a same plant. Also, must not be confused the essential oils neither with the culinary essences and perfumes. Essential oils are highly concentrated in active chemical elements and

INTRODUCERE

Considerată arbust de talie mica, Lavanda este o plantă perenă, avand frunze chiar şi iarna. De regula frunzele sunt verde-argintiu, dar sunt şi soiuri cu frunze verzi sau argintii. Cultura de lavanda atinge maturitatea în 2-5 ani, şi poate fi exploatata fără probleme 30-40 de ani. Lavanda (Lavandula) are mai multe specii, printre care: officinalis, latifolia, stoechas etc.

In tara noastra cel mai intalnit soi de lavanda este cel cu frunze inguste, avand latimea de 3 - 4mm si o lungime de 30 - 40mm numit *Lavandula angustifolia*. Pentru realizarea unei plantatii de lavanda pe o suprafata de 1ha, sunt necesari circa 18000 - 19.000 de butasi care ajung la maturitate dupa 3 ani, iar productia poate ajunge la 4000-4500 kg/ha de floare verde (proaspata). Daca recoltarea din vara se face in mod corespunzator, se mai poate efectua o a doua recoltare in toamna din care s-ar putea obtine inca 1000-1500 kg de floare de lavanda.

Dintre plantele a caror compozitie chimica poate genera o insemnata cantitate de uleiuri volatile si apa de flori, lavanda ocupa un loc fruntas. Din punct de vedere chimic, uleiurile volatile sunt amestecuri complexe de hidrocarburi alifatice si aromatice, aldehide, alcooli, esteri si alti constituenti, predominand insa compusii din clasa terpenoidelor. In trecut, aceste uleiuri erau numite uleiuri eterice, uleiuri esentiale sau esente aromatice.

Extragerea unei arome din mediul sau natural nu este o operatie usoara. Aceasta trebuie izolată sau concentrată cu un minimum de pierderi, de modificări de compoziție si fără introducerea unor impurități. Uleiurile volatile pot fi extrase din diverse parti ale plantei: flori, seminte, frunze, tulpini, coji, radacini, rizomi, tuberculi, muguri florali etc.

Desi sunt numite uleiuri, aceste substante nu contin materii grase: o picatura de ulei esential pusa pe o foaie de hartie nu va lasa nicio urma, spre deosebire de una de ulei vegetal. Totusi, proprietatile uleiurilor esentiale nu trebuie confundate cu cele ale frunzelor sau florilor unei aceleiasi plante. De asemenea, nu trebuie confundate uleiurile esentiale nici cu esentele culinare si parfumurile. Uleiurile esentiale sunt foarte concentrate in elemente chimice active si pot prezenta anumite riscuri. Unii compusi sunt agresivi in raport cu pielea sau mucoasele, altii pot fi toxici in doze mari

may present certain risks. Some compounds are aggressive relative to the skin or mucous membranes, others can be toxic in high doses or when used on a long period of time. As for the domestic use, have to know that some compounds (such as ketones) are toxic and must never be absorbed. In principle, the essential oils must not be ingested in its pure state. Therefore, when using them must consider the recommendations for use.

The soothing properties of the lavender are indicated in the states of hysteria and neurasthenia, of melancholy or anxiety. In such cases, lavender is used in the form of dry powder which is kept in a hermetically sealed jar.

Benefits of lavender essential oil:

- the lavender oil has a calming scent, which makes it an excellent tonic for nerves. Therefore helps in treating of migraine, headaches, anxiety, depression, nervous tension and emotional stress. The soft flavour eliminates the nervous exhaustion and anxiety, increasing the mental activity.
- the lavender oil induces sleep, and therefore, it is often recommended for insomnia.
- the lavender oil is also an excellent remedy for various types of pains, including those caused by the muscular pains, tense muscles, rheumatism, sprains, backache and lumbago. A regular massage with lavender oil ameliorates the pains in joints.
- the lavender oil is beneficial for the urinary tract, because it stimulates the urine production. It helps the restoration of the hormonal equilibrium and reduces cystitis or the urinary bladder inflammation. It also reduces any associated cramps.
- the lavender oil is widely used for various respiratory problems, including throat infections, flu, cough, asthma, sinus congestion, bronchitis, whooping cough, laryngitis and tonsillitis. This oil is used either in the form of vapor, or applied to the skin of the neck, chest and back. It is also added to vaporizers and inhalers for cold and cough.
- the medical benefits of the lavender oil as regards the skin can be attributed to its antiseptic and antifungal properties. It is used to treat various skin disorders such as the acne, wrinkles, psoriasis and other inflammations. Heals wounds, cuts, burns, sunburn very fast, deoarece ajuta la formarea tesuturilor cicatrice. The lavender oil is added to chamomile for eczema treatment.
- the lavender oil is a blood circulation stimulant. It lowers the blood pressure and is used for hypertension.
- the lavender oil is useful for digestion, because it increases the intestine motility. It stimulates the production of gastric and biliary juices thus helping to the treatment of indigestion, stomach aches, colics, vomiting and diarrhea.
- the regular consumption of lavender oil provides resistance to disease.

Other benefits of the lavender oil include its ability to treat leucorrhea. It is also effective against insect bites. This oil is also used to reject the mosquito and moths. A number of mosquito repellent contain lavender oil as one ingredient.

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By the methode of distillation with water vapor, is obtained also a significant amount of floral water. The resulting water is a hydrolate and contains an average of 2-4% micromoles of essential oils. Lavender

sau daca sunt utilizati pe o perioada lunga de timp. Cat priveste utilizarea interna, trebuie stiut ca unii compusi (cum ar fi cetonele) sunt toxici si nu trebuie niciodata sa fie absorbiti. In principiu, uleiurile esentiale nu trebuie sa fie ingerate in stare pura. De aceea, in momentul utilizarii acestora trebuie sa se tina seama de recomandarile de utilizare.

Proprietățile calmante ale lavandei sunt indicate în stările de isterie şi de neurastenie, de melancolie sau de anxietate. În astfel de cazuri, lavanda se foloseşte sub formă de pulbere uscată care se păstrează într-un borcan ermetic.

Beneficiile uleiului esential de lavanda:

- uleiul de lavanda are un parfum calmant, ceea ce-l face un tonic excelent pentru nervi. Prin urmare, ajuta in tratarea migrenei, durerilor de cap, anxietate, depresie, tensiune nervoasa si stres emotional. Aroma racoritoare elimina epuizarea nervoasa si nelinistea, crescand activitatea mentala.
- uleiul de lavanda induce somnul si, prin urmare, este adesea recomandat pentru insomnie.
- uleiul de lavanda este, de asemenea, un remediu excelent pentru diferite tipuri de dureri, inclusiv cele cauzate de durerile musculare, muschi incordati, reumatism, entorse, dureri de spate si lumbago. Un masaj regulat cu ulei de lavanda amelioreaza durerile in articulatii.
- uleiul de lavanda este benefic pentru caile urinare, deoarece stimuleaza productia de urina. El ajuta la restabilirea echilibrului hormonal si reduce cistitele sau inflamatiile vezicii urinare. Acesta reduce de asemenea, orice crampe asociate.
- uleiul de lavanda este larg utilizat pentru diverse probleme respiratorii, inclusiv infectii ale gatului, gripa, tuse, astm, congestia sinusurilor, bronsita, tuse convulsiva, laringita si amigdalite. Acest ulei este utilizat fie sub forma de vapori sau aplicat pe pielea gatului, piept si spate. Este, de asemenea adaugat in vaporizatoare si inhalatoare pentru receala si tuse.
- beneficiile medicale ale uleiului de lavanda in ceea ce priveste pielea pot fi atribuite proprietatilor sale antiseptice si antifungice. Acesta este utilizat pentru a trata diverse afectiuni ale pielii, cum ar fi acneea, ridurile, psoriazisul si alte inflamatii. Se vindeca rani, taieturi, arsuri, arsurile solare foarte rapid, deoarece ajuta la formarea tesuturilor cicatrice. Uleiul de lavanda se adauga la musetel pentru tratarea eczemelor.
- uleiul de lavanda este un stimulent al circulatiei sanguine. Acesta scade tensiunea arteriala si este folosit pentru hipertensiune.
- uleiul de lavanda este util pentru digestie, deoarece creste mobilitatea intestinului. Acesta stimuleaza producerea de sucuri gastrice si biliare si, astfel, ajuta la tratarea indigestiei, durerilor de stomac, colicilor, varsaturilor si diareei.
- consumul regulat de ulei de lavanda ofera rezistenta la boli.

Alte beneficii ale uleiului de lavanda includ capacitatea sa de a trata leucoreea. De asemenea, este eficient impotriva muscaturilor de insecte. Acest ulei este folosit si pentru a respinge tantarii si moliile. O serie de repelente impotriva tantarilor contin ulei de levantica ca unul dintre ingrediente.

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Prin metoda distilarii cu vapori de apa, se obtine si o insemnata cantitate de apa florara. Apa rezultată este un hidrolat şi conține în medie 2-4% micromolecule de uleiuri

hydrolate has similar properties to the essential oils and, having a lower concentration, is highly sought especially in the cosmetics industry.

Benefits of water flowers (of lavender)

The therapeutic qualities of the lavender water are so numerous that it becomes difficult to put them into a selective action field, so: increases the defense power and recovery of the body, has a regenerating action on the epidermis, it is a quick remedy for scratches, wounds, allergic and solar erythema, eczemas, acne, has antiseptic and regenerative power on the tissues.

TECHNOLOGIES TO OBTAIN VOLATILE OILS

Industrial extraction of volatile oils from various aromatic herbs is done by different methods depending on their specific qualities. Each method is important and has its place in the production process of essential oils.

The main methods for obtaining the volatile oils are:

- water vapor distillation;
- volatile oil extraction with organic solvents;
- animal fat extraction: enfleurage and maceration;
- Liquefied gas extraction (supercritical CO_2);
- extraction by pressure;
- adsorption on an adsorbent material.

- *Volatile oil extraction with organic solvents:* applies particularly to obtain of natural fresheners perishable under the temperature influence and that can not be obtained by processes based on the steam distillation. The operation consists of the exhaustion of vegetable raw material with a solvent and then isolating the odorous principles or aromatics, allowing the evaporation of the solvent by distillation.
- *Extraction with animal fats:* the use of fats as a medium of extraction of gases and odors from flowers is a technique used exclusively in perfumery, based on the properties of volatile oils of being soluble in fats and on the affinity that the fats have to odors.
- *Extraction with liquefied gases:* the evolutions in the technological sector and the deepening from physicochemical point of view of the unitary operations made that this process to become industrially applicable. The advantages offered by the liquefied gases are the following: reduced thermal consumption; possibility of excluding the contact with oxygen; the inexistence of the problems derived from the presence of solvent residues in extracts; the use of non-toxic gases (CO_2, freons, butane etc.).
- *Extraction by pressing:* this method of obtaining the volatile oils is applied in few cases and only at those plants or parts of plants in which the volatile oil is found in large amounts, accumulated in secreting glands superficially disposed. Industrially, the procedure is applied for obtaining the volatile oils from citrus fruits (lemons, oranges, bergamot etc.). The volatile oils obtained in this way have superior qualities to the similar ones, obtained by entrainment with water vapors, because are eliminated the factors that cause degradations on them.
- *Adsorption on an absorbent material:* This technique consists in extraction of odorous from flowers by their absorbtion on a support with a high adsorption capacity such as: active carbon, silica gel and the alumina. The method has some advantages over the extraction on fats or with solvents. Firstly because the natural raw material does not touch the absorbent, can "survive" throughout the extraction, the biochemical processes to produce odoriferous substances continuing a while, allowing a higher yield than in the other extractive procedures. The industrial application of this method, under the name of

esențiale. Hidrolatul de lavandă are proprietăți similare uleiurilor esențiale, cu o concetrație mai mică, ceea ce îl face să fie foarte căutat mai ales în industria cosmeticelor.

Beneficiile apei de flori (de lavanda)

Calitatile terapeutice ale apei de lavanda sunt atat de numeroase incat devine dificil sa le pui intr-un camp de actiune selectiv, astfel: creste puterea de aparare si refacere a organismului, are o actiune regeneranta asupra epidermului, este un remediu rapid pentru zgarieturi, plagi eritem alergic si solar, eczeme, acnee, are putere antiseptica si regeneranta asupra tesuturilor.

TEHNOLOGII DE OBTINERE A ULEIURILOR VOLATILE

Extractia industriala a uleiurilor volatile din diverse plante aromatice se executa dupa metode diferite in functie de insusirile caracteristice ale acestora. Fiecare metoda este importanta si isi are locul in procesul de producere al uleiurilor esentiale.

Principalele metode de obtinere a uleiurilor volatile sunt:

- distilare cu vapori de apa;
- extractia uleiurilor volatile cu solventi organici;
- extractia cu grasimi animale: enfleurage si macerare;
- extractia cu gaze lichefiate (CO_2 supercritic);
- extractia prin presare;
- adsorbtia pe un material adsorbant.

- *Extractia uleiurilor volatile cu solventi organici:* se aplica in special pentru obtinerea acelor odorante naturale care sunt usor alterabile sub influenta temperaturii si care nu pot fi obtinute prin procedee bazate pe antrenarea cu vapori. Operatiunea consta in epuizarea materiei prime vegetale cu un solvent si apoi izolarea principiilor odorante sau aromatice, permitand evaporarea solventului prin distilare.
- *Extractia cu grasimi animale:* utilizarea grasimilor ca mediu de extractie a substantelor odorante din flori este o tehnica folosita exclusiv in parfumerie, bazata pe proprietatea uleiurilor volatile de a fi solubile in grasimi si pe afinitatea pe care o au grasimile fata de mirosuri.
- *Extractia cu gaze lichefiate:* evolutiile in sectorul tehnologic si aprofundarea din punct de vedere fizicochimic a operatiilor unitare au facut ca acest procedeu sa devina aplicabil la scara industriala. Avantajele oferite de gazele lichefiate sunt urmatoarele: consum termic redus; posibilitatea excluderii contactului cu oxigenul; inexistenta problemelor derivate din prezenta reziduurilor de solventi in extracte; utilizarea unor gaze netoxice (CO_2, freoni, butan etc.).
- *Extractia prin presare:* acest procedeu de obtinere a uleiurilor volatile se aplica in putine cazuri si numai la acele plante sau parti din plante in care uleiul volatil se gaseste in cantitate mare, acumulat in glande secretoare dispuse superficial. Industrial, procedeul se aplica pentru obtinerea uleiurilor volatile din fructe citrice (lamai, portocale, bergamot etc.). Uleiurile volatile obtinute pe aceasta cale au calitati superioare celor similare,obtinute prin antrenare cu vapori de apa, deoarece sunt eliminati factorii care produc degradari asupra lor.
- *Adsorbtia pe un material adsorbant:* aceasta tehnica consta in extractia odorantelor din flori prin adsorbtia lor pe un suport cu o mare capacitate de adsorbtie cum ar fi: carbunele activ, gelul de silice si alumina. Procedeul prezinta unele avantaje fata de extractia pe grasimi sau cu solventi. In primul rand datorita faptului ca materia prima naturala nu vine in contact cu adsorbantul, poate sa "supravietuiasca" pe tot timpul extractiei, procesele biochimice de producere a substantelor odorante continuand o vreme, permitand un randament mai mare

dynamic adsorption is practiced in the last decades and is aimed primarily those flowers from which the odoriferous can not be obtained except by enfleurage, such as the daffodils, hyacinths, lilac etc.

- *Distillation with water vapors:* is the method used routinely at the volatile oils extraction from most of aromatic plants; is commonly used for the industrial-scale extraction, but also has widespread use at laboratory level. By this method, the water vapors penetrate the vegetative mass subjected to distillation, destroy the Oleifici glands casing, volatilize the oil and then mixes with it. The mixture of water vapors and oil vapors refrigerant (condensation vessel) where it turns into a liquid which is nothing but the mixture of water and volatile oil. This mixture reaches the Florentine vessel (separation vessel) which hosts the separation namely the volatile oil being lighter it will splash over the water. Depending on the arrangement mode of the raw material into the boiler, are known the following types of distillation:

1. Distillation in water: is used for all the volatile oils which do not decompose at 100° C. The raw material is placed into water in a ratio of 1: 4 (at one part of raw material are put four parts of water by weight);
2. Distillation in water and water vapors: applies to the volatile oils at which certain components are dissolved in water, reason for which the raw material is disposed over the water. Heating the water into the boiler to transform it in vapors is made either by direct fire, or by blind pipes with steam. The volatile oil will be so extracted by the vapors that are formed.
3. Distillation with water vapors: is used in the extraction of the most oils. The process consists in the passage of water vapors obtained in certain installations for the production of the steam, in special boilers at relatively high temperatures and pressures, through the vegetative mass (flowers, herb etc.), placed into special baskets.

The distillation with water vapors is the most widespread method and is applied in the most countries producing volatile oils.

The distillation plant components are: the source of steam, the boiler in which is placed the raw material, the refrigerant vessel and the Florentine vessel for the separation of the volatile oil and the flower water.

The source of steam can be an electric generator for the steam production, one boiler working with gas / diesel, wood (pallets) or an electric kettle.

The boiler (tank) for distillation must be made of stainless steel as well as the input and output vapors pipes, as well as the sieve from the inside on which are placed the plants.

The lid must be of the same material, and on the top of it, must be installed an indicator for the indoor temperature display and safety valves which must open when into the vessel is formed overpressure.

The refrigerant vessel and the cooling coil must also be made of stainless steel. The cooling water temperature in the upper side of the vessel, must be maintained at a value between 27 ... 37°C.

The last component of the plant and the perhaps the most important, is *the essences separator* (the Florentine vessel). It is designed to separate the essential oils and the floral water.

The connections between the components of the installation are made only through fittings and pipes of stainless steel and special hoses, resistant to high temperatures and pressures.

In this context, within INMA Bucharest, Testing Department - TD, have been conducted a series of

decat in celelalte procedee extractive. Aplicarea industriala a acestui procedeu, sub numele de adsorbtie dinamica, se practica in ultimele decenii si vizeaza in primul rand acele flori din care odorantele nu se pot obtine decat prin enfleurage, cum sunt narcisele, zambilele, liliacul etc.

- *Distilarea cu vapori de apa:* este metoda folosita in mod curent la extractia uleiurilor volatile din majoritatea plantelor aromatice; este frecvent utilizata pentru extractia la scara industriala, dar are si utilizare pe scara larga la nivel de laborator. Prin aceasta metoda, vaporii de apa patrund in masa vegetativa, supusa distilarii, distrug invelisul glandelor oleifere, volatilizeaza uleiul si apoi se amesteca cu acesta. Amestecul de vapori de apa si vapori de ulei trece in refrigerent (vas de condensare), unde se transforma intr-un lichid care nu este altceva decat amestecul de apa si ulei volatil. Acest amestec ajunge in vasul florentin (vas de separare) unde are loc separarea si anume, uleiul volatil fiind mai usor se va depune in strat deasupra apei. In functie de modul de asezare a materiei prime in cazan, se cunosc urmatoarele tipuri de distilare:

1. Distilare in apa: se utilizeaza pentru toate uleiurile volatile care nu se descompun la temperatura de 100°C. Materia prima se pune in apa in raport 1:4 (la o parte materie prima se pun patru parti de apa in greutate);
2. Distilare in apa si vapori de apa: se aplica la uleiurile volatile la care anumite componente se dizolva in apa, fapt pentru care materia prima se aseaza deasupra apei. Incalzirea apei in cazan in vederea transformarii in vapori se face fie cu foc direct, fie prin conducte oarbe cu abur. Uleiul volatil va fi astfel extras de vaporii care se formeaza.
3. Distilarea cu vapori de apa: se foloseste in extractia celor mai multe uleiuri. Procedeul consta in trecerea vaporilor de apa obtinuti in anumite instalatii de producere a aburului, in cazane speciale la temperaturi si presiuni destul de ridicate, prin masa vegetativa (flori, iarba etc.), asezata in cosuri speciale.

Distilarea cu vapori de apa este metoda cea mai raspandita si se aplica in majoritatea tarilor producatoare de uleiuri volatile.

Componentele instalatiei pentru distilare sunt: sursa de abur, cazanul in care se aseaza materia prima, vasul refrigerent si vasul florentin pentru separarea uleiului volatil si apa de flori.

Sursa de abur poate fi un generator electric pentru producerea aburului, un cazan care functioneaza cu gaz/diesel, lemne (pelete) sau un fierbator electric.

Cazanul (cuva) de distilare trebuie sa fie realizat din material INOX la fel ca si conductele de intrare si iesire a vaporilor, precum si sita din interior pe care se pun plantele.

Capacul trebuie sa fie din acelasi material, iar pe partea superioara a acestuia, trebuiesc montate un indicator pentru afisarea temperaturii din interior si supape de siguranta care sa se deschida in cazul in care in vas se formeaza suprapresiune.

Vasul refrigerent si serpentina pentru racire trebuie deasemenea confectionate din material INOX. Temperatura apei de racire, in partea superioara a vasului, trebuie mentinuta la o valoare cuprinsa intre 27…37 °C.

Ultima componenta a instalatiei si poate cea mai importanta, o constitue *separatorul de esente* (vasul florentin). Acesta are rolul de a separa uleiurile esntiale de apa florara.

Legaturile dintre componentele instalatiei se fac numai prin racorduri si conducte din INOX si furtune special, rezistente la temperaturi si presiuni inalte.

In acest context, in cadrul INMA-Bucuresti, Departament Incercari - DI, s-au efectuat o serie de experimentari in vederea obtinerii de uleiuri esentiale,

experiments in view of obtaining of essential oils, using a distillation plant with steam generator under pressure (Fig. 1).

utilizandu-se o instalatie de distilare cu generator de abur sub presiune (fig. 1).

Fig. 1 – Distillation plant with pressurized steam generator

The distillation boiler has a capacity of 500 l in which can be introduced up to 40 kg of green plants, but not more than 3/4 of the capacity of the vessel. The first set of experiments was conducted in laboratory conditions, in order to extract oils from dried lavender scrap from the variety of *Lavandula angustifolia*, harvested a year ago. The second set of experiments was conducted in exploitation conditions, in Ocna Mures, at a lavender plantation of the same variety, using plants harvested 1-2 days ago, but also very fresh plants, harvested just before to be used.

The fresh inflorescences lavender harvesting was performed semi mechanized, utilizing a lavender harvesting equipment realized within INMA Bucharest, equipped with a mower with oscillating cutters with curved blades, mounted on a light chassis (Fig. 2).

Cazanul pentru distilare are o capacitate de 500 l in care se pot introduce pana la 40kg de plante verzi, dar nu mai mult de 3/4 din capacitatea vasului. Primul set de experimentari s-a realizat in conditii de laborator, in scopul extragerii de uleiuri din resturi de lavanda uscata din soiul *Lavandula angustifoli,* recoltata cu un an in urma. Al doilea set de experimentari s-a realizat in conditii de exploatare, in localitatea Ocna Mures, la o plantatie de lavanda din acelasi soi, utilizand plante recoltate cu 1-2 zile in urma, dar si plante foarte proaspete, recoltate chiar inainte de a fi utilizate.

Recoltarea inflorescentelor proaspete de lavanda s-a efectuat semi-mecanizat, utilizand un echipament de recoltat lavanda realizat in cadrul INMA Bucuresti, dotat cu o cositoare cu aparat de taiere cu lame oscilante curbate, montate pe un sasiu usor (fig. 2).

Fig. 2 – Lavender harvesting equipment

RESULTS

The results of the tests performed at INMA Bucharest and Ocna Mures are presented in Tables 1, 2 and 3.

REZULTATE

Rezultatele testelor efectuate la INMA Bucuresti si Ocna Mures sunt prezentate in tabelele 1, 2 si 3.

Table 1

The results of experiments utilizing lavender flower scraps

Determined parameters	Test 1	Test 2
The mass of raw material , [kg]	36	38
Air temperature , [°C]	15	17
The temperature of the steam leaving the generator, [°C]	124	130
The temperature in the boiler steam distillation entry, [°C]	107,5	108,3
The temperature of the steam inside the distillation boiler /, [°C]	105	105
Steam temperature at the entrance of the cooling vessel /, [°C]	88.5	89
Cooling water temperature, [°C]	11	11

Duration of test ,[min]	85	75
The volume of volatile oil , [l]	0.085	0.090
Floral water volume obtained, [l]	28	26

Table 2

The results of experiments using lavender flower harvested of 2 days

Determined parameters	Test 1	Test 2
The mass of raw material , [kg]	32	35
Air temperature , [°C]	29	29
The temperature of the steam leaving the generator, [°C]	130	131
The temperature in the boiler steam distillation entry, [°C]	107	108
The temperature of the steam inside the distillation boiler , [°C]	105	105
Steam temperature at the entrance of the cooling vessel , [°C]	90	91
Cooling water temperature, [°C]	19	20
Duration of test , [min]	65	60
The volume of volatile oil, [l]	0.18	0.20
Floral water volume obtained, [l]	23	22

Table 3

The results of experiments using lavender flower just harvested (10-15 min)

Determined parameters	Test 1	Test 2	Test 3
The mass of raw material , [kg]	32	35	40
Air temperature / *Temperatura aer*, [°C]	30	30	31
The temperature of the steam leaving the generator , [°C]	131	130	130
The temperature in the boiler steam distillation entry, [°C]	107	107,5	108
The temperature of the steam inside the distillation boiler , [°C]	105	105	105
Steam temperature at the entrance of the cooling vessel ,[°C]	91	91,5	91,5
Cooling water temperature , [°C]	20	20	21
Duration of test , [min]	55	65	75
The volume of volatile oil , [l]	0.22	0.26	0.31
Floral water volume obtained , [l]	20	22	27

CONCLUSIONS

Lavender occupies a prominent place amongst the plants whose chemical composition can generate a significant amount of essential oils and flower water, the capitalization of these products representing an important source of income for farmers.

For the lavender grown in Romania is extremely important the knowledge of the culture technology in order to obtain a high quality raw material, under the conditions of increasing of the requirement on the market of the products in the field.

In the category of methods for obtaining volatile oils, the distillation with water vapors is the most widespread method and is applied in most countries with tradition in this area.

Following the experiments undertaken, was found that as a main condition for more efficient recovery of the culture of lavender and obtaining as significant quantities of essential oil is to process the lavender flower as quickly after harvesting. It is also necessary the use of modern technologies for the rapid harvesting and processing of the lavenderplants.

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CONCLUZII

Lavanda ocupa un loc de frunte in categoria plantelor a caror compozitie chimica poate genera o insemnata cantitate de uleiuri volatile si apa de flori, valorificarea acestor produse reprezentand o sursa importanta de venituri pentru fermieri.

Pentru lavanda cultivata in tara noastra este extrem de importanta cunoasterea tehnologiei de cultură in vederea obtinerii unei materii prime de calitate, in conditiile cresterii cerinței pe piata produselor de profil.

Din categoria metodelor de obtinere a uleiurilor volatile, distilarea cu vapori de apa este metoda cea mai raspandita si se aplica in majoritatea tarilor cu traditie in acest domeniu.

In urma experimentarilor intreprinse, s-a constatat ca o conditie principala pentru valorificarea cat mai eficienta a culturii de lavanda si obtinerea unor cantitati cat mai insemnate de ulei esential este aceea de a prelucra floarea de lavanda cat mai rapid dupa recoltare. Este necesara, de asemenea, utilizarea unor tehnologii moderne pentru recoltarea si prelucrarea rapida a plantelor de lavanda.

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STRUCTURAL STATICAL ANALYSIS OF WORKING BODIES OF AGRICULTURAL CULTIVATORS
/
ANALIZA STATICĂ STRUCTURALĂ A ORGANELOR DE LUCRU ALE CULTIVATOARELOR AGRICOLE

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Abstract: *in this paper is presented an advanced methodology for the analysis of stress and strain distribution (statical structural analysis using the finite element method) in the working bodies of agricultural cultivators for seedbed preparation in order to optimize them. The geometrical model of soil working body was develoepd in SolidWorks format before being taken and transferred to the program of analysis with finite elenets (ANSYS), in order to perform the necessary resistance calculations made in linear static domain. The obtained results provide valuable information on proper geometric dimensioning of the working bodies of agricultural cultivators.*

Keywords: *finite element method, structural statical analysis, working body, agricultural cultivator*

Rezumat: *În cadrul acestei lucrări, este prezentată o metodologie avansată de analiză a distribuţiei tensiunilor şi deformaţiilor (analiză statică structurală utilizând metoda elementelor finite) în organele de lucru ale cultivatoarelor agricole destinate pregătirii patului germinativ, în vederea optimizării acestora. Modelul geometric al organului de lucrat solul a fost realizat în format SolidWorks după care a fost preluat şi transferat către programul de analiză cu elemente finite (ANSYS), în vederea efectuării calculelor de rezistență necesare, calcule realizate în domeniul liniar static. Rezultatele obţinute oferă informaţii foarte valoroase cu privire la dimensionarea geometrică corespunzătoare a organelor de lucru ale cultivatoarelor agricole.*

Cuvinte cheie: *metoda elementelor finite, analiză statică structurală, organ de lucru, cultivator agricol*

INTRODUCTION

Following the expansion of soil degradation processes due to conventional agriculture and technological mistakes, over the years, the so-called conservative agricultural technologies have been studied and implemented in practice. These technologies have contributed substantially to the improvement of soil fertility and productivity and, thus, of other environmental resources. The most important component of conservation technological systems, as in the case of conventional ones, is soil tillage – loosening and processing – and the introduction of seed into the soil. Switching from conventional tillage systems to the conservative ones was not easy and generated a lot of questions that needed relevant answers, scientifically based, some of them being obtained through fundamental and applied research carried out under local specific conditions. Conservative systems are based on the less intense loosening of soil, made by different methods, without furrow return and only while maintaining a given amount of crop residues on soil surface, being considered for this reason as environmental protection strategies.

Agriultural cultivators are equipment with an increasingly widespread for seedbed preparation in order to establish crops, especially in the current conservative cultivation technologies. Besides the fact that these equipment must achieve a soil processing with superior qualitative and energy indices, their weight must be as small as possible and their reliability must be as good as possible. Currently, it is possible to shorten spectacularly the cycle of conception-design-testing-production of such equipment by using the finite element method for the analysis of stress and strain distribution of their resistance

INTRODUCERE

Ca urmare a extinderii proceselor degradării solului datorită agriculturii convenționale şi a greşelilor tehnologice, de-a lungul anilor, au fost studiate şi implementate în practică aşa numitele tehnologii agricole conservative. Aceste tehnologii conservative au contribuit substanțial la ameliorarea şi îmbunătățirea stării de fertilitate şi productivitate a solului şi în consecință a altor resurse de mediu. Cea mai importantă componentă a sistemelor tehnologice conservative, ca şi în cazul celor convenționale, o reprezintă lucrarea solului -modul de afânare, de prelucrare - şi introducere a seminței in sol. Trecerea de la sistemele convenționale de lucrare a solului la cele conservative nu a fost simplă şi a dat naştere la o mulțime de întrebări la care au fost necesare răspunsuri pertinente, bine fundamentate ştiințific, parte dintre ele fiind obținute prin cercetări fundamentale şi aplicative realizate în condiții specifice locale. Sistemele conservative se bazează pe afânarea mai puțin intensă a solului, realizată prin diferite metode, fără întoarcerea brazdei şi numai în condițiile păstrării la suprafața solului a unei anumite cantități de resturi vegetale, fiind considerate din acest motiv strategii ecologice de protecție.

Cultivatoarele agricole sunt echipamente care au o tot mai larga raspandire pentru pregatirea patului germinativ in vederea infiintarii culturilor, mai ales in cadrul actualelor tehnologii conservative de cultivare. Pe langa faptul ca aceste echipamente trebuie sa realizeze o prelucrare a solului cu indici calitativi si energetici superiori, greutatea acestora trebuie sa fie cat mai mica iar fiabilitatea acestora sa fie cat mai buna. In prezent este posibila scurtarea spectaculoasa a ciclului de conceptie-proiectare-testare-fabricatie a acestor echipamente prin utilizarea metodei elementelor finite pentru analiza distributiei tensiunilor si deformatiilor din elementele de rezistenta ale acestora

elements (frames, tool holders, working tools, etc.).

MATERIAL AND METHOD

The experimental model of technical equipment for conservative processing of soil is semi-mounted and works in aggregate with tractors in range of 330-550 HP.

The equipment (fig. 1) consists of: drawbar with towing ring (1); working bodies type knife chisel with extension (2); preceding disks (3); double bearing support (4); identification tablet (5); central frame (6); transport train (7); rear roller (8); lights kit (9); hydraulic installation for folding of lateral frames (10);); hydraulic installation for working depth adjustment of the discs (12); disc levening bar (13).

(cadre, suporti pentru scule, organe de lucru, etc.).

MATERIAL ŞI METODĂ

Modelul experimental de echipament tehnic pentru prelucrarea conservativă a solului este de tip semipurtat şi lucrează în agregat cu tractoare de 330-550 CP.

Echipamentul (fig. 1) se compune din: proțap cu inel de remorcare (1); organe de lucru de tip cuțit daltă cu prelungire (2); discuri anterioare (3); suport dublu de susținere (4); tăbliță de identificare (5); cadrul central (6); tren de transport (7); tavalug posterior (8), kit lumini (9); instalație hidraulică pentru rabatarea cadrelor laterale (10); instalație hidraulică pentru reglarea adâncimii de lucru a tavalugului (11); instalație hidraulică pentru reglarea adâncimii de lucru a discurilor (12); bară cu discuri nivelatoare (13).

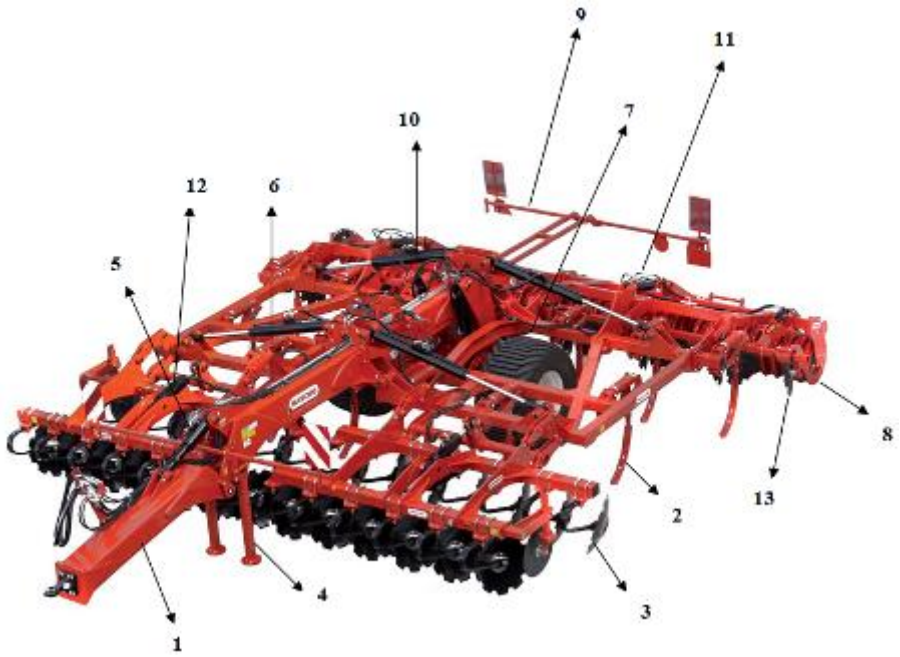

Fig. 1 – Technical equipment for conservative soil processing – three-dimensional view

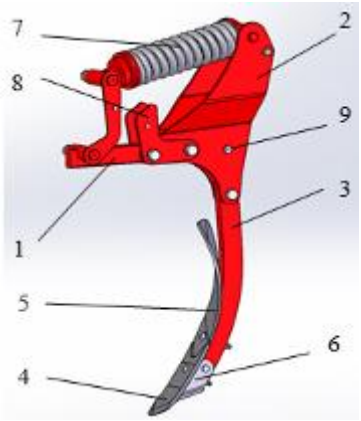

Fig. 2 – Main working body of the cultivator

Soil working body (fig. 2) is designed to dislodge the soil to a depth of up to 25 cm, to raise, stir and turn crop residues, is mounted on the frame of technical equipment for conservative soil processing. Soil working body consists of a support (1) on which are mounted two support plates (2) on one hand, for assembling a rigid support (3) provided with a chisel (4) for soil decompaction, an extension (5) for slight twisting of crop residues and a cutting knife (6) of the bottom of the furrow and on the other hand, for assembling a

Organul de lucrat solul (fig. 2) are rolul de a disloca solul pe o adâncime de până la 25 cm, ridica, amestecă şi întoarce resturile vegetale, este montat pe cadrul echipamentului tehnic de prelucrare conservativă a solului. Organul de lucrat solul este alcătuit dintr-un suport (1) pe care sunt montate două plăci suport (2) pe de o parte, pentru asamblarea unui suport rigid (3) prevăzut cu o daltă (4) cu rol de decompactare a solului, o prelungire (5) cu rol de răsucire uşoară a resturilor vegetale şi un cuţit de tăiere (6) a fundului brazdei şi pe de altă parte, pentru

pretensioned spring (7) which allows absorbing most part of the towing tension and of the plates (8) for the limitation of the spring stroke.

The geometric model of soil processing in conservative system was developed in SolidWorks format and transferred to the analysis program with finite elements (ANSYS), in order to perform the required resistance calculations, which were made in linear static domani. In figure 4 is presented the meshed model of the working body. Given that the investigated structure was modeled geometrical three-dimensional, it was chosen that in the meshing process to use a 3D finite element, of Solid type. His is a three-dimensional element, of rectangular shape, with 20 nodes (on each corner and at each mid side) with three degrees of freedom on each node: nodal translations in the directions of OX, OY and OZ axis. The element supports the theory of plasticity, hiperplasticity, large specific displacements and strains; the material used S355OL52.

In figure 5 is presented dthe geometrical shape of the finite element, used in the meshing process. The rectangular shape of the finite element represents the native shape, whereas the other shapes, found in the right side of the figure, represent degenerated forms, that may arise in the case of complex geometries as shapes (in areas in which are found junction radius, thickness variations etc.).

asamblarea unui arc pretensionat (7) care permite absorbirea celei mai mari părți a tensiunii de tractare şi a unor plăci (8) cu rol de limitare a cursei arcului.

Modelul geometric al organului de lucrat solul în sistem conservativ a fost realizat în format SolidWorks şi transferat către programul de analiză cu elemente finite (ANSYS), în vederea efectuării calculelor de rezistență necesare, calcule realizate în domeniul liniar static (fig.3). În figura 4 este prezentat modelul discretizat al organului de lucru. Ținând cont că structura investigată a fost modelată geometric tridimensional, s-a optat ca în procesul de discretizare să se folosească un element finit 3D, de tip Solid. Acesta este un element tridimensional, de formă paralelipipedică, având 20 de noduri (în fiecare colt şi la jumătatea fiecărei laturi) cu trei grade de libertate pe fiecare nod: translații nodale pe direcțiile axelor OX, OY şi OZ. Elementul suportă teoria plasticității, hiperelasticității, deplasări şi deformații specifice mari; materialul utilizat: S355OL52.

În figura 5 este prezentată forma geometrică a elementului finit, utilizat în procesul de discretizare. Forma paralelipipedică a elementului finit reprezintă forma nativă, pe când, celelalte forme, regăsite în partea dreaptă a figurii, reprezintă forme degenerate, care pot apărea în cazul unor geometrii complexe ca formă (în zonele în care se întâlnesc raze de racordare, variații de grosime etc.).

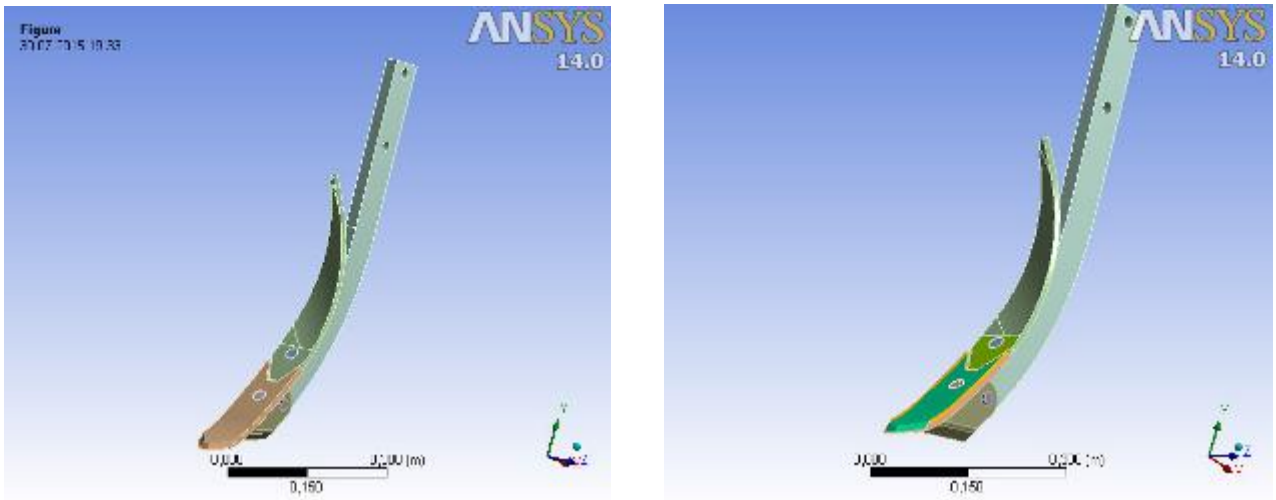

Fig. 3 – Geometric model of working body taken in ANSYS

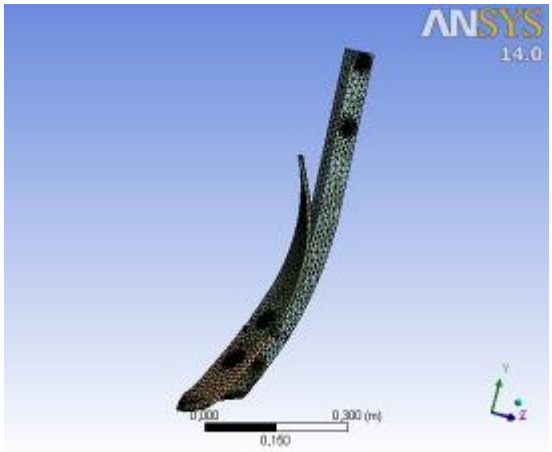

Fig. 4 – Meshed model of the working body

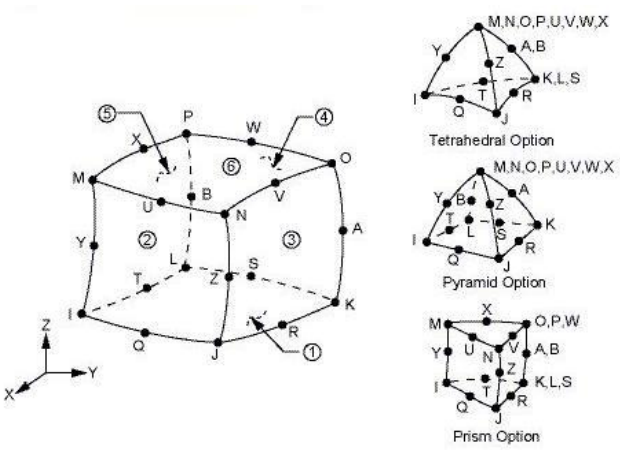

Fig. 5 – Geometry of the finite element

RESULTS

The results of the static analysis of the working of the cultivator are presented in the following figures. These consist of: distribution of total deformation, distribution of normal pressures on the coulter of the working body, distribution of equivalent stress by the Von Mises criterion in both the coulter and the wing of the working body, but also in support of the working body.

REZULTATE

Rezultatele analizei statice a organului de lucru al cultivatorului sunt prezentate în figurile următoare. Acestea constau în: distribuţia deformaţiilor totale, distribuţia presiunilor normale pe brăzdarul organului de lucru, distribuţia tensiunilor echivalente conform criteriului Von-Mises atât în brăzdar, cât şi în aripa organului de lucru, dar şi în suportul organului de lucru.

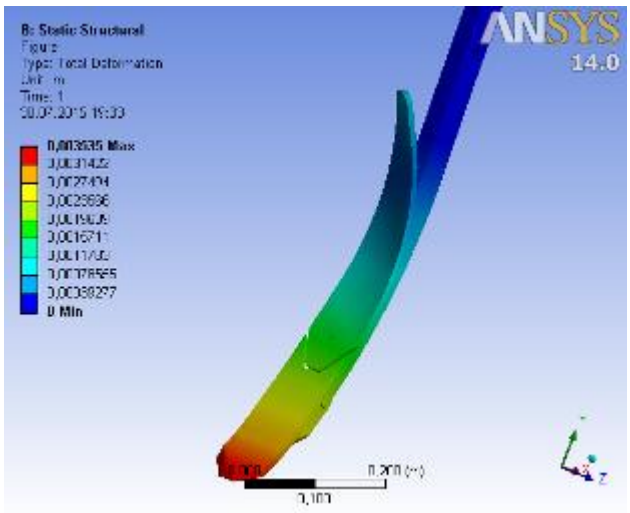

Fig. 6 – Distribution of total deformation

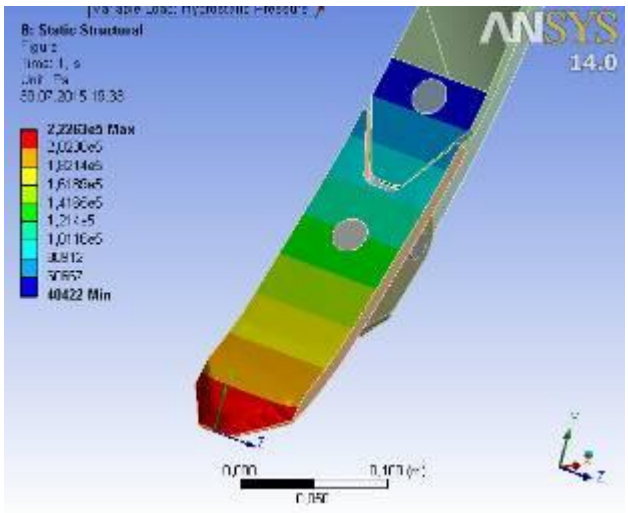

Fig. 7 – Distribution of normal pressures on the working body

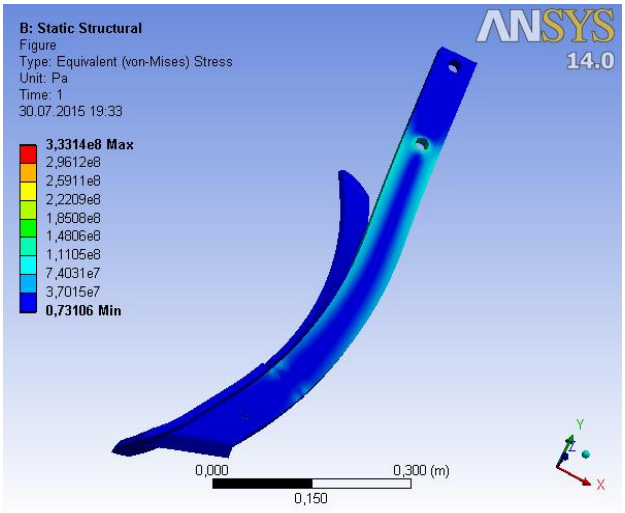

Fig. 8 – Distribution of equivalent stress

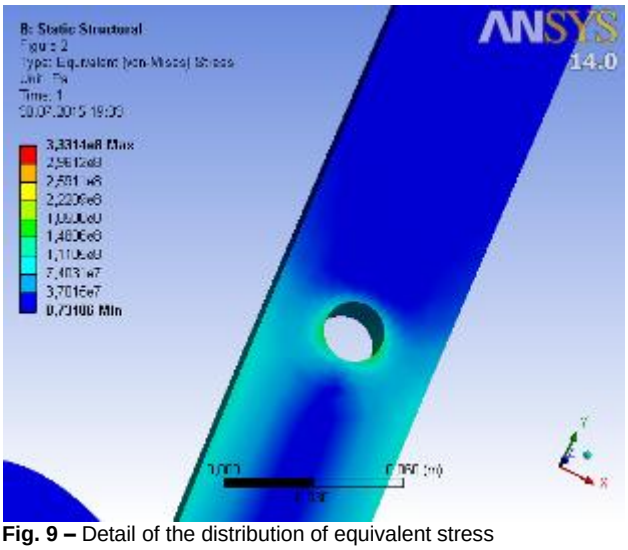

Fig. 9 – Detail of the distribution of equivalent stress

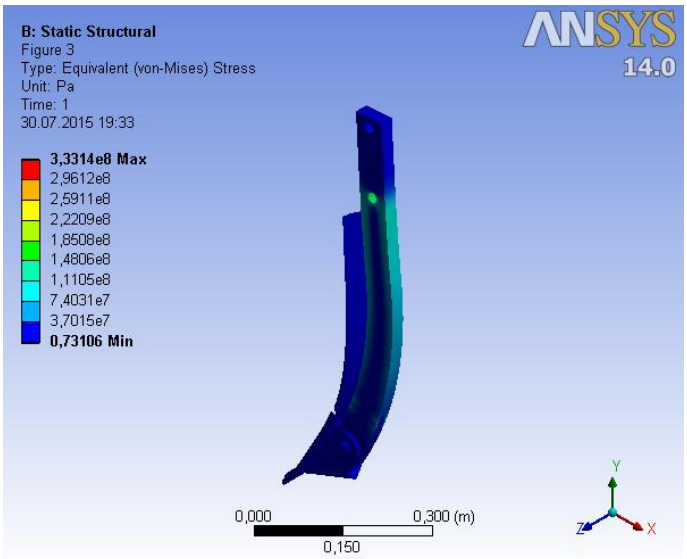

Fig. 10 – Distribution of equivalent stress in the support of the working body

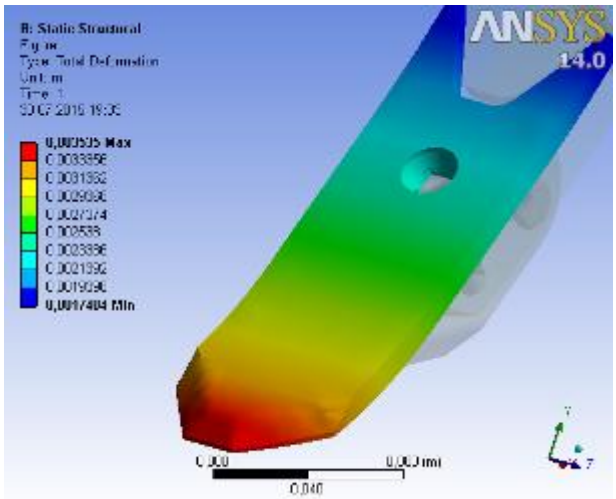

Fig. 11 –Distribution of deformation on the coulter of the working body

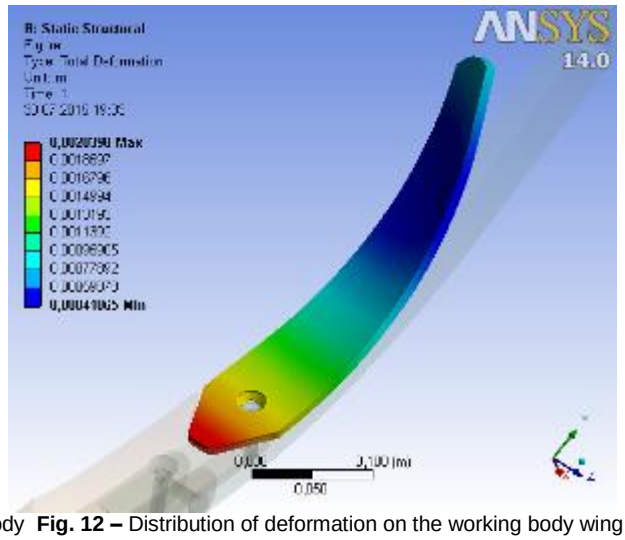

Fig. 12 – Distribution of deformation on the working body wing

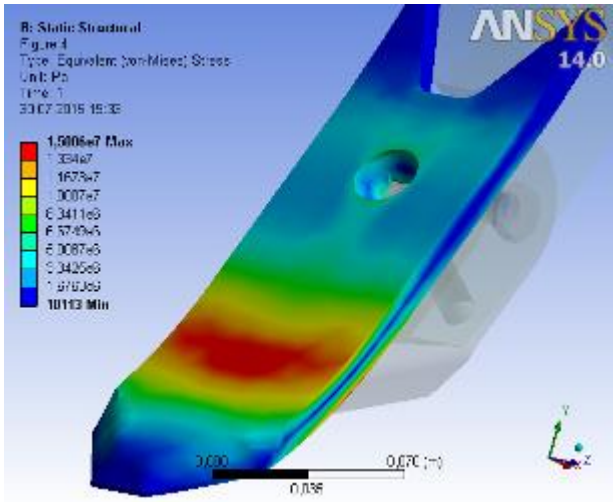

Fig. 13 – Distribution of stress on the coulter of the working body

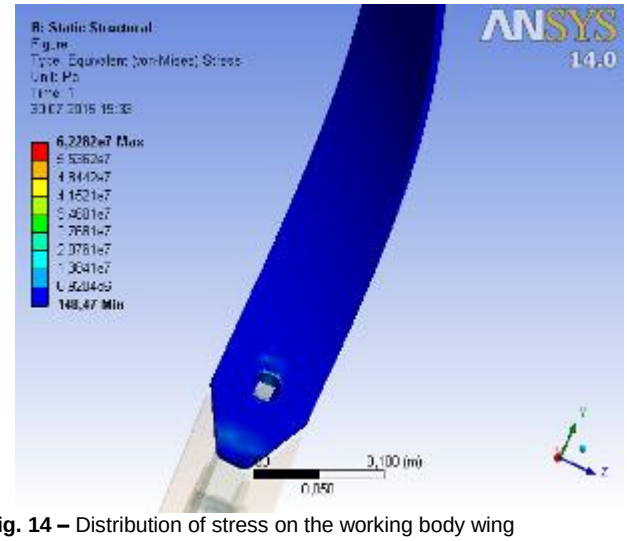

Fig. 14 – Distribution of stress on the working body wing

CONCLUSIONS

- Theoretical structural static analysis of the working body can be used to determine deformations in plastic field;

CONCLUZII

- Analiza structurală statică teoretică a organului de lucru poate fi utilizată pentru determinarea deformațiilor în domeniul plastic;

- This analysis can be used as a tool for determining the mechanical strength and hence the reliability of the working;
- To obtain a conclusive result on the active organ deformation resistance, static structural analysis is completed with tests under real working: the stand - Hidropuls or in expoitation).

ACKNOWLEDGEMENTS

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- Această analiză poate fi utilizată ca instrument pentru determinarea rezistenței mecanice şi implicit a fiabilității organului de lucru;
- Pentru obținerea unui rezultat concludent asupra rezistenței de deformații a organului activ, analiza structurală statică se completează cu încercări în condiții reale de lucru: pe stand - Hidropuls sau în exploatare).

MULȚUMIRI

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MANAGEMENTUL INDUSTRIEI OȚELULUI ÎN CONTEXTUL DEZVOLTĂRII DURABILE / *THE MANAGEMENT OF STEEL INDUSTRY IN THE CONTEXT OF DURABLE DEVELOPMENT*

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Abstract: *The durable development imposes the respect of economic, social and environment-protection requests. The objective of this paper is the emphasis of applying a rational management at the level of all the siderurgical operators in order for a healthy economic growth to be assured, correlated with the environment protection. In this sense, the study is based on the analysis of a data set which relates to the growth rhythm of the GDP, raw steel production and the consume of finished steel products/capita for the significant countries from the perspective of these indicators. Also, there are emphasized the objectives of sustainable development and the requests of the systematic management imposed by them at the level of the operators from the siderurgical industry.*

Keywords: *steel industry, management, durable development, economic growth.*

Rezumat: *Dezvoltarea durabilă impune respectare cerințelor economice, sociale şi de protejare a mediului. Obiectivul acestei lucrări este evidențierea aplicării unui management rational la nivelul tuturor operatorilor din industria siderurgică astfel încât să se asigure o creştere economică sănătoasă, corelată cu protejarea mediului. În acest sens, studiul se bazează pe analiza unui set de date ce se raportează la ritmul de creştere al PIB, producția de oțel crud şi consumul de finished steel products/capita pentru țările semnificative din perspectiva acestor indicatori. De semenea, sunt evidențiate obiectivele dezvoltării sustenabile şi cerințele managementului sistematic impus de acestea la nivelul operatorilor din industria siderurgică.*

Cuvinte cheie: *industria oțelului, management, dezvoltare durabilă, creştere economică.*

INTRODUCTION

The steel is one of the omnipresent elements in our day-to-day life, because it presents a series of characteristics which recommend it compared to other materials (mechanical resistance, possibility of recycling in a high percent, machinability and easy maintenance etc.). Thus, the steel industry became an extremely important branch within the world economy by the products supplied to a large number of sectors as well as the contribution to the economic development and the assurance of a high number of work places [1]. This last aspect is sustained by the data supplied by the current statistics that sustain the fact that over 2 million people are implicated in the direct industry and the number of generated work places is appreciated to over 50 million people if the links with other sectors are taken into consideration [2]. The usage of steel recorded an important growth worldwide, respectively by over 7 times compared to 1950, a similar trend, by 1.5 times, being estimated for 2050, compared to the actual situation.

In terms of consumption/capita, there was reached a 220 kg level.

The demand for this product is sustained by the construction activity of homes, electrical plants, and wind farms or for the realization of infrastructure elements in transport domains. But a great importance will have the innovations in the domain which will permit the reduction of production costs, the increase of added value and the infiltration on new markets.

MATERIAL AND METHOD

TENDENCES RECORDED ON THE GLOBAL STEEL MARKET

The industrialization process, emphasized by the level of emerging countries determined an obvious growing trend of the world steel market after 2000. In terms of producing raw steel, an increase of 54, 37% is remarked in 2014 compared to 2000, obviously with fluctuations from one year to another. Geographically,

INTRODUCERE

Oțelul este unul din elementele omniprezente în viața de zi cu zi, întrucât prezintă o serie de caracteristici ce îl recomandă în comparație cu alte materiale (rezistență mecanică, posibilitate de reciclare într-un procent ridicat, prelucrabilitate şi întreținere facilă, ş.a.). Astfel, industria oțelului a devenit o ramură extrem de importantă în cadrul economiei mondiale prin produsele livrate unui număr mare de sectoare dar şi prin contribuția la dezvoltarea economică şi asigurarea unui număr mare de locuri de muncă. [1] Acest ultim aspect este susținut de datele furnizate de statisticile curente, care susțin faptul că peste 2 milioane de oameni sunt implicați în industria directă, iar dacă se au în vedere legăturile cu alte sectoare numărul de locuri de muncă generate este apreciat la peste 50 de milioane de oameni[2]. Utilizarea oțelului a cunoscut o creştere importantă la nivel mondial, respectiv de peste 7 ori comparativ cu anul 1950, fiind estimată o tendință similară de 1,5 ori pentru anul 2050, comparativ cu situația actuală. Din punct de vedere al consumului pe cap de locuitor, s-a ajuns la un nivel de peste 220 / Kg.

Cererea pentru acest produs este susținută de activitatea de construcție a locuințelor, centralelor electrice, parcurilor eoliene, sau de realizare a unor elemente de infrastructură în domeniul transporturilor. Dar, o importanță deosebită o vor avea inovațiile în domeniu care vor permite reducerea costurilor de producție, creşterea valorii adăugate şi pătrunderea pe noi piețe.

MATERIAL ŞI METODĂ

TENDINȚE ÎNREGISTRATE PE PIAȚA MONDIALĂ A OȚELULUI

Procesul de industrializare accentuat de la nivelul țărilor emergente a determinat o tendință evidentă de creştere a pieței mondiale a oțelului după anul 2000. Din punct de vedere al producției de oțel crud, se remarcă o creştere cu 54,37 / % în anul 2014 comparativ cu anul 2000, evident, cu fluctuații de la un an la altul. Din punct de vedere geografic, Asia este continentul unde se

Asia is the continent where is concentrated the largest production as well as the demand of raw steel. In this matter, in the production domain a dominant trend is remarked, with a percent of 67, 94% in 2014 from the global volume, especially as a consequence of the domination of China, with a percent of 49, 51% from the world production, respectively 73.87% from Asia production. The given situation was recorded alongside an internal over-capacity of China, a fact which determined the modification of importer position into the exporter one. In this matter, the consumption/capita is also significant, China being situated currently on the 5th place worldwide, with 515, 7 kg/capita compared with South Korea, which recorded a steel consumption of 1057.4 kg/capita.
The raw steel production at a global level is reflected in Figure 1.

concentrează cea mai mare producție dar şi cerere de oțel crud. În acest sens, se remarcă tendința dominantă în domeniul producției, cu un procent de 67,94 % în anul 2014 din volumul global, în special ca urmare a dominației Chinei, cu un procent de 49,51 % din producția mondială, respectiv 73,87 % din producția Asiei. Situația precizată s-a înregistrat pe fondul unei supracapacități interne a Chinei, fapt ce a determinat modificarea poziției de importator în poziția de exportator. Semnificativ în acest sens este şi consumul pe cap de locuitor, China situându-se în prezent pe locul 5 în lume, cu 515,1 kg / capita, comparativ cu South Koreea, care a înregistrat un consum de oțel de 1057,4 kg / capita.

Evoluția producției de oțel crud la nivel mondial este reflectată în Figura 1.

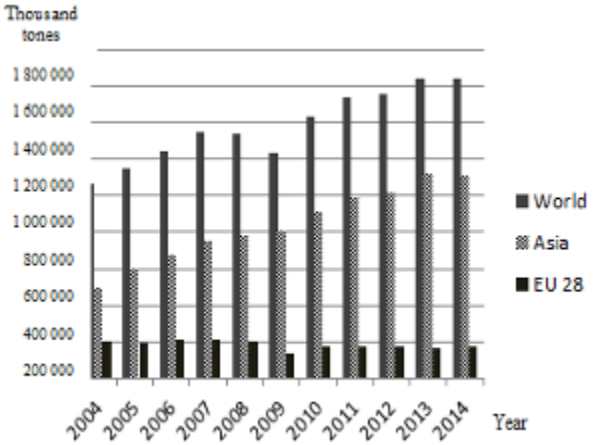

Fig. 1 - The evolution of crude steel production in 2004 - 2014

From the Figure 1 the growing trend of the world production of raw steel can be found, with an inflection point in 2009, as a result of the economic-financial crisis effects, when the total production level decreased with 7.8% compared with the previous year. But this trajectory was not similar at the levelof different regions. Thus, if Asia can be remarked by a continuous growth, even in the recession phase, at the EU level the trend was of production diminishing on the whole interval and much lower in 2009, respectively with 29.81% from 2008. This situation is the result of an action of an ensemble of factors, respectively: the demand reduction, in the context of the situation deterioration within steel-consumer industries; the existence of a production over-capacity (the usage of production capacity in a proportion of 71.6% is recorded worldwide); the usage of support measures of siderurgical sectors at the level of production countries, with a direct impact over the concurrence conditions; the access to raw materials and their price; the higher energy cost in Europe in comparison with other areas in the world, with direct implications over competitiveness.

Besides, the discrepancy between Asia and Europe became more and more obvious during the analyzed interval. Thus, if in 2004 the ratio between the production shares in the global volume was of 47.35% / 21.32%, in 2014 a significant accentuation can be found in favor of Asia: 67.94% / 12.54%.

If the hierarchy is clear regarding the production (the first three positions are occupied by Asia, Europe and CIS), at a consumer level another situation can be

Din Figura 1 se poate constata tendința de creştere a producției mondiale de oțel crud în intervalul analizat, cu un punct de inflexiune în anul 2009, ca urmare a efectelor crizei economico – financiare, când, nivelul total al producției a scăzut cu 7,8 % comparativ cu anul anterior. Însă, această traiectorie nu a fost similară la nivelul diferitelor regiuni. Astfel, dacă Asia se remarcă printr-o creştere continuă, chiar şi în faza de recesiune, la nivelul UE tendința a fost de diminuare a producției pe tot intervalul şi mult mai mare în anul 2009, respectiv cu 29,81 % față de anul 2008. Această situație este rezultatul acțiunii unui ansamblu de factori, respectiv: diminuarea cererii, în contextul înrăutățirii situației la nivelul industriilor consumatoare de oțel; existența unei supracapacități de producție (la nivel mondial, se înregistrează utilizarea capacității de producție într-o proporție de 71,6 %); utilizarea unor măsuri de susținere a sectoarelor siderurgice la nivelul țărilor producătoare, cu impact direct asupra condițiilor de concurență; accesul la materii prime şi prețul acestora; costul mai ridicat la energie în Europa comparativ cu alte zone ale lumii, cu implicații directe asupra competitivității.

De altfel, discrepanța dintre Asia şi Europa a devenit tot mai evidentă pe parcursul intervalului analizat. Astfel, dacă în anul 2004, raportul dintre ponderile producției în volumul global a fost de 47,35 % / 21,32 %, în 2014 se constată o accentuare semnificativă în favoarea Asiei: 67,94 % / 12,54 %.

Dacă în ceea ce priveşte producția, ierarhia este clară (primele trei poziții sunt ocupate de Asia, Europa şi CIS), la nivelul consumului se remarcă o altă situație (în

remarked (in the consumer top there can be found South Korea, Taiwan, Czech Republic, Japan, China). Thus, this is differentiating on countries, depending on GDP, urbanization degree, natural factors action (for example, in the countries situated geographic areas with a high risk degree from a seismically point of view, the steel is a preferred material for building constructions, because of its resistance characteristics), the structure of the industry or the realization of export of products which incorporates a large volume of steel (ships, cars etc.).

MANAGERIAL OBJECTIVES IN SIDERURGICAL INDUSTRY IN THE CONTEXT OF DURABLE DEVELOPMENT

Years when obtaining profit by all means was the prime objective passed. The world is aware of the fact that protecting the environment is extremely important, alongside saving energetic resources and water reserves. In this context, the siderurgical industry must fit into the general environment-protection trend, having in view the fact that this branch is energy-intensive and polluting. A part of the operators from this sector started to promote a systematic management in the way of obtaining new products with the help of modern technologies and per formant equipment. Though, there are still investors that vise only the profit, especially in the periods when a reduction in the economic activity is recorded, under the impact of several recession phenomena or under the action of some external factors.

In this sense, studies made in the most recent years at a level of metallurgic industry companies emphasized a negative situation of economical-financial performance indicators [3]. The main causes are represented by: the increase of raw material prices and energy fare; the usage of old equipment, characterized by a high consumption of energy; the deterioration of economic situation at the level of downstream industrial sectors (constructions, auto-industry, electronic industry, mechanical industry etc.) and, implicitly, the reduction of demand for siderurgical products in the context of an over-capacity on the global market; the occurrence of the global economic and financial crisis; unfair concurrence; difficulties in external markets access etc. If the characteristics of siderurgical industry and steel are taken in view, there is obvious that economic operators from siderurgical industry must choose to promote a management system based on sustainable performance and durable development. Generally, it is considered that the sustainable development in industry represents “a process of a process of continuous improvement of environmental, economic and social performance of enterprises and sustainability performance is interpreted as a result of management of sustainability aspects in enterprises”[4]. Concretely, it can be considered that the durable development must assure the accomplishment of several objectives (Figure 2).

It can be observed that the progress can be assured by the activity developed in industry by the application of a macro-economic policy mix. If the previous specifications are taken into account, the importance of applying measures of systematic management at the level of operators in the steel industry can be identified, whereas the steel is a 100% recyclable material (because of this aspect, steel is the most recycled material, with a quantity which exceeds 650 Mt annually, so over 65% of the newly-produced steel is old steel), and this process determines important energy and material savings (Recycling accounts for significant energy and raw

topul consumatorilor se situează South Korea, Taiwan, Republica Cehă, Japonia, China). Astfel, acesta se diferențiază pe țări, în funcție de PIB, gradul de urbanizare, acțiunea factorilor naturali (spre exemplu, în țările situate în zone geografice cu un grad ridicat de risc din punct de vedere seismic, oțelul este un material preferat pentru realizarea construcțiilor, datorită caracteristicilor sale de rezistență), structura industriei sau realizarea de exporturi de produse ce încorporează un volum mare de oțel (vapoare, maşini ş.a.).

OBIECTIVE MANAGERIALE ÎN INDUSTRIA SIDERURGICĂ ÎN CONTEXTUL DEZVOLTĂRII DURABILE

Anii în care obținerea profitului cu orice preț este obiectivul primordial au trecut. Lumea a conştientizat faptul că protejarea mediului înconjurător este extrem de importantă, alături de economisirea resurselor energetice şi a rezervelor de apă. În acest context, industria siderurgică trebuie să se încadreze în tendința generală de protejare a mediului, având în vedere faptul că reprezintă o ramură energofagă şi poluantă. O parte a operatorilor din acest sector a început să promoveze un management sistematic în sensul obținerii unor produse noi, cu ajutorul unor tehnologii moderne şi a unor echipamente performante. Totuşi, există şi investitori care vizează doar profitul, mai ales în perioadele în care se înregistrează o diminuare a activității economice, sub impactul unor fenomene de recesiune sau al acțiunii unor factori externi. În acest sens, studiile realizate la nivelul companiilor din industria metalurgică în ultimii ani au evidențiat o situație negativă a indicatorilor de performanță economico – financiară. [3] Cauzele principale sunt reprezentate de: majorarea prețurilor la materiile prime şi a tarifelor la energie; utilizarea unor echipamente şi utilaje vechi, caracterizate de un consum mare de energie; înrăutățirea situației economice la nivelul sectoarelor industriale din aval (construcții, industria auto, industria electronică, industria mecanică, ş.a.), şi, implicit, reducerea cererii pentru produsele siderurgice, pe fondul unei supracapacități pe piața mondială; manifestarea crizei economice şi financiare mondială; concurența neloială; dificultăți în accesul pe piețele externe ş.a. Dacă se au în vedere şi caracteristicile industriei siderurgice precum şi ale oțelului, este evident faptul că operatorii economici din industria siderurgică trebuie să opteze pentru promovarea unui sistem de management al performanței sustenabile şi al dezvoltării durabile. În general, se consideră că dezvoltarea sustenabilă în industrie reprezintă ,, a process of continuous improvement of environmental, economic and social performance of enterprises and sustainability performance is interpreted as a result of management of sustainability aspects in enterprises. [4] Concret, se poate considera că dezvoltarea durabilă trebuie să asigure îndeplinirea mai multor obiective (Figura 2).

Se poate observa faptul că progresul poate fi asigurat de activitatea desfăşurată în industrie prin aplicarea unui mix de politici macroeconomice. Dacă se au în vedere precizările anterioare, se poate identifica importanța aplicării unor măsuri de management sistematic la nivelul operatorilor din industria oțelului, întrucât: oțelul este un material 100 % reciclabil (datorită acestui aspect, este cel mai reciclat material, cu o cantitate ce depăşeşte 650 Mt anual, astfel încât peste 65 % din oțelul nou produs reprezintă oțel vechi), iar acest proces determină economii importante de energie şi materiale (Recycling accounts for significant energy and raw materials

materials savings: more than 1,400 kg of iron ore, 740 kg of coal, and 120 kg of limestone are saved for every ton of steel scrap made into new steel.) [2];different procedures can be applied to steel in order to assure an extension of its lifetime (every 90 seconds, 1 ton of steel is transformed into rust) and, implicitly, resources and energy savings and a diminution of a negative impact to the environment (thermal galvanizing, cadmium etc.); a great number of activities is dependent of the products furnished by siderurgical industry, a fact that influences significantly the number of work places from the entire industry; the steel is used on a large scale for obtaining products necessary to satisfy the personal needs, but also to assure a modern infrastructure, with direct implications over the social progress. The result of applying a macro-economic policy mix is emphasized by the real economic growth rate (Figure 3).

savings: more than 1,400 kg of iron ore, 740 kg of coal, and 120 kg of limestone are saved for every tonne of steel scrap made into new steel). [2]; oțelului i se pot aplica diferite procedee, astfel încât să i se asigure o prelungire a duratei de viață (la fiecare 90 secunde, 1 tonă de oțel se transformă în rugină), şi, implicit, o economisire a resurselor şi energiei şi o diminuare a impactului negativ asupra mediului (zincare termică, cadmiere, ş.a); un număr mare de activități este dependent de produsele furnizate de industria siderurgică, fapt ce influențează semnificativ numărul de locuri de muncă din întreaga industrie; oțelul se utilizează pe scară largă pentru obținerea produselor necesare satisfacerii nevoilor personale, dar şi pentru asigurarea unei infrastructuri moderne, cu implicații directe asupra progresului social. Rezultatul aplicării unui mix de politici macroeconomice este pus în evidență de rata creşterii economice reale (Figura 3).

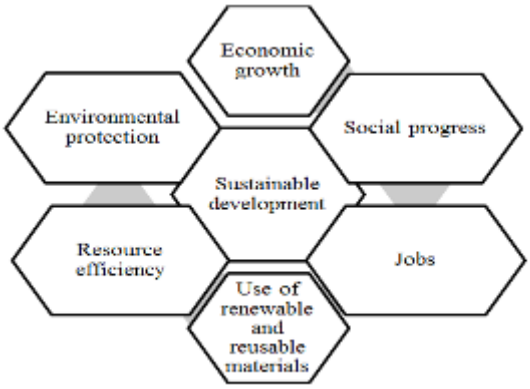

Fig. 2 - Objectives of sustainable development

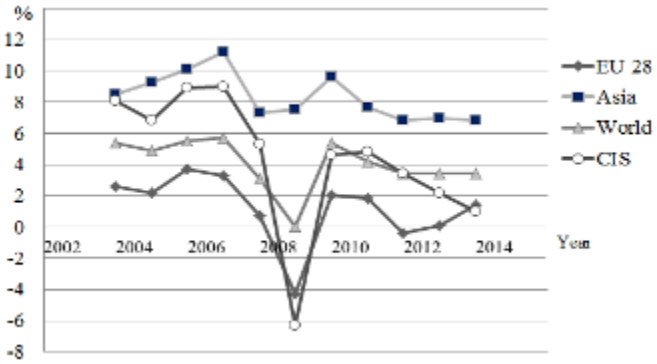

Fig. 3 - The evolution of economic growth rate

Table 1

The evolution of the economic growth rate and the growth rhythm of crude steel production %

Year	EU 28		Asia		World		CIS	
	Re	Rg	Re	Rg	Re	Rg	Re	Rg
2005	2,2	-3,4	9,3	18,9	4,9	8	6,8	-0,1
2006	3,7	5,9	10,1	12,6	5,5	8,9	8,9	5,8
2007	3,3	1,3	11,2	12,3	5,7	7,8	9	3,5
2008	0,7	-5,5	7,3	3,3	3,1	-0,3	5,3	-7,9
2009	**-4,3**	**-29,8**	**7,5**	**3,4**	**0**	**-7,8**	**-6,3**	**-14,5**
2010	2	23,9	9,6	13,1	5,4	15,7	4,6	10,7
2011	1,8	2,8	7,7	8,3	4,2	7,2	4,8	4,1
2012	-0,4	-5,1	6,8	3,1	3,4	1,4	3,4	-1,5
2013	0,1	-1,4	7	9,4	3,4	5,7	2,2	-2,4
2014	1,4	-1,8	6,8	-0,7	3,4	-0,5	1	-2,1

Legend: *Re – economic growth rate; Rg - growth rhythm or crude steel production Source: [5], own calculation based on [6]*

RESULTS

For the identification of the influence exercised by the economic situation over the siderurgical industry activity, data from Table 1 can be followed, data structured at the level of the most important groups in terms of raw steel production. Thus, a significant impact of the economic crisis over the steel production from EU and CIS can be found. Instead, in Asia, the product diminution was not quite big immediately after the crisis, but, surprisingly, in 2014, even if the economic growth rhythm was positive. The conclusion resulting from this situation is that the steel production is influenced by a group of factors, the economic situation being important, but not determinant. Instead, a sustained economic growth represents a real resource support for satisfying social and ecological needs. In this matter, the economic operators must be aware of the fact that a durable organization is the one that promotes a performant management, while using technologies which permit obtaining products without environment degradation and with efficient resource consumption. Obviously, the possibility of promoting the requirements of a durable management is strictly connected by the volume of the available financial resources. This aspect cannot be neglected, especially in the context of imposing the limited resources allocation for reaching the proposed objectives, a fact that can generate significant risks [7]. In addition, they must also relate to the production volume and cost, so as to assure the profitability of the activity [8].

CONCLUSIONS

Durable development is an extremely important concept in the context of the necessity of adopting global measures, which reduce the poverty and assure the environment protection. The assurance of a correlation between the economic growth, social protection and environment protection must represent a fundamental objective of macro-economic policies from every state, as well as of the international agreements and conventions in the domain. From this point of view, the fundamental challenge is rising in front of the industrial policy, which must respond to the requirements of the assurance of the quantity necessary to consumption but also those of rational usage of resources and environment protection. The siderurgical industry is an extremely important component of the industry with a major role within the managerial strategies which vise the assurance of the durable development coordinates. In this matter, the made research permitted synthesizing the next conclusions:

- ✓ For quantifying the sustainable performance from the siderurgical industry there can be used both qualitative and quantity indicators; in this matter, the production of raw steel can be emphasized; the consumption of steel/capita; the CO_2 emission for producing a ton of steel; the number of work places generated by this branch, correlated with other downstream branches; the quantity of recycled steel; the energy consumption for producing a ton of steel etc.
- ✓ The siderurgical industry furnishes one of the most used materials in the life of the people, being the single 100% recyclable material;
- ✓ The recyclability of steel has a benefic impact to the environment, because an important reduction of CO_2 emissions is made (it is considered that a ton of recycled steel determines a diminution of approximately 1.5 tons of CO_2 emissions;
- ✓ The industry operators vise the obtaining of profit and the appliance of durable development measures is conditioned by the existence of enough

REZULTATE

Pentru identificarea influenței exercitate de situația economică asupra activității din industria siderurgică, se pot urmări datele din tabelul 1, structurate la nivelul celor mai importante grupuri din punct de vedere al producției de oțel brut. Astfel, se poate constata un impact semnificativ al crizei economice asupra producției de oțel la nivelul EU şi al CIS. În schimb, în Asia, diminuarea producției nu a fost la fel de mare imediat după criză, ci surprinzător, în anul 2014, chiar dacă ritmul de creştere economică a fost pozitiv. Concluzia ce poate fi desprinsă din această situație este aceea că producția de oțel este influențată de un ansamblu de factori, situația economică fiind importantă, dar nu decisivă. În schimb, o creştere economică susținută reprezintă un suport real de resurse pentru satisfacerea nevoilor sociale şi ecologice. În acest sens, operatorii economici trebuie conştientizeze faptul că o organizație durabilă este cea care promovează un management performant, pe fondul utilizării unor tehnologii care permit obținerea unor produse fără degradarea mediului şi cu un comsum eficient de resurse. Evident, posibilitatea promovării cerințelor unui management durabil este strict legată de volumul resurselor financiare disponibile. Acest aspect nu poate fi neglijat, mai ales în contextul în care se impune alocarea resurselor limitate pentru atingerea obiectivelor propuse, fapt ce poate genera riscuri semnificative. [7] În plus, ei trebuie să se raporteze la volumul şi costul producției, astfel încât să asigure reantabilizarea activității [8].

CONCLUZII

Dezvoltarea durabilă este un concept extrem de important în contextul necesității adoptării unor măsuri la nivel global, care să diminueze sărăcia şi să asigure protejarea mediului. Asigurarea unei corelații între creşterea economică, protecția socială şi protecția mediului trebuie să reprezinte un obiectiv fundamental al politicilor macroeconomice din orice stat, precum şi al acordurilor şi convențiilor internaționale în domeniu. Din acest punct de vedere, provocarea fundamentală se ridică în fața politicii industriale, care trebuie să răspundă cerințelor de asigurare a cantității de produse necesară consumului dar şi celor de utilizare rațională a resurselor şi de protejare a mediului. Industria siderurgică este o componentă a industriei extrem de importantă, cu un rol major în cadrul strategiilor manageriale ce vizează asigurarea coordonatelor dezvoltării durabile. În acest sens, cercetarea realizată a permis sintetizarea următoarelor concluzii:

- ✓ pentru cuantificarea performanței sustenabile din industria siderurgică, se pot utiliza atât indicatori calitativi cât şi cantitativi; în acest sens, se pot evidenția producția de oțel crud; consumul de otel / capita; emisia de CO_2 pentru producerea unei tone de oțel; numărul de locuri de muncă generat de această ramură, corelat cu alte ramuri din aval; cantitatea de oțel reciclat; consumul de energie pentru producerea unei tone de oțel ş.a.;
- ✓ industria siderurgică furnizează unul dintre cele mai utilizate material în viața oamenilor, fiind singurul recliclabil 100 %;
- ✓ capacitatea de reciclare a oțelului are un impact benefic asupra mediului, întrucât este realizată o reducere importantă a emisiilor de CO_2 (se consideră că o tonă de oțel reciclat determină o diminuare de aproximativ 1,5 tone emisii de CO_2);
- ✓ operatorii din industrie vizează obținerea de profit, iar aplicarea unor măsuri de dezvoltare durabilă este condiționată de existența unor resurse financiare

financial resources;

✓ The managerial activity within the industrial organizations is influenced by the action of the natural and biological factors;

✓ The managers of the operators from the siderurgical industry must vise the appliance of durable technologies which permit both the development of an effective activity and the efficient usage of resources.

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suficiente;

✓ activitatea managerială în cadrul organizațiilor industriale este influențată de acțiunea factorilor naturali şi biologici;

✓ managerii operatorilor din industria siderurgică trebuie să vizeze aplicarea unor tehnologii durabile, care permit atât desfăşurarea unei activități eficiente cât şi protejarea mediului şi utilizarea eficientă a resurselor;

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STABILITY ANALYSIS OF THE AGRICULTURAL ARTICULATED VEHICLE BASED ON INTERVAL METHOD
/
基于区间数学法的农业铰接车的稳定性分析

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Abstract: *The agricultural mechanization operation is highly efficient, but many types of agricultural mechanical equipment are difficult to move or to operate on hilly terrain and mountains. Thus, these machines play a limited role. This study designs an agricultural articulated vehicle whose front and rear bodies exhibit relative yawing and a rolling degree of freedom; this vehicle can perform agricultural construction operations on different terrains. The agricultural articulated vehicle may roll over during operations such as digging; therefore, its stability should be determined. This research builds a dynamic model of the vehicle during digging through homogeneous coordinate transformation and with the use of the multi-body dynamics method. The interval method is applied to the stability analysis for such operations and describes the uncertain parameters that affect stability as a bounded interval. The stabilities of the front and the rear bodies are analyzed as follows: first, the influence of tire deformation on the rear body stability of the vehicle is determined. The critical rollover angle of the vehicle decreases with an increase in tire deformation. Second, the influence of different digging material weights on the front body stability of the vehicle is measured. Finally, the results obtained with the interval analysis method indicate that the vehicle remains stable while digging if the values of yaw angle φ and roll angle θ are located in the minimum envelope zone of [−42°, 42°] and [−28°, 28°]. The analysis results can guide structural improvement, provide an early warning for rollover during digging, and extend the application range of the proposed vehicle in agricultural construction.*

Keywords: *Agricultural articulated vehicle; Multi-body dynamics; Interval analysis; Stability*

摘要：*农业机械化生产虽然效率高，但是在地形复杂的丘陵地带和山区，很多农用机械设备移动和操作困难，难以发挥作用。设计了一种农业铰接车，它的前后车体相对有横摆和扭转自由度，可以在不同的地形下进行农业工程作业。农业铰接车在农业作业，例如挖掘过程中容易产生倾翻，需要研究挖掘作业过程中的稳定性，本文采用齐次坐标变换和多刚体动力学方法，建立了农业铰接车挖掘作业时的动力学方模型。在挖掘作业稳定性分析中，应用区间数学法，把影响稳定性的不确定参数作为一个数学区间，然后结合车辆的稳定性判据，分别对农业铰接车前后车体的稳定性进行了分析，首先，分析了轮胎变形对后车体倾翻稳定性的影响；其次，分析了挖掘物质量的不同对前车体倾翻稳定性的影响。最后，通过仿真分析，在挖掘作业过程中，保证车辆不产生倾翻，前后车体的横摆角φ和侧偏角θ落在[-42°，42°]和[-28°，28°]的包络区域内。分析结果可以为 农业铰接车结构设计的改进和挖掘稳定性预警提供设计方法和参考，拓展它在农业工程中的应用范围。*

关键词: *农业铰接车；多刚体动力学；区间分析法；稳定性*

INTRODUCTION

Wheeled construction machineries have been applied to various aspects of agricultural production, such as grapery ditching, soil loosening and preparation in upland fields, the exploitation of low-lying and easily waterlogged wasteland, water supply, and dredging work in paddy fields, given that these processes are difficult to perform manually. Moreover, efficiency is low and the operational hazard is high. In north China, the construction machineries should also be used for farmland water conservancy in the winter because of the frozen surface layer. The use of construction machineries has effectively economized on manpower, shortened product time, and saved cost. Nonetheless, many types of agricultural mechanical equipment are difficult to move and control on hilly terrains and mountains; thus, these machines play a limited role. In this study, we design a vehicle whose front and rear bodies are joined by a universal hinge; this vehicle displays relative yawing and a rolling degree of freedom. Therefore, the wheels can make

引言

轮式工程机械已经用到农业生产的各个方面，如葡萄园挖沟作业；旱田的松土、整地；地势低洼、易涝的荒地开发；水田给水清淤工程，人工作业相当困难，而且效率低，作业危险性大；在北方冬季里进行农田水利施工，地表冻层，只有采用工程机械可以施工。工程机械应用在农业生产上，节约了大量劳动力，又缩短了生产时间，节省成本。但是在地形复杂的丘陵地带和山区，由于很多农用机械设备移动和操作困难，难以发挥作用。因此我们设计了一种农业铰接车，它的前车体和后车体采用铰链关节连接，前后车体相对有横摆和扭转自由度，在复杂的农田地形下车轮充分和地面接触，增加了车辆的运动和作业的稳

sufficient contact with the complex farmland terrain, and vehicle stability improves for operating and digging operations. The vehicle can adapt to different terrain environments for agricultural production, is low-cost, possesses a simple structure, is convenient to operate, and is widely applicable. Nonetheless, the stability of agricultural construction vehicle operation on hills, mountains, and paddy fields containing silt must be determined; at present, studies on agricultural mountain vehicles mainly concentrate on static and dynamic stabilities to overcome obstacles [1, 9, 3, 10] and to warn against rollover in advance [6, 13, 7]. According to statistics, more than 90% of rollover accidents related to agricultural mountain vehicles occurred in operation [8, 2] rather than in running. Few studies have been conducted on vehicle rollover in agricultural construction operations although the complex operation environment and uncertain factors, such as vehicle position and pose, tire deformation, and digging state, influence the stability of agricultural construction vehicles. Furthermore, traditional stability analysis methods are applied only in specific states [10, 4]. The current study applies the interval method to an analysis of stability during digging, describes all factors that affect stability as a bounded interval, and derives a dynamic equation. The effect of all uncertain factors on vehicle stability is determined with the stability criterion in combination with the interval method. Researching vehicle stability in agricultural construction operation generates a reference for structure design improvement as well as for follow-up rollover protection and early warning system design. Thus, the safety and convenience of vehicle implementation in the agricultural construction operation are improved.

MATERIALS AND METHODS

Dynamic Model for an Agricultural Articulated Vehicle

The backhoe device of the agricultural articulated vehicle is driven by a hydraulic system, and the revolving mechanism is driven by two lever-type cylinders, as shown in Figure 1. This vehicle can excavate soil and rock at different heights, angles and distances, as depicted in Figure 2. Furthermore, the operating range of the agricultural articulated vehicle is presented in Table 1.

定性，能更好的适应不同农业生产的地形环境，它的结构简单，操作方便，成本也低廉，应用更广泛。农业工程车辆在丘陵、山区或者淤泥的水田工作，需要研究它工作过程中的稳定性。目前国内外对于山地农业工程车辆的稳定性研究，主要集中在车辆静态稳定性研究和越障行驶中的动态稳定性研究[1,9,3,10]以及车辆侧翻预警研究[6,13,7]等。根据文献资料统计山地农业工程车辆的倾翻 90%以上都是在作业过程中发生的[8,2]，而工程车行驶过程中的倾翻较少。对于工程车在农业工程作业过程的倾翻研究，国内外相关文献资料极少；山地农业工程车挖掘作业环境复杂，车体位姿，轮胎变形，挖掘工作状态等不确定性因素多，常用的求解稳定性的数学方法，只能求解特定状态下的车体稳定性[10,4]。本文利用区间数学的方法，分析农业铰接车在工作过程中的稳定，把影响农业铰接车稳定性的任一不确定因素当成一个数学区间，建立动力学方程，结合铰接式车辆倾翻的稳定性判据，求解农业铰接车的动力学方程，得到在不确定因素影响下，农业铰接车前后车体姿态的范围。通过研究农业铰接车在农业工程作业中的稳定性研究，可以为农业铰接车的结构设计改进和后期防倾翻预警系统设计提供参考依据，能够使车辆更安全方便的应用于农业工程生产建设。

材料与方法

农业铰接车动力学模型

农业铰接车的挖掘装置通过液压系统驱动，挖掘臂回转系统采用杠杆式双液压缸驱动方式，如图 1 所示，可以实现农业铰接车在不同角度、不同高度、不同距离的挖掘作业，如图 2 所示，农业铰接车的作业装置作业范围如表 1 所示。

Fig.1 -Wasteland development operation of the vehicle

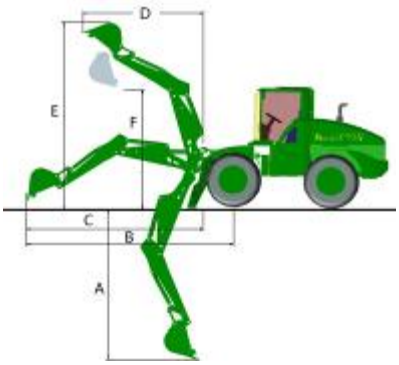

Fig.2 - Sketch of the vehicle operating range

Table 1

Parameters of the vehicle operating device

Definition of the parameter	Parameter values
A. Maximum digging depth	3.03 m
B. The horizontal distance between the bucket and the center of the front wheel	5.31 m
C. The horizontal distance between the bucket and the rotating center	4.11 m
D. The horizontal distance between the bucket on top and the rotating center	2.64 m
E. Maximum digging height	3.40 m
F. Maximum unloading height	2.85 m

Many uncertain factors are observed in this scenario, such as the velocity of the backhoe device, its angular velocity, and the attitude displayed during the operation process. The interval method is applied to solve the problem of stability given uncertain factors. The vehicle and the backhoe device are simplified as a rigid body, and the vehicle coordinate system is built through the multi-body dynamics method, as illustrated in Figure 3.

工作过程中，挖掘装置的速度、角速度及在工作区域位姿等影响农业铰接车稳定性的不确定参数众多，采用区间分析方法，能有效解决包含不定参数的系统分析问题。农业铰接车和其挖掘装置简化成刚体，通过多刚体动力学方法建模。建立农业铰接车坐标系，如图 3 所示。

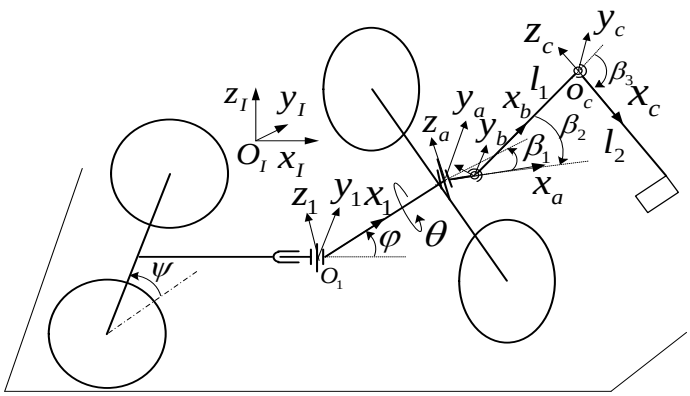

Fig.3 -Schematic for the vehicle coordinate system

where the origin of the inertial coordinate system $O_I x_I y_I z_I$ is the rear body centroid M_r and axle x_I is detected along the drive shaft of the rear body. Axle z_I is the vertical axis, and the front and rear bodies are joined by a universal hinge. The front body coordinate system $O_1 x_1 y_1 z_1$ originates at the yaw hinge, and the roll angle of the rear body is represented by ψ. The roll and yaw angles of the front body are denoted by θ and φ, respectively. The backhoe device and the front body are also connected through a universal hinge. The yaw angle between the backhoe device and the front body is represented by β_1, the pitching angle is denoted by β_2, and the angle between the boom and the bucket rod corresponds to β_3.

The position vector of point P in coordinate system B is ${}^B\vec{p}$, which transforms the coordinate system A into ${}^A\vec{p}$. This vector is described in the form of homogeneous coordinates:

其中惯性系 $O_I x_I y_I z_I$ 原点在后车体质心 M_r， x_I 轴沿后车体传动轴方向。 z_I 轴铅垂向上。前后车体之间为万向铰连接，前车体本体坐标系为 $O_1 x_1 y_1 z_1$，原点在横摆铰接点处。后车体的侧偏角为 ψ，前车体的侧偏角为 θ，横摆角为 φ。挖掘装置和前车体通过万向铰连接，挖掘装置和前车体传动轴之间的横摆角为 β_1，俯仰角为 β_2，动臂和斗杆之间角度为 β_3。

空间一点 P，在坐标系 B 中位置矢量为 ${}^B\vec{p}$，则变换到坐标系 A 中位置矢量采用齐次坐标可表示为：

$$\begin{bmatrix} {}^A\vec{p} \\ 1 \end{bmatrix} = \begin{bmatrix} {}^A R_B & {}^A p_{Bo} \\ 0 & 1 \end{bmatrix} \begin{bmatrix} {}^B\vec{p} \\ 1 \end{bmatrix} = {}^A T_B \begin{bmatrix} {}^B\vec{p} \\ 1 \end{bmatrix} \tag{1}$$

where ${}^{A}T_B$ is the matrix of position and orientation transformation from the B coordinate system to the A coordinate system, ${}^{A}R_B$ is the attitude matrix from the B coordinate system to the A coordinate system, and ${}^{A}\vec{p}_{Bo}$ is the position vector that indicates the origin of coordinate system B in coordinate system A.

When the vehicle excavates soil and rock, the body vehicles remain motionless, and the backhoe device alone moves. The boom and the bucket rod can be simplified as rods with lengths that are denoted by l_1 and l_2. The centroids of both the boom and the bucket rod are positioned at the middle points; moreover, the bucket and the digging mixture are simplified as the centralization mass of m_3. The driving moment of the backhoe device is represented by M_1, M_2, M_3, and the force of the backhoe device during digging is illustrated in Figure 4.

其中 ${}^{A}T_B$ 为坐标系 B 系到 A 系的位姿变换，${}^{A}R_B$ 为 B 系到 A 系的姿态变换矩阵，${}^{A}\vec{p}_{Bo}$ 为 B 系的原点在 A 系中的位置矢量。

农业铰接车在挖掘作业时，车体行进到工作位置固定，只有工作装置进行一系列的挖掘作业。工作装置的动臂和斗杆可简化成杆长度为 l_1，l_2 的杆，动臂和斗杆的质心在均在杆的中点，铲斗和挖掘物可看作 m_3 的集中质量点。挖掘装置的转动关节力矩为 M_1，M_2，M_3，则工作中，挖掘装置的受力如图 4 所示。

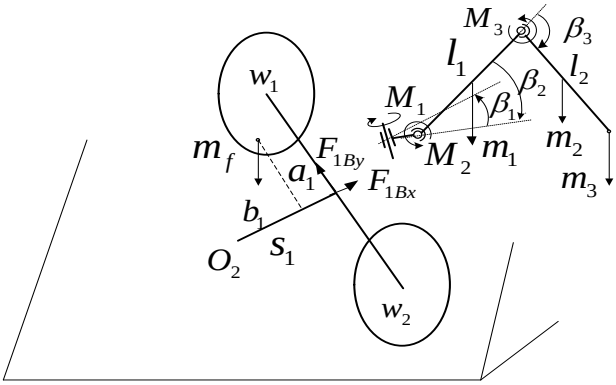

Fig.4 -Forces exerted on the front body during digging

In the inertial coordinate system, the position vector of centroid m_1 of the boom, centroid m_2 of the bucket rod, and centroid m_3 of the digging mixture are written as

在惯性坐标系下，动臂质心 m_1，斗杆质心 m_2，挖掘物质心 m_3 的位置矢量为：

$$\begin{bmatrix} {}^{O}\vec{p}_{m1} \\ 1 \end{bmatrix} = {}^{O}T_1\,{}^{1}T_a\,{}^{a}T_b \begin{bmatrix} {}^{b}\vec{p}_{m1} \\ 1 \end{bmatrix} \tag{2}$$

$$\begin{bmatrix} {}^{O}\vec{p}_{m2} \\ 1 \end{bmatrix} = {}^{O}T_1\,{}^{1}T_a\,{}^{a}T_b\,{}^{b}T_c \begin{bmatrix} {}^{c}\vec{p}_{m2} \\ 1 \end{bmatrix} \tag{3}$$

$$\begin{bmatrix} {}^{O}\vec{p}_{m3} \\ 1 \end{bmatrix} = {}^{O}T_1\,{}^{1}T_a\,{}^{a}T_b\,{}^{b}T_c \begin{bmatrix} {}^{c}\vec{p}_{m3} \\ 1 \end{bmatrix} \tag{4}$$

The angle velocity of the boom l_1 and the bucket rod l_2 in the inertial coordinate system can be described as

动臂 l_1 和斗杆 l_2 在惯性系中的角速度可以表示为：

$${}^{O}\vec{\omega}_{m1} = {}^{O}R_1\,{}^{1}R_a\dot{\vec{\beta}}_1 + {}^{O}R_1\,{}^{1}R_a\,{}^{a}R_b\dot{\vec{\beta}}_2 \tag{5}$$

$${}^{O}\vec{\omega}_{m2} = {}^{O}R_1\,{}^{1}R_a\dot{\vec{\beta}}_1 + {}^{O}R_1\,{}^{1}R_a\,{}^{a}R_b\dot{\vec{\beta}}_2 + {}^{O}R_1\,{}^{1}R_a\,{}^{a}R_b\,{}^{b}R_c\dot{\vec{\beta}}_3 \tag{6}$$

The velocity and the acceleration of m_1, m_2, m_3 can be written as

质心 m_1，m_2，m_3 的在惯性系下的速度和加速度可表述为：

$${}^{O}\vec{v}_{mi} = {}^{O}\vec{\omega}_{mi} \times {}^{O}\vec{p}_{mi} \tag{7}$$

$${}^{O}\vec{a}_{mi} = {}^{O}\vec{\varepsilon}_{mi} \times {}^{O}\vec{p}_{mi} + {}^{O}\vec{\omega}_{mi} \times {}^{O}\vec{v}_{mi} \tag{8}$$

where $i=1,2,3$, ${}^{O}\vec{\omega}_{m2}={}^{O}\vec{\omega}_{m3}$, ${}^{O}\vec{\varepsilon}_{m2}={}^{O}\vec{\varepsilon}_{m3}$, and $\vec{\varepsilon}=d\vec{\omega}/dt$ is angular acceleration.

We define β_1 , β_2 , β_3 as generalized coordinates. The driving moment M_1 , M_2 , M_3 is calculated by solving the Lagrange equation. When the vehicle performs a digging task under the assumption that the acceleration of the boom and of the bucket rod is represented by $\vec{\varepsilon}=0$, the kinetic energy of the boom and bucket rod system is written as

其中 $i=1,2,3$, ${}^{O}\vec{\omega}_{m2}={}^{O}\vec{\omega}_{m3}$, ${}^{O}\vec{\varepsilon}_{m2}={}^{O}\vec{\varepsilon}_{m3}$, $\vec{\varepsilon}=d\vec{\omega}/dt$ 为角加速度。

设 β_1、β_2、β_3 为广义坐标，采用拉格朗日方程求解驱动力矩 M_1、M_2、M_3，农业铰接车在挖掘工作时，假设动臂斗杆的加速度 $\vec{\varepsilon}=0$，则 农业铰接车动臂斗杆系统的动能可写为：

$$T=\frac{1}{2}\sum_{i=1}^{3}m_i\,{}^{O}\vec{v}_{mi}^{T}\,{}^{O}\vec{v}_{mi}+\frac{1}{2}\sum_{i=1}^{2}{}^{O}\vec{\omega}_{mi}^{T}\vec{J}_{mi}\,{}^{O}\vec{\omega}_{mi} \tag{9}$$

The potential energy in the system is written as

系统势能可写为：

$$V=\sum_{i=1}^{3}m_i\,{}^{O}\vec{p}_{mi}^{\,T}\vec{g} \tag{10}$$

The driving moment is calculated as

求得驱动力矩为：

$$M_i=\frac{d}{dt}\left(\frac{\partial L}{\partial\dot{\beta}_i}\right)-\frac{\partial L}{\partial\beta_i} \tag{11}$$

where $L=T-V$ is the Lagrange function.

When D'Alembert's principle is applied, the force and the moment of the front body as induced by the backhoe device can be computed as

其中 $L=T-V$ 为拉格朗日函数。

根据达郎贝尔原理可求得挖掘装置对前车体的作用力和作用力矩为：

$$\vec{F}_{1B}={}^{1}R_O\sum_{i=1}^{3}m_i\,{}^{O}\vec{a}_{mi} \tag{12}$$

$$\vec{M}_{1B}=-({}^{1}R_a\vec{M}_1+{}^{1}R_a\,{}^{a}R_b\vec{M}_2+{}^{1}R_a\,{}^{a}R_b\,{}^{b}R_c\vec{M}_3) \tag{13}$$

The vehicle consists of two parts. During digging, the front body may be influenced by the boom and bucket rod motion. When the force on wheels w_1 and w_3 is zero, the front and rear bodies tip over at approximately O_2W_2 and O_2W_4 , respectively, as shown in Figure 5.

由于农业铰接车分为前后两部分，挖掘作业时，由于动臂斗杆的影响，前车体最容易发生倾翻。此时有轮 w_1、w_3 受力为零，前车体绕 O_2W_2 轴倾翻，后车体绕 O_2W_4 轴倾翻，如图 5 所示。

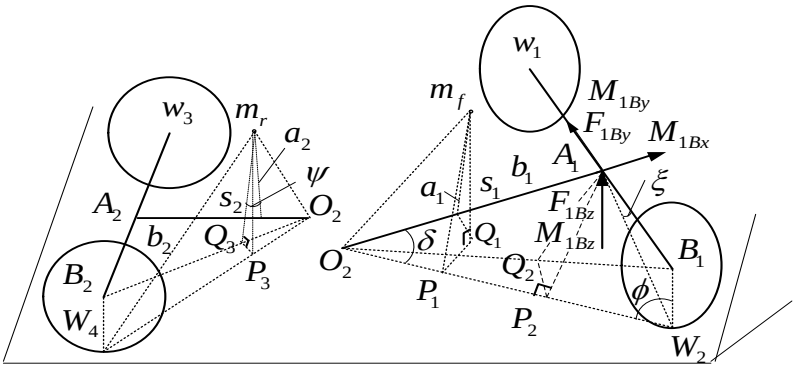

Fig.5 - Schematic of vehicle stability

The front and rear bodies of the vehicle are stationary during digging; this problem is one of static stability.

When the rear body remains stable, its centroid m_2 should be located in plane $\Delta A_2B_2O_2$. Thus, the centroid can be calculated as

设农业铰接车的前后车体在挖掘作业过程中静止不动，前后车体属于静态稳定性问题。

当后车体保持稳定时，后车体质心 m_2 应落到平面 $\Delta A_2B_2O_2$ 内，可得：

$$Q_3P_3>0 \tag{14}$$

The roll angle of the rear body in stable state can be computed by using the geometric relation presented in Figure 5.

通过图 5 中几何关系，可得后车体保持稳定时的侧偏角为：

$$\psi < \arctan\left(\frac{s_2 d(s_2-b_2)\sqrt{d^2+s_2^2}}{d^2 s_2 a_2 - 2d^2 b_2 r + s_2^3 r + s_2^3 a_2 - s_2^2 b_2 r} - \frac{\delta}{2d}\frac{s_2}{\sqrt{d^2+s_2^2}}\right) \tag{15}$$

where δ is the static deformation of the tire when the vehicle is unstable. In the experiment, the measured value of the tire radius is [0.736 m, 0.775 m].

When the front body is in stable state, the moment of mass center m_1, which is relative to axle O_2W_3, is greater than the other moments that are also relative to this axle. Therefore, we can obtain

其中 δ 为失稳时轮胎的静变形量。通过测量，轮胎滚动半径变化量为[0.736m, 0.775m]。

前车体保持稳定时，前车体质心 m_1 绕轴 O_2W_3 的力矩大于其它外力绕轴此轴的力矩。因此，通过计算可得：

$$\begin{aligned} & m_1 g \cdot \sqrt{\frac{(s_1-b_1)^2(\delta^2+d^2)}{(s_1^2+d^2)\cos^2\varphi} + \frac{s_1^2 a_1^2 \sin^2\theta}{s_1^2+d^2+r^2}} > \\ & F_{1Bz}\frac{s_1\sqrt{s_1^2+d^2}\sqrt{r^2+d^2}}{\sqrt{s_1^2+d^2+r^2}} - s_1 r \cdot F_{1By} + s_1 \cdot M_{1Bx} - d \cdot M_{1By} - r \cdot M_{1Bz} \end{aligned} \tag{16}$$

When the vehicle is performing a digging task, the uncertain interval parameters are the angles β_1, β_2, β_3 among the boom, the bucket rod, and the rotational velocity $\dot{\beta}_1$, $\dot{\beta}_2$, $\dot{\beta}_3$, the mass of the digging material m_t, and the deformation of the tire δ. To obtain acceptable stability in the digging operation, the allowable range of roll angle θ and yaw angle φ should be determined with the interval method.

对于农业铰接车来说，当在进行挖掘作业时，动臂斗杆间夹角 β_1、β_2、β_3，以及转动角速度 $\dot{\beta}_1$、$\dot{\beta}_2$、$\dot{\beta}_3$，m_t，轮胎变形量 δ 分别为不确定的区间参数，要保证挖掘作业过程中前车体的稳定性，需要求解在不确定区间参数中，农业铰接车的前车体侧偏角 θ 和横摆角 φ 的允许范围。

Analysis of Stability in Digging Operations based on the Interval Method

Interval analysis theory has been applied to many project fields [5, 12]. The closed interval of a real number can be described as

区间法分析农业铰接车挖掘作业稳定性

目前区间分析理论已经应用于很多工程领域[5,12]。实的闭区间可表示为：

$$X^I = [\underline{X}, \overline{X}] = \left\{ X \in R \mid \underline{X} \le X \le \overline{X} \right\} \tag{17}$$

where $\underline{X}$ and $\overline{X}$ are the interval endpoints.

When the center interval method is applied, Eq. (17) is rewritten as

其中 $\underline{X}$，$\overline{X}$ 分别称为区间的下端点和上端点。

采用中心区间法，式（17）可以表示为：

$$X^I = X^C + \Delta X\, e_\Delta \tag{18}$$

where X^C is defined as the middle point of the interval, ΔX is defined as the interval radius, and the range of e_Δ is [-1, 1].

The vehicle parameters can be written in the interval form

其中 X^C 称为区间中点，ΔX 称为区间半径，e_Δ 的范围为[-1, 1]。

农业铰接车的设计参数, 可以用区间法表示为：

$$\begin{cases} \beta_1 = \dfrac{\pi}{2} e_\Delta \\ \beta_2 = \dfrac{\pi}{6} + \dfrac{\pi}{6} e_\Delta \\ \beta_3 = 0.39\pi + 0.39\pi e_\Delta \\ \dot{\beta}_1 = \dfrac{\pi}{3} e_\Delta \\ \dot{\beta}_2 = 0.055\pi + 0.055\pi e_\Delta \\ \dot{\beta}_3 = 0.055\pi + 0.055\pi e_\Delta \\ m_t = 300 + 300 e_\Delta \\ \delta = 0.7555 + 0.0195 e_\Delta \end{cases} \tag{19}$$

Eq. (19) is substituted into Eq. (16) to yield

$$F(\theta, \varphi, e_\Delta) > 0 \tag{20}$$

When the agricultural articulated vehicle is performing a digging task, the values of the parameters that maintain front body stability must satisfy the boundary conditions of Eq. (20). The vehicle parameters are l_1 = 2.4 m, l_2 = 2 m, m_1 = 600 kg, m_2 = 450 kg, m_f = 7000 kg, and m_r = 5900 kg. The track value is $2d$ = 1.6 m, and the wheel radius value is r = 0.75 m, S_1 = 0.72 m, S_2 = 2.2 m, a_1 = 0.65 m, a_2 = 0.65 m, b_1 = 0.2 m, and b_2 = 1.4 m. The range of the roll angle θ is [−40°, 40°], and the range of the yaw angle φ is [−42°, 42°].

RESULTS

Influence of Tire Deformation on Rear Body Stability

When the roll angle of the rear body vehicle increases, tire deformation changes. As a result, the actual rollover angle shifts as well. The relationship between the rollover angle of the rear body and tire deformation is calculated with Eq. (15); the result is shown in Figure 6.

The rollover angle of the rear body decreases when tire deformation increases in Figure 6. Thus, this deformation should be considered in the analysis of vehicle stability during agricultural construction to enhance the accuracy of the calculated rollover angle. If tire deformation is disregarded, then the calculated rollover angle is large; when this angle is used in the design of a vehicle rollover warning system, rollover accidents occur easily.

把式（19）代入式（16），可得到如下函数：

当农业铰接车挖掘时，保证前车体稳定性，车体相关参数的取值需要满足式（20）。农业铰接车设计参数为：l_1 =2.4m，l_2 =2m，m_1 =600kg，m_2 =450kg，m_f =7000kg，m_r =5900kg，轮距 $2d$ =1.6m，车轮半径 r =0.75m，S_1 =0.72m，S_2 =2.2m，a_1 =0.65m，a_2 =0.65m，b_1 =0.52m，b_2 =1.4m，侧偏角 θ 的设计范围为[-40°，40°]，横摆角 φ 的设计范围为[-42°，42°]。

结果

轮胎变形量对后车体稳定性的影响

农业铰接车的后车体的侧偏角的增大，后车体左边和右边轮胎上的受力产生变化，轮胎的变形量就随着改变，造成后车体实际失稳的侧偏角也会不同。根据后车体侧偏的稳定性公式（15），可得后车体保持稳定的侧偏角随轮胎变形量的变化关系如图 6 所示。

由图 6 可知，轮胎变形量的增大，后车体失稳时的侧偏角会变小。所以在挖掘作业稳定性分析时，必须要考虑轮胎才能使计算的保持稳定性的侧偏角更准确，如果不考虑轮胎变形，会使计算的稳定侧偏角偏大，按照此计算结果进行倾翻预警设计，容易造成车辆翻车事故。

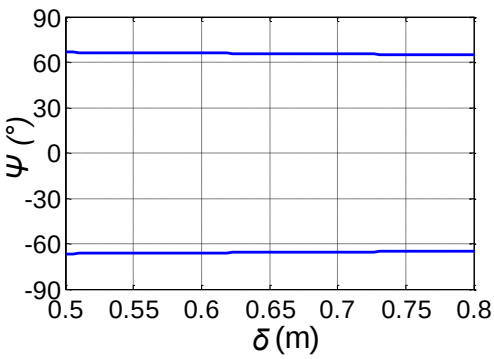

Fig.6 - Variation in the rollover angle of the rear body with tire deformation

Influence of Digging Material Weight on Front Body Stability

When the agricultural articulated vehicle is working, the digging material weight in the bucket strongly affects front body stability. If $\varphi = 0$, then the boom and bucket rod of the digging device are motionless, $\beta_2 = 0.12\pi$, $\beta_3 = 0.3\pi$, the rotation angular velocity around the Z_a axis is denoted by $\dot{\beta}_1$, and $\dot{\beta}_1 = 0.3\pi / \mathrm{s}$. When the digging material weight is m_t =0 kg and m_t =300 kg, the stability curves of the front body are as depicted in Figure 7.

挖掘物质量对前车体稳定性的影响

当农业铰接车进行作业时，抓斗中挖掘物质量对前车体的倾翻稳定性有很大的影响，若给定 $\varphi = 0$，挖掘装置的动臂和斗杆相对不动，$\beta_2 = 0.12\pi$，$\beta_3 = 0.3\pi$ 只有绕 Z_a 轴的转动角速度 $\dot{\beta}_1$，设 $\dot{\beta}_1 = 0.3\pi / \mathrm{s}$，当铲斗中的挖掘物质量 m_t =0 kg 和 m_t =300 kg 时，可以分别求的前车体保持倾翻稳定性的曲线，如图 7 所示。

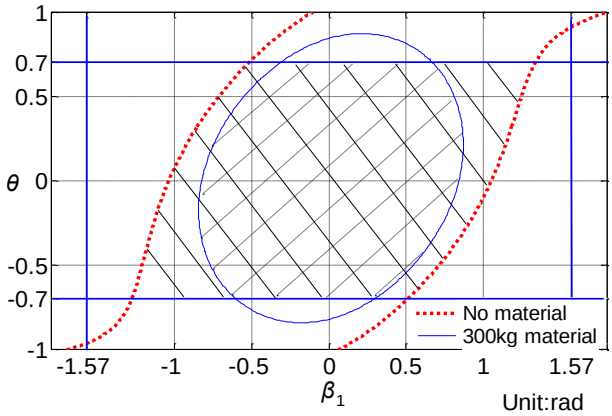

Fig.7 - Stability region of the front body under different digging material weights

According to the stability analysis results, the front body is stable when m_t =0 kg and if the roll angle of the front body θ and the rotation angle of the digging device β_1 are located in the elliptic region surrounded by a solid line. The same is true when m_t =300 kg, if θ and β_1 are located in the region surrounded by the dotted line. The range of θ is [−40°, 40°], and the range of β_1 is [−90°, 90°]; therefore, the stability region of the front body is the intersection of the same parameters under different conditions. This region is denoted by the areas marked with solid and dotted slashes in Figure 7.

Influence of All the Parameters on Front Body Stability

As per an analysis of the influence of all the parameters on front body stability based on Eq. (19) and (20), the values of φ and θ should be located in the minimum envelope zone of $F(\theta, \varphi, e_\Delta) > 0$ when $e_\Delta \in [-1,1]$. The simulation result is presented in Figure 8.

The maximum value of roll angle θ, which maintains the stability of the front body, is ± 28°, as indicated in Figure 8, when the vehicle is performing a digging task and if the value of yaw angle φ is zero. The roll angle decreases with an increase in yaw angle. Thus, the value of the roll angle cannot reach the extreme point ±40°. When the value of the yaw angle reaches such points (lines 1 and 2 are displayed in Figure 8), roll angle value is ±18.7°. Therefore, the front body is stable when the values of roll angle θ and of yaw angle φ are located in the region shown in Figure8; otherwise, the front body faces the risk of tipping over.

根据稳定性分析结果，可知当 m_t =0 kg 时，前车体倾角 θ 和挖掘装置转角 β_1 在曲线围成的椭圆区域内，前车体是稳定的；当 m_t =300 kg 时，前车体倾角 θ 和挖掘装置转角 β_1 在曲线围成的区域内，前车体是稳定的；由于 θ 的范围为[-40°，40°]，β_1 的范围为[-90°，90°]，所以实际的前车体挖掘中的稳定性应该是同一参数不同取值范围的交集，为图 7 中的斜实线和斜虚线区域。

前车体稳定性的所有参数综合影响分析

根据公式（19）和公式（20）分析所有参数对农业铰接车前车体稳定性影响，则 φ，θ 取值为：对于任意给定的 $e_\Delta \in [-1,1]$，φ，θ 应在函数 $F(\theta, \varphi, e_\Delta) > 0$ 的最小包络区域内，计算结果如图 8 所示。

由图 8 分析结果可知，在农业铰接车在挖掘作业时，当横摆角 φ 为 0 时，前车体保持稳定的最大侧偏角 θ 约为±28°，随着横摆角 φ 的增大，侧偏角 θ 减小，无法达到车体设计的侧偏角极限范围±40°。当横摆角 φ 增大到车体设计的极限位置时（图 8 中直线 1 和直线 2），侧偏角 θ 约为±18.7°。前车体侧偏角 θ、横摆角 φ 的值落在图中区域内时，前车体能保证挖掘时的稳定性，不会有倾翻风险，当落在区域外时，可能会有倾翻的风险。

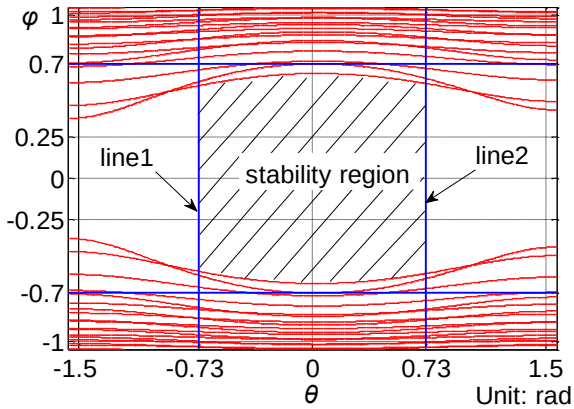

Fig.8 - Stable region of the front body during digging

CONCLUSION

Agricultural articulated vehicles can adapt well to different terrains; thus, such vehicles can be used on the rough terrains of upland fields, paddy fields, and mountainous and hilly areas during agricultural production. To protect the safety of the operator, the stability of this vehicle must be determined during agricultural production. We analyze the stabilities of the front and rear bodies when the vehicle performs a digging task. The factors that affect stability during digging operations are defined as the mathematical interval. Moreover, we build a stability analysis model in combination with multi-body dynamics, the interval method, and the stability criterion to analyze vehicle stability. The region of the roll and yaw angles is determined based on the simulation result and the yaw angle keeps the front body stable. Therefore, the simulation results can be fed back to a designer to optimize vehicle design and to provide data for early rollover warning design in agricultural production.

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结论

农业铰接车因为地形适应能力强，在农业工程作业中可以应用在旱地、水田、山地等地形环境恶劣的地方，但是为了保证操作者的人身安全，研究农业铰接车在农业工程作业时的稳定性是十分重要的。本文对前车体和后车体在挖掘作业过程中的稳定性进行了单独分析。在建立静态稳定性分析模型时，把影响挖掘过程中稳定性的因素设为数学区间，结合多体动力学、区间数学方法和稳定性判据，来分析挖掘过程中的车体稳定性。通过仿真计算分析得到前车体在挖掘过程中不发生倾翻的侧偏角和横摆角区域范围。通过分析挖掘过程中的稳定性计算结果，可以反馈给设计人员改进和提高农业铰接车的结构设计，同时也可以为农业工程作业中车辆的倾翻预警装置研发提供参考。

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INNOVATIVE TECHNOLOGY FOR WORKS MECHANIZATION OF MODELING AND DIRECT SEEDING IN FIELD FOR ONION CROP

TEHNOLOGIE INOVATIVĂ PENTRU MECANIZAREA LUCRĂRILOR DE MODELAT ŞI SEMĂNAT DIRECT ÎN CÂMP A CULTURII DE CEAPĂ

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Abstract: *The paper presents constructive and experimental aspects of an innovative technology for mechanization the modeling and direct seeding in field works of crop onions. Experiments have led to reduced energy consumption values in the technological variant wich perform with a single equipment the soil modeling and sowing works. Results obtained by using innovative technology can be used by farmers to obtain mainly a substantial reduction in energy consumption and also for execution of a working system with beneficial effects on the environment in terms of maintaining soil structure, reduce air pollution, the development of the root system of plants.*

Keywords: *innovative technology, modeling, direct seeding, crop onions*

Rezumat: *În lucrare sunt prezentate aspecte constructive şi experimentale ale unei tehnologii inovative pentru mecanizarea lucrărilor de modelat şi semănat direct în câmp a culturii de ceapă. În urma cercetărilor experimentale au rezultat valori ale consumurilor energetice reduse în varianta tehnologică în care lucrările de modelat solul şi semănat se execută concomitent cu un singur echipament tehnic. Rezultatele obținute sunt utile fermierilor pentru asimilarea tehnologiei inovative, în vederea obținerii în principal a unei reduceri substanțiale a consumurilor energetice şi totodată, pentru executarea unui sistem de lucrări cu efecte benefice asupra mediului în ceea ce priveşte menținerea structurii solului, reducerea poluării aerului, dezvoltarea sistemului radicular al plantelor.*

Cuvinte cheie: *tehnologie inovativă, modelat, semănat direct, cultura de ceapă*

INTRODUCTION

Vegetables consumption, expressed as a percentage employed in human nutrition, is an important indicator for assessing the standard of living. Viewed in this aspect, vegetable production has a particularly high economic importance worldwide. The economic importance of the vegetable has gained new dimensions, by developing forced crops in greenhouses, protected crops and especially by switching to vegetable concentrate, to establishment of specialized and profiled units. [8] Vegetable, an important sector of production of agrifood goods, presents a great importance for the national economy in general and agriculture in particular, and for economic agents involved. By the assets that it owns, both in public and private domain - fertile land, mostly arranged for irrigation, specific construction (greenhouses, solariums, seedbeds), or schedule (halls, warehouses), mechanical means (tractors, machines, installations) - farming is an important segment of national wealth, who must be preserved and developed further. [6,7] By new investment is required modernization and development of existing technical and material facilities, in order to increase the economic returns and profitability of production. Throughout time agriculture and farming have recorded numerous steps that led to modification and changes of addressed practices, to change the mentality and ways to exploit the existing resources. In this way, promote sustainable agriculture requires to respect some conditions primary related with crop rotation, rational fertilization, weed control, diseases, pests and reduce of energy consumption. [2,10,15]

To achieve higher production quantitatively and qualitatively, economically efficient, it is necessary to apply advanced technology culture and at the same time to use a proper range, adapted to the area and specializes in harvest destination. [14]

The major changes that have occurred in the

INTRODUCERE

Consumul de legume, exprimat ca pondere ocupată în alimentația omului, constituie un important indice de apreciere a nivelului de trai. Privită sub acest aspect, producerea legumelor prezintă o importanță economică deosebit de mare pe plan mondial. Astfel, importanța economică a legumiculturii a căpătat noi dimensiuni, prin dezvoltarea culturilor forțate în sere, a culturilor protejate şi în mod special prin trecerea la concentrarea legumiculturii, la înființarea de unități profilate şi specializate [8]. Legumicultura, un sector important al producției de bunuri agroalimentare, prezintă o mare importanță atât pentru economia națională în general şi cea agricolă în special, cât şi pentru agenții economici implicați. Prin însuşi patrimoniul pe care-l deține, atât în domeniul public cât şi cel privat - terenuri fertile, preponderent amenajate pentru irigat, construcții specifice (sere, solarii, răsadnițe), sau anexe (hale, magazii), mijloace mecanice (tractoare, maşini, instalații) - legumicultura reprezintă un important segment al avuției naționale, care trebuie păstrat şi dezvoltat în continuare[6,7]. Prin investiții noi se impune modernizarea şi dezvoltarea dotărilor tehnico-materiale existente, în vederea creşterii randamentelor economice şi a profitabilității producției. De-a lungul timpului agricultura şi implicit legumicultura au înregistrat numeroase etape care au dus la modificarea şi evoluția practicilor abordate, la schimbarea mentalității şi a modalităților de exploatare a resurselor existente. În acest sens, promovarea unei agriculturi durabile presupune respectarea unor condiții primordial legate de rotația culturilor, fertilizarea rațională, controlul buruienilor, bolilor, dăunătorilor şi reducerea consumurilor energetice. [2,10,15]

Pentru a obține producții superioare cantitativ şi calitativ, eficiente din punct de vedere economic, este necesar să se aplice tehnologii de cultură performante şi în acelaşi timp să se utilizeze un sortiment adecvat, adaptat condițiilor zonei şi specializat pe destinația

Romanian agriculture requires a reassessment of mechanization technologies for vegetable crop establishment, finding innovative technology solutions to obtain competitive crops, with reduced consuming, and last but not least, with reduced environmental impact.

Seeking to meet the requirements above, the paper authors have made experimental research with an innovative technology for works mechanization of modeling and direct seeding in field for onion crop.

MATERIAL AND METHOD

One of the most common vegetables, especially in the south and southeast of our country, the onions, a biennial or three-year, containing mineral salts (sodium, potassium, iron, sulfur, iodine, silicon, phosphate), antibiotic principles, carbohydrates, lipids, sucrose, organic acids, sterols, vitamins (vitamin C, vitamins of the group B vitamin E), volatile oil, saponin. A prerequisite to achieve maximum onion production with minimum costs assumed that all machinery and technical equipment components of the start-ups technology are interrelated in terms of technical, economic and organizational. In this regard, for choosing agricultural machinery and technical equipment of the innovative technology for mechanization the modeling and direct seeding in field onion crops it was considered the following criteria:

- Mechanization zoning, determined by the topography of the land, soil resistance, crop plan structure, the availability of labor;
- Technically possible to use due to the technical characteristics of the machinery and technical equipment, how to meet the requirements of agro, technical performance;
- Economic efficiency, reflected in reduced recovery time of investments in machinery and technical equipment.

Figure 1 presents the existing technological alternatives for mechanization the modeling and direct sowing in field works of onion culture.

recoltei. [14]

Schimbările majore care au avut loc în agricultura românească impun o reevaluare a tehnologiilor de mecanizare pentru înfiinţarea culturilor legumicole, găsirea unor soluţii tehnologice inovative pentru obţinerea de recolte competitive, cu consumuri reduse şi nu în ultimul rând, cu impact redus asupra mediului.

Căutând să răspundă cerinţelor de mai sus, autorii lucrării au efectuat cercetări experimentale cu o tehnologie inovativă pentru mecanizarea lucrărilor de modelat şi semănat direct în câmp a culturii de ceapă.

MATERIALE ŞI METODĂ

Una din cele mai des întâlnite legume, mai ales în partea de sud şi sud-est a ţării noastre, este ceapa, o plantă bienală sau trienală, care conţine săruri minerale (sodiu, potasiu, fier, sulf, iod, siliciu, fosfat), principii antibiotice, glucide, lipide, zaharoză, acizi organici, steroli, vitamine (vitamina C, vitamine din grupul B, vitamina E), ulei volatil, saponine. O condiţie esenţială pentru obţinerea unor producţii de ceapă maxime cu costuri minime presupune ca totalitatea maşinilor şi echipamentelor tehnice componente tehnologiei pentru înfiinţare, să fie corelate între ele din punct de vedere tehnic, economic şi organizatoric. În acest sens, pentru alegerea maşinilor şi echipamentelor tehnice agricole din cadrul tehnologiei inovative pentru mecanizarea lucrărilor de modelat şi semănat direct în câmp a culturii de ceapă s-a ţinut cont de următoarele criterii:

- zonalitatea mecanizării, determinată de relieful terenului, rezistenţa solului, structura planului de culturi, disponibilul de forţă de muncă;
- tehnica posibilă de folosit determinată de caracteristicile tehnice ale maşinilor şi echipamentelor tehnice, de modul de satisfacere a cerinţelor agrotehnice, de performanţele lor tehnice;
- eficienta economică, concretizată prin timp redus de recuperare a investiţiilor făcute în maşini şi echipamente tehnice.

În figura 1, sunt prezentate variantele tehnologice existente pentru mecanizarea lucrărilor de modelat şi semănat direct în câmp a culturii de ceapă.

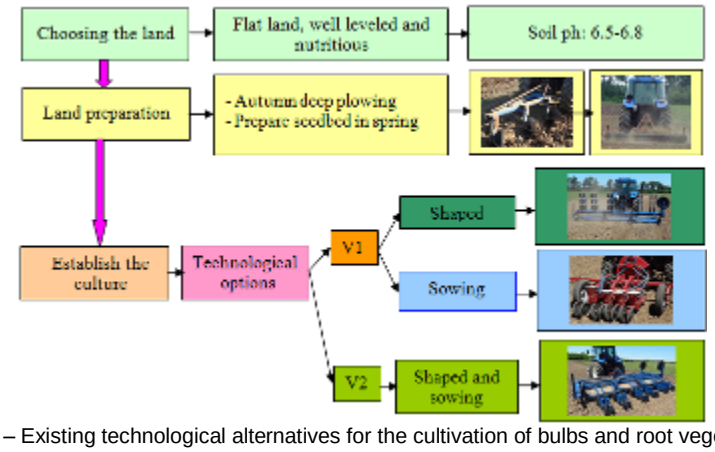


Fig. 1 – Existing technological alternatives for the cultivation of bulbs and root vegetables

Preparing the ground, for the establishment in spring of onion crop directly in the field, it was to perform the following works:

- Furrow plow to a depth of at least 20 ... 25 cm in autumn;
- Loosening shallow the soil by one pass with adjustable Harrows early spring;
- To obtain high yields and good quality onion crop establishment, was insured a drilling scheme specific for this culture. This scheme (Table 1) is designed to

Pregătirea terenului, pentru înfiinţarea în primăvară a culturii de ceapă direct în câmp, a constat în efectuarea următoarelor lucrări:

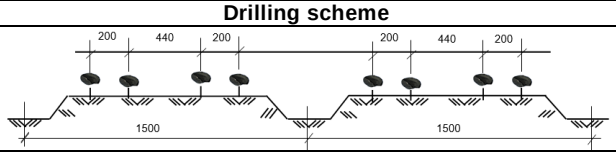
- arătură cu plugul la o adâncime de cel puţin 20…25 cm în toamnă;
- afânarea solului superficial printr-o trecere cu o grapă cu colţi reglabili primăvara devreme;
- în vederea obţinerii unor producţii ridicate şi de bună calitate, la înfiinţarea culturii de ceapă, s-a asigurat o schemă de semănat specifică acestei culturi. Această

provide optimal conditions for plant growth and fruiting. Onion seeds are small and sown directly in the field, early spring.

schemă (tabelul 1) are rolul de a asigura plantelor condiții optime pentru dezvoltare şi fructificare. Semințele de ceapă sunt de mici dimensiuni şi se seamănă direct în câmp, primăvara devreme.

Table 1

Drilling scheme specific for onion culture

Culture	Drilling scheme
Onion - Plant distance in the row, mm: 30…35 - Sowing, kg/ha: 5 - Seeding depth, cm: 2	

In the experimental research of innovative technology has been used a new technical equipment running in a single-pass the following:
- Prepare the seedbed layer at a depth of 2 ... 6 cm;
- Breaking the crust layer with teaspoon type passive organ;
- Modeling the soil on layer;
- Modeling / rehabilitation of irrigation culverts;
- Sowing onion seeds.

The technical equipment (fig. 2) comprises a front frame fitted with some passive working tools for soil loosening simultaneously with the shaping layer, and a rear frame fitted with some seeding sections provided with mechanical device for seed distribution for bulbs and roots vegetable crops.

În cadrul cercetărilor experimentale ale tehnologiei inovative a fost utilizat un echipament tehnic nou care execută la o singură trecere următoarele operații:
- pregătirea patului germinativ pe strat la adâncimea de 2…6 cm;
- spargerea crustei pe strat cu organe pasive tip linguriță;
- modelarea solului pe strat;
- modelarea/refacerea rigolelor de udare;
- semănatul semințelor de ceapă.

Echipamentul tehnic (fig. 2) are în componență un cadru anterior echipat cu nişte organe de lucru pasive pentru afânarea solului concomitent cu modelarea pe strat şi un cadru posterior echipat cu nişte secții pentru semănat prevăzute cu aparat mecanic de distribuție semințe pentru culturi de legume bulboase şi rădăcinoase.

Fig. 2 - Technical equipment for sowing onion seeds while preparing and shaping the soil

The rear frame is hinged, by means of a port sections bar and some supports assembled with some ties to a frame bar located behind the passive working organs from the front frame. In addition, if it does not carry out the seeding work, the rear frame is folded by rotating the bearing tube sections in the vertical plane at an angle of 90° and fastened with bolts, and the sowing section mounted articulated on the bar sections with an articulated parallelogram, consisting in two pairs of arms, is blocked by stretching a spring, which makes a bolt located on one arm to remain stuck in a hole with a special profile of a cover plate mounted articulated on the other arm. The technical equipment is made according to the patent application filed with OSIM. No. A00383 / 08.06.2015. [3]

The main technical characteristics of the machinery are shown in Table 2.

Cadrul posterior este montat articulat, prin intermediul unei bare port secții pentru semănat şi a unor suporturi care sunt asamblați cu nişte bride pe o bară cadru situată în spatele organelor de lucru pasive de la cadrul anterior. De asemenea, pentru cazul când nu se realizează lucrarea de semănat cadrul posterior este rabatat prin rotirea barei port secții în plan vertical cu un unghi de 90° şi fixarea cu nişte bolțuri, iar secția pentru semănat montată articulat pe bara port secții cu un paralelogram articulat, constituit din două perechi de brațe, este blocată prin întinderea unui resort, care face ca un bolț situat pe unul din brațe să rămână blocat într-o gaură cu un profil special a unei platbande montată articulat pe celălalt braț. Echipamentul tehnic este realizat în acord cu cererea de brevet de invenție înregistrată la OSIM. cu nr. A00383/08.06.2015. [3]

Principalele caracteristici tehnice ale echipamentului tehnic sunt prezentate în tabelul 2.

Table 2

Technical characteristics of technical equipment

Characteristics	Value
Energy source	Wheel tractors of 65 HP
Type of equipment	Trailed in transport and worn in work
Width, m	4,5
Layer width (crest), mm	1040
The number of layers, pcs.	3

Distance between trenches, mm	1500
Number of sowing modules, pcs.	3
The maximum number of sowing sections on module, pcs.	4
Distance between sowing sections, mm	200…280

Before carrying out the experimental research with technical equipment were made following adjustments:

- Loosening depth adjustment on layer, by adjusting the positions of spoon knife vertically from the position of shoe for limiting depth work;
- Height layer adjustment by fitting forming sheath at a distance from the roller recovery culverts;
- Adjust the equipment vertically by screwing or unscrewing the upper link, so they have working bodies parallel to the ground in the working position;
- Adjusting the horizontality by lengthening or shortening the lower link in order to achieve the same working depth over the whole width;
- Adjusting the seeding depth by adjusting the coulter against precompaction wheel;
- Adjust the distance between seeds on row by choosing distribution disc with a number of alveoli properly to seed distributed.

Experimental investigations were performed using equipment and measuring devices tested in laboratories accredited, under the validity period stated on the labels of verification.

In laboratory conditions were determined the following parameters:

- *Storage area S*, which has been calculated by the relation:

Înainte de efectuarea cercetărilor experimentale cu echipamentul tehnic au fost efectuate următoarele reglaje:

- reglarea adâncimii de afânare pe strat, prin reglarea pozițiilor cuțitelor linguriță pe verticală, față de poziția patinei de limitare a adâncimii de lucru;
- reglarea înălțimii stratului prin montarea mantalelor formatoare la o distanță față de patinele de refacere a rigolelor;
- reglarea echipamentului în plan vertical prin înşurubarea sau deşurubarea tirantului central, astfel ca acesta sa aibă organele de lucru paralele cu solul în poziția de lucru;
- reglarea orizontalității prin lungirea sau scurtarea tiranților laterali în vederea realizării aceleiaşi adâncimi de lucru pe toată lățimea;
- reglarea adâncimii de semănat prin reglarea brăzdarului față de roata de pretasare;
- reglarea distanței dintre semințe pe rând prin alegerea discului de distribuție cu un număr de alveole corespunzător seminței distribuite.

Cercetările experimentale s-au efectuat utilizând aparatură şi dispozitive de măsurat verificate în laboratoare acreditate, aflate în perioada de valabilitate inscripționată pe etichetele de verificare.

În condiții de laborator au fost determinați următorii parametri:

- Suprafața de stocare *S*, care a fost calculată cu relația:

$$S = (L_s + 0{,}5)\,(B_s + 0{,}5),\ [\mathrm{mm}^2] \qquad (1)$$

where:

L_s is the total length in the storage position, in mm;

B_s - the total width in the storage position, in mm.

- **Masses of unit tractor New Holland TD 80D + technical equipment**, which were determined by weighing using the balance scales. The percentage of load on the front axle reported to the total mass of the tractor New Holland TD 80D [13] with the technical equipment was calculated with the relationship:

unde:

L_s este lungimea totală în poziție de stocare, în mm;

B_s - lățimea totală în poziție de stocare, în mm.

- Masele agregatului tractor TD 80D New Holland + echipament tehnic, care au fost determinate prin cântărire cu ajutorul cântarului balanță. Valoarea procentuală a încărcării pe puntea față raportată la masa totală a tractorului TD 80D New Holland [13] cu echipamentul tehnic s-a calculat cu relația:

$$\frac{M_{Tpf}}{M_{Tpt}} \cdot 100\ ,\ [\%] \qquad (2)$$

where:

M_{Tpf} is the mass of the tractor New Holland TD 80D with technical equipment on the front axle;

M_{Tpt} - total weight of tractor New Holland TD 80D with technical equipment.

In laboratory conditions were determined following work qualitative indices:

- The seeding precision as the distance between seeds per row;
- The percentage of nests with two or more seeds (double);
- The percentage of nests seedless (goals).

On the basis of experimental research were the density requirements on row, provided in onion crop growing technologies directly sown in the field. Precision measurements were made by collecting and weighing the seeds distributed. It was calculated the average distance between seeds in a row. Measurements were performed in triplicate for three sowing sections on a length corresponding with at least 1,500 seeds sown.The average distance between seeds in a row was calculated using the formula:

unde:

M_{Tpf} este masa tractorului TD 80D New Holland cu echipamentul tehnic pe puntea din față;

M_{Tpt} - masa totală a tractorului TD 80D New Holland cu echipamentul tehnic.

În condiții de laborator au fost determinați următorii indici calitativi de lucru:

- precizia de semănat ca distanță între semințe pe rând;
- procentul de cuiburi cu două sau mai multe semințe (duble);
- procentul de cuiburi fără semințe (goluri).

La baza cercetărilor experimentale au stat cerințele privind densitatea pe rând, prevăzute în tehnologiile de cultivare a culturii de ceapă semănată direct în câmp. Determinările de precizie au fost făcute prin colectarea şi cântărirea semințelor distribuite. S-a calculat distanța medie dintre semințe pe rând. Determinările au fost efectuate în trei repetiții pentru trei secții de semănat pe o lungime corespunzătoare cu minim 1500 de semințe semănate. Distanța medie dintre semințe pe rând s-a calculat cu relația:

$$d_{medie} = \frac{L}{Q_m} \times MMB, mm \quad (3)$$

In the field conditions were determined the following energy indicators:

- The actual working speed V_e, in m/s, was calculated with the equation (4). It was measured with roulette on samples field a linear space *s* and was marked with two milestones its beginning and end. Upon entering in the working regime of the tractor + technical equipment aggregate in the samples space, was started the timer and at the discharge side was stopped and has been read the *t* time. They were made determinations for three gears. For each gear were made five repetitions on which was calculated the arithmetic mean.

În condiții de câmp au fost determinați următorii indici energetici:

- Viteza de lucru efectivă V_e, în m/s, s-a calculat cu relația (4). S-a măsurat cu ruleta pe terenul de probe un spațiu liniar *s* şi s-a marcat cu câte 2 jaloane începutul şi sfârşitul acestuia. La intrarea în regim de lucru a agregatului tractor+echipament tehnic în spațiul de probe, s-a pornit cronometrul, iar la ieşirea din acesta s-a oprit şi s-a citit timpul *t*. S-au efectuat determinări pentru trei trepte de viteză. Pentru fiecare treaptă de viteză s-au efectuat 5 repetiții pe baza cărora s-a calculat media aritmetică.

$$V_e = \frac{3{,}6 \times s}{t}, m/s \quad (4)$$

Tensile Strength F_t, in N, between the tractor and machinery (resistance force to tensile strength) was measured with a frame with strain gauges [1]. Coupling the frame to the tractor linkage [12] was made by binding the central and lower link of the tractor to the central and lateral pins of the frame. For measurement and experimental data acquisition was used a Tensometry modern equipment consisting in an MGCplus amplifier system and data acquisition [11], with 16 analog input channels and 16 digital output channels and a ML455 HBM boost mode. The MGCplus power supply system was a lead storage battery, with a voltage of 12 V.

For registration the acquired data directly into the computer was used a Catman software [9] specialized for data acquisition and processing, which allowed filtering signals from the transducers and determination of minimum, maximum and average of them.

- **Traction power P_t**, in kW, was determined indirectly, by calculation, based on average values of the traction force F_t and average speed work (travel) V_e from tractor - technical equipment unit, using relationship [4]:

- **Forța de tracțiune F_t**, în N, dintre tractor şi echipamentul tehnic (forța de rezistență la tracțiune) s-a determinat cu o rama cu traductoare tensometrice [1]. Cuplarea ramei la mecanismul de suspendare al tractorului [12] s-a realizat prin legarea tiranților laterali şi central ai tractorului la bolțurile laterale şi central de pe ramă. Pentru măsurarea şi achiziția datelor experimentale s-a utilizat un echipament modern de tensometrie format dintr-un sistem de amplificare şi achiziție date tip MGCplus [11], cu 16 canale de intrare analogice şi 16 canale de ieşire digitale şi cu un modul de amplificare ML455 HBM. Sursa de alimentare a sistemului MGCplus a fost o baterie de acumulatori cu plumb, cu tensiunea de 12 V. Pentru înregistrarea datelor achiziționate direct în computer s-a utilizat un soft CATMAN [9] specializat pentru achiziția şi prelucrarea datelor, care a permis filtrarea semnalelor primite de la traductoare şi determinarea valorilor minime, maxime şi medii ale acestora.

- **Puterea de tracțiune *Pt***, în kW, s-a determinat indirect, prin calcul, pe baza valorilor medii obținute ale forței de tracțiune F_t şi vitezei medii de lucru (deplasare) V_e a agregatului tractor-echipament tehnic, utilizând relația 5 [4]:

$$P_{tr} = \frac{F_{tr} \times V_e}{1000}, kW \quad (5)$$

- **Theoretical working capacity W_{ef}**, in ha / h

The theoretical working capacity was calculated with the relationship [5]

- Capacitatea teoretică de lucru W_{ef}, în ha/h

Capacitatea teoretică de lucru s-a calculat cu relația 6 [5]:

$$W_{ef} = 0{,}1 \times B_l \times V_e, ha/h \quad (6)$$

in which:
- B_l is working width of technical equipment, in m
- V_e - working speed, in km/h.

în care:
- B_l este lățimea de lucru a echipamentului tehnic, în m
- V_e - viteza de lucru, în km/h.

RESULTS

The determined constructive parameters are shown in Table 3.

REZULTATE

Parametrii constructivi determinați sunt prezentați în tabelul 3.

Table 3

Constructive parameters

Parameter	Value
- Length of storage, L_s	1950
- Width storage, B_s	5252
- Storage height, H_s	1545
- Storage area, S [m^2]	10.241

The percentage of load on the front axle reported to the total mass of the tractor has a value of 32.16% to the front axle load, which meets the requirement of stability in the longitudinal plan because the unit does not Cabra (according to internal regulations on the vehicle traffic, the load on the front axle must be less than 20% of the unit mass).

Valoarea procentuală a încărcării pe puntea față raportată la masa totală a tractorului a avut o valoare de 32,16 % pentru încărcarea pe puntea față, care satisface cerința de stabilitate în plan longitudinal pentru ca agregatul să nu cabreze (conform reglementărilor interne privind circulația vehiculelor, sarcina pe puntea față trebuie să fie mai mare de 20 % din masa agregatului).

Quality indices values obtained in laboratory conditions are presented in Table 4.

Valorile indicilor calitativi obținuți în condiții de laborator sunt prezentate în tabelul 4.

Table 4

Quality indices values obtained in laboratory conditions

Crop	Distance between seeds in a row, cm		Nr. seeds per meter		Features of distributing disc
	Agronomic requirement	It is feasible	Agronomic requirement	It is feasible	
Directly sown onions	2…4	1.6…15.5	33…50	6…62	Φ3 30 holes

For onion seed with characteristics:
- 1000 grain weight: 3.5 g;
- Purity: 99.2%;
- Germination: 89%,

the drilling sections have been adjusted as follows:
- Used discs distributed: 30 holes, Φ3
- Adjustable distance between seeds in a row: d = 30 mm.

The quantities of collected seed in triplicate for three seed sections are shown in Table 5.

Pentru sămânța de ceapă cu caracteristicile:
- masa a 1000 boabe: 3,5 g;
- puritatea: 99,2 %;
- germinația: 89 %,

secțiile de semănat au fost reglate astfel:
- discurile de distribuit folosite: 30 găuri, Φ3
- distanța reglată între semințe pe rând: d = 30 mm.

Cantitățile de sămânță colectate în trei repetiții pentru trei secții de semănat sunt prezentate în tabelul 5.

Table 5

The results made with onion seed

	The quantity of collected seed, g		
	Section 1	Section 2	Section 3
Repeat 1	5,3	5,2	5,1
Repeat 2	5,4	5,1	5,4
Repeat 3	5,2	5,4	5,5
Average value	**5,3**	**5,23**	**5,33**

Qualitative indices obtained from the measurements are shown in Table 6.

Indicii calitativi obținuți în urma măsurătorilor sunt prezentați în tabelul 6.

Table 6

Qualitative indices obtained for onion sowing in shaped land

Qualitative indices	Section 1	Section 2	Section 3
The calculated average distance, mm	29,7	30,1	29,5
The percentage of nesting with two or more seeds (double), %	0	0	0
The percentage of seedless nests (goals), %	0	0	0

The energy indices obtained at the work of preparing the seedbed with technical equipment, which was equipped as V1 variant – for shaping the ground, are shown in Table 7.

Indicii energetici obținuți la lucrarea de pregătit patul germinativ cu echipamentul tehnic, care a fost echipat în Varianta V1 - pentru modelarea solului, sunt prezentați în tabelul 7.

Table 7

Energy indices obtained with New Holland TD 80D tractor + technical equipment unit (equipped as V1 variant - modelling soil)

Determined parameters	Value
Travel speed, m/s	0,96
Tensile Strength, N	11520
Pullpower, kW	11,06
Actual working capacity W_{ef}, ha/h	1,55

The chart traction for New Holland TD 80D tractor + technical equipment unit (equipped as V1 variant - modelling soil) is shown in Figure 3.

Diagrama de tracțiune a agregatului tractor TD 80D New Holland + echipamentul tehnic (echipat în Varianta V1 - modelat solul) este prezentată în figura 3.

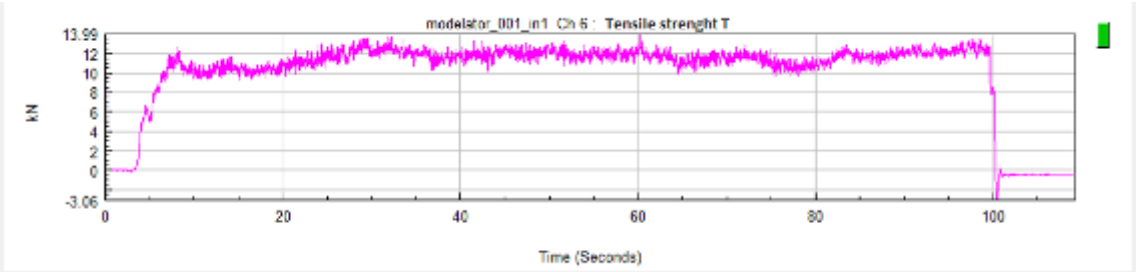


Fig. 3 - The chart traction for New Holland TD 80D tractor + technical equipment unit (equipped as V1 variant - modelling soil)

In figure 4 it is shown a look during the determination of energy indicators for New Holland TD 80D tractor + technical equipment unit (equipped as V1 variant - modelling soil).

În figura 4 este prezentat un aspect din timpul determinării indicilor energetici pentru agregatul tractor TD 80D New Holland + echipamentul tehnic (echipat în Varianta V1 - modelat solul).

Fig. 4 - A look during the determination of energy indicators for New Holland TD 80D tractor +technical equipment unit (equipped as V1 variant - modelling soil)

The energy indices obtained at the work of preparing the seedbed with technical equipment, which was equipped as V2 variant – for shaping the ground when sowing onion crop directly in the field, are shown in Table 8.

Indicii energetici obținuți la lucrarea de pregătit patul germinativ cu echipamentul tehnic, care a fost echipat în Varianta V2 - pentru modelarea solului concomitent cu semănatul culturii de ceapă direct în câmp, sunt prezentați în tabelul 8.

Table 8

The energy indices obtained with New Holland TD 80D tractor + technical equipment unit (equipped as V2 variant - modelling soil and sowing directly in the field)

Determined parameters	Value
Travel speed, m/s	0,82
Tensile Strength, N	12960
Pullpower, kW	10,63
Actual working capacity W_{ef}, ha/h	1,33

The chart traction for New Holland TD 80D tractor + technical equipment unit (equipped as V2 variant - modelling soil and sowing directly in the field) is shown in Figure 5.

Diagrama de tracțiune a agregatului tractor TD 80D New Holland + echipamentul tehnic ESM (echipat în Varianta V2 - modelat solul şi semănat direct în câmp) este prezentată în figura 5.

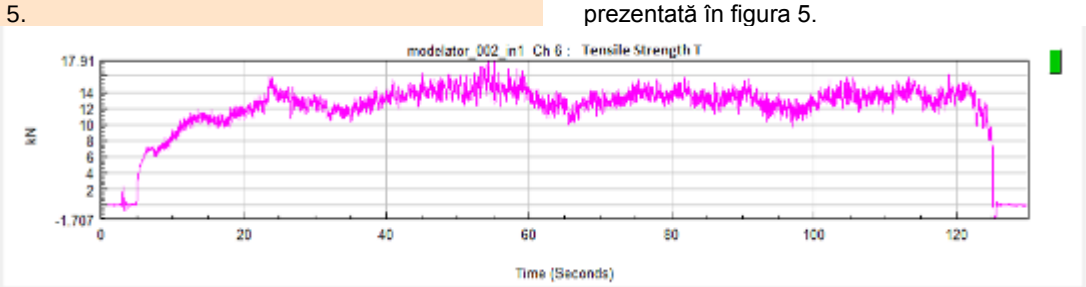


Fig. 5 - The chart traction for New Holland TD 80D tractor + technical equipment unit (equipped as V2 variant - modelling soil and sowing directly in the field)

A look during the determination of energy indicators for New Holland TD 80D tractor + technical equipment unit (equipped as V2 variant - modelling soil and sowing directly in the field) is shown in Figure 6.

Un aspect din timpul determinării indicilor energetici pentru agregatul tractor TD 80D New Holland + echipamentul tehnic (echipat în Varianta V2 - modelat şi semănat direct în câmp) este prezentat în figura 6.

Fig. 6 - A look during the determination of energy indicators for New Holland TD 80D tractor + technical equipment unit (equipped as V2 variant - modelling soil and sowing directly in the field)

CONCLUSIONS

Analyzing the results after experimenting the innovative technology follows next:

- New technical equipment for innovative technology has an 10.241 m^2 storage area, wich is similar to the similar equipment;

CONCLUZII

Din analiza rezultatelor obținute în urma experimentării tehnologiei inovative rezultă că:

- echipamentul tehnic nou destinat tehnologiei inovative are o suprafața de stocare de 10.241 m^2, care este asemănătoare cu cea a echipamentelor similare;

- Is respected the longitudinal stability requirement because the unit does not Cabra, because the percentage of load on the tractor front axle is bigger than 20% of the aggregate mass;
- Precision seeding as distance between seeds in row for technical equipment was 99%, value which complies with the agronomic requirements;

Operational it is recommended application of V2 variant (machinery equipped for modelling soil and sowing) because it requires lower energy consumption reported to V1 version (machinery equipped for modelling soil + drill for drilling work).

The application of V2 variant is advantageous, through the beneficial effects on the environment (reducing soil compaction, reducing air pollution, conservation of soil structure) that suspend additional mechanical work to be performed in V1 variant (seeding work with a drill for vegetables).

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- este respectată cerința de stabilitate în plan longitudinal pentru ca agregatul să nu cabreze, deoarece sarcina pe puntea față a tractorului este mai mare de 20 % din masa agregatului;
- precizia de semănat ca distanță între semințe pe rând a echipamentului tehnic a avut valoarea de 99 %, care se încadrează în cerințele agrotehnice.

În exploatare se recomandă aplicarea variantei V2 (echipamentul tehnic echipat pentru modelat solul şi semănat) deoarece aceasta se efectuează cu consumuri energetice reduse față de varianta V1 (echipamentul tehnic echipat pentru modelat solul + semănătoarea pentru lucrarea de semănat).

Aplicarea variantei V2 este avantajoasă şi datorită efectelor benefice pe care le are asupra mediului (reducerea tasării solului, reducerea poluării aerului, conservarea structurii solului) prin faptul că suspendă lucrările mecanice ce trebuie executate suplimentar în varianta V1 (lucrarea de semănat cu o semănătoare pentru legume).

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FUEL SYSTEM OF THE TRACTOR DIESEL WITH MULTISTAGE HEATING
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ТОПЛИВНАЯ СИСТЕМА ДИЗЕЛЯ С МНОГОСТУПЕНЧАТЫМ ПОДОГРЕВОМ

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Abstract: The design of the fuel system of the tractor diesel with the multistage heating, allowing to apply pure rapeseed oil as fuel in the diesel engine is described in the article.

Keywords: *fuel, rapeseed oil, kinematic viscosity, fuel system, multistage heating*

INTRODUCTION

Despite the development of new deposits of traditional energy sources, the question of their alternatives is extremely sharp. The reason for it is the fact that natural resources are limited, the prices for traditional energy sources constantly increase while the ecological situation on the planet gets worse.

The researches in the field of alternative and renewable fuels have been the prerogative of the energy and resource saving programs of many countries for a long time [1,6,7]. Many scientists of world-wide reputation achieved good results in the sphere of alternative energy sources. Data released in the sphere of atomic energy, solar energy, the usage of wind power generators and tidal energy of seas and oceans, as well as the application of biofuels revealed the positive points of alternative power-engineering, defined tasks and the ways of their solutions. Inspite of high variability of alternative power-engineering, the majority of scientific works with positive results won't get wide manufacturing application in the nearest future for many reasons. Therefore, many European scientists and engineers think that "atom", "hydrogen" and recuperative system will be applied in manufacturing only in 40-50 years. This time will take a transitional period, when biofuel will be used as a fuel for already existing combustion engine models. By now biofuel gained trust and confidence of many countries. It is used in its pure state (alcohols replacing gasoline; biodiesel replacing traditional mineral diesel fuel; biogas in gas generator units) as mixtures with mineral fuels (E5, E15, E80, E85, B10, B20, etc.) and as a fuel additives [2,7].

In the context of agricultural enterprises the most suitable alternative for diesel fuel nowadays is bleached RO, meeting the requirements of the German standard V 51605. The use of pure RO as a fuel for diesel engines results in the following negative effects: loss of power, increased fuel consumption, shortened life of the fuel equipment, impair starting in cold weather, increased incrustration and lacquer formation, etc. [1,3,8].

The presence of negative moments in the operation of

АННОТАЦИЯ: В статье описана конструкция топливной системы тракторного дизеля с многоступенчатым подогревом, позволяющая использовать чистое рапсовое масло в качестве топлива в дизельном двигателе.

Ключевые слова: топливо, рапсовое масло, кинематическая вязкость, топливная система, многоступенчатый подогрев.

ВВЕДЕНИЕ.

Несмотря на, разработку новых месторождений традиционных источников энергии остро стоит вопрос альтернативы. Причинами тому являются исчерпаемость полезных ископаемых, постоянное повышение цен на традиционные энергоносители и ухудшение экологической обстановки на планете.

Исследования в сфере альтернативных и возобновляемых видов топлив давно уже стали прерогативой программ энерго- и ресурсосберегающих технологий многих стран [1,6,7]. Многие ученые мира добились значительных результатов в сфере альтернативной энергетики. Опубликованные результаты работ в сфере атомной энергетики, солнечной энергии, использования ветряных генераторов, приливной энергии морей и океанов, а также применение биотоплив раскрыли положительные аспекты альтернативной энергетики, определили следующие задачи и пути их решения. Несмотря на широкую вариативность альтернативной энергетики, в ближайшей перспективе большинство положительных результатов работ ученых по тем или иным причинам широкого внедрения в производство не получат. Поэтому, как считают многие европейские ученые и инженеры, прежде чем «атом», «водород», или рекуперативные системы будут полностью освоены производством, пройдет около 40-50 лет. Это время является переходным периодом в течение которого в качестве топлива для уже существующих моделей двигателей внутреннего сгорания будет использоваться биотопливо. К настоящему времени биотопливо уже завоевало доверие и надежду многих стран мира. Его используют как в чистом виде (спирты, замещающие бензин; биодизель, замещающий традиционное минеральное ДТ; биогаз – в газогенераторных установках), как смеси с минеральными топливами (Е5, Е15, Е80, Е85, В10, В20 и т.д.) так и в качестве добавки к минеральным топливам [2,7].

В условиях сельскохозяйственных предприятий наиболее подходящей альтернативой ДТ, в настоящее время является отбеленное РМ, отвечающее требованиям немецкого стандарта V 51605. Применение чистого РМ в качестве топлива для дизельных двигателей приводит к следующим негативным моментам: снижению мощности, повышению расхода топлива, сокращению срока службы топливной аппаратуры, затрудненному пуску двигателя в холодное время года, повышенному нагаро- и лакообразованию, и т.д. [1,3,8].

Наличие отрицательных моментов в процессе эксплуатации дизельных двигателей на РМ связано, в

diesel engines due to RO, is primarily connected with the increased values of the kinematic viscosity compared to diesel fuel (DF). In terms of agricultural enterprises heating is the most effective way to reduce the viscosity of the pure RO and its mixtures with diesel fuel with a high content of RO.

MATERIAL AND METHOD

Based on the temperature characteristics and the seasonal field work, we investigated the dependence of the kinematic viscosity of the pure RO and its mixtures with diesel fuel on the temperature and the content of the RO in the mixture with diesel fuel.

As the RO we used a sample obtained by hot pressing followed by filtration settling of these breeds of rape: Northerner, Salsa, Ahat, Luned, Rohan, Krauser, Solar KL, Mobil KL, Lighthouse, Zorn, Proxima, Capital, Leader, Winner, Sfint and Heros. The DF applied in the research met the requirements of GOST R 52368 - 2005 "The National Standard of the Russian Federation. Diesel fuel Euro. Specifications were in line with quality D, class 2.

In the process of research we determined the kinematic viscosity of pure RO, as well as its mixtures with DF, where DF content was gradually increased to 100% in 10% increments. The temperature range of viscosity determination was from 20 to 90 ^{o}C. The determination of kinematic viscosity was carried out according to GOST 33-2000 "Oil products. Transparent and opaque liquids. Determination of kinematic viscosity and calculation of dynamic viscosity". The mixture heating was conducted in a water-bath, the instruments for measuring kinematic viscosity were capillary viscometers type IWF-1m. The experimental methods were treated with the methods of interpolation and extrapolation

RESULTS

The determination of dependences of kinematic viscosity on temperature and composition of fuel mix (fig. 1 and 2) was the result of the researches, first of all.

The more RO the mixture contains, the lower the content of harmful substances in the exhaust gases and the fuel price and the higher energy independence of the enterprise (on condition of intrafarm RO production), however the kinematic viscosity of the mixture is higher. At a temperature of 0 ^{o}C the RO viscosity is by 36,67 … 22,003 times higher than of the DF. Gradual temperature increase of the fuel mixtures to 40 ^{o}C gives sharp decrease in viscosity. For example, at pure RO the kinematic viscosity of the testing sample while heating to 40 ^{o}C decreases by 4,5 times in comparison with value at 0 ^{o}C and attains 24,503 cSt. Further temperature increase entailed to slower decrease in viscosity. And at a temperature of 90 ^{o}C the viscosity of pure RO attains the value of about 7,384 cSt that allows to minimize the above-mentioned negative moments at operation of diesel engines of a domestic production on this fuel.

первую очередь, с повышенными по сравнению с дизельным топливом (ДТ) значениями кинематической вязкости. В условиях сельскохозяйственных предприятий подогрев является наиболее эффективным способом снижения вязкости чистого РМ и его смесей с ДТ с высоким содержанием РМ.

МАТЕРИАЛ И МЕТОДЫ

Исходя из температурных особенностей и сезонности проведения полевых работ, нами были исследованы зависимости кинематической вязкости чистого РМ и его смесей с ДТ от температуры и от содержания РМ в смеси с ДТ.

В качестве РМ выступал образец, полученный путем горячего отжима с последующей фильтрацией и отстаиванием, следующих сортов рапса: Северянин, Сальса, Ахат, Лунеди, Рохан, Краузер, Солар КЛ, Мобиль КЛ, Маяк, Зорны, Проксимо, Столичный, Лидер, Лауреат, Сфинт и Герос. ДТ, применяемое в исследованиях отвечало требованиям ГОСТ Р 52368 – 2005. «Национальный стандарт Российской Федерации. Топливо дизельное Евро. Технические условия» и соответствовало сорту D, классу 2.

В процессе исследований была определена кинематическая вязкость чистого РМ, а также его смесей с ДТ, где содержание ДТ постепенно повышалось до 100% с шагом 10%. Температурный диапазон определения вязкости составил от 20 до 90 ^{o}C. Определение кинематической вязкости осуществлялось согласно ГОСТ 33-2000 «Нефтепродукты. Прозрачные и непрозрачные жидкости. Определение кинематической вязкости и расчет динамической вязкости». Нагрев смесей производился на водяной бане, приборами для измерения кинематической вязкости служили капиллярные вискозиметры типа ВПЖ-1м.

Полученные экспериментальные данные были обработаны методами интерполяции и экстраполяции.

РЕЗУЛЬТАТЫ

Результатом исследований явилось, в первую очередь, определение зависимостей кинематической вязкости от температуры и состава топливной смеси (рис. 1 и 2).

Чем выше в смеси содержание РМ, тем ниже содержание вредных веществ в отработавших газах, стоимость топлива и выше энергоавтономность хозяйства (при условии внутрихозяйственного получения РМ), однако тем выше кинематическая вязкость смеси. При температуре 0 ^{o}C вязкость РМ в 36,67…22,003 раза выше чем у ДТ. Постепенное повышение температуры смесевых топлив до 40 ^{o}C приводит резкому снижение вязкости. К примеру, у чистого РМ кинематическая вязкость при достижении испытуемого образца температуры 40 ^{o}C снижается 4,5 раза в сравнении со значением при 0 ^{o}C и достигает 24,503 сСт. Дальнейшее повышении температуры повлекло к более плавному снижению вязкости. И при температуре 90 ^{o}C вязкость чистого РМ достигает значения около 7,384 сСт, что позволяет минимизировать вышеперечисленные отрицательные моменты при эксплуатации дизельных двигателей отечественного производства на данном топливе.

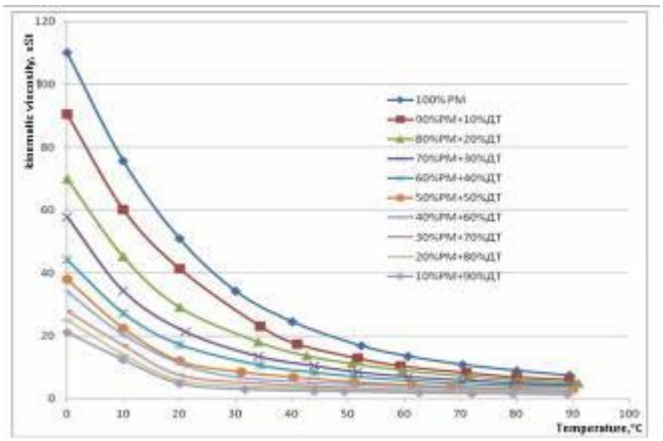

Fig. 1 –- The dependence of the fuel mixture kinematic viscosity on temperature - kinematic viscosity, PM – RO

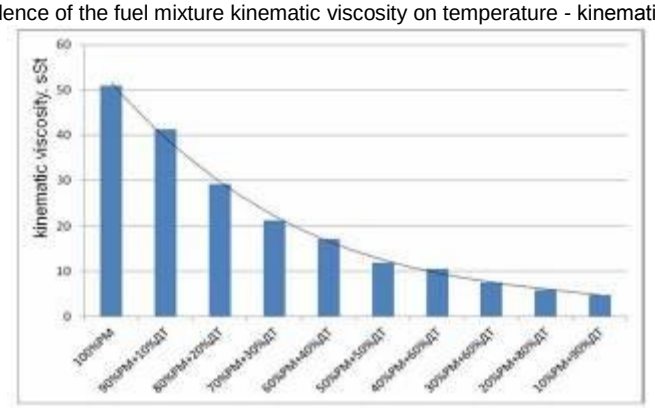

Fig. 2 -– The dependence of the fuel mixture kinematic viscosity on its content at a temperature of 20 °C

For temperature range from 0 to 40 °C for all the fuel mixtures sharp decrease in viscosity is typical. The raised content of DF in them (from 40% and more) also gives decrease in fuel mix viscosity.

In general the analysis of the results of researches with testing samples confirmed the possibility of use as fuel for diesel engines fuel mixtures containing less than 30% of RO at an ambient temperature 20 °C. However, the use of fuel mixtures with the low content of RO is ineffective from the point of view of ecology and economy, and the use of fuel mixtures with the high content of RO without heating is impossible. The heating of RO up to the temperature of 70…90 °C provides decrease in kinematic viscosity, increase in the fineness of injection, reduce of the flame length, i.e. promotes the improvement of the carburetion and combustion processes [5].

We offered a design (figure 3) of a dual-fuel system of the tractor diesel with RO multistage heating, which provides the use of vegetable-based oil. It contains a mineral fuel tank 1, vegetable-based fuel tank 2, where are a heat exchanger 6 and a temperature sensor 21 of the vegetable-based fuel set, mineral fuel intake line 3, vegetable-based fuel intake line 7, hydraulic directional valve 11 located in front of the fuel fine filter 12, ultrasonic filter 13 located in front of the injection pump 14, electric heaters 16 located in front of the nozzles 15, a fuel drain line 17 from the nozzles 15 and a fuel drain line 18 from the injection

Для темпепратурного диапазоно от 0 до 40 °C для всех смесевых топлив характерно резкое снижение вязкости. Повышенное содержание в смеси ДТ (от 40% и выше) также приводит к снижению вязкости смесевого топлива.

В целом анализ результатов исследований испытуемых образцов подтвердил возможность использования в качестве топлива для дизельных двигателей топливных смесей с содержание РМ до 30% при температуре окружающей среды 20 °C. Однако применение топливных смесей с низким содержанием РМ малоэффективно с точки зрения экологии и экономики, а смесевых топлив с высоким содержанием РМ без подогрева невозможно. Подогрев РМ до температуры 70…90 °C обеспечивает снижение кинематической вязкости, повышению мелкодисперсноти распыла, сокращению длины факела, т.е. способствует в целом улучшению процесса смесеобразования и сгорания [5].

Нами предложенная конструкция (рисунок 3) двухтопливной системы тракторного дизеля с многоступенчатым подогревом РМ, которая, обеспечивает применение растительного масла. Она содержит бак минерального топлива 1, бак 2 растительного топлива, в котором установлены теплообменник 6 и датчик 21 температуры растительного топлива, линию 3 забора минерального топлива, линию 7 забора растительного топлива, электрогидрораспределитель 11, установленный перед фильтром 12 тонкой очистки топлива, ультразвуковой фильтр 13, расположенный перед топливным насосом высокого давления (ТНВД) 14, электрические подогреватели 16, установленные перед форсунками 15, линию 17 слива топлива из форсунок 15 и линию 18

pump 14, an electronic control unit (ECU) 19, position sensor 20 of the fuel pump rail, located in the fuel pump regulator body. Line 3 of the intake mineral fuels contains first -stage fuel filter 4 and an electric booster pump 5 with a pressure relief valve. Line 7 of the vegetable-based fuel intake, in its turn, contains first-stage fuel filter 8, fuel pump 9 of a standard power supply system and the PTC thermistor heater 10 [4].

слива топлива из ТНВД 14, электронный блок управления (ЭБУ) 19, датчик 20 положения рейки ТНВД, расположенный в корпусе регулятора ТНВД. Линия 3 забора минерального топлив содержит фильтр 4 грубой очистки и электрический подкачивающий насос 5 с редукционным клапаном. Линия 7 забора растительного топлива, в свою очередь, содержит фильтр 8 грубой очистки, топливоподкачивающий насос 9 штатной системы питания и позисторный подогреватель 10 [4].

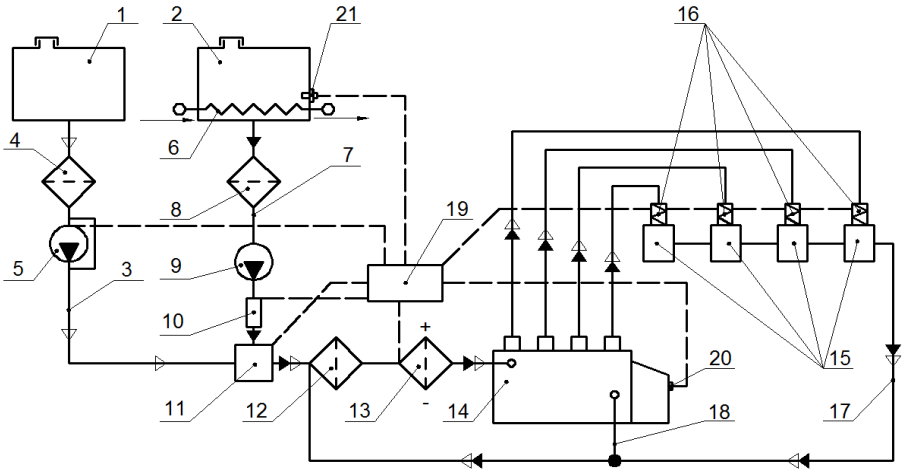

Fig. 3 -– The diagram of the dual-fuel system of the tractor diesel with multistage heating

The first heating stage includes heat exchanger 6, connected to the engine cooling system and heating the vegetable-based oil in tank 2 to the temperature of 20...30 °C, that ensures its pumpability even at low ambient temperatures.

The second heating stage is represented by PTC heater 10, which is self-regulated and serves to heat the vegetable-based oil to a temperature of 60...70 °C, which ensures its good pumpability through the fine filter 12 and ultrasonic filter 13.

The third stage of heating is realized as electric heaters 16 mounted directly in front of the nozzles 15. The vegetable-based oil at this stage is heated to a temperature of 80...90 °C. Electric heaters 16 contain posistors, which stand for control units, so they are self-regulated. The heating of the vegetable-based oil to a temperature of 80...90 °C during injection ensures less flame length and a finer spray compared with lower preheating temperatures.

The dual-fuel system of a tractor diesel with multistage heating operates in the following way:

The start and warming up of the engine is carried out on diesel fuel. At the same time it is supplied by the electric boost pump 5 from the tank through the first-stage fuel filter 4, hydraulic directional valve 11, the fine filter and ultrasonic filter 13 in the high pressure pump 14. Then the diesel fuel through the electric heaters 16 is supplied to the nozzles 15. When the engine is warming up and during the operation with diesel fuel ultrasonic filter 13 and electrical heaters 16 are switched off. The excess of diesel fuel from the nozzles 15 and the fuel pump 14 through the drain lines 17 and 18 are supplied to the fine filter 12.

When heating and during the engine operation the coolant of its system circulates through the heat exchanger 6. Once the temperature of the vegetable-based oil reaches the level of 20...30 °C in the tank 2 of

Первая ступень подогрева включает теплообменник 6, подсоединенный к системе охлаждения двигателя и подогревающий растительное масло в баке 2 до температуры 20…30 °С, что обеспечивает его хорошую прокачиваемость даже при низких температурах окружающей среды.

Вторая ступень подогрева представлена позисторным подогревателем 10, который является саморегулирующимся и служит для подогрева растительного масла до температуры 60…70 °С, что обеспечивает его хорошую прокачиваемость через фильтр тонкой очистки 12 и ультразвуковой фильтр 13.

Третья ступень подогрева реализована в виде электрических подогревателей 16, установленных непосредственно перед форсунками 15. Растительное масло на этой ступени подогревается до температуры 80…90 °С Электрические подогреватели 16 содержат в качестве управляющих элементов позисторы, поэтому являются саморегулирующимися. Подогрев растительного масла до температуры 80…90 °С при впрыске обеспечивает меньшую длину факела и более мелкий распыл в сравнении с более низкими температурами подогрева.

Двухтопливная система тракторного дизеля с многоступенчатым подогревом работает следующим образом.

Пуск и прогрев двигателя осуществляются на дизельном топливе. При этом оно подается электрическим подкачивающим насосом 5 из бака 1 через фильтр 4 грубой очистки, электрогидрораспределитель 11, фильтр 12 тонкой очистки топлива и ультразвуковой фильтр 13 в ТНВД 14. Далее дизельное топливо через электрические подогреватели 16 поступает в форсунки 15. Во время прогрева двигателя и при работе на дизельном топливе ультразвуковой фильтр 13 и электрические подогреватели 16 отключены. Излишки дизельного топлива из форсунок 15 и ТНВД 14 по линиям слива 17 и 18 подаются в фильтр тонкой очистки 12.

При подогреве и во время работы двигателя охлаждающая жидкость из его системы циркулирует через теплообменник 6. По достижении температуры растительного масла 20…30 °С в баке 2 ЭБУ 19,

the electric control unit 19, perceiving this option by the temperature sensor 21, switches the hydraulic directional valve11 in the position of supplying vegetable-based oil and also starts the work of heaters 10 and 16 as well as ultrasonic filter 13. The main function of the ultrasonic filter 13 is further reduction of the kinematic viscosity of the vegetable-based oil.

After switching the hydraulic directional valve 11 in the position of supplying vegetable-based oil, the oil supply stops because the ECU 19 turns the electric boost pump 5 off (the ECU 19 gives signal for the spool of the hydraulic directional valve to stop the diesel fuel supply into the system), the fuel boost pump 9 of the standard power system, delivers warmed to 20...30 ^{o}C vegetable-based oil from tank 2 through a first-stage fuel filter 8 into the posistor heater 10 where it is heated to 60...70 ^{o}C. Then the oil is sent by the hydraulic directional valve 11 through the fine filter 12 in an ultrasonic fuel filter 13, where the vegetable-based oil is subjected to cavitation treatment, whereby its viscosity is further reduced, and it is supplied into the high pressure pump 14 and then to the electric heaters 16, where it is heated up to 80...90 ^{o}C and the injection nozzles 15 spray it into the combustion chamber. The excess of vegetable-based oil from the nozzles 15 and the high pressure pump 14 through the lines 17 and 18 are sent to the fine filter 12.

Thanks to the use of PTC thermistor in the heaters 10 and 16, the latter automatically maintain the temperature of vegetable-based oil in the fuel system. In the PTC heater 10, they have two functions: they are heating elements and at the same time they maintain the oil temperature in the range of 60...70 ^{o}C. The heating elements in the electric heaters 16 are spirals, while posistors serve as elements supporting the temperature in the range of 80...90 ^{o}C.

At steady state conditions of the minimum stable speed and regimes of part-load engine (to 35%), the latter runs on diesel fuel. [4] When working on the above-mentioned modes the rail position sensor 20 of the fuel pump sends a signal to the ECU 19, which puts the system on diesel fuel. The ECU 19, used in the dual-fuel system, allows a person to switch from one fuel to another one manually.

Before stopping the engine, the fuel system is converted to pure diesel fuel and the engine should run on it for about 5 minutes (depending on operating mode).

The usage of the offered dual-fuel system of the tractor diesel engine will allow to apply vegetable-based oil as a fuel in cold season and improve the overall efficiency of the engine on this type of fuel.

CONCLUSIONS

1. The dependences of kinematic viscosity on temperature and content of fuel mix are defined in the research.
2. Some additional proposals to the existing guidelines for the application of the vegetable-based oils fuel mixtures are added, among others the fuel optimum temperature range 80 … 90 ^{o}C is determined, which provides the best injection and combustion in the cylinders.
3. The devices allowing to apply RO-based biofuel for diesel engines are developed.
4. A 3-stage energy-saving fuel heating system allowing to apply biofuel year-round is developed, which after all

воспринимающий данный параметр посредством датчика температуры 21, переключает электрогидрораспределитель 11 в положение подачи растительного масла и одновременно включает в работу подогреватели 10 и 16, а также ультразвуковой фильтр 13. Основное назначение ультразвукового фильтра 13 – дополнительное снижение кинематической вязкости растительного масла.

После переключения электрогидрораспределителя 11 в положение подачи растительного масла подача дизельного топлива прекращается, поскольку ЭБУ 19 отключает электрический подкачивающий насос 5 (золотник электрогидрораспределителя по сигналу ЭБУ 19 перекрывает доступ дизельного топлива в систему), топливоподкачивающий насос 9 штатной системы питания, подает подогретое до 20…30 ^{o}C растительное масло из бака 2 через фильтр 8 грубой очистки в позисторный подогреватель 10, где оно нагревается до 60…70 ^{o}C. Далее масло направляется электрогидрораспределителем 11 через фильтр тонкой очистки топлива 12 в ультразвуковой фильтр 13. Здесь растительное масло подвергается кавитационной обработке, в результате чего его вязкость дополнительно снижается, и оно подается в ТНВД 14, а оттуда в электрические подогреватели 16, где подогревается до 80…90 ^{o}C и впрыскивается форсунками 15 в камеры сгорания. Излишки растительного масла из форсунок 15 и ТНВД 14 по линиям 17 и 18 слива направляются в фильтр 12 тонкой очистки топлива.

Благодаря применению позисторов в подогревателях 10 и 16, последние автоматически поддерживают температуру растительного масла в топливной системе. В позисторном подогревателе 10 они выполняют две функции: являются нагревательными элементами и в тоже время поддерживают температуру растительного масла в пределах 60…70 ^{o}C. Нагревательными элементами в электрических подогревателях. 16 являются спирали, а позисторы выполняют роль элементов, поддерживающих температурный режим в пределах 80…90 ^{o}C.

На установившихся режимах минимально устойчивых оборотов и режимах неполной загрузки двигателя (до 35%), последний работает на дизельном топливе [4]. При работе на вышеуказанных режимах датчик положения рейки ТНВД 20 подает сигнал на ЭБУ 19, который переводит систему на дизельное топливо. ЭБУ 19, применяемый в данной двухтопливной системе, позволяет переходить с одного вида топлива на другой в ручном режиме.

Перед остановкой двигателя топливную систему переводят на чистое дизельное топливо и дают двигателю поработать около 5 минут (в зависимости от режима работы).

Использование предлагаемой двухтопливной системы тракторного двигателя позволит применять в качестве топлива в холодное время года растительное масло и в целом повысить эффективность работы двигателя на данном виде топлива.

ВЫВОДЫ

1. В ходе проведения исследований определены зависимости кинематической вязкости топлив от температуры и состава смеси.
2. Разработаны дополнительные предложения к существующим рекомендациям по применению смесевых топлив на основе растительных масел, в том числе установлен оптимальный диапазан температур топлива 80...90 ^{o}C при котором происходит наилучший впрыск и сгорание в цилиндрах.
3. Разработаны устройства позволяющие применять в качестве топлива для дизельных двигателей биотоплива на основе РМ.
4. Разработана энергоэффективная 3-х ступенчатая

increases the operating efficiency of the machine-tractor aggregates.

Acknowledgement

The reliability of the results is confirmed by the comparative researches of the fuel equipment of diesel engines (D-243) and the act from 02.06.2014. about the introduction of the results of the work at the enterprise. On the developed devices there are copyright certificates of the Russian Federation No. 135002, No. 011230 and No. 116219.

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система подогрева топлива, позволяющая круглогодично использовать растительное биотопливо, что в конечном итоге повышает эксплуатационные показатели машинно-тракторного агрегата.

АППРОБАЦИЯ И ДОСТОВЕРНОСТЬ

Достоверность результатов подтверждается сравнительными исследованиями топливной аппаратуры дизельных двигателей (Д-243) и актом от 02.06.2014г. о внедрении результатов работы на предприятии. На разработанные устройства имеются авторские свидетельства РФ №135002, №011230 и №116219.

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DEFINITION OF PERFORMANCES OF CONVEYOR POTATO-PLANTER APPARATUS WITH PINNING DEVICES
/
ВИЗНАЧЕННЯ ПОКАЗНИКІВ РОБОТИ КОНВЕЄРНИХ КАРТОПЛЕВИСАДЖУВАЛЬНИХ АПАРАТІВ З НАКОЛЮВАЛЬНИМИ ПРИСТРОЯМИ

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Abstract: *The advantages and disadvantages of different designs of potato-planter apparatus are analyzed. A new designs of the conveyor potato-planter apparatus with pinning devices are presents. The performances of potato-planters with this apparatus are defined, namely deviation from straightness of planted rows and deviation from the specified row width depending on the angle of slope and soil moisture.*

Keywords: *conveyor, potato-planter apparatus, pinning device, ring, needle, chain, potato, slope, moisture*

INTRODUCTION

For agricultural operations in conditions of flat terrain a farm equipment that is designed for the working conditions of the plain are used. At the same time many cultures around the world are grown in conditions which are not characterized as flat. That there are crops that are grown on the hills, roughness and slopes. In such conditions, equipment that is designed to work in the plain, cannot work efficiently. When working in such special conditions in all kinds of flat equipment appear a shortcomings that can be so significant that generally lead to the impossibility of its application. This includes tillage, sowing, planting, harvesting and other machinery. This also fully applies to such important operations like planting potatoes. On this operation the potato-planters which have a different designs of potato-planter apparatus are used [2, 4, 5].

Recently the conveyor potato-planter apparatus are distributed, which have many advantages, basic of which are a small size. This advantage allows to use such potato-planter apparatus and accordingly the potato-planters in the unit with small size tractors that worked well when working on slopes. A certain disadvantage of the given apparatus is a ring design, which does not provide reliable potatoes holding by the work of potato-planter in terms of uneven terrain, on the slopes, where there are vibrations and unit tilts. Logically, the question of a reconstruction of rings that can provide reliable potatoes holding when using the unit in rough environment of slopes. The most perspective here can be an applying of pinning device, such as a needle on the ring, which pin the potato and holds it firmly.

In many scientific papers the questions concerning of work of potato-planters with conveyor type apparatus are described [3, 7]. But in these papers the improving of design of potato-planter apparatus are not considered, not paid attention to basic agronomic performances researches of these potato-planters. These

Резюме: *Проаналізовано переваги та недоліки різних конструкцій картоплевисаджувальних апаратів. Подані нові конструкції конвеєрних картоплевисаджувальних апаратів з наколювальними пристроями. Визначені показники роботи картоплевисаджувальних машин з даними апаратами, а саме відхилення від прямолінійності висаджених рядків та відхилення від заданої ширини міжрядь в залежності від кута схилу та вологості грунту.*

Ключові слова: *конвеєр, картоплевисаджувальний апарат, наколювальний пристрій, кільце, голка, ланцюг, картопля, схил, вологість*

ПЕРЕДУМОВА

При проведенні сільськогосподарських операцій в умовах рівнинного рельєфу застосовується сільськогосподарська техніка, що призначена для умов роботи на рівнині. В той же час багато культур у всьому світі вирощуються в умовах, які не характеризуються як рівнинні. Тобто існують культури, які вирощуються на пагорбах, нерівностях і схилах. В таких умовах техніка, що призначена для роботи на рівнині, не може працювати якісно. При роботі в таких особливих умовах у всіх видів рівнинної техніки проявляються недоліки, які можуть бути настільки суттєвими, що призводять взагалі до неможливості її застосування. Це стосується грунтообробних, посівних, садильних, збиральних та інших машин. Це також повністю стосується такої важливої операції як висаджування картоплі. На даній операції застосовуються картоплевисаджувальні машини, які мають різні конструкції висаджувальних апаратів [2, 4, 5].

Останнім часом набули поширення висаджувальні апарати конвеєрного типу, які мають багато переваг, основна з яких це компактність. Ця перевага дозволяє використовувати такі картоплевисаджувальні апарати і, відповідно, картоплевисаджувальні машини в агрегаті з малогабиритними тракторами, які добре зарекомендували себе при роботі на схилах. Певним недоліком данного апарату є конструкція кільця, яка не забезпечує надійне утримання картоплини при роботі картоплевисаджувальної машини в умовах нерівного рельєфу, на схилах, де виникають вібрації і перекоси агрегату. Логічно постає питання певної реконструкції кілець, що зможе забезпечити надійне утримання картоплини при роботі агрегату в несприятливих умовах схилів. Найбільш перспективним тут може бути застосування наколювального пристрою, а саме голки на кільці, яка наколює картоплину і міцно її тримає.

В багатьох наукових працях описані питання, які стосуються роботи картоплевисаджувальних машин з апаратами конвеєрного типу [3, 7]. Але в даних працях не розглянуті питання удосконалення конструкції висаджувальних апаратів, не приділено увагу дослідженням основних агротехнічних показників роботи даних картоплевисаджувальних машин. Дані

performances are important from point of view of potato-planter using in terms of slopes and by vibrations.

MATERIAL AND METHOD

For qualitative operation of potatoes planting we proposed two designs of conveyor potato-planter apparatus with pining devices [6]. On the chain conveyor of apparatus at regular intervals the rings are placed. To each ring the needle on the bearer is attached. In one design a needle at the side of the ring is attached (Fig. 1), and in the second design - from the rings bottom (Fig. 2).

показники є важливими з точки зору використання картоплевисаджувальних машин в умовах схилів і при вібраціях.

МАТЕРІАЛ І МЕТОДИКА

Для якісного виконання операції висаджування картоплі нами запропоновані дві конструкції конвеєрних картоплевисаджувальних апаратів з наколювальними пристроями [6]. На ланцюговому конвеєрі апаратів через рівні проміжки розміщені кільця. До кожного кільця прикріплена голка на опорі. В одній конструкції голка прикріплена збоку кільця (рис. 1), а в другій конструкції – знизу кільця (рис. 2).

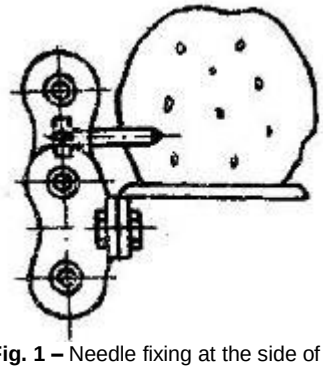

Fig. 1 – Needle fixing at the side of the ring

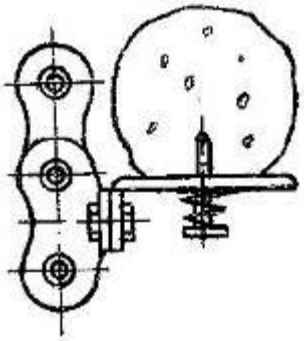

Fig. 2 - Needle fixing from the rings bottom

Potato-planter apparatus with lateral needle on a flexible plate contains of rings, fasteners, chain conveyor, sprocket, plate, needle, guard (Fig. 1). On the chain conveyor at regular intervals the rings are attached. Above each ring considering in the course of the ascending branch of the conveyor chain, namely to the chain conveyors link located above this ring, the flexible plate is rigidly attached, to the center of which the needle is attached.

In this potato-planter apparatus the needles axis located in a transverse direction to the movement of the conveyor chain and, accordingly, the needle pricks the potato from side. This allows to keep potato in the ring better, namely to counteract better to the weight of potato, under the influence of which it tries to fall out of the ring. This is because the force required to move the potato pinned on a needle in a transverse direction to the axis of the needle is greater than that required to move the potato along the axis of the needle. Thus, the potato pricked from the side by the needle is held better on that needle and a ring. According a potato can be pricked at the smaller depth and the needles reverse movement from potato requires less power and takes less time.

But this design is more complicated from the constructive point of view than that in which the needle attached from the rings bottom. We consider this design, which is relatively simple and can be more common.

Potato-planter apparatus with spring needle, which is attached from the rings bottom contain of bend *1*, ring-

Картоплевисаджувальний апарат з боковою голкою на гнучкій пластині містить кільця, кріплення, ланцюговий транспортер, зірочку, пластини, голки, козирок (рис. 1). На ланцюговому транспортері через рівні проміжки закріплені кільця. Над кожним кільцем, якщо рахувати по ходу руху висхідної вітки ланцюгового транспортера, а саме до ланки ланцюгового транспортера, що розташована над даним кільцем, жорстко прикріплена гнучка пластина, до якої по центру прикріплена голка.

В даному картоплевисаджувальному апараті вісь голки розташована в поперечному напрямку до руху ланцюгового транспортера і, відповідно, голка проколює картоплину збоку. Дана обставина дозволяє краще тримати картоплину в кільці, а саме краще протидіяти вазі картоплини, під дією якої вона намагається випасти з кільця. Це викликано тим, що сила, необхідна для переміщення наколотої на голку картоплини в поперечному до осі голки напрямку є більшою, ніж та, що необхідна для переміщення картоплини вздовж осі голки. Таким чином, проколота збоку голкою картоплина краще тримається на даній голці та в кільці. Відповідно бульбу картоплі можна проколювати на меншу глибину і відведення голки з бульби потребує меншої сили і займає менше часу.

Але така конструкція є більш складною з конструктивної точки зору ніж та, де голка прикріплена знизу кільця. Розглянемо цю конструкцію, яка є порівняно простою і може знайти більше поширення.

Картоплевисаджувальний апарат з пружинною голкою, що прикріплена знизу кільця містить відвід *1*,

scoops *2*, fasteners *3*, chain conveyor *4*, sprocket *5*, guard *6*, needles *7*, bearers *8*, guides *9*, springs *10* (Fig. 3). Fig. 4 presents the tractor with potato-planter with apparatus with spring needle, which is attached from the rings bottom.

ложечки-кільця *2*, кріплення *3*, ланцюговий транспортер *4*, зірочку *5*, козирок 6, голки *7*, опори *8*, напрямні *9*, пружини *10* (рис. 3). На рис. 4 поданий трактор з картоплевисаджувальною машиною з висаджувальним апаратом з пружинною голкою, що прикріплена знизу кільця.

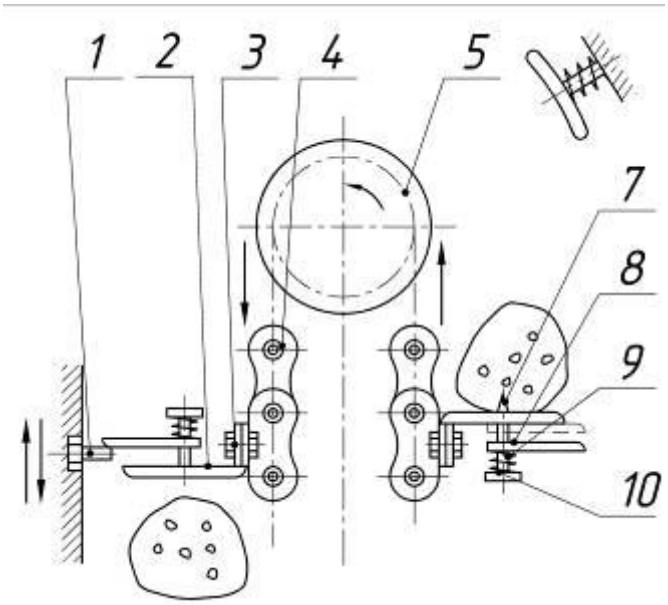

Fig. 3 – Potato-planter apparatus with spring needle, which is attached from the rings bottom
1 – bend / 2 – ring-scoops ; 3 – fasteners; 4 – chain conveyor; 5 – sprocket; 6 – guard;
7 – needles; 8 – bearers; 9 – guides; 10 – springs

Fig. 4 – Tractor with potato-planter with apparatus with spring needle

Chain conveyor *4* includes driven sprocket *5*. On the conveyor *4* at regular intervals the ring-scoops *2* by the fasteners *3* (bolt with nut) are fixed. To make this fix the ring-scoop *2* and the relevant parts of the conveyor *4* have a lugs. Each ring-scoop *2* is designed as a ring, to the bottom of which, considering in the course of the ascending branch of conveyor *4* (on Fig. 3 the ascending branch of the conveyor is located on the right of the sprocket *5*), diametrically opposite to each other the guides *9* are fixed rigidly, which have the removable

Ланцюговий транспортер *4* містить ведену зірочку *5*. На транспортері *4* через рівні проміжки закріплені ложечки-кільця *2* за допомогою кріплення *3* (болт з гайкою). Для здійснення такого кріплення ложечка-кільце *2* і відповідні ланки транспортера *4* мають стовщення. Кожна ложечка-кільце *2* виконана у вигляді кільця, до нижньої частини якого, якщо рахувати по ходу руху висхідної вітки транспортера *4* (на фіг. 3 висхідна вітка транспортера розташована справа від зірочки *5*), діаметрально навпроти один до одного жорстко закріплені напрямні *9*, що мають на кінцях

stops (nuts with washers) at the ends. On the guides *9* through the holes made therein put on free the bearer *8* with the ledge on which the needle *7* is rigidly fixed so that it takes place in the center of the ring. At the guides *9* in area between stops and bearer *8* the springs *10* are putted on also. In the elliptical hole of casing the guard *6* by nut is fixed. It is a curved plate with threaded pins and notch for the ledge of the bearer *8*. On the threaded pins the springs of guard *6* are putted on. In the elliptical hole of casing that covers the chain conveyor 4 is fixed by means of nut the bend *1*, which is a plate with threaded pin. Using the elliptical holes the bend *1* and guard *6* can be fixed in different positions.

Potato-planter apparatus works as follows. When moving potato-planter the bearing drive wheels are rotated and through transmission system set in motion the driven sprocket *5* and accordingly the conveyor *4* with ring-scoops. Ascending branch of the conveyor *4* moves in the bunker with root crops and catch those which are on the ring-scoops *2* way. The ledge of the bearer *8*, the end part of which is made round, overhand a little from the ring toward the bunker with root crops. This allows during movement of the conveyor *4* to conduct a turning as of the total mass of potato, and, most importantly, directly at this ring-scoop *2* and thus help to direct potato to this ring-scoop *2*. The weight of potatoes presses on the ledge of the bearer *8*, under the action of which the bearer *8* is moved a little down, compressing the spring *10* partly and accordingly moving the needle *7* down, reducing its length in the upper area above the ring. This allows for getting into the ring-scoop *2* of potato virtually any size, with needle *7* prick only partially a roots. As a result the root that got the ring-scoop *2*, located on the ring and additionally fixed in this position by the needle *7*, which pricked it and thus fixed it in the ring-scoop and hold from vibrations and possible displacement. Further, by upward movement the ring-scoop *2* with the root move out of the zone where the mass of all roots is and the pressure on ledge of the bearer *8* disappears. Under the action of the spring *10* the bearing *8* is raised and the needle *7* pricks the root 7 at the deeper depth. The guard *6* presses root to the ring-scoop *2*, helping thus to pricks it better on the needle *7*. In this position the root hold up in ring-spoon *2* firmly and cannot get away of it under its own weight, and it is important during the second phase of movement, when caught root goes gradually to conveyors *4* branch that moves down (located to the left of sprocket *5*), and in this position the root continues to be fixed in the ring-scoop *2* by the needle *7*, which holds it. When the bearer *8* by its ledge run into the bend *1*, then it starts to move away from the ring again the force of the springs *10* and the needle *7* goes out of the root, releasing it. Released root under its own weight begins to drop and then get into the coulter. The ledge of the bearer *8*, which is made of a flexible material turn away gradually from the bend *1* and the springs *10* began to press again the bearer *8* to the ring, i.e. return the bearer *8* with the needle *7* in starting position.

RESULTS

Since the design of a needle that is attached to the rings bottom is more simple and widespread we define

знімні упори (гайки з шайбами). На напрямні *9* надіта вільно крізь виконані в них отвори опора *8* з виступом, на якій жорстко закріплена голка *7* таким чином, що вона займає місце по центру кільця. На напрямні *9* також надіті пружини *10* в зоні між упорами і опорою *8*. В еліпсному отворі кожуха закріплений за допомогою гайки козирок *6*. Він являє соібою криволінійну пластину з різьбовими штирями і вирізом під виступ опори *8*. На різьбові штирі надіті пружини козирка *6*. В еліпсному отворі кожуха, що прикриває ланцюговий транспортер *4* закріплений за допомогою гайки відвід *1*, який являє собою пластину з різьбовим штирем. За рахунок еліпсних отворів відвід *1* і козирок *6* можна фіксувати в різних положеннях.

Картоплевисаджувальний апарат працює так. При русі картоплевисаджувальної машини опорно-приводні колеса обертаються і через систему передач приводять в рух ведену зірочку *5* і відповідно транспортер *4* з ложечками-кільцями *2*. Висхідна вітка транспортера *4* рухається в бункері з коренеплодами, та захоплює ті з них, які знаходяться на шляху руху ложечок-кілець *2*. Виступ опори *8*, кінцева частина якого виконана округлою, дещо виступає за межі кільця в бік бункера з коренеплодами. Ця обставина дозволяє під час руху транспортера *4* здійснювати ворушіння як всієї маси бульб картоплі, так і, що особливо важливо, безпосередньо біля даного ложечки-кільця *2* і, таким чином, допомагати спрямовувати певну бульбу до даного ложечки-кільця *2*. Маса бульб картоплі здійснює тиск на виступ опори *8*, під дією якого дана опора *8* дещо зміщується вниз, стискуючи частково пружину *10* і відповідно переміщаючи голку *7* вниз, зменшуючи її довжину у верхньому напрямку над поверхнею кільця. Це дозволяє забезпечити потрапляння до ложечки-кільця *2* картоплі практично будь-якої величини, при цьому голка *7* тільки частково наколює коренеплоди. В результаті коренеплід, що потрапив до ложечки-кільця *2*, розташовується на кільці і додатково фіксується в такому положенні голкою *7*, що наколола його і, таким чином, закріпила її в ложечці і тримає від коливань і можливих зміщень. Далі при русі вверх ложечка-кільце *2* з коренеплодом виходить з зони, де знаходиться маса усіх коренеплодів, і тиск на виступ опори *8* зникає. Під дією пружини *10* опора *8* піднімається і голка *7* вже проколює коренеплід на більшу глибину. Козирок *6* притискає коренеплід до ложечки-кільця *2*, допомагаючи таким чином, кращому його насаджуванню на голку *7*. В такому положенні коренеплід тримається в ложечці-кільці *2* міцно і не може зійти з нього під дією власної ваги, що є важливим під час другого етапу руху, тобто коли захоплений коренеплід поступово переходить на вітку транспортера *4*, що рухається вниз (яка розташована зліва від зірочки *5*), і в цьому положенні даний коренеплід продовжує бути фіксованим в ложечці-кільці *2* голкою *7*, яка тримає його. Коли опора *8* своїм виступом наїжджає на відвід *1*, то вона починає відходити від кільця долаючи опір пружин *10* і голка *7* виходить з коренеплоду, звільняючи його. Звільнений коренеплід під дією власної ваги починає падати і далі потрапляє в сошник. Виступ опори *8*, що виконаний з гнучкого матеріалу, поступово сходить з відводу *1*, а пружини *10* знов притискають опору *8* до кільця, тобто повертають опору *8* з голкою 7 в початкове положення.

РЕЗУЛЬТАТИ

Оскільки конструкція з голкою, що прикріплена знизу кільця є більш простою і поширеною визначимо її

its basic agronomic performance. Experimentally researched deviation from straightness of planted potato rows for two machines: standard (without a pinning device) and experimental. Experimental design (described above) is improved, as has a potato-planter apparatus with needles in the rings bottom.

To determine the deviation from linearity we drew the straight line, starting from the first planted potatoes, then every 3 meters we measured the deviation in one or another side of it in cm.

Motion stability of potato-planter on slopes (even on slopes of 10-12º) provided mainly by coulter, which is plunged in the soil to a depth of about 15 cm and therefore creates by its cheek the side reactions that prevents sliding unit.

So for motion stability on slopes it suffices to apply a simple coulter of standard design, unlike, for example, the seedling planter (here the coulter plunges to a depth of 10 cm) [1]. And then to stabilize here the direction of motion we must apply except the coulter an additional stabilizing devices.

Fig. 5 presents a graph of dependence of potato rows straightness *П* on the steepness of the slope *α* at different soil moisture *W* when using a standard potato-planter. This change coms in curvilinear dependence, that approximates the function of the form $П = bα^c$, where $c > 1$. Variation parameters: for $W = 18$ % - $\overline{П} = 0.85$ cm, $σ = ± 0.03$ cm, $V = 3.5$ %, $m = ± 0.005$ cm, $P = 0.59$ %; for $W = 22$ % - $\overline{П} = 0.92$ cm, $σ = ± 0.035$ cm, $V = 3.8$ %, $m = ± 0.006$ cm, $P = 0.65$ %; for $W = 25$ % - $\overline{П} = 0.97$ cm, $σ = ± 0.04$ cm, $V = 4.1$ %, $m = ± 0.007$ cm, $P = 0.72$ %.

Graphs analysis shows that increasing of the angle of slope affects the deviation of potato rows straightness, because on a steep slope there is a breakdown of the unit course-keeping ability. Not quite perfect potato-planter apparatus cannot provide sufficiently accurate parameter value of the deviation of potato rows straightness, which is of $P ≈ 2.6$ cm at soil moisture of $W = 25$%.

Fig. 6 presents a graph of dependence of potato rows straightness *П* on the steepness of the slope *α* at different soil moisture *W* when using an experimental potato-planter.

This change coms in curvilinear dependence, that approximates the function of the form $П = bα^c$, where $c > 1$. Variation parameters: for $W = 18$ % - $\overline{П} = 0.7$ cm, $σ = ± 0.02$ cm, $V = 2.9$ %, $m = ± 0.004$ cm, $P = 0.57$ %; for $W = 22$ % - $\overline{П} = 0.75$ cm, $σ = ± 0.025$ cm, $V = 3.3$ %, $m = ± 0.005$ cm, $P = 0.67$ %; for $W = 25$% - $\overline{П} = 0.82$ cm, $σ = ± 0.03$ cm, $V = 3.7$ %, $m = ± 0.005$ cm, $P = 0.6$ %.

Graphs analysis shows that increasing of the angle of slope affects the deviation of potato rows straightness, because on a steep slope, as in the previous case, there is a breakdown of the unit course-keeping ability. In experimental potato-planter this deviation is maximum of 2.0 cm, which is less than in the previous case. This is due to the improved design of developed new machine, in which the use of new design of apparatus with pinning device helps to place potatoes accurately in the planned rows line.

основні агротехнічні показники роботи. Експериментально досліджувалось відхилення від прямолінійності рядків висаджених бульб картоплі для двох машин: стандартної (без наколювального пристрою) і експериментальної. Експериментальна конструкція (описана вище) є вдосконаленою, оскільки має висаджувальний апарат з голками знизу кілець.

Для визначення відхилення від прямолінійності проводили пряму лінію, починаючи від першої висадженої картоплини, далі через кожні 3 м вимірювали від неї відхилення в один чи іншій бік в см.

Стабільність руху картоплевисаджувальної машини на схилах (навіть крутістю 10-12º) забезпечується в основному сошником, який занурюється в ґрунт на глибину приблизно 15 см і, відповідно, створює щокою бокові реакції, які запобігають сповзанню агрегату. Таким чином, для стабільності руху на схилі достатньо застосувати простий сошник стандартної конструкції, на відміну, наприклад, від розсадосадильних машин (тут сошник занурюється на глибину до 10 см) [1]. І тут для стабілізації напрямку руху необхідно крім сошника застосовувати додаткові стабілізуючі пристрої.

На рис. 5 подані графіки залежності прямолінійності рядків *П* бульб картоплі від крутизни схилу *α* при різній вологості ґрунту *W* при роботі стандартної картоплевисаджувальної машини. Дана зміна відбувається за криволінійною залежністю, що наближається до функції виду $П = bα^c$, де $c > 1$. Варіаційні показники: для $W = 18$ % - $\overline{П} = 0{,}85$ см, $σ = ± 0{,}03$ см, $V = 3{,}5$ %, $m = ± 0{,}005$ см, $P = 0{,}59$ %; для $W = 22$ % - $\overline{П} = 0{,}92$ см, $σ = ± 0{,}035$ см, $V = 3{,}8$ %, $m = ± 0{,}006$ см, $P = 0{,}65$ %; для $W = 25$ % - $\overline{П} = 0{,}97$ см, $σ = ± 0{,}04$ см, $V = 4{,}1$ %, $m = ± 0{,}007$ см, $P = 0{,}72$ %.

Аналіз графіка показує, що збільшення кута схилу впливає на відхилення від прямолінійності рядків бульб картоплі, оскільки на більш крутому схилі спостерігається порушення курсової стійкості агрегату. Не зовсім досконалий висаджувальний апарат не дозволяє забезпечити досить точне значення показника відхилення від прямолінійності рядків бульб, яке досягає $П ≈ 2{,}6$ см при вологості ґрунту $W = 25$ %.

На рис. 6 подані графіки залежності прямолінійності рядків *П* бульб картоплі від крутизни схилу *α* при різній вологості ґрунту *W* при роботі експериментальної картоплевисаджувальної машини.

Дана зміна відбувається за криволінійною залежністю і наближається до функції виду $П = bα^c$, де $c > 1$. Варіаційні показники: для $W = 18$ % - $\overline{П} = 0{,}7$ см, $σ = ± 0{,}02$ см, $V = 2{,}9$ %, $m = ± 0{,}004$ см, $P = 0{,}57$ %; для $W = 22$ % - $\overline{П} = 0{,}75$ см, $σ = ± 0{,}025$ см, $V = 3{,}3$ %, $m = ± 0{,}005$ см, $P = 0{,}67$ %; для $W = 25$% - $\overline{П} = 0{,}82$ см, $σ = ± 0{,}03$ см, $V = 3{,}7$ %, $m = ± 0{,}005$ см, $P = 0{,}6$ %.

Аналіз графіка показує, що збільшення кута схилу впливає на відхилення від прямолінійності рядків бульб картоплі, оскільки на більш крутому схилі, так як і у попередньому випадку, є певне порушення курсової стійкості машини. В експериментальній машині дане відхилення становить максимум 2,0 см, що менше, ніж в попередньому випадку. Це пояснюється вдосконаленою конструкцією розробленої нової машини, в якій використання нової конструкції апарату з наколювальним пристроєм сприяє розташуванню бульби картоплі досить точно по лінії наміченого рядка.

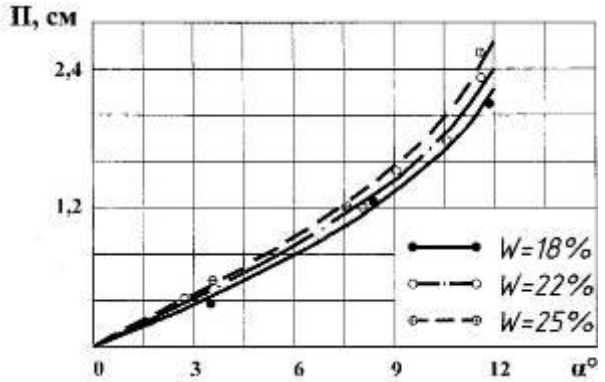

Fig. 5 – Graph of dependence of potato rows straightness *П* on the steepness of the slope *α* at different soil moisture *W* by the work of standard potato-planter

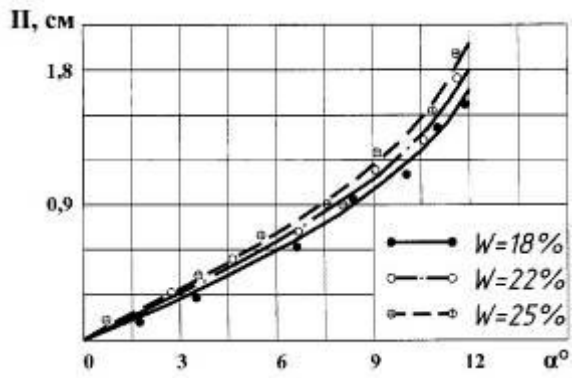

Fig. 6 – Graph of dependence of potato rows straightness *П* on the steepness of the slope *α* at different soil moisture *W* by the work of experimental potato-planter

Also we researched experimentally the deviation from the specified planted potato rows width for two machines: standard and experimental. We researched the deviation of width for guess rows spacing because the deviation of major space between rows for all kinds of planting do not exceed acceptable by agrotechnical requirements, i.e. ± 1.5 cm.

Fig. 7 presents a graphs of dependence of deviation from the rows width *B* on the steepness of the slope *α* at different soil moisture *W* when using a standard potato-planter. This change coms in curvilinear dependence, that approximates the function of the form $B = b\alpha^c$, where $c > 1$. Variation parameters: for $W = 18\%$ - $\overline{B}$ = 1.83 cm, $\sigma = \pm 0.63$ cm, $V = 34.4$ %, $m = \pm 0.126$ cm, $P = 6.9$ %; for $W = 22\%$ - $\overline{B}$ = 1.63 cm, $\sigma = \pm 0.58$ cm, $V = 35.6$ %, $m = \pm 0.12$ cm, $P = 7.4$ %; for $W = 25\%$ - $\overline{B}$ = 1.4 cm, $\sigma = \pm 0.49$ cm, $V = 35$ %, $m = \pm 0.1$ cm, $P = 7.1$ %.

Graphs analysis shows that increasing of the angle of slope affects the deviation from the rows width, because on a steep slope there is sliding process and the breakdown of the unit course-keeping ability. Not quite perfect potato-planter apparatus cannot provide an accurate rectilinear potatoes planting, which leads to maximum deviation from the rows width to 4 cm at soil moisture of $W = 25\%$. By other values of the moisture and therefore more solid soil the motion of unit is more stable due to higher soil reactions on the cheek coulter and therefore the deviation from the rows width will be lower.

Fig. 8 presents a graphs of dependence of deviation from the rows width *B* on the steepness of the slope *α* at different soil moisture *W* when using an experimental potato-planter. This change coms in curvilinear dependence, that approximates the function of the form $B = b\alpha^c$, where $c > 1$. Variation parameters: for $W = 18\%$ - $\overline{B}$ = 1.52 cm, $\sigma = \pm 0.52$ cm, $V = 34.2$ %, $m = \pm 0.1$ cm, $P = 6.6$ %; for $W = 22\%$ - $\overline{B}$ = 1.15 cm, $\sigma = \pm 0.38$ cm, $V = 33$ %, $m = \pm 0.08$ cm, $P = 6.9$ %; for $W = 25\%$ - $\overline{B}$ = 0.96 cm, $\sigma = \pm 0.35$ cm, $V = 36.5$ %, $m = \pm 0.07$ cm, $P = 7.3$ %.

Також експериментально досліджувалось відхилення від заданої ширини міжрядь висаджених бульб картоплі для двох машин: стандартної і експериментальної. Досліджували відхилення ширини для стикових міжрядь, оскільки відхилення основних міжрядь для всіх видів садіння не перевищують допустимого за агротехнічними правилами, тобто ± 1,5 см.

На рис. 7 подані графіки залежності відхилення ширини міжрядь *B* від крутості схилу *α* при різній вологості ґрунту *W* при роботі стандартної картоплевисаджувальної машини. Дана зміна відбувається за криволінійною залежністю, що наближається за значенням до функції виду $B = b\alpha^c$, де $c > 1$. Варіаційні показники: для $W = 18\%$ - $\overline{B}$ = 1,83 см, $\sigma = \pm 0{,}63$ см, $V = 34{,}4$ %, $m = \pm 0{,}126$ см, $P = 6{,}9$ %; для $W = 22\%$ - $\overline{B}$ = 1,63 см, $\sigma = \pm 0{,}58$ см, $V = 35{,}6$ %, $m = \pm 0{,}12$ см, $P = 7{,}4$ %; для $W = 25\%$ - $\overline{B}$ = 1,4 см, $\sigma = \pm 0{,}49$ см, $V = 35$ %, $m = \pm 0{,}1$ см, $P = 7{,}1$ %.

Аналіз графіка показує, що збільшення кута схилу впливає на відхилення ширини міжрядь, оскільки на більш крутому схилі відбувається процес сповзання і порушення курсової стійкості агрегату. Також не зовсім досконалий картоплевисаджувальний апарат не дозволяє забезпечити точне прямолінійне висаджування картоплі, що призводить до максимального відхилення ширини міжрядь до 4 см при вологості ґрунту $W = 25$ %. При інших значеннях вологості і, відповідно, більш твердому ґрунті рух агрегату є більш стабільним за рахунок більших реакцій ґрунту на щоку сошника і тому значення відхилення ширини міжрядь буде менше.

На рис. 8 подані графіки залежності відхилення ширини міжрядь *B* від крутості схилу *α* при різній вологості ґрунту *W* при роботі експериментальної картоплевисаджувальної машини. Дана зміна відбувається за криволінійною залежністю, що наближається за значенням до функції виду $B = b\alpha^c$, де $c > 1$. Варіаційні показники: для $W = 18\%$ - $\overline{B}$ = 1,52 см, $\sigma = \pm 0{,}52$ см, $V = 34{,}2$ %, $m = \pm 0{,}1$ см, $P = 6{,}6$ %; для $W = 22\%$ - $\overline{B}$ = 1,15 см, $\sigma = \pm 0{,}38$ см, $V = 33$ %, $m = \pm 0{,}08$ см, $P = 6{,}9$ %; для $W = 25\%$ - $\overline{B}$ = 0,96 см, $\sigma = \pm 0{,}35$ см, $V = 36{,}5$ %, $m = \pm 0{,}07$ см, $P = 7{,}3$ %.

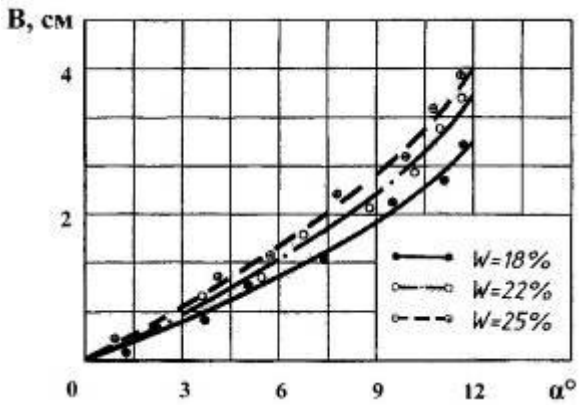

Fig. 7 – Graph of dependence of deviation from the rows width *B* on the steepness of the slope *α* at different soil moisture *W* by the work of standard potato-planter

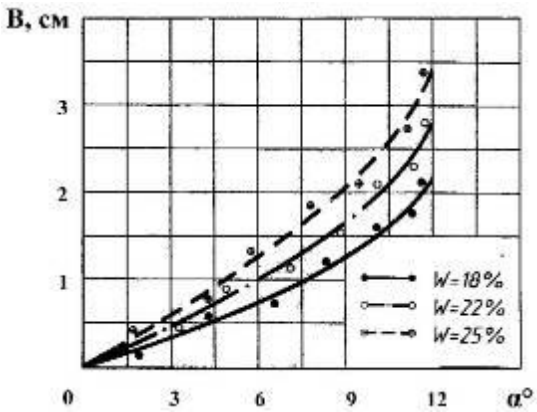

Fig. 8 – Graph of dependence of deviation from the rows width *B* on the steepness of the slope *α* at different soil moisture *W* by the work of experimental potato-planter

Graphs analysis shows that increasing of the angle of slope affects the deviation from the rows width, because on a steep slope there is the breakdown of the unit course-keeping ability. In experimental potato-planter this deviation is maximum of *B* ≈ 3.5 cm at soil moisture of *W* = 25%, which is less than in the previous case and within the permissible range by agrotechnical requirements.

The improved design of developed new machine with new design of potato-planter apparatus with pinning device helps to place potatoes accurately in the planned rows line.

CONCLUSIONS

New designs of conveyor apparatus of potato-planter which are based on the pining devices are developed. In one design a needle at the side of the ring of potato-planter apparatus is attached, and in the second design - from the rings bottom.

It is established that the design of lateral needle is more complicated from the constructive point of view than that in which the needle is attached from the rings bottom, so the last design is relatively simple and can be more common.

Experimentally researched the deviation from straightness of planted rows *П* and deviation from the specified potatoes rows width *B* for two machines: standard (without pinning device) and experimental (with potato-planter apparatus with needles fixing from the rings bottom). In experimental potato-planter this deviations accordingly is maximum *П* = 2 cm and *B* ≈ 3.5 cm, which is less than in standard machine and within the permissible range by agrotechnical requirements.

The experiments confirm the advantage of the experimental unit.

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Аналіз графіка показує, що збільшення кута схилу впливає на відхилення ширини міжрядь, оскільки на більш крутому схилі відбувається процес певного порушення курсової стійкості агрегату. В експериментальній машині дане відхилення становить максимум *B* ≈ 3,5 см при вологості ґрунту *W* = 25 %, що менше, ніж для попереднього випадку і знаходиться в допустимих межах згідно з агротехнічними правилами.

Вдосконалена конструкція розробленої нової машини з новим картоплевисаджувальним апаратом з наколювальним пристроєм сприяє досить точному висаджуванню бульб картоплі по лінії наміченого рядка.

ВИСНОВКИ

Розроблені нові конструкції конвеєрних висаджувальних апаратів картоплевисаджувальних машин, основою яких є наколювальний пристрій з голкою. В одній конструкції голка прикріплена збоку кільця картоплевисаджувального апарата, а в другій конструкції – знизу кільця.

Встановлено, що конструкція з боковою голкою є більш складною з конструктивної точки зору ніж та, де голка прикріплена знизу кільця, тому остання конструкція є порівняно простою і може знайти більше поширення.

Експериментально досліджено відхилення від прямолінійності рядків *П* і відхлення від заданої ширини міжрядь *B* висаджених бульб картоплі для двох машин: стандартної (без наколювального пристрою) і експериментальної (з висаджувальним апаратом з голками знизу кілець). В експериментальній машині дані відхилення відповідно становлять максимум *П* = 2 см і *B* ≈ 3,5 см, що менше, ніж у стандартної машини і знаходиться в допустимих межах згідно з агротехнічними правилами.

Проведені експерименти підтверджують перевагу експериментального агрегату.

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INVESTIGATING THE FORCE PARAMETERS OF FORMING THE SCREW PURIFYING ELEMENTS
/
ДОСЛІДЖЕННЯ СИЛОВИХ ПАРАМЕТРІВ ФОРМОУТВОРЕННЯ ГВИНТОВИХ ОЧИСНИХ ЕЛЕМЕНТІВ

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Abstract: The design of disk digger with the possibility of cleaning work surfaces drives. The analysis and the choice of Г - like screws. An appropriate power and kinematic calculations suggested screw disc cleaners root crop.

Key words: digging disk, auger cleaner, Г-shaped ,cleaner.

INTRODUCTION

Г-shaped spiral augers have great future application in transport and technological systems. In particular such helix widely used to supply dry, wet, sticky, lumpy, fibrous products in agriculture, food, building, chemical and other industries and so on. But they possess additional characteristics that, depending on the inclination of the spiral can manifest themselves as functions increasing resistance to movement of of the transported of the material to the surface of displacement, or vice versa - reducing friction material is transported to the surface displacement. In the first case, this phenomenon can be widely used in the performance of processes wiping or shredding of different materials, and the second - in the performance Branch of processes and cutting of various materials from the surface moving.

The problem of efficiency of screw conveyors are devoted to work Grigoriev A.V. Hevko B.M. [1] Rohatyn R.M. and othersin which there were investigated creation and operation of screw mechanisms. The issues involved in separation woroch root Pylypets M.I. Hevko R.B. Tkachenko I.G. Vyvyurka and others. The study profiling helical spirals and transporting processes relevant Г-shaped screws engaged Rohatynskiy R.M., Vasylkiv V.V. [2] and other scientists.

MATERIAL AND METHOD

The aim of this research is the development of cleaner screw design for efficient purification discs digging root crops from contamination that will reduce energy costs when operating mechanism and improving the quality of cleaning root crops.

The process is accompanied by significant excavation of roots and soil sticking to the surfaces of the disk Vorukh archeologists. Therefore, Г-shaped spiral augers which are equipped with a digging device to effectively carry out their cleaning process, accompanied by the removal woroch spiral from the working surface of the disk digger. Accordingly, under these conditions the strength necessary to overcome the resistance movement of material important impact angle of inclination μ helical spiral in its cross section (Fig. 1). Therefore the most appropriate use of spiral inclined towards the outer contour of transportation, because the normal force vector between the coil and casing N_1, acting on the load side of the coil, directed in the direction of the tangent to the casing at an

Резюме: Розроблено конструкцію дискового копача із можливістю очищення робочих поверхонь дисків. Проаналізовано й обґрунтовано вибір Г–подібних шнекових очисників. Проведено силовий і кінематичний розрахунок запропонованих шнекових очисників дискових копачів коренеплодів.

Ключові слова: диски копачів, шнекові очисники, Г-подібні, очищення.

ПЕРЕДМОВА

Г-подібні спіралі шнеків мають значну перспективу застосування у транспортно-технологічних системах. Зокрема такі спіралі широко використовуються для подачі сухих, вологих, клейких, кускових, волокнистих продуктів у сільськогосподарському виробництві, в харчовій, будівельній, хімічній та інших галузях промисловості тощо. Проте вони володіють додатковими характеристиками, що, в залежності від нахилу спіралі, можуть проявлятися в якості функції збільшення опору переміщення транспортованого матеріалу до поверхні переміщення, чи навпаки – зменшення тертя переміщуваного матеріалу до поверхні переміщення. В першому випадку це явище можна широко використовувати при виконанні процесів протирання чи подрібнення різних матеріалів, а в другому - при виконанні процесів відділення та підрізання різних матеріалів від поверхні переміщення.

Проблемі ефективності роботи шнеків транспортерів присвячені праці Григорьева А.В. , Гевка Б.М. [1] , Рогатинського Р.М та інших, в яких були проведені дослідження створення та функціонування гвинтових механізмів. Питаннями сепарації вороху коренеплодів займалися Пилипець М.І., Гевко Р.Б., Ткаченко І.Г., Вивюрка та інші. Дослідженням профілювання гвинтових спіралей та процесами транспортування профільними Г-подібними шнеками займалися Рогатинський Р.М., Васильків В.В. [2] та інші вчені.

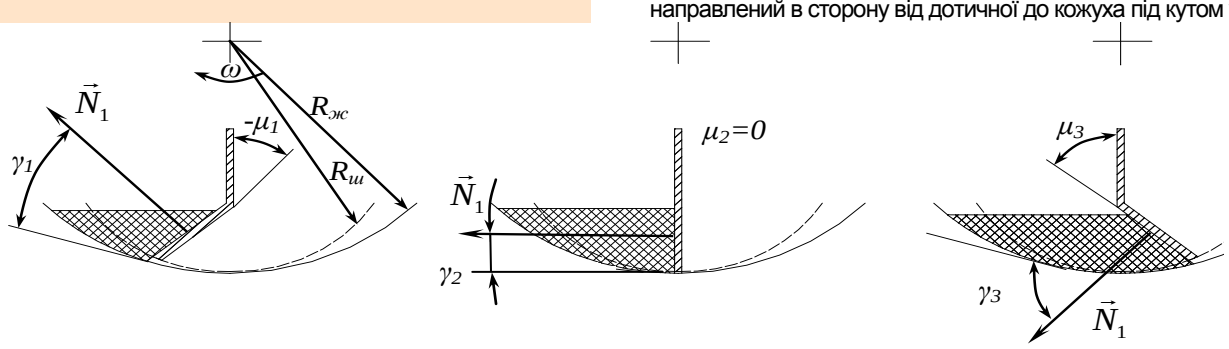
МАТЕРІАЛ І МЕТОДИКА

Метою даного дослідження є розроблення конструкції шнекового очисника для ефективного очищення викопуючих дисків коренеплодів від забруднення, що забезпечить зменшення енерговитрат при роботі механізму й підвищення якості очищення коренеплодів.

Процес викопування коренеплодів супроводжується значним налипання ґрунту й воруху на поверхнях дискових копачів. Тому Г-подібні спіралі шнеків, якими оснащуються викопуючі пристрої, дозволяють ефективно проводити процес їх очищення, що супроводжується зняттям вороху спіраллю з робочої поверхні диска копача. Відповідно за таких умов на силу, необхідну для подолання опору переміщення матеріалу, важливе значення має вплив кута нахилу μ гвинтової спіралі у її поперечному перерізі (рис. 1). Виходячи з цього найбільш доцільно використовувати спіраль з нахиленим зовнішнім контуром у напрямку транспортування, бо вектор нормальної сили між витком і

angle γ1.

кожухом $\overline{N}_1$, який діє на вантаж зі сторони витка, направлений в сторону від дотичної до кожуха під кутом γ1.



а) б) в)

Fig. 1 - Estimated circuit for determining the effect of slope angle helical tape in cross-section of the process jamming material: a) spiral slope in the direction of transportation; b) radial spiral; c) the slope of the spiral in the opposite direction to the direction of transport

Investigating the force parameters of forming the screw purifying elements

The process of manufacturing the screw purifying elements is as follows:

1. Bending the shelf on a tape using the rollers.
2. Coiling the given tape with a shelf around a collet.

The process of coiling such a tape around the collet is shown in Fig.2.

Виготовлення гвинтових очисних елементів проходить в такій послідовності:

1. Гнуття полички на стрічці за допомогою роликів.
2. Навивання одержаної стрічки з поличкою на оправу.

Розглянемо процес навивання такої стрічки на оправу, який представлено на рис. 2.

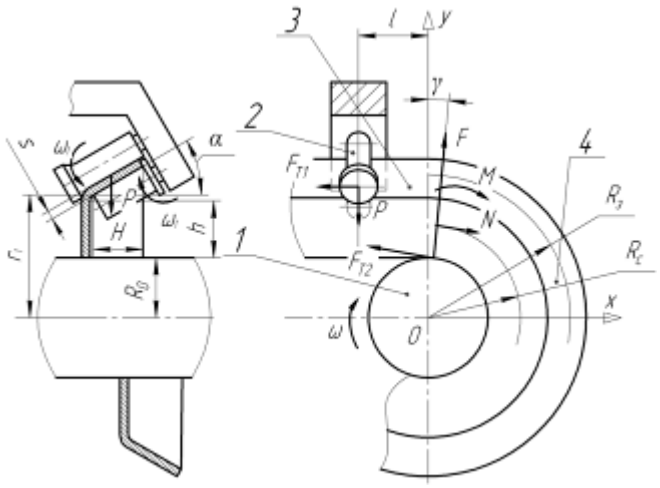


Fig. 2 - Computational model of coiling the tape around the collet. 1 – collet; 2 – clamp roller; 3 – tape; 4 – screw element

While coiling, the compression of tape fibers along the inner diameter occurs, as well as the tension of tape fibers along the outer diameter of the screw-purifying element. That is, in the shelf's zone, only the strain deformations occur, as well as in the workpiece's vertical part – the compressive deformations. Having considered the process of deformation in the hot state, the moment of tape bending in these zones can be defined.

As it is known, the radial stresses, occurring in the tape shelf, are determined by the formula [1]:

В процесі навивання відбувається стиснення волокон стрічки на внутрішньому діаметрі і розтяг волокон стрічки на зовнішньому діаметрі гвинтового очисного елемента. Тобто в зоні полички виникають лише деформації розтягу, а на вертикальній частині заготовки – деформації стиску. Визначимо момент згину стрічки в цих зонах, розглянувши процес деформації в гарячому стані.

Як відомо, радіальні напруження, що виникають у поличці стрічки визначаються за формулою [1]:

$$\sigma_{\rho 1} = -\beta\sigma_s \cdot \ln\frac{R}{\rho} \qquad (1)$$

where β – the coefficient, which depends on the impact of the mean primary stress, equals 1.15;

σs – the liquid limit of screw clamping element material, MPa;

R – the outer bending radius, mm;

ρ – the polar coordinate of bending radius, mm.

де β - коефіцієнт, що враховує вплив середнього головного напруження, дорівнює 1,15;

σs – границя текучості матеріалу гвинтового затискного елементу, МПа;

R – зовнішній радіус гнуття, мм;

ρ - полярна координата радіуса гнуття, мм.

Similarly, the radial stresses in the compression zone can be determined [2]:

Аналогічно визначаємо радіальні напруження в зоні стиску [2]:

$$\sigma_{\rho 2} = -\beta\sigma_s \cdot \ln\frac{\rho}{r}, \tag{2}$$

where r – the inner bending radius, mm.
Tangential stresses in the tension zone:

де r – внутрішній радіус гнуття, мм.
Тангенціальні напруження в зоні розтягу:

$$\sigma_{\theta 1} = \beta\sigma_s \cdot \left(1 - \ln\frac{R}{\rho}\right) \tag{3}$$

Tangential stresses in the compression zone:

Тангенціальні напруження в зоні стиску:

$$\sigma_{\theta 2} = -\beta\sigma_s \cdot \left(1 + \ln\frac{\rho}{r}\right) \tag{4}$$

According to the computational model in Fig. 1, the radius of bending the workpiece's shelf changes from r1 to r (x), where

Згідно розрахункової схеми на рис. 1 радіус гнуття полички заготовки змінюється від r1 до r(x), де

$$r(x) = r_1 + x \cdot \mathrm{tg}\,\alpha \tag{5}$$

where r1 – the smallest inner radius of bending the shelf, mm;
α - the inclination angle of the shelf, grade.
The outer radius of bending the workpiece:

де r1 – найменший внутрішній радіус гнуття полички, мм;
α - кут нахилу полички, град.
Зовнішній радіус гнуття заготовки:

$$R(x) = r_1 + \frac{s}{\cos\alpha} + x \cdot tg\alpha, \tag{6}$$

where s – the tape thickness, mm.
The value of bending moment while coiling with heating is considered as the integral sum from tangential stresses along the height of elementary elements' workpiece.

де s – товщина стрічки, мм.
Значення моменту гнуття під час навивання із підігрівом визначемо як інтегральну суму по висоті заготовки елементарних елементів від тангенціальних напружень

$$M = \int_0^H \int_{r(x)}^{R(x)} \sigma_{\theta 1}\rho d\rho dx + s\int_{R_0}^{R_0+h} \sigma_{\theta 2}\rho d\rho, \tag{7}$$

where ρ_H - the radius of neutral surface of stresses, mm;
h – the height of the workpiece's vertical part, mm;
H – the height of the screw element's shelf, mm;
Using formulas (3) – (6) in the equation (7) we obtain:

де ρ_H - радіус нейтральної поверхні напружень, мм;
h – висота вертикальної частини заготовки, мм;
H – висота полички гвинтового елемента, мм.
Підставляючи формули (3) - (6), у рівняння (7) одержуємо:

$$M = \int_0^H \int_{r_1+x\cdot tg\alpha}^{r_1+\frac{s}{\cos\alpha}+x\cdot tg\alpha} \beta\sigma_s \cdot \left(1 - \ln\frac{r_1 + \frac{s}{\cos\alpha} + x\cdot tg\alpha}{\rho}\right) \cdot \rho d\rho dx + s\int_{R_0}^{R_0+h} -\beta\sigma_s \cdot \left(1 + \ln\frac{\rho}{R_0}\right)\rho d\rho \tag{8}$$

where R_0 - the collet radius, mm;
Having transformed the equation (8), we obtain:

де R_0 - радіус оправи, мм;
Після перетворень рівняння (8) одержуємо:

$$M = \frac{1}{2}\cdot\beta\cdot\sigma_s([bH\left(r_1 + \frac{1}{2}b + Htg\alpha\right) + \frac{H}{3}(H\cdot tg\alpha\cdot\left(-r_1D + tg\alpha KH + \frac{1}{2}b + 3r_1K - Dtg\alpha H\right) +$$
$$+3r_1^2(K-D) - b(b+r_1)) + \frac{r_1^3(K-D-C+\ln r_1) + b^3(K-C) + r_1b^2}{tg\alpha}] + s(-\frac{1}{2}((R_0+h)^2 - R_0^2) - \tag{9}$$
$$-(R_0+h)^2\ln\left(\frac{R_0+h}{R_0}\right)),$$

where the following marks are used:

де використано наступні позначення:

$$b = \frac{s}{\cos\alpha};$$

$$K = \ln(r_1 + b + Htg\alpha);$$

$$C = \ln(r_1 + b)$$
$$D = \ln\left(r_1 + Htg\alpha\right).$$

According to the computational model in Fig. 1, the equilibrium equation of a tape part under deformation can be written as follows:

Згідно розрахункової схеми на рис. 1 рівняння рівноваги частини стрічки, що піддається деформації запишемо наступним чином:

$$\left.\begin{aligned} &\text{по осі x: } -F_{T1} - F_{T2}\cdot\cos\gamma + N\cdot\cos\gamma + F\cdot\sin\gamma = 0;\\ &\text{по осі y: } -P + F_{T2}\cdot\sin\gamma - N\cdot\sin\gamma + F\cdot\cos\gamma = 0;\\ &\text{сума моментів: } P\cdot l + F_{T1}\cdot R_з + F_{T2}\cdot R_0 - N\cdot R_c - M = 0, \end{aligned}\right\} \quad (10)$$

where F_{T1}- the friction force between the tape and the roller, H;

F_{T2}- the friction force between the tape and the collet, H;

γ - the collet's turning angle, grade;

N- the direct force, H;

F- the resultant force of the tape normal contact stresses, H;

P- the bending force by the clamp roller, H;

l- the distance between the collet centre and the clamp roller centre, mm;

R_3 - the mean radius of screw element's interaction, mm;

R_c - the mean radius of screw element, mm;

The friction forces can be developed from the dependences:

де F_{T1}- сила тертя між роликом та стрічкою, Н;

F_{T2} - сила тертя між стрічкою та оправою, Н;

γ - кут повороту оправи, град;

N - поздовжня сила, Н;

F- рівнодіюча нормальних контактних напружень на стрічці, Н;

P - сила гнуття притискним роликом, Н;

l - відстань між центрами оправи та притискного ролика, мм;

R_3 - середній радіус взаємодії гвинтового елемента, мм;

R_c - середній радіус гвинтового елемента, мм;

Сили тертя визначаємо за залежностями:

$$F_{T1} = \mu_1 \cdot P; \quad (11)$$
$$F_{T2} = \mu_2 \cdot F, \quad (12)$$

where μ_1 - the coefficient of friction between the clamp roller and the tape;

μ_2 - the coefficient of friction between the collet and the crew element.

The resultant force of normal contact stresses is determined by the formula:

де μ_1 - коефіцієнт тертя між притискним роликом та стрічкою;

μ_2 - коефіцієнт тертя між оправою та гвинтовим елементом.

Рівнодіючу нормальних контактних напружень знаходимо за формулою:

$$F = \sigma_r \cdot s \cdot L, \quad (13)$$

where σ_r - the contact normal stresses along the screw workpiece's inner radius, MPa;

s - the tape thickness, mm;

L - the length of contact along the inner diameter, mm.

Provided the bending moment M is known, all forces, which occur while coiling, can be found after solving the equation system (7). In the given case:

де σ_r - контактні нормальні напруження на внутрішньому радіусу гвинтової заготовки, МПа;

s - товщина стрічки, мм;

L- довжина контакту по внутрішньому діаметру, мм.

При відомому моменті гнуття M можна знайти усі сили, що виникають в процесі навивання, розв'язавши систему рівнянь (7). В даному випадку:

$$F = \frac{-P\cdot\left(\mu_1\cdot tg\gamma - 1\right)}{\mu_2\cdot\sin\gamma + tg\gamma\cdot\left(-\mu_2\cdot\cos\gamma + \sin\gamma\right) + \cos\gamma}; \quad (14)$$

$$N = \frac{\mu_1\cdot P + F\cdot\left(\mu_2\cdot\cos\gamma + \sin\gamma\right)}{\cos\gamma}. \quad (15)$$

According to the results of experimental research, the maximum bending force P by clamp roller occurs at the beginning stage of deformation, that is, when the angle γ equals zero. Therefore, to simplify calculations, the solution of equations system (10) will be as follows:

Експериментальні дослідження показали, що максимальна сила гнуття P притискним роликом виникає на початковій стадії деформування, тобто, коли кут γ рівний нулю. Тому, для спрощення розрахунків, розв'язок системи рівнянь (10) буде наступним:

$$P = F \quad (16)$$
$$N = \left(\mu_1 + \mu_2\right)\cdot P; \quad (17)$$
$$P = \frac{M}{l + \mu_1\cdot(R_з - 1) + \mu_2\cdot\left(R_0 - 1\right)} \quad (18)$$

It should be noted that the friction coefficient μ_1 between the clamp roller and the profiled tape is the given value and does not correlate directly with the value of contacting materials' friction

Слід зауважити, що тут коефіцієнт тертя μ_1 між притискним роликом і профільною стрічкою є величиною приведеною і не відповідає безпосередньому значенню

coefficient. The moment applied to coining the collet depends on collets' structural peculiarities, and is generally defined as it is shown in Fig. 1., accordingly to the dependences:

коефіцієнта тертя для контактуючих матеріалів. Момент, який необхідно прикласти для обертання оправи, залежить від конструктивних особливостей оправ і в загальному випадку визначається згідно рис. 1 за залежністю:

$$M_O = k_M \cdot P \cdot \left(l + \mu_1 \cdot R_з\right) \tag{19}$$

where k_M – the coefficient, which depends on the structural manufacture of the collet.

Based on the proposed above formulas, the required technological equipment can be designed. Thus, to reduce the torque of collet, and consequently to reduce the required power of coiling the screw workpiece, it is necessary to minimize friction coefficient μ_1, for example, using the lubricants.

The coiling of a screw element being executed in the cold state, the workpiece material is being strengthened. Consequently, the bending moment increases, which can be determined by the formula:

де k_M – коефіцієнт, що враховує конструктивні виконання оправи.

На основі приведених вище формул можна проектувати необхідне технологічне оснащення. При цьому, для зменшення моменту обертання оправи, а отже, і зменшення необхідної потужності навивання гвинтової заготовки, потрібно звести до мінімуму коефіцієнт тертя μ_1, наприклад, використовуючи змащувальні речовини.

Якщо процес навивання гвинтового елемента виконувати в холодному стані, в матеріалі заготовки проходить процес зміцнення, в наслідок чого зростає момент гнуття, який можна визначити за формулою:

$$M = \int_0^H \int_{r_1 + x \cdot tg\alpha}^{r_1 + \frac{s}{\cos\alpha} + x \cdot tg\alpha} \beta \left[\sigma_{TO} \cdot \left(1 - \ln \frac{r_1 + \frac{s}{\cos\alpha} + x \cdot tg\alpha}{\rho} \right) + \frac{\Pi}{2} \cdot \left(2 \ln \frac{\rho}{R_c} - \ln \frac{\rho \left(r_1 + \frac{s}{\cos\alpha} + x \cdot tg\alpha \right)}{R_c^2} \ln \frac{\left(r_1 + \frac{s}{\cos\alpha} + x \cdot tg\alpha \right)}{\rho} \right) \right] \cdot \rho d\rho dx + \tag{20}$$

$$+ s\beta \int_{R_0}^{R_0 + h} \left[\sigma_{TO} \left(1 + \ln \frac{\rho}{R_0} \right) + \frac{\Pi}{2} \left(2 \ln \frac{R_0 + h}{\rho} + \ln \frac{(R_0 + h)^2}{\rho R_0} \ln \frac{\rho}{R_0} \right) \right] \rho d\rho,$$

where σ_{TO} - extrapolated liquid limit, MPa;

П- strengthening linear module, MPa.

The analytical method of solving the equation (20) is rather cumbersome, that is why the specific numerical value of bending moment should be defined by the numerical method, using appropriate software. Such method significantly reduces the calculation time.

An example of such calculation is shown in the graph in Fig. 3.

Analyzing the graph in Fig. 2 we conclude: the shelf height and its inclination angle increases, the moment of bending the screw element increases as well.

Based on the graph in Fig. 3 and formula (18), the graphs of dependence of the tape bending force on the shelf height can be drawn (Fig. 4).

де σ_{TO} - екстрапольована границя текучості, МПа;

П- лінійний модуль зміцнення, МПа.

Розв'язок рівняння (20) аналітичним методом є досить громіздким, тому визначення конкретного числового значення моменту гнуття доцільно проводити числовим методом, використовуючи відповідні комп'ютерні програми, що значно зменшить час на розрахунок.

Приклад такого розрахунку представлено у вигляді графіка на рис. 3.

Згідно графіка на рис. 2 робимо висновок, що при збільшення висоти полички і кута її нахилу момент гнуття гвинтового елемента зростає.

На основі даних із графіка на рис. 3 та формули (18) будуємо графіки залежності сили гнуття стрічки від висоти полички (рис. 4).

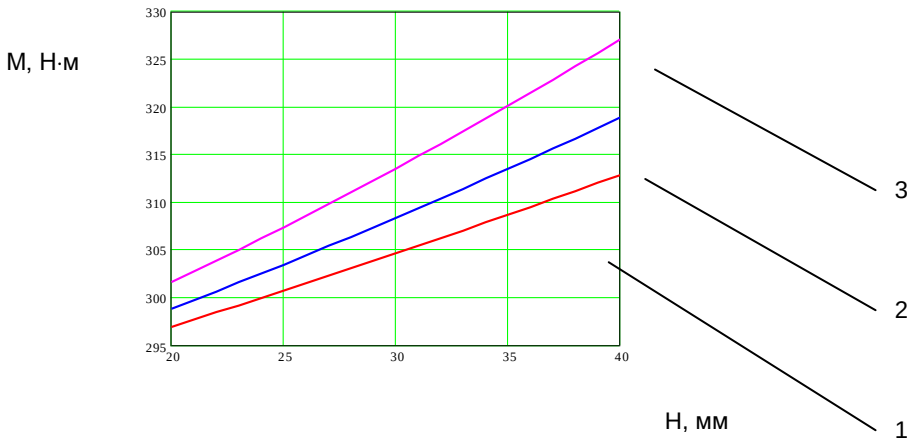


Fig.. 3 - Graph of dependence of tape bending moment on height shelf (steel 08kp) s=1,5мм, R_0 =30мм: 1 - α=10град, 2 - α=20град; 3 - α=30grade.

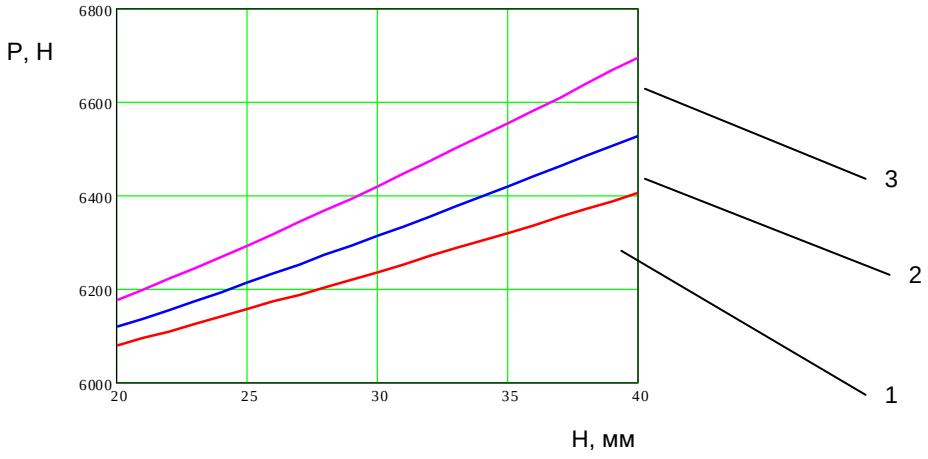


Fig. 4 - Graph of dependence of the tape bending force on the shelf height (steel 08kp) s=1,5мм, R_0 =30мм: 1 - α=10град, 2 - α=20град; 3 - α=30grade.

Having analyzed the graphs in Figures 2 and 3, we conclude that mainly the vertical part of the workpiece deforms; and while increasing the shelf height and the inclination angle of the screw element, the bending force increases as well. As the main working surface of a screw-purifying element is a shelf, the cuts on the vertical part of the tape must be performed to reduce the bending moment of such tape.

CONCLUSIONS

As a result of investigations proved the practical feasibility of the proposed mechanism for clearing L-shaped spirals screw drives archeologists working surfaces

The proposed treatment technology manufacturing screw elements by bending the tape on shelves using clips and coiling the resulting tape with a shelf to be set.

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Аналіз одержаних графіків на рисунках 2 та 3 показав, що більша частина деформації заготовки припадає на її вертикальну частину, при збільшення висоти полички і кута її нахилу сила гнуття гвинтового елемента зростає. Оскільки основною робочою поверхнею гвинтового очисного елемента є поличка, то для зменшення моменту гнуття такої стрічки необхідно виконувати вирізи на вертикальній частині стрічки.

ВИСНОВКИ

В результаті досліджень доведена практична доцільність використання запропонованого механізму очищення Г-подібними спіралями шнеків робочих поверхонь дисків копачів

Запропонована технологія виготовлення гвинтових очисних елементів шляхом гнуття полички на стрічці за допомогою роликів та навивання одержаної стрічки з поличкою на оправу.

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THE STUDY OF BULK MATERIAL KINEMATICS IN A SCREW CONVEYOR-MIXER
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ДОСЛІДЖЕННЯ КІНЕМАТИКИ СИПКОГО МАТЕРІАЛУ В ГВИНТОВОМУ КОНВЕЄРІ-ЗМІШУВАЧІ

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Abstract: Based on the equation of motion in a screw conveyor-mixer, the kinematics of bulk material is researched. The motion of bulk material in medium speed operation mode of screw conveyor-mixer is analyzed in details. The technique of determining the nature of loading the screw conveyor elements is developed. The analytical dependences for determining the speed change of the given bulk material volume in relation to a casing in medium speed mode of conveyor while mixing the bulk material are developed. This technique can be widely used for designing the screw transport and technological systems.

Key words: screw working body, screw conveyor, auger, bulk material.

INTRODUCTION

Nowadays screw conveyors are widely used for technological transporting and mixing the bulk materials. These conveyors are characterized by simplicity of their design. They are highly reliable, easy to use and easy to adapt when used in automated systems, and they are ecologically friendly as well [1, 5, 6-7]. To cut down power consumption and to increase the quality of mixing the bulk materials, a number of screw mixers' original designs are developed. The use of the working body depends on the peculiarities of bulk material loading the auger as well as on the peculiarities of the nature of bulk material motion, and the practicability of using the auger working body.

The advantages of using such augers include the increase of load coefficient in the area of transporting the bulk material from a tanker into auger that leads to the increase of conveyor's productivity.

Analysis of recent research and publications. The works of Grygoryev A.M. [2], Hewko B.M., Rohatynskyi R.M. [4, 8], Hewko I.B. [3, 9] and others are dedicated to the issue of transporting and mixing different materials. However, taking into account the diversity of technological processes and structural designs of screw transport and technological mechanisms (STTM), this issue requires further research and refinement of various parameters of theoretical and practical importance.

The objective is to develop engineering methods of computing the screw conveyor-mixer operation mode with a choice of kinematic and dynamic parameters that minimize their power consumption.

MATERIAL AND METHOD

To mix the bulk material effectively, the conveyor should work in the medium speed mode. This is the characteristic feature of screw conveyor-mixers (fig. 1). Based on experimental research it is proved that the material in the cross section of conveyor casing is lifted to the upper point and falls on the inner surface of the cylindrical casing under the force of gravity,

Резюме: *Приведено дослідження кінематики сипкого матеріалу на основі рівнянь руху у гвинтовому конвеєрі-змішувачі. Проведено детальний аналіз руху сипкого матеріалу у середньошвидкісному режимі гвинтовому конвеєрі-змішувачі і розроблено методику встановлення характеру навантаження на елементи гвинтового конвеєра, виведено аналітичні залежності для визначення зміни швидкості руху виділеного об'єму сипкого матеріалу відносно кожуха у середньошвидкісному режимі конвеєра під час змішування сипкого матеріалу, що можна широко використовувати при проектуванні гвинтових транспортно-технологічних систем.*

Ключові слова: *гвинтовий робочий орган, гвинтовий конвеєр, шнек, сипкий матеріал.*

ПЕРЕДМОВА

Для технологічних операцій переміщення і змішування сипких матеріалів велике розповсюдження набули гвинтові конвеєри, які характеризуються простотою конструкції та, відповідно, високою надійністю, прості в користуванні та легкістю адаптування при використанні в автоматизованих системах, екологічністю використання [1, 5, 6-7]. Для зменшення енергетичних витрат і підвищення якості змішування сипких матеріалів розроблено ряд оригінальних конструкцій гвинтових змішувачів. Застосування таких шнеків потребує вирішення питань, пов'язаних з особливостями визначення навантажень на робочий орган та характеру руху сипкого матеріалу, а також доцільності їх використання.

До переваг застосування таких шнеків можна віднести збільшення коефіцієнта завантаження у зоні переміщення сипкого матеріалу із бункера на шнек, що призводить до зростання його продуктивності.

Аналіз останніх досліджень і публікацій. Питанням транспортування і змішування різних матеріалів присвячені праці Григор'єва А.М. [2], Гевко Б.М., Рогатинського Р.М. [4, 8], Гевко І.Б. [3, 9] та інших. Однак, враховуючи різноманітність технологічних процесів і конструктивного виконання гвинтових транспортно-технологічних механізмів (ГТТМ), потребує подальших досліджень та уточнень різних параметрів теоретичного й практичного значення.

Мета роботи є розроблення інженерної методики розрахунку середньошвидкісному режимі гвинтового конвеєра-змішувачіа з вибором кінематичних та динамічних параметрів, які мінімізують їх енергоємність.

МАТЕРІАЛ І МЕТОДИКА

Для зменшення енергетичних витрат і травмування зерна та збільшення надійності гвинтових робочих органів розроблено ряд оригінальних конструкцій гвинтових конвеєрів-змішувачів. Застосування таких конвеєрів потребує вирішення питань, пов'язаних з характером руху сипкого матеріалу, а також доцільності їх використання.

Особливістю гвинтових конвеєрів-змішувачів (рис. 1.) є те, що для ефективного змішування сипкого матеріалу конвеєр повинен працювати у середньошвидкісному

repeating the cycle by the cycle.

The motion trajectories of the given bulk material volume in the cross section of conveyor casing in the fast- and medium speed modes are compared in fig. 2.

The angular parameter θ is determined by the nature of bulk material motion during the screw conveyor operation. To determine the nature of bulk material transportation, the motion of the given bulk material volume along the coordinates xyz (fig. 1) should be considered.

режимі. При цьому на основі експериментальних досліджень встановлено, що матеріал у поперечному перерізі кожуха конвеєра піднімається до верхньої точки і під дією сили ваги падає на внутрішню циліндричну поверхню кожуха, повторюючи наступний цикл.

Порівняння траєкторій руху виділеного об'єму сипкого матеріалу у поперечному перерізі кожуха конвеєра при швидкісному та середньошвидкісному режимах представлено на рис. 2.

Під час роботи гвинтового конвеєра кутовий параметр θ визначається особливостями руху сипкого матеріалу. Для встановлення характеру переміщення сипкого матеріалу розглянемо рух виділеного об'єму сипкого матеріалу в координатах xyz (рис. 1).

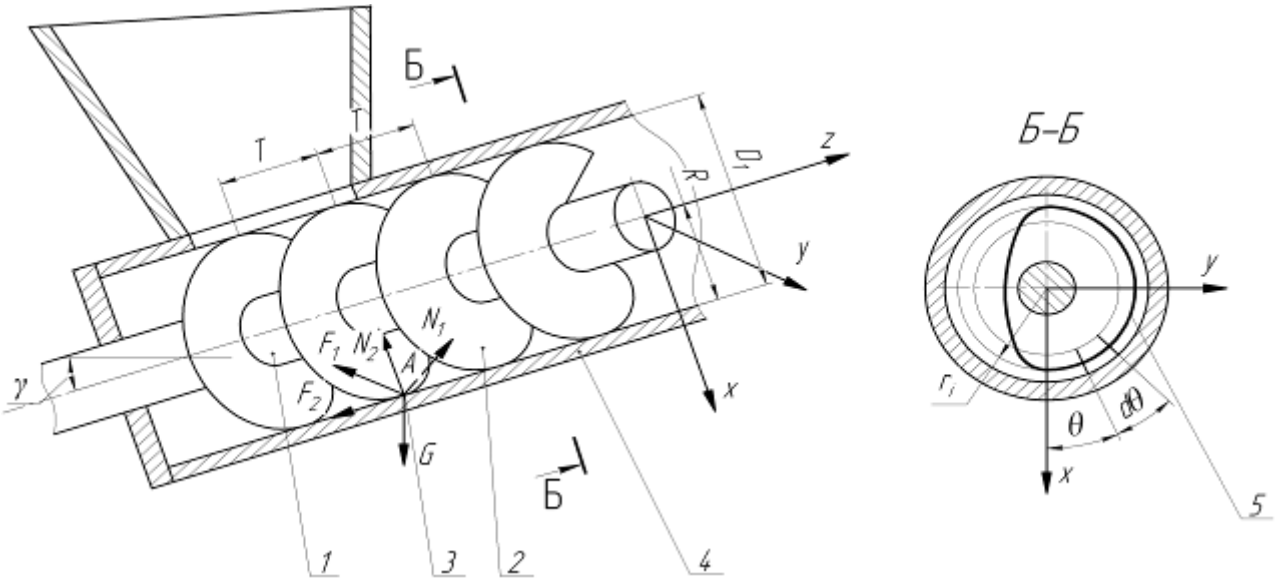

Fig. 1. Computation scheme of transporting the given bulk material volume in the inclined screw conveyor: 1 - drive shaft; 2 – screw working body; 3 – given bulk material volume; 4 – casing; 5 – trajectory of bulk material motion in the medium speed mode (mode of transporting and mixing)

When the conveyor operates in the medium speed mode, the bulk material is mixed and transported simultaneously. Taking into account the contact of the given bulk material volume *A* with the auger's screw surface and the cylindrical surface of the casing, the placement is determined by the radial parameter *R* and the angular parameter *θ*.

Розглянемо середньошвидкісний режим роботи конвеєра, при якому відбувається одночасне змішування та транспортування сипкого матеріалу. Із умови контакту виділеного об'єму сипкого матеріалу *A* з гвинтовою поверхнею шнека та циліндричною поверхнею кожуха, її розміщення визначається радіальним параметром *R* і кутовим параметром *θ*.

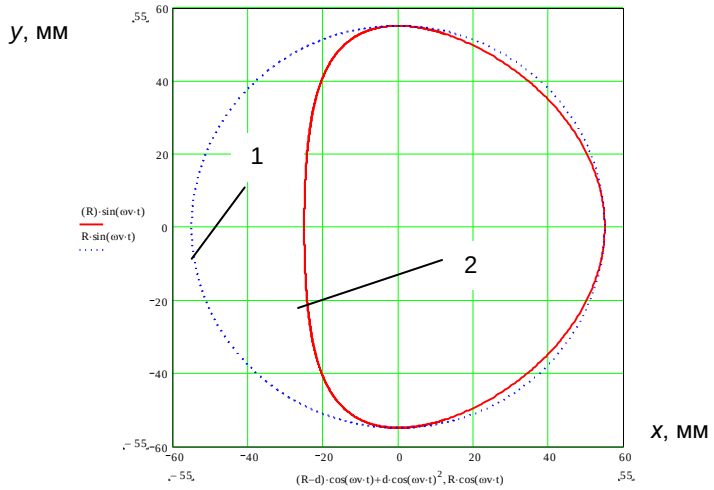

Fig. 2. Motion trajectories of the given bulk material volume in cross section of casing in the fast speed 1 and medium speed 2 modes as compared

In parametric form, with sufficient approximation, the coordinates of the given bulk material volume *A* are determined by the dependences:

В параметричному вигляді, з достатньою апроксимацією, координати виділеного об'єму сипкого матеріалу *A* визначаються такими залежностями:

$$\begin{cases} x_A = (R-d)\cdot\cos\theta + d\cos^2\theta; \\ y_A = R\cdot\sin\theta; \\ z_A = \dfrac{T_0(\omega t-\theta)}{2\pi}. \end{cases} \quad , \qquad (1)$$

where x_A, y_A, z_A, – coordinates of the given bulk material volume, m; R – radial parameter of the given bulk material volume, m; θ – angular parameter of the given bulk material volume, rad; ω – angular speed of working body rotation, rad/s; t – time, s; d – parameter that determines the displacement of motion trajectory of the given bulk material volume in medium speed mode as compared with the fast speed mode, T_0 - step, mm.

Parameter d is the function of angular speed of working body rotation, the inner radius of casing, and the transported material properties. The angular speed of working body rotation increases, the parameter d decreases. The inner radius of casing increases, the parameter d increases as well. In fast speed mode d=0, this parameter can be determined with the use of parametrical dependences based on experimental research.

Motion speeds of the given bulk material volume related to the auger along the axes x, y, z:

де x_A, y_A, z_A, – координати виділеного об'єму сипкого матеріалу, м; R – радіальний параметр виділеного об'єму сипкого матеріалу, м; θ – кутовий параметр виділеного об'єму сипкого матеріалу, рад; ω – кутова швидкість обертання шнека, рад/с; t – час, с; d – параметр, що визначає зміщення траєкторії руху виділеного об'єму сипкого матеріалу при середньошвидкісному режимі від швидкісного режиму, мм; T_0 - крок витків, мм.

Параметр d є функцією кутової швидкості обертання шнека, внутрішнього радіуса кожуха та властивостей транспортованого матеріалу, при чому із збільшенням кутової швидкості обертання шнека цей параметр зменшується, а при збільшенні внутрішнього радіуса кожуха – збільшується. При швидкохідному режимі d=0. Цей параметр можна визначити за емпіричними залежностями на основі експериментальних досліджень.

Швидкості руху виділеного об'єму сипкого матеріалу відносно шнека в напрямку осей x, y, z:

$$\begin{cases} \dot{x}_1 = \dot{x}_A - \dot{x}_{1u}; \\ \dot{y}_1 = \dot{y}_A - \dot{y}_{1u}; \\ \dot{z}_1 = \dot{z}_A - \dot{z}_{1u}, \end{cases} \qquad (2)$$

where $\dot{x}_A$, $\dot{y}_A$, $\dot{z}_A$, - projections of motion speed of the given bulk material volume on the axes of coordinates xyz, m/s.
$\dot{x}_{1u}$, $\dot{y}_{1u}$, $\dot{z}_{1u}$ – projections of motion speed of the working body on the axes of coordinates xyz, m/s.
As the casing is motionless, the motion speeds of the given bulk material volume related to the casing along the axes x, y, z equal:

де $\dot{x}_A$, $\dot{y}_A$, $\dot{z}_A$, - проекції швидкості руху виділеного об'єму сипкого матеріалу на осі координат xyz, м/с; $\dot{x}_{1u}$, $\dot{y}_{1u}$, $\dot{z}_{1u}$ – проекції швидкості руху шнека на осі координат xyz, м/с.
Оскільки кожух нерухомий, то швидкості руху виділеного об'єму сипкого матеріалу відносно кожуха в напрямку осей x, y, z, дорівнюють:

$$\begin{cases} \dot{x}_2 = \dot{x}_A; \\ \dot{y}_2 = \dot{y}_A;; \\ \dot{z}_2 = \dot{z}_A. \end{cases} \quad . \qquad (3)$$

The projections of motion speed of the given bulk material volume are defined by differentiating the equation (1) for the general case, when $R \neq const$:

Проекції швидкості руху виділеного об'єму сипкого матеріалу знаходимо, диференціюючи рівняння (1.1) для загального випадку, коли $R \neq const$:

$$\begin{cases} \dot{x}_A = \dfrac{d(R-d)}{dt}\cos\theta - (R-d)\cdot\sin\theta\cdot\dfrac{d\theta}{dt} + \dfrac{d(d)}{dt}\cos^2\theta - 2d\cos\theta\sin\theta\dfrac{d\theta}{dt}; \\ \dot{y}_A = \dfrac{dR}{dt}\sin\theta + R\cdot\cos\theta\cdot\dfrac{d\theta}{dt}; \\ \dot{z}_A = \dfrac{T}{2\pi}\left(\omega - \dfrac{d\theta}{dt}\right). \end{cases} \quad , \qquad (4)$$

Motion speed of screw working body is determined by dependences:

Швидкість руху гвинтового робочого органу визначаємо за залежностями:

$$\begin{cases} \dot{x}_{1u} = R\cdot\omega\sin\theta; \\ \dot{y}_{1u} = R\cdot\omega\cos\theta; \\ \dot{z}_{1u} = 0. \end{cases} \qquad (5)$$

According to (2) and taking into account the dependences (4) and (5), we develop the formulas:

Згідно з (2), враховуючи залежності (4) і (5), знаходимо:

$$\begin{cases} \dot{x}_1 = \dfrac{d(R-d)}{dt}\cos\theta + R\cdot\sin\theta\cdot\left(\omega - \dfrac{d\theta}{dt}\right) + d\sin\theta\dfrac{d\theta}{dt} + \dfrac{d(d)}{dt}\cos^2\theta - 2d\cos\theta\sin\theta\dfrac{d\theta}{dt}; \\ \dot{y}_1 = \dfrac{dR}{dt}\sin\theta - R\cdot\cos\theta\cdot\left(\omega - \dfrac{d\theta}{dt}\right); \\ \dot{z}_1 = \dfrac{T_0}{2\pi}\left(\omega - \dfrac{d\theta}{dt}\right). \end{cases} \qquad (6)$$

The modules of motion speed of the given bulk material volume are determined by formulas:

Модулі швидкості руху виділеного об'єму сипкого матеріалу визначаємо за формулами:

$$|\dot{s}_1| = \sqrt{\dot{x}_1^2 + \dot{y}_1^2 + \dot{z}_1^2}\ ; \qquad (7)$$

$$|\dot{s}_2| = \sqrt{\dot{x}_A^2 + \dot{y}_A^2 + \dot{z}_A^2}\ . \qquad (8)$$

Inserting the equations (4) and (6) into (7) and (8), and hypothesizing that the casing has a cylindrical shape with R = const, d = const, after the cuts, we get the formulas:

Підставляючи рівняння (4) і (6) у (7) і (8), приймаючи допущення, що жолоб має циліндричну форму, при цьому R=const, d=const, після скорочень, отримаємо:

$$|\dot{s}_1| = \sqrt{\left(R^2 + \frac{T_0^2}{4\pi^2}\right)\left(\omega - \frac{d\theta}{dt}\right)^2 + 2Rd\sin^2\theta\left(\omega - \frac{d\theta}{dt}\right)\frac{d\theta}{dt}(1-2\cos\theta) + d^2\sin^2\theta\left(\frac{d\theta}{dt}\right)^2(1-2\cos\theta)^2}\,; \tag{9}$$

$$|\dot{s}_2| = \sqrt{R^2\left(\frac{d\theta}{dt}\right)^2 + \frac{T_0^2}{4\pi^2}\left(\omega - \frac{d\theta}{dt}\right)^2 + 2Rd\sin^2\theta\left(\frac{d\theta}{dt}\right)^2(1-2\cos\theta) + d^2\sin^2\theta\left(\frac{d\theta}{dt}\right)^2(1-2\cos\theta)^2}\,. \tag{10}$$

The acceleration of the given bulk material volume is determined by differentiating the equation (6) when R=const; d=const.

Прискорення виділеного об'єму сипкого матеріалу визначаємо, диференціюючи рівняння (6) при R=const; d=const.

$$\begin{cases} \ddot{x} = R\cos\theta\frac{d\theta}{dt}\left(\omega - \frac{d\theta}{dt}\right) - R\sin\theta\frac{d^2\theta}{dt^2} + d\cos\theta\frac{d^2\theta}{dt^2} + d\sin\theta\frac{d^2\theta}{dt^2} + \\ +2d\left(\sin^2(\theta)\frac{d^2\theta}{dt^2} - \cos^2(\theta)\frac{d^2\theta}{dt^2} - 2\cos\theta\sin\theta\frac{d^2\theta}{dt^2}\right); \\ \ddot{y} = R\sin\theta\frac{d\theta}{dt}\left(\omega - \frac{d\theta}{dt}\right) + R\cos\theta\frac{d^2\theta}{dt^2}; \\ \ddot{z} = -\frac{T_0}{2\pi}\frac{d^2\theta}{dt^2}. \end{cases} \tag{11}$$

RESULTS AND DISCUSSION

The numerical and experimental research as well as the research presented in the work [8] prove that the stable mode of transportation is set regardless of the initial conditions of transportation after the passage of transitional mode zone.

The stable mode of transportation in medium speed mode of conveyor (fig.3) should be considered, In this mode the bulk material is transported along the complex screw trajectory; and when the bulk material is lifted to the upper point, the following conditions are actual: $\frac{d\theta}{dt} = const = \omega_в$, $\frac{d^2\theta}{dt^2} = 0$, $\frac{dR}{dt} = 0$, $R = const$, $\frac{d(d)}{dt} = 0$, $d = const$, where $\omega_в$ - angular speed of working body rotation, rad/s.

РЕЗУЛЬТАТИ

Результати числових та експериментальних досліджень, а також досліджень, представлених в роботі [8] свідчать, що незалежно від початкових умов транспортування після проходження зони перехідного режиму встановлюється стабільний режим транспортування.

Розглянемо стабільний режим транспортування у середньошвидкісному конвеєрі (рис. 3), в якому сипкий матеріал рухається по складній гвинтовій траєкторії і для якого при підніманні вантажу до верхньої точки дійсні умови: $\frac{d\theta}{dt} = const = \omega_в$, $\frac{d^2\theta}{dt^2} = 0$, $\frac{dR}{dt} = 0$, $R = const$, $\frac{d(d)}{dt} = 0$, $d = const$, де $\omega_в$ - кутова швидкість обертання сипкого матеріалу, рад/с.

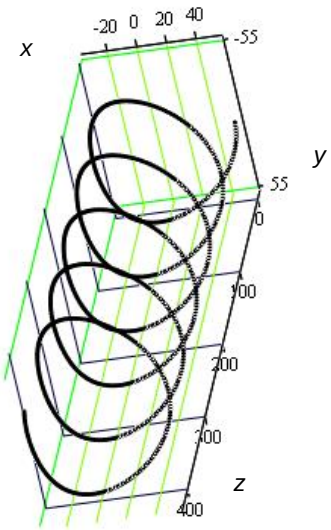

Fig. 3. Motion trajectory of the given bulk material volume in medium speed mode of conveyor R=55 mm, ω=15 rad/s.

Under the acceptable conditions from (6), the projections of motion speed of the given bulk material volume related to the auger on the axis of coordinate system xyz can be developed

При прийнятих умовах з (6) знайдемо проекції швидкості руху виділеного об'єму сипкого матеріалу відносно шнека на осі системи координат xyz

$$\begin{cases} \dot{x}_1 = R\cdot\sin(\omega_в t)\cdot(\omega-\omega_в) + d\sin(\omega_в t)\omega_в - 2d\cos(\omega_в t)\sin(\omega_в t)\omega_в; \\ \dot{y}_1 = -R\cdot\cos(\omega_в t)\cdot(\omega-\omega_в); \\ \dot{z}_1 = \dfrac{T_0}{2\pi}(\omega-\omega_в). \end{cases} \quad (12)$$

Projections of motion speed of the given bulk material volume related to the casing on the axis of coordinate system xyz:

Проекції швидкості руху виділеного об'єму сипкого матеріалу відносно кожуха на осі системи координат xyz:

$$\begin{cases} \dot{x}_2 = (R-d)\cdot\sin(\omega_в t)\cdot\omega_в - 2d\cos(\omega_в t)\sin(\omega_в t)\omega_в; \\ \dot{y}_2 = R\cdot\cos(\omega_в t)\cdot\omega_в; \\ \dot{z}_2 = \dfrac{T}{2\pi}(\omega-\omega_в). \end{cases} \quad (13)$$

Modules of motion speed of the given bulk material volume are determined by formulas:

Модулі швидкості руху виділеного об'єму сипкого матеріалу визначаємо за виразами:

$$|\dot{s}_1| = \sqrt{\left(R^2 + \frac{T_0^2}{4\pi^2}\right)(\omega-\omega_в)^2 + 2Rd\sin^2(\omega_в)(\omega-\omega_в)\omega_в(1-2\cos(\omega_в)) + d^2\sin^2(\omega_в)(\omega_в)^2(1-2\cos(\omega_в))^2}; \quad (14)$$

$$|\dot{s}_2| = \sqrt{R^2(\omega_в)^2 + \frac{T_0^2}{4\pi^2}(\omega-\omega_в)^2 + 2Rd\sin^2(\omega_в)(\omega_в)^2(1-2\cos(\omega_в)) + d^2\sin^2(\omega_в)(\omega_в)^2(1-2\cos(\omega_в))^2}. \quad (15)$$

Based on the formula (15), the graphics of changing the motion speed of the given bulk material

На основі формули (15) будовані графіки зміни швидкості руху виділеного об'єму сипкого матеріалу

volume in time related to the casing in medium speed mode of conveyor (fig. 4) are developed:

відносно кожуха у сердньошвидкісному режимі конвеєра в часі (рис. 4)

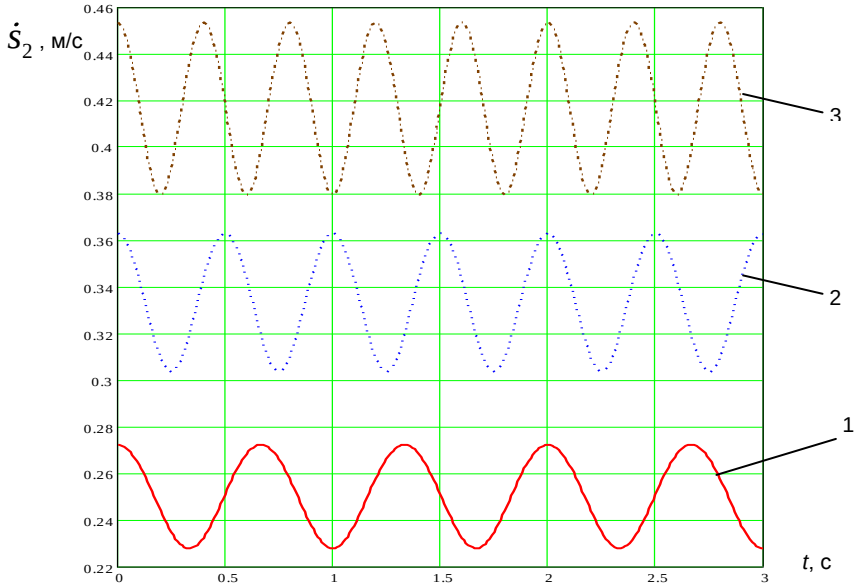

Fig. 4. Graphics of changing the motion speed of the given bulk material volume in time related to the casing in medium speed mode of conveyor *R*=0,055m, T0=0,11m :
1 - n=90rpm; 2 - n=120rpm; 3 - n=150rpm

Acceleration of the given bulk material volume is determined by equations:

Прискорення виділеного об'єму сипкого матеріалу визначаємо за рівняннями:

$$\begin{cases} \ddot{x} = R\omega_в \cos(\omega_в t)(\omega - \omega_в); \\ \ddot{y} = R\omega_в \sin(\omega_в t)(\omega - \omega_в); \\ \ddot{z} = 0. \end{cases} \quad (16)$$

Based on the graphics in Fig. 4 we conclude that the speeds of bulk material transportation periodically change when the screw conveyor in medium speed mode are used. This fact intensifies the process of mixing.

На основі графіків рис. 4 можна зробити висновки, що при застосуванні гвинтових конвеєрів на середньошвидкісних режимах відбувається періодична зміна швидкості переміщення сипкого матеріалу, що сприяє інтенсифікації процесу змішування.

t, c

CONCLUSIONS

1. The engineering technique of determining the nature of loading on the elements in medium speed mode of screw conveyor, on the casing and the screw working body in particular is developed. The speeds of bulk material transportation periodically change when the augers with axis motion are used. This fact improves the process of mixing the bulk materials.
2. The analytical dependences to determine the parameters during transportation of the given bulk material are developed. These dependences can be widely used in designing the screw transport and technological systems.

ВИСНОВОК

1. Розроблено інженерну методику встановлення характеру навантаження на елементи на середньошвидкісному режимі гвинтовому конвеєрі: на кожух та на гвинтовий робочий орган. Встановлено, що при застосуванні шнеків з осьовим рухом відбувається коливання швидкості транспортування, що покращує умови змішування сипких матеріалів.
2. Виведено аналітичні залежності для визначення параметрів під час переміщення виділеного об'єму сипкого матеріалу, що можна широко використовувати при проектуванні гвинтових транспортно-технологічних систем.

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CONSIDERATIONS REGARDING ECO-DESIGN ELEMENTS USED IN THE CONSTRUCTION OF AGRICULTURAL MACHINERY
/
CONSIDERAȚII PRIVIND UTILIZAREA UNOR ELEMENTE DE ECODESIGN ÎN CONSTRUCȚIA MAŞINILOR AGRICOLE

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Abstract:
The paper presents a study regarding current issues generated by global super industrialization which causes environmental degradation through the depletion of natural resources, pollutants, noise as well as suffocation caused by resulted waste, both biodegradable and hazardous ones. There are also presented some concerns of the designers for making "green" products arguing the need and benefits in relation to the environment in general.

Keywords: *eco-design, ecology, enviroment, 'green' products, ergonomics*

INTRODUCTION

Eco-design is not a passing fashion, is a necessity to reduce the impact of pollutants on the environment!

The 'green' products impose another vision of creativity and innovation.

The basic idea in ECODESIGN is to reduce environmental impact throughout the product life cycle by an improved product design, to meet the legally binding (current EU Directives and harmonized standards).

Agricultural machines, as every product placed on the market are energy intensive consumers, both for their achievement, and while working, acting aggressive to external environment, soil and agricultural products designed for consumption.

Agricultural machines incorporate large amounts of metals and plastics with pollutant circuit and active bodies require the production of alloys with superior characteristics, which involves laborious and expensive technologies.

Also, the fact that legislation on products environmental impact of is implemented in a growing pace worldwide encourages organizations to improve their environmental performance of their products.

These organizations need guidance to know how to work systematically to achieve environmental objectives and ensure continuous improvement of the environmental performance of products.

MATERIAL AND METHOD

Eco-Design in manufacture of agricultural machinery

There are an infinite number of formulations that define the industrial design using expressions that largely overlap and lead to the same idea, which includes conception, design and functional products, useful and aesthetic in the same time in industrial series production.

In the category of industrial products enter raw materials, processed materials, subassemblies, sub

Rezumat:
Lucrarea prezintă un studiu privind problemele actuale generate de superindustrializarea globală care determină degradarea mediului înconjurător prin secătuirea resurselor naturale, noxe, zgomot, precum şi prin sufocarea datorată deşeurilor rezultate, atât cele biodegradabile, cât şi cele periculoase. Sunt prezentate, de asemenea unele preocupări ale proiectanților pentru realizarea de produse „verzi" argumentând necesitatea şi avantajele acestora în relația cu mediul, în general.

Cuvinte cheie: *ecodesign, ecologie, mediu, produse „verzi", ergonomie.*

INTRODUCERE

Ecodesignul nu este o modă trecătoare, este o necesitate pentru reducerea impactului produselor poluante asupra mediului!

Produsele „verzi" impun o altă viziune privind creativitate şi inovare.

Ideea de bază în ECODESIGN este reducerea impactului asupra mediului de-a lungul întregului ciclu de viață al produselor printr-o proiectare îmbunătățită a produsului, care să respecte cadrul legal obligatoriu (Directivele europene în vigoare şi standardele armonizate).

Maşinile agricole, ca de altfel orice produs introdus pe piață, sunt mari consumatoare de energie, atât pentru realizarea lor, cât şi în timpul lucrului, acționând agresiv asupra mediului exterior, solului şi produselor agricole destinate consumului.

Maşinile agricole înglobează cantități mari de metale, dar şi de materiale plastice cu circuit poluant, iar organele active necesită realizarea din aliaje cu caracteristici superioare, care presupune tehnologii laborioase şi costisitoare.

De asemenea, faptul că legislația referitoare la impactul produselor asupra mediului este implementată într-un ritm tot mai mare la nivel mondial încurajează organizațiile să îşi îmbunătățească performanța de mediu a produselor lor. Aceste organizații au nevoie de îndrumare pentru a şti cum să depună eforturi în mod sistematic, pentru a atinge obiectivele de mediu şi pentru a asigura îmbunătățirea continuă a performanței de mediu a produselor.

MATERIAL ŞI METODĂ

Ecodesignul în construcția maşinilor agricole

Există o infinitate de formulări definitorii ale designului industrial, folosind expresii care în mare parte se suprapun şi conduc la aceeaşi idee, care include concepția, proiectarea şi realizarea produselor funcționale, utile şi estetice în acelaşi timp, în cadrul producției de serie industrială.

În categoria produselor industriale intră materii prime, materiale prelucrate, subansambluri, componente standardizate, unelte şi maşini de lucru, utilaje şi

standardized components, tools and working machines and equipment with working etc.

Given that it must firmly move beyond consumerism by all means, Eco-design try to save what can be possible through the efforts of many teams and inter-disciplinary projects with innovative ideas.

Have been developed different categories of eco-design activities [2]:
- additional design which involves the addition of new functions dedicated to a product that will be able to execute more operations (e.g. sowing machines and fertilizing);
- redesigning by improving the parameters of a product without changing its structure and technical solutions (ex. the working bodies of agricultural cutters or cultivators);
- new product design, updated, through whole product life cycle;
- innovative design, groundbreaking solutions that completely change the solutions, but which can compete for conservative competition or monopolize the market (e.g. water or air engine);
- visionary design which will have to wait for the right time to implement.

RESULTS

The introduction in mass production of agricultural machines follow the same steps as for the achievement of any product: purchase of raw materials, manufacture of parts in addition to the standardized ones, which mounts as they are, assembly, distribution and sale, use, repair and reuse, removal after overcoming life use, recycling the materials and final their disposal.

A main concern is to find opportunities for modular equipment enabling interchangeability when using the same energy source or the same frame for fitting different working parts, depending on the operations to be performed.

Many machines work only a short period of time/year, in a given crop season, and their storage and maintenance costs are a problem generating additional unjustified.

Eco-design of agricultural machinery includes a new approach in designing these products. Innovative solutions are provided to the current problems regarding conception of supple structures and resilient, aesthetics, functionality, both of the operations which they perform are mechanized, automated and ergonomically in relationship with operators, saving material and energy production, environmental protection, disassembly and recycling opportunities, and more.

Products which include professional eco-design characteristics are so called "green" products and are distinct labeled and buyers / sellers / consumers can decide, in function of their quality / price ratio, acceptance.

Marketing analyzes demonstrated superiority of the "green" business products and manufacturing companies, and customers equally satisfying.

Along design evolution of agricultural machinery were taken into account in addition to their performance the security issues, ensuring comfort and maintaining the health of operators and environmental requirements.

The leading industry firms have improved their product

echipamente cu organe de lucru etc.

În condițiile în care se impune cu tărie depăşirea stadiului de consumerism cu orice preț, ecodesignul încearcă să salveze ce se mai poate, prin eforturile unor echipe multi şi inter-disciplinare de proiectanți cu idei inovative.

S-au dezvoltat diferite categorii de activități în ecoproiectare [2]:
- *proiectarea adițională* care presupune adăugarea de funcții noi unui produs consacrat, care va putea să execute mai multe operații (ex. maşini de semănat şi fertilizat);
- *reproiectarea* prin îmbunătățirea parametrilor unui produs, fără a-i schimba structura şi soluțiile tehnice (ex. organele de lucru ale frezelor agricole sau ale cultivatoarelor);
- *proiectarea de produs nou,* actualizat, pornind de la zero cu întregul ciclu de viață al produsului;
- *proiectarea inovativă,* revoluționară, care schimbă complet soluțiile, dar care poate intra în lupta cu concurența conservatoare sau care a monopolizat piața (ex. motorul cu apă sau cu aer);
- *proiectarea vizionară* care va trebui să-şi mai aştepte timpul potrivit pentru aplicare.

REZULTATE

Introducerea în fabricația de serie a maşinilor agricole urmează aceeaşi paşi ca la realizarea oricărui produs: achiziționarea de materii prime, fabricarea unor părți componente pe lângă cele standardizate care se montează ca atare, asamblarea, distribuția şi vânzarea, utilizarea, repararea şi refolosirea, scoaterea din uz după depăşirea duratei de viață, reciclarea materialelor şi eliminarea finală.

O preocupare importantă este pentru găsirea posibilităților de modulare a echipamentelor care să permită interschimbabilitatea în cazul folosirii aceleiaşi surse energetice sau aceluiaşi cadru pentru echiparea cu diferite organe de lucru, în funcție de operațiile care trebuie executate.

Multe maşini lucrează doar o perioadă scurtă de timp/an, într-o anume campanie agricolă, iar stocarea acestora şi întreținerea constituie o problemă generatoare de costuri suplimentare, nejustificate.

Ecodesignul maşinilor agricole include o nouă abordare a proiectarii acestor produse. Se soluționează inovativ problemele actuale legate de concepția, structurile suple şi rezistente, aspectul estetic, funcționalitatea, atât a operațiilor pe care le execută mecanizat şi automatizat, cât şi din punct de vedere ergonomic în relația cu operatorii, economia de material şi de energie în fabricarea produselor, protecția mediului, posibilități de dezasamblare şi reciclare, precum şi multe altele.

Produsele care includ caracteristicile ecodesignului profesionist se numesc produse “verzi” şi sunt etichetate distinct, iar cumpărătorii/vânzătorii/consumatorii pot decide, în funcție de raportul calitate/preț, acceptarea acestora.

Analizele de marketing au demostrat superioritatea produselor “verzi” şi a afacerilor firmelor producătoare, satisfăcând în aceeaşi măsură şi clienții.

De-a lungul evoluției în proiectarea maşinilor agricole s-au avut in vedere pe langa performanta acestora si problemele de securitate, asigurarea confortului şi menținerea sănătății operatorilor precum si cerintele de mediu. Firme de renume în domeniu şi-au îmbunătățit gama de produse dintre care exemplificam:
- Firma New Holland a actualizat Seria T8 cu tehnologia

range, among which can be exemplified:
- New Holland company updated T8 ™ Series with ECOBlue ™ Hi-ESCR technology, in conformity with emissions standards for Tier 4B.

All new T8 range is now much stronger and maintains, in the same time fuel efficiency consume.

By ECO Blue ™ Hi ESCR technology, whenever is needed, the engine has a reaction rate significantly faster than equivalent models equipped with Tier 3.
Thus, the tractor can maintain a constant speed even during sudden load change, for example when pulling a heavy trailer.
Improving productive performance and reducing the operational costs and fuel consumption are significant.
- John Deere company manufactured the "clean" tractor, Clean multi fuel (Fig.2) that can use different kinds of fuels, including bio, separately or in combination. Various sensors measure the viscosity, density and temperature of the fuel. Depending on the data that sensors transmit, engine control unit decides which setting to do in order to meet the pollution standards.

ECOBlue ™ Hi-eSCR pentru respectarea standardelor de emisii Tier 4B. Întreaga nouă gamă T8 este acum mult mai puternică şi îşi menține, în acelaşi timp, eficiența utilizării de combustibil. Noua seria T8 introduce, de asemenea, o serie de îmbunătățiri în ceea ce priveşte confortul operatorului, dotarea cu accesorii şi uşurința în întreținere.
Prin tehnologia ECOBlue™ Hi-ESCR, ori de câte ori este nevoie, motorul are o viteză de reacție semnificativ mai rapidă față de modelele echivalente dotate cu Tier 3. Astfel, tractorul poate menține o viteză constantă chiar şi în timpul schimbărilor bruşte de sarcină, spre exemplu atunci când tractează o remorcă grea.
Îmbunătățirea performanțelor productive şi reducerea costurilor operaționale şi a consumului de combustibil sunt semnificative.
- Firma John Deere, a realizat tractorul "curat", Clean multi-fuel (Fig.2) care poate folosi carburanți de diferite feluri, inclusiv bio, separat sau în amestec. Diferiți senzori măsoară vâscozitatea, densitatea sau temperatura carburantului. În funcție de datele pe care le transmit senzorii, unitatea de control a motorului decide ce setări trebuie să facă, astfel încât să respecte normele de poluare.

Fig. 1 - T8 serie tractor - New Holland

Fig.2- John Deere-clean multi-fuel tractor

- New Holland TC5000 series combine Harvester (Figure 3) possess a spacious and ergonomic cab that provides a high quality of grains with lower operating and maintenance costs.
- 320 CLAAS TUCANO company (Figura.4) is a combine

- Combina de recoltat New Holland seria TC5000, (Fig.3) poseda o cabină spațioasă şi ergonomică, oferă o calitate deosebită a boabelor cu costuri de operare şi întreținere mici.
- Combina TUCANO 320 a firmei CLAAS (Fig.4), este o

from medium class, ideal for farmers with 250-300 ha. The cab, control center of TUCANO combine is designed so that provides optimum visibility in all directions.
Together with many other features such as: CMOTION, CEBIS or pilot GPS, it creates an extremely comfortable environment, which significantly improves productivity. The multifunction control lever CMOTION was developed specifically for ergonomics of right hand and is integrated into the driver's seat armrest, ensuring a maximum comfort while driving and setting TUCANO combine.

combină din clasa medie, ideală pentru fermierii cu 250-300 ha. Cabina, centrul de control al combinei TUCANO este proiectată astfel încât oferă o vizibilitate optimă în toate direcțiile. Impreună cu numeroase alte caracteristici, cum ar fi: CMOTION, CEBIS sau GPS pilot, aceasta creează un mediu extrem de confortabil, care îmbunătățeşte semnificativ productivitatea. Maneta multifuncțională CMOTION a fost dezvoltată special pentru ergonomia mâinii drepte fiind integrată în cotiera scaunului şoferului, conferind un grad maxim de confort în timpul conducerii şi setării combinei TUCANO.

Fig. 3 - TC5070 New Holland harvesting combine

Fig.4 - Claas Tucano Combine

Fig. 5 – Incorporated computer for operations parameters recording, equipped with DGPS technology

Fig. 6 – GPS networking of agricultural operations

Machines that perform phyto-sanitary works comprise automation elements that determine the diminishing to minimum of additional substances necessary to plants growing, or combined multifunctional machines that reduce the number of passages in the same field along with noxious emissions, generated by propulsion forces (Fig.5).

Information and control technologies allow various settings, automated operation sequences, such as soil or harvesting mapping (Fig. 6).

CONCLUSIONS

The field is rather comprehensive, including technical solutions for manufacturing reduced weight machines, made of „environmental-friendly" materials with small influence in terms of noxious effects on operator, plants, soil, air, ecosystems, etc during work.

At the same time, assembling/disassembling solutions ensuring an efficient transport by packaging possibilities or easy material recycling, have been developed.

It is not too exaggerate if one extends the term of intelligent product to this category of machines that reached a certain development stage so that the operators are not any more simple manipulators, but interpreters of IT data, able to optimize the machinery adjustment, adapted to each particular situation, in order to get a high quality work..

It is also noticeable that future technology in agricultural machinery field aims three important directions:

- integration more and more sophisticated of information and communication technologies (ICT) within the agricultural machines. Complex equipment will be easy to use due to internet, mobile phones and tablets. Tablet becomes a unique operator, the interface between man and machine, being able to be also used to transfer data and build land maps.

Maşinile care efectuează lucrări de întreţinere fitosanitare au încorporate elemente de automatizare care conduc la reducerea la minim a substanţelor adiţionale necesării dezvoltării plantelor, sau maşini combinate, multifuncţionale care reduc numărul de treceri pe aceeaşi suprafaţă de teren, în paralel cu reducerea noxelor iminente degajate de sursele de propulsie (Fig.5).

Tehnologiile de informaţii şi control permit o varietate de setări, secvenţe automate de operare, cum ar fi cartarea solurilor sau a recoltelor (Fig. 6)

CONCLUZII

Domeniul este vast, include soluţii tehnice de realizare suplă a maşinilor din materiale „prietenoase" mediului şi cu influenţă minimă privind efectele nocive în timpul lucrului asupra operatorului, plantelor, solului, aerului, ecosistemelor etc.

De asemenea, s-au dezvoltat soluţii de asamblare / dezasamblare care asigură un transport eficient prin posibilităţile de ambalare sau uşurinţă în procesul de reciclare a materialelor.

Nu e deloc exagerată extinderea termenului de produs inteligent şi la această categorie de maşini care au ajuns la un asemenea stadiu de dezvoltare încât operatorii nu mai sunt simpli conducători, sau mânuitori, ci interpreţi ai datelor computerizate capabili să intervină pentru optimizarea continuă a reglajelor, adaptate diferitelor situaţii, în vederea unei lucrări de calitate.

Se poate constata de asemenea că tehnologia viitorului in domeniul maşinilor agricole are în vedere trei mari direcţii:

- integrarea din ce în ce mai sofisticată a tehnologiilor de informare şi comunicare (ICT) în maşinile agricole. Utilajele complexe vor fi uşor de folosit datorită internetului, a telefoanelor mobile şi a tabletelor. Tableta devine operator unic, interfaţa între om şi maşină, aceasta putând fi folosită şi pentru transfer de date şi realizarea de hărţi ale terenurilor.

-innovation of technical, economic and environment efficiency of this equipment and its easy and simple utilization. Efficiency aims both the machine working process, but also its internal functions, starting from energy performances up to engines, transmission systems, soil friendly attitude or wheels pressure
- equipment's reliability.

Within this context, eco-design with its innovative elements could be in the near future the key which stops the destruction of planet by man foolish actions, in his love of gain.

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http://www.EcoDesignARC.info
- Prospect produse General Leasing
- Prospect produse New Holland
- Prospect produse CLAAS

- inovația în eficiența tehnică, economică şi de mediu a acestor utilaje, dar şi uşurința cu care pot fi folosite. Eficiența vizează atât modul de lucru al maşinii, dar şi funcțiunile interne ale acesteia, de la performanțele de energie până la motoare, sisteme de transmisie, atitudinea prietenoasă cu solul sau la presiunea din roți
- siguranța pe care o oferă utilajul în exploatare.

În acest context ecodesignul cu elementele sale inovative ar putea fi cheia măcar a stopării distrugerii, în viitorul mai mult sau mai puțin apropiat, a planetei de către om, prin acțiunile sale nesăbuite, în goana după câştig.

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http://www.EcoDesignARC.info
- Prospect produse John Deere
- Prospect produse New Holland
- Prospect produse CLAAS

PROPOSALS FOR IMPROVING THE PROCESS OF SEED DISTRIBUTION / *PROPUNERI PENTRU ÎMBUNĂTĂȚIREA PROCESULUI DE DISTRIBUȚIE A SEMINȚELOR*

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Abstract: *The paper presents theoretical studies performed to adapt a universal drills for sowing of seeds for different sizes by improving their distribution process, changing the distributor groove.*

Keywords: *seed, process, distribution, culture, uniformity*

Rezumat: *Lucrarea prezintă studiile teoretice realizate pentru adaptarea unei semănători universale pentru semănatul semințelor de dimensiuni diferite, prin îmbunătțirea procesului de distribuție al acestora, modificând distribuitorul cu caneluri.*

Cuvinte cheie: *sămânță, proces, distribuție, cultură, uniformitate*

INTRODUCTION

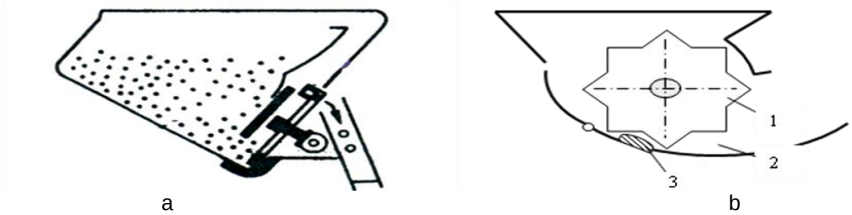
The theoretical studies conducted in an attempt to provide a drill seeds of different sizes that can be used to establish the cultures in the nursery or light soils, in accordance with the uniformity of the sowing depth, keeping the seeding constant, the uniformity of the distribution of seed row [2, 5].

Any universal drill has in its construction components of the devices shown in Figure 1:

INTRODUCERE

Prin studii teoretice efectuate s-a încercat de a realiza o semănătoare de semințe de diferite dimensiuni care să poate fi utilizată pentru înființarea culturilor în pepinieră sau pe soluri uşoare, cu respectarea uniformității adâncimii de semănat, menținerea adâncimii de semănat constantă, la uniformitatea de distribuire a semințelor pe rând [2, 5].

Orice semănătoare universală are in construcția ei dispozitivele componentele prezentate în figura 1:



a b

Fig. 1 - Parts of a sower- a) seed box; b) dispensing devices; box of variable volume, 1-distributor with angled groove floor with adjustable position 2, 3 volumes of distributed to a rotating seed

MATERIAL AND METHOD

The possibility of using universal seeder for sowing of seeds of different sizes is reduced because each type of seed depending on crop has its properties. Thus the relief angle or the angle of the flow is different, as well as its surface (rough, smooth, with bristles, etc.).

For these reasons, the uniformity of the distribution is small, so a time between the seed and the amount of seed per unit area delivered. [1,3],

To this end was studied distributor groove camera settings used in the construction of distribution of drills with mechanical distribution shown in the figure below.

MATERIAL ŞI METODĂ

Posibilitatile de a folosi semănătorile universale pentru semănatul semințelor de diferite dimensiuni sunt reduse datorită faptului că fiecare tip de sămânță in funcție de cultură are proprietățile ei. Astfel unghiul de aşezare respectiv unghiul de curgere este diferit, la fel şi suprafața acestora (rugoasă, netedă, cu perişori etc.).
Din aceste motive uniformitatea de distribuire este mică, atât între semințe pe rând cât şi cantitatea de semințe distribuită pe unitatea de suprafață [1,3],

În acest scop s-a luat în studiu distribuitorul cu caneluri folosit în construcția aparatatului de distribuție al semănătorilor cu distribuție mecanică prezentat în figura de mai jos.

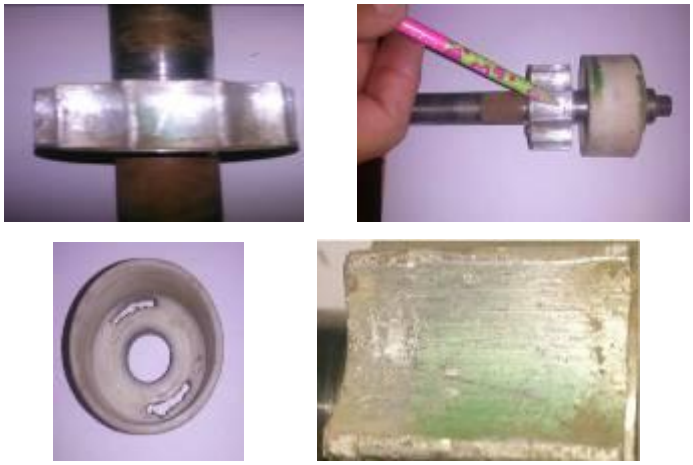


Fig. 2 - Distributor used in the construction of INMA drill

Distributor with inclined grooves and the dosing volume variable, L the length of the distributor, D-outer diameter α- the angle of the grooves is based on the cone and ensures that the alignment of the seed distribution thereof.

Seed box is provided with a mechanical stirrer placed in the bottom of the enclosure to help to supply continuous power distribution apparatus.

Calculations on the sowing box sowing machine must determine their optimal volume space Drills pathway between two consecutive feeds, orifice size flow of seeds etc.

These elements and their relationships are related to the rule of calculation of seed per hectare, the distance between seeds in a row, the sown area, working capacity of the machine etc., and monitored most Drills.

To calculate the quantity of seed using the following equation [5]:

Distribuitor cu caneluri înclinate şi volum de dozare variabil, L- lungimea distribuitorului, D-diametrul exterior, α- unghiul de înclinare a canelurilor care este în funcție de conul de aşezare al semințelor şi asigură continuitatea de distribuire a acestora.

Cutia de semințe este prevăzută cu agitator mecanic aşezat în partea inferioară a cutiei care ajută la alimentarea continuă a aparatului de distribuție .

Calculele referitoare la cutia de semințe a maşinii de semănat trebuie să stabilească volumul optim al acestora, spațiul parcurs de maşina de semănat între două alimentări consecutive, dimensiunea orificiului de curgere a semințelor etc.

Aceste elemente şi relațiile lor de calcul sunt legate de norma de sămânță la hectar, distanța între semințe pe rând, suprafața însămânțată, capacitatea de lucru a maşinii etc., elemente monitorizabile la cele mai multe maşini de semănat.

Pentru calculul cantității de semințe se foloseşte următoarea relație [5]:

$$qm = \frac{\Sigma qi}{n} [g] \quad (1)$$

Where: qi- seed mass;
n number of distribution boxes.

Sowing instability constant speed was calculated with formula [8, 62, 96]:

Unde: qi- masa semințelor;
n- numărul casetelor de distribuție.

Instabilitatea normei de semănat la viteză constantă a fost calculată cu formula [8, 62, 96]:

$$i = \frac{\sqrt{\frac{\Sigma(N_m - N_i)^2}{n}}}{N_m} \cdot 100, [\%] \quad (2)$$

In case of:
Nm - arithmetic average mass of three repetitions;
Ni - arithmetic average mass for each repetition;
n number of repetitions.

The amount of seed distributed to regulate the minimum flow, maximum flow rate and the flow rate typically on the scale on the gearbox without taking into account the characteristics of the seeds is shown in Table 1.

În cazul în care:
Nm -masa medie aritmetica a trei repetiții;
Ni -masa medie aritmetică pentru fiecare repetiție;
n - numărul de repetiții.

Cantitatea de semințe distribuită la reglarea de debit minim, debit maxim şi debitul de uzual în funcție de gradația de pe cutia de viteze fără a ține cont de caracteristicile semințelor este prezentată în tabelul 1.

Table 1

Adjustment possibilities seed flow

		Working speed / km/h			
		3.8	6.2	8	10
100	Maximum flow	534	515	515	508
65		344	341	340	323
60		307	306	305	295
55	Usual flow	276	273	Gradation on the transaxle	Flow characteristics
50		234	233	231	220
45		202	197	197	194
40		169	167	166	163
20	Minimum flow	13	13	13	12.7

To achieve those proposed to consider the possibility of replacing parts or removing them from construction drill follows:

- Agitators type fingers can be replaced with a mechanism of movement (vibration) box of seeds during work;
- Seed distribution apparatus can be made as groove cylinders with inclined channels made of plastic mounted in boxes from the same material; [4]

Pentru realizarea celor propuse s-a luat în calcul posibilitățile de înlocuire a unor componente sau chiar eliminarea lor din construcția semănătorii, astfel:

- agitatoarele de tipul ax cu degete pot fi înlocuite cu un mecanism de mişcare (vibrare) a cutiei de semințe în timpul lucrului;
- aparatele de distribuție a semințelor pot fi realizate sub forma unor cilindrii canelați, cu canuluri înclinate din masă plastică montate în casete din acelaşi material;[4]

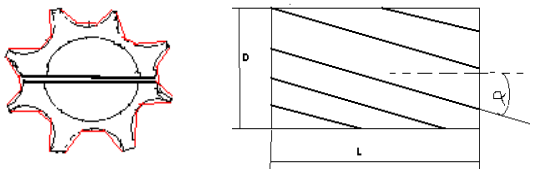


Fig. 3 - Aparat de distribuție tip cilindru cu caneluri înclinate

To achieve angled grooves and increased flow capacity of seed from the cavity formed between the fingers distributor proposed to amend the cup and using the prismatic form presented in Figure 4.

Pentru realizarea canelurilor înclinate si cresterea capacitațiide curgere a semintelor din cavitatea formata intre pintenii distribuitorului se propune modificarea formei de cupă si folosirea formei de prismoid prezentată in figura 4.

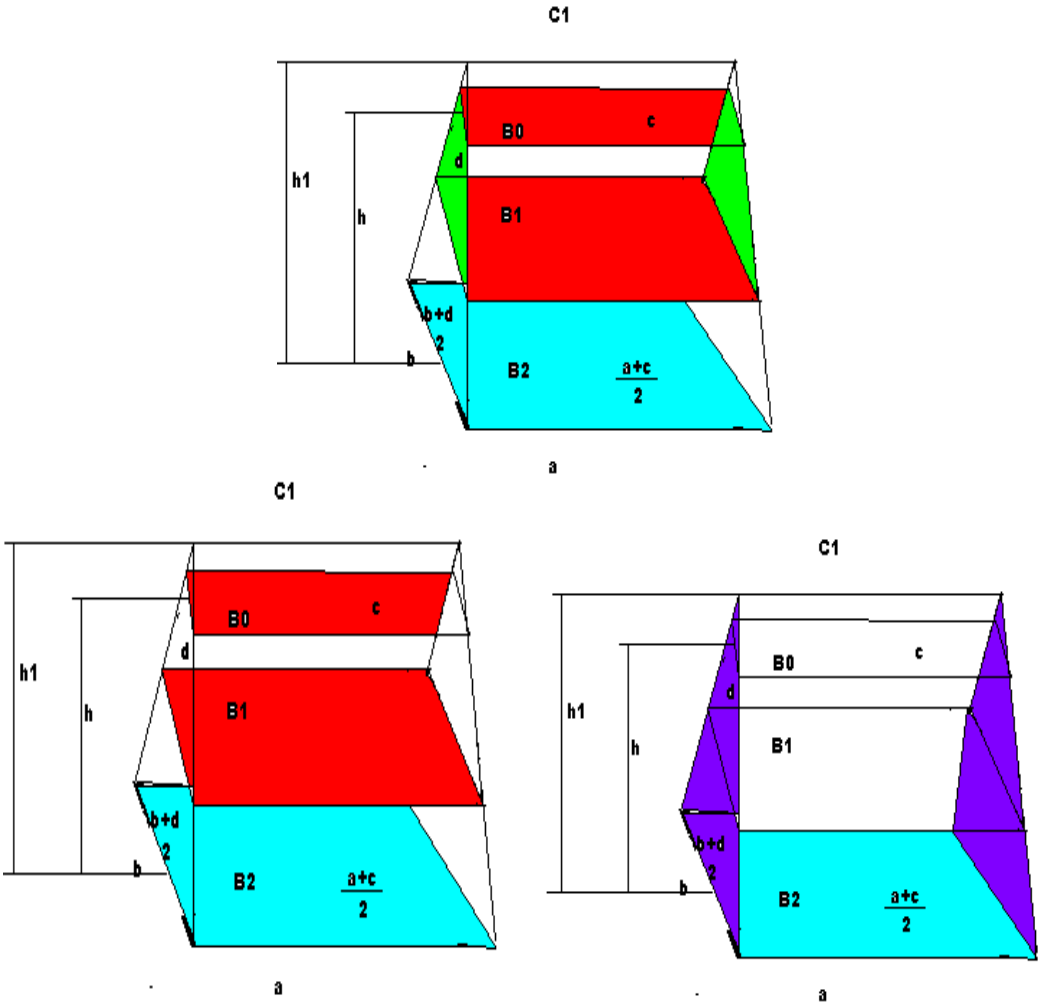


Fig. 4 - Forma de prismoid propusa pentru realizarea canelurilor inclinate ale distribuitorului

To calculate the volume between the grooves Kepler's rule was used.

Pentru calculul volumului cuprins intre caneluri s-a folosit regula lui Kepler.

$$V = h[2(a*b+c*d)+a*d+bc]/6 \quad (3)$$

Where: V represents the volume and, a, b, c, d, h are measured and reported in Figure 4.

To calculate the volume between the cylindrical grooves using Figure 5.

In care valorile :V reprezinta volumul iar, a,b,c,d,h sunt masurabile si prezentate in fig.4.

Pentru calculul volumului cuprins intre canelurile cilindrice s-a folosit figura 5.

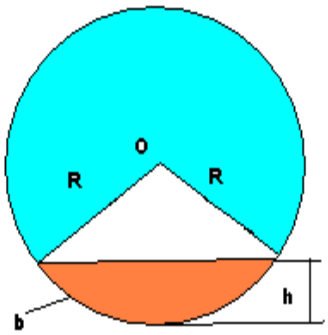


Fig.5 - Cylindrical grooves calculate the area using circular sector

$$A = 1/2b*r-1/2s(r-b) \text{ iar,} \quad (4)$$

$$V=A*l \quad (5)$$

Wherein: A is the area of the circular sector
V is the cavity volume annular grooves
l is the length of grooves
s rope is circular segment
S = α0 / 360-b * r * ππr2 / 2
r, b, α are measurable values

CONCLUSIONS

- ✓ Following the theoretical calculations revealed that respective circular cavities prismoidală volume is approximately equal, the difference is very small.
- ✓ Downloading seeds of cavidatea prismoidală slanted walls is continuing against the circular wall that is grouped.
- ✓ seed flow is influenced by the flat shape of the cavity walls and the angle of inclination.
- ✓ Operation requires no additional training drill.
- We recommend using plastic dispenser manufacturing method thereof Rapid Prototyping with the possibility sectioning in two removable parts that allow quick replacement thereof depending on the size of the seed.
- It is also recommended creating a system that allows driving sleeve which limits the drive shaft movement instead of seeds that can be mounted distributor.
- Move sleeve covering the grooves to be achieved by driving a screw mechanism and gradually sector.

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In care: A reprezinta aria sectorului circular
V reprezinta volumul cavitatii canelurilor circulare
l reprezinta lungimea canelurilor
s reprezinta coarda segmentului circular
$S=\alpha^0/360*\pi r^2-b*r/2$
r,b,α sunt valori masurabile

CONCLUZII

- ✓ In urma calculelor teoretice a rezultat faptul că volumul cavitatilor circular respective prismoidală este aproximativ egal, diferenta fiind foarte mică;
- ✓ Descarcarea semințelor din cavidatea prismoidală cu pereți inclinați se face continu față de cea a pereților circulari care se face grupat.
- ✓ Curgerea semințelor e influențată de forma plană a peretilor cavitătii si de unghiul de inclinare.
- ✓ Exploatarea semănătorii nu necesită o pregătire suplimentară.
- Se recomandă confecționarea distribuitorului folosind masele plastic prin metoda Rapid Prototyping cu posibilitatea secționării acestuia in doua părți demontabile care permit inlocuirea rapida a acestuia in funcție de dimensiunile semințelor.
- Se recomanda de asemenea realizarea unui sistem care permite deplasarea bucşei care limiteaza zona de antrenare a semințelor in locul deplasării axului pe care se poate monta distribuitorul.
- Deplasarea bucşei care acoperă canelurile sa se realizeze prin actionarea unui mecanism cu filet si sector gradat.

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NUMERICAL AND EXPERIMENTAL VIBRATION ANALYSIS OF THE SUSPENSION SYSTEM OF AN AGRICULTURAL MACHINERY
/
ANALIZĂ NUMERICĂ ŞI EXPERIMENTALĂ A VIBRAȚIILOR SISTEMULUI DE SUSPENSIE AL UNEI MAŞINI AGRICOLE

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Abstract: *The paper analyses the bending vibrations of leaf springs, devices that are largely used in agricultural machinery. The studied type of spring is modeled as a system of straight superposed bars, consisting of three bars of different lengths, fixed at one end and free at the other. The paper presents, in its first part, a theoretical study, by the discretization method, of the free vibrations of the studied model, with the determination of the eigenfrequencies of the system. The cases in which the bars are clamped with strong and weak tightening, respectively, are analyzed. For the case of weak tightening, two modalities are proposed for the computation of the influence coefficients matrix, necessary for determining the differential equations of the vibration. In the second part of the paper, the eigenfrequencies of the system are determined experimentally for the two cases and a comparative study of the analytical and numerical results is performed.*

Keywords: *bending vibrations, leaf spring, eigenfrequencies, discretization, influence coefficient.*

INTRODUCTION

Leaf springs are frequently used in agricultural machinery for the damping of vibrations; thus, the development of methods for their efficient modeling and computation are of a particular practical interest. In the paper, the bending vibrations of a leaf spring, modeled as a system of superposed bars, are analyzed. The system consists of three bars with different lengths, fixed at one end and free at the other. A theoretical study of the free vibrations of the studied model is first performed, by the discretization method, with the computation of the eigenfrequencies of the system. The cases in which the bars are clamped with weak and strong tightening, respectively, are analyzed. For the case of weak tightening, two modalities are proposed for the computation of the influence coefficient matrix, necessary for the determination of the differential equations of vibration. Next, an experimental study for the determination, for the two cases, of the eigenfrequencies of the system is presented. The paper is concluded with a comparative study of analytical and numerical results.

The paper continues previous studies of the authors, in which the discretization method and the influence coefficients method were applied for the study of the free and forced vibrations of other types of mechanical systems, demonstrating the efficiency of the mentioned method in the assessment of vibration characteristics [1, 2, 3, 4].

DESCRIPTION OF THE SYSTEM

For the study of the vibrations of a leaf spring, used as a main element of the suspension system in many agricultural machinery (Fig. 1), a system of three superposed bars, with rectangular, constant and identical cross-sections, made from the same material, fixed at one end and free at the other, is adopted as a study model

Rezumat: *Articolul analizează vibrațiile de încovoiere ale arcurilor lamelare, dispozitive de largă utilizare la maşinile agricole. Tipul de arc studiat este modelat ca un sistem de bare drepte suprapuse, fiind format din trei bare de dimensiuni diferite, încastrate la un capăt şi libere la celălalt. Articolul prezintă, în prima sa parte, un studiu teoretic al vibrațiilor libere pentru modelul studiat, prin metoda discretizării, cu determinarea frecvențelor proprii ale sistemului. Se analizează cazurile în care barele sunt prinse cu strângere slabă, respectiv puternică. În cazul strângerii slabe, sunt propuse două modalități de calcul a matricei coeficienților de influență, necesară pentru determinarea ecuațiilor diferențiale ale vibrațiilor. În partea a doua a articolului, sunt determinate pe cale experimentală, în cele două cazuri, frecvențele proprii ale sistemului şi este efectuată o analiză comparativă a rezultatelor obținute analitic şi numeric.*

Cuvinte cheie: *vibrații de încovoiere, arc lamelar, frecvențe proprii, discretizare, coeficient de influență.*

INTRODUCERE

Arcurile lamelare sunt frecvent utilizate la maşinile agricole pentru amortizarea vibrațiilor, motiv pentru care dezvoltarea unor metode eficiente de modelare şi calcul al lor este de un deosebit interes practic. În articol se analizează vibrațiile de încovoiere ale unui arc lamelar, modelat ca un sistem de bare drepte suprapuse. Sistemul este format din trei bare de lungimi diferite, încastrate la un capăt şi libere la celălalt. Este realizat mai întâi un studiu teoretic al vibrațiilor libere pentru modelul studiat, prin metoda discretizării, cu determinarea frecvențelor proprii ale sistemului. Se analizează cazurile în care barele sunt prinse cu strângere slabă, respectiv puternică. În cazul strângerii slabe, sunt propuse două modalități de calcul a matricei coeficienților de influență, necesari pentru determinarea ecuațiilor diferențiale ale vibrațiilor. În continuare, este prezentat un studiu experimental de determinare în cele două cazuri a frecvențelor proprii ale sistemului. Articolul se încheie cu o analiză comparativă a rezultatelor obținute analitic şi numeric.

Articolul continuă studii anterioare ale autorilor, în care metoda discretizării şi metoda coeficienților de influență au fost aplicate pentru studiul vibrațiilor libere şi forțate ale unor alte tipuri de sisteme mecanice, demonstrându-se eficiența metodelor respective în estimarea caracteristicilor vibrațiilor [1, 2, 3, 4].

DESCRIEREA SISTEMULUI

Pentru studiul vibrațiilor unui arc lamelar, utilizat ca element principal al sistemului de suspensie la multe maşini agricole (fig. 1), se adoptă ca model de studiu un sistem de trei bare suprapuse, cu secțiuni dreptunghiulare constante şi identice, de lungimi diferite, realizate din

(Fig. 2)
The bar system performs bending vibrations in the plane *Oxz*.

acelaşi material, încastrate la un capăt şi libere la celălalt (Fig. 13).
Sistemul de bare efectuează oscilații de încovoiere în planul *Oxz*.

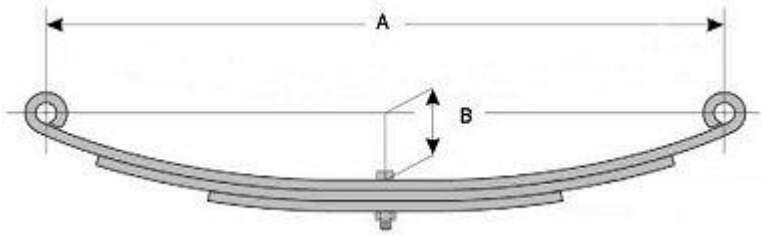

Fig. 12 – The suspension system

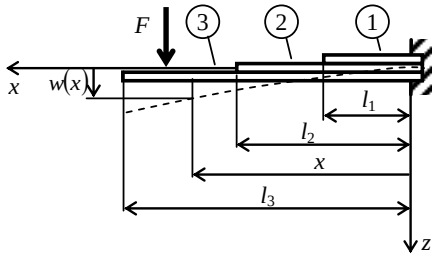

Fig. 13 – Leaf spring model

The bars are kept in permanent contact by the use of tightening clamps, such that the deflections of all bars are equal in the same transverse section. If the tightening of these bars is weak, the bars slide on one another during the bending, forming a system of elastic bodies mounted in parallel. If the tightening is strong, the bars do not slide and the system behaves like a single bar with variable section, equal to the sum of the component sections. The paper analyzes both situations, the first of them by using two theoretical methods. Three analysis cases result, all of them based on the modeling by the discretization method and on the study of vibrations by the influence coefficients method.

Barele sunt ținute în contact permanent cu ajutorul unor cleme de fixare, astfel încât deplasările tuturor barelor în aceeaşi secțiune transversală sunt egale. Dacă strângerea acestor cleme este redusă, barele alunecă una peste alta în timpul încovoierii, alcătuind un sistem de corpuri elastice montate în paralel. Dacă strângerea este puternică, barele nu alunecă, sistemul comportându-se ca o singură bară, de secțiune variabilă, egală cu suma secțiunilor componente. Lucrarea analizează ambele situații, prima dintre ele cu ajutorul a două metode teoretice. Rezultă trei cazuri de calcul, toate bazate pe modelare prin metoda discretizării şi pe studiul vibrațiilor prin metoda coeficienților de influență.

MATHEMATICAL MODEL – GENERAL ASPECTS

As known from the literature, the approximate study of the vibrations of continuous bodies can be performed by the discretization method, which consists in the approximation of the system by a number *n* of material points, connected by elastic elements of negligible mass [11]. For the studied system, the model in Figure 3 results.
The mass in section i is

MODELARE MATEMATICĂ – ASPECTE GENERALE

Aşa cum se cunoaşte din literatura de specialitate, studiul aproximativ al vibrațiilor corpurilor continue se poate face cu ajutorul metodei discretizării, ce constă în aproximarea sistemului printr-un număr *n* de puncte materiale, conectate prin elemente elastice de masă neglijabilă [6]. În cazul sistemului studiat rezultă modelul din figura 2.
Masa din secțiunea i este

$$m_i = \rho b\, h(x) \Delta x_i \quad (i = 1,2,\ldots,n), \tag{35}$$

where ρ is the density of the bar material, b is the width of the bar section,

unde ρ este densitatea materialului barei, b este lățimea secțiunii barelor,

$$h(x) = \begin{cases} h_1 = 2h_0 & \text{if / } da\check{a} \quad 0 < x \le l_1 \\ h_2 = 2h_0 & \text{if / } da\check{a} \quad l_1 < x \le l_2 \\ h_3 = 3h_0 & \text{if / } da\check{a} \quad l_2 \le x \le l_3 \end{cases} \tag{36}$$

represents the height of the cross-section of the bar package, h_0 is the height of the section of a bar and

reprezintă înălțimea secțiunii pachetului de bare, h_0 este înălțimea secțiunii unei bare, iar

$$\Delta x_i = x_i - x_{i-1} \quad (i = 1,2,\ldots,n) \tag{37}$$

is the distance between sections $i-1$ and i.

este distanța dintre secțiunile $i-1$ şi i.

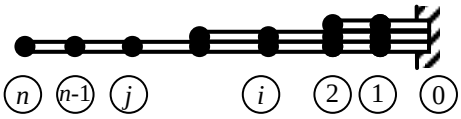

Fig. 14 - Discretized system of beams

The vibrations of the discrete system can be studied with the methods specific to the systems with a finite number of degrees of freedom [6, 7, 8, 9]. One of these is the influence coefficients method [6, 9].

Vibrațiile sistemului discret rezultat pot fi studiate cu metodele specifice sistemelor cu un număr finit de grade de libertate [6, 7, 8, 9]. Una dintre acestea este metoda coeficienților de influență [6, 9].

As known from the literature, the influence coefficient δ_{ij} is defined as the transverse displacement

Aşa cum se cunoaşte din literatură, coeficientul de influenţă δ_{ij} este definit ca deplasarea transversală

$$w_i = w(x_i), \tag{38}$$

undergone by section i, when the bar is submitted to a force equal to unity, applied perpendicularly in the section j.

In the case of a homogeneous bar fixed at one end and free at the other [6, 9],

suferită de secţiunea i, atunci când bare este acţionată de o forţă egală cu unitatea, aplicată perpendicular în secţiunea j.

În cazul unei bare omogene încastrate la un capăt şi liberă la celălalt [6, 9],

$$\delta_{ij} = \delta_{ji} = \frac{x_i^2}{2EI_y}\left(x_j - \frac{x_i}{3}\right) \quad \text{if} \quad x_i < x_j, \tag{39}$$

where E is the Young's modulus of the bar material and I_y is the moment of inertia of the cross-section.

In the general case of a bar with variable section, in which the moment of inertia varies with the x abscissa, the deformation in section i produced by a force applied in section j takes the form [10]

unde E este modulul lui Young al materialului barei, iar I_y este momentul de inerţie al secţiunii transversale.

În cazul general, al unei bare de secţiune variabilă, în care momentul de inerţie variază cu abscisa x, deformaţia din secţiunea i produsă de o forţă aplicată în secţiunea j ia forma [10]

$$w(x_i) = \int_0^{x_i}\left(\int_0^{x} \frac{F(x_j - x)}{EI_y(x)}\,\mathrm{d}x\right)\mathrm{d}x \quad \text{if} \quad x_i < x_j. \tag{40}$$

The influence coefficients result from this relation:

Rezultă de aici coeficienţii de influenţă:

$$\delta_{ij} = \int_0^{x_i}\left(\int_0^{x} \frac{x_j - x}{EI_y(x)}\,\mathrm{d}x\right)\mathrm{d}x \quad \text{if} \quad x_i < x_j. \tag{41}$$

It is shown that the differential equations of the free vibrations take the form [6, 9]

Se arată că ecuaţiile diferenţiale ale vibraţiilor libere iau forma [6, 9]

$$[D]\{\ddot{w}\} + \{w\} = \{0\}, \tag{42}$$

where the following were introduced:
- dynamic matrix

unde s-au introdus:
- matricea dinamică

$$[D] = \begin{bmatrix} \delta_{11} & \delta_{12} & \cdots & \delta_{1n} \\ \delta_{21} & \delta_{22} & \cdots & \delta_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ \delta_{n1} & \delta_{n2} & \cdots & \delta_{nn} \end{bmatrix} \cdot \begin{bmatrix} m_1 & 0 & \cdots & 0 \\ 0 & m_2 & \cdots & 0 \\ \cdots & \cdots & \cdots & \cdots \\ 0 & 0 & \cdots & m_n \end{bmatrix}, \tag{43}$$

- state vector

- vectorul de stare

$$\{w\} = (w_1 \quad w_2 \quad \ldots \quad w_n)^T, \tag{44}$$

- null vector

- vectorul nul

$$\{0\} = (0 \quad 0 \quad \ldots \quad 0)^T. \tag{45}$$

Under these conditions, denoting by α_i $(i = 1,2,\ldots,n)$ the eigenvalues of the matrix (43) and $\{a\}_i$ the corresponding eigenvectors, the circular eigenfrequencies of the system result,

În aceste condiţii, notând cu α_i $(i = 1,2,\ldots,n)$ valorile proprii ale matricei (43) şi $\{a\}_i$ vectorii proprii corespunzători, rezultă pulsaţiile proprii ale sistemului,

$$\omega_i = \left(\sqrt{\alpha_i}\right)^{-1}, \tag{46}$$

as well as the eigenmodes

precum şi modurile proprii de vibraţie,

$$\{w\}_i = \{a\}_i \cos(\omega_i t - \varphi_i). \tag{47}$$

THE CASE OF WEAK TIGHTENING – FIRST MEHOD

In the case of weak tightening, the influence coefficients of the bar package can be determined with formula (41), in which

CAZUL STRĂNGERII SLABE – PRIMA METODĂ

În cazul strângerii slabe, coeficienții de influență ai pachetului de bare se pot determina cu formula (41), în care

$$I(x)=\begin{cases} I_1 = 2I_0 & \text{if / } da\check{c}\check{a} \quad 0 < x \le l_1 \\ I_2 = 2I_0 & \text{if / } da\check{c}\check{a} \quad l_1 < x \le l_2 \\ I_3 = 3I_0 & \text{if / } da\check{c}\check{a} \quad l_2 \le x \le l_3 \end{cases} \tag{48}$$

where the moment of inertia of a bar in the package was introduced,

unde s-a introdus momentul de inerție al unei bare din pachet,

$$I_0 = \frac{b\,h_0^3}{12}. \tag{49}$$

THE CASE OF WEAK TIGHTENING – SECOND METHOD

A more general method for the study of the bar package is based on the observation that the elasticity matrix $[K]$ of a system of elastic bodies mounted in parallel can be obtained by adding the elastic matrices corresponding to each body.

The elasticity matrix of the bar k $(k=1,2,3)$ is linked to the influence coefficients matrix of the same bar by the relation

CAZUL STRĂNGERII SLABE – A DOUA METODĂ

O metodă mai generală de studiu al pachetului de bare, se bazează pe observația că matricea de elasticitate $[K]$ a unui sistem de copuri elastice montate în paralel se obține adunând matricele elastice corespunzătoare fiecărui corp component.

Matricea de elasticitate a barei k $(k=1,2,3)$ este legată de matricea coeficienților de influență a aceleiaşi bare prin relația

$$[K]_k = [\delta]_k^{-1}. \tag{50}$$

It should be noted that, since the lengths of the bars are not equal, the number of sections of discretization differs from one bar to another and, therefore, the dimensions of matrices $[K]_k$ $(k=1,2,3)$ are also not equal. Consequently, in the assemblage of matrix $[K]$ of the system, modified matrices $[K']_k$ will be used, obtained by completing the matrices $[K]_k$ with null lines and columns, corresponding to the sections that are not covered by the concerned bars.

Finally, the matrix of the influence coefficients of the system is determined.

Este de remarcat că, deoarece lungimile barelor sunt diferite, numărul de secțiuni de discretizare diferă de la o bară la alta şi, în consecință, dimensiunile matricelor $[K]_k$ $(k=1,2,3)$ sunt, la rândul lor, diferite. Ca urmare, în compunerea matricei $[K]$ a sistemului se vor utiliza matricele modificate $[K']_k$ prin completarea matricelor $[K]_k$ cu linii şi coloane nule, corespunzătoare secțiunilor neacoperite de barele respective.

În final, se determină matricea coeficienților de influență a sistemului,

$$[\delta] = [K]^{-1}. \tag{51}$$

THE CASE OF STRONG TIGHTENING

In the case of strong tightening, the influence coefficients of the system can be determined with relation (41), in which

CAZUL STRĂNGERII PUTERNICE

În cazul strângerii puternice, coeficienții de influență ai sistemului se pot determina cu formula (41), în care

$$I(x) = \frac{b\,h^3(x)}{12}, \tag{52}$$

where $h(x)$ is given by formulas (36).

unde $h(x)$ este dat de formulele (36).

NUMERICAL STUDY

The numerical study of the vibrations of the beam was performed based of the following values:

STUDIU NUMERIC

Studiul numeric al vibrațiilor sistemului s-a efectuat considerând următoarele valori:

$$l_1 = 0.260\text{m}, \quad l_1 = 0.537\text{m}, \quad l_3 = 0.865\text{m},$$

$$E = 210\text{x}10^9\ \text{N/m}^2, \quad \rho = 7850\,\text{kg/m}^3, \quad b = 0.025\text{m}, \quad h_0 = 0.008\text{m} \quad n = 157.$$

The first 10 circular eigenfrequencies and the corresponding eigenfrequencies in the three analysis cases are presented in Table 1.

Primele 10 pulsații proprii obținute şi frecvențele proprii corespunzătoare in cele trei cazuri de calcul sunt prezentate in tabelul 1.

Table 4

Values of the first 10 circular eigenfrequencies and the corresponding eigenfrequencies

	Weak tightening – first method		Weak tightening – second method		Strong tightening	
i	ω_i [s^{-1}]	f_i [Hz]	ω_i [s^{-1}]	f_i [Hz]	ω_i [s^{-1}]	f_i [Hz]
1	81.97	13.05	82.19	13.08	190.83	30.37
2	359.36	57.19	360.21	57.33	594.58	94.63
3	931.44	148.24	933.19	148.52	1617.09	257.37
4	1867.93	297.29	1870.05	297.63	2864.48	455.9
5	3021.86	480.94	3021.56	480.9	5253.97	836.2
6	4585.05	729.73	4584.61	729.66	7379.12	1174.42
7	6384.88	1016.18	6369.45	1013.73	10653.4	1695.55
8	8528.96	1357.43	8512.19	1354.76	13627.3	2168.85
9	11087.8	1764.68	11061.7	1760.52	18383.6	2925.84
10	13583.6	2161.89	13505.8	2149.52	22522.1	3584.5

EXPERIMENTAL STUDY

The experimental study of the system was performed on the measuring stand shown in Figures 4-16.

STUDIUL EXPERIMENTAL

Studiul experimental al sistemului s-a efectuat cu ajutorul bancului de probă prezentat în figurile 4-16.

Fig. 15 - Measuring Stand

Fig. 16 – Sistem de prindere între bare

A measuring chain with four Bruel&Kjær accelerometers, type 4508 B004, was used, numbered from 0 to 3, an acquisition board NI9233 and a laptop.
Accelerometer 3 was placed at the free end of the bar 3, while accelerometer 0 was placed on bar 1, near the fixing system. Accelerometers 1 and 2 were placed on bars 2 and 3, respectively.
Free vibrations produced by applying percussions on the bar were studied.
The obtained data were processed with LabVIEW program, resulting in the spectra of Figures 7 -7.
The vibrations produced in a free elastic system reveal the

S-a utilizat un lanț de măsură cu patru accelerometre, Bruel&Kjær, tip 4508 B004, numerotate de la 0 la 3, o placă de achiziție NI9233 şi un laptop.
Accelerometrul 3 a fost amplasat în capul liber al barei 3, iar accelerometrul 0 pe bara 1, lângă încastrare. Accelerometrele 1 şi 2 au fost plasate pe barele 2, respectiv 3.
S-au studiat vibrațiile libere, produse prin aplicare unor percuții pe bară.
Datele au fost prelucrate cu ajutorul programului LabVIEW, obținându-se spectrele din figura 7 -7.
Vibrațiile produse într-un sistem elastic liber scot în

eigenfrequencies of the system, that can be identified by the analysis in the frequency domain of the acceleration signals measured in time and recorded.

evidență frecvențele proprii ale sistemului, care pot fi identificate prin analiza în frecvență a semnalelor de accelerație măsurate în timp şi înregistrate.

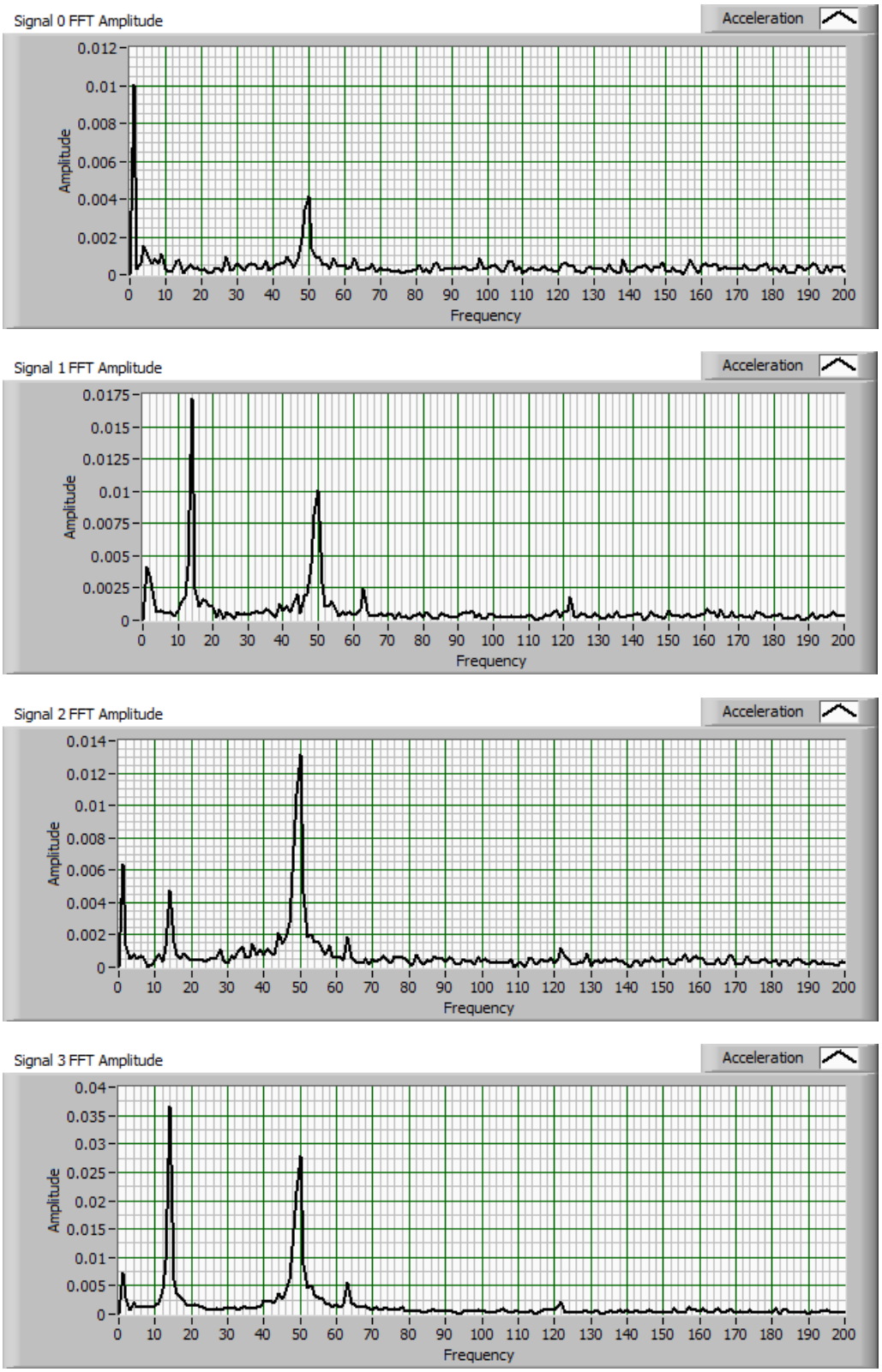

Fig. 17 - Free vibrations spectra – weak tightening

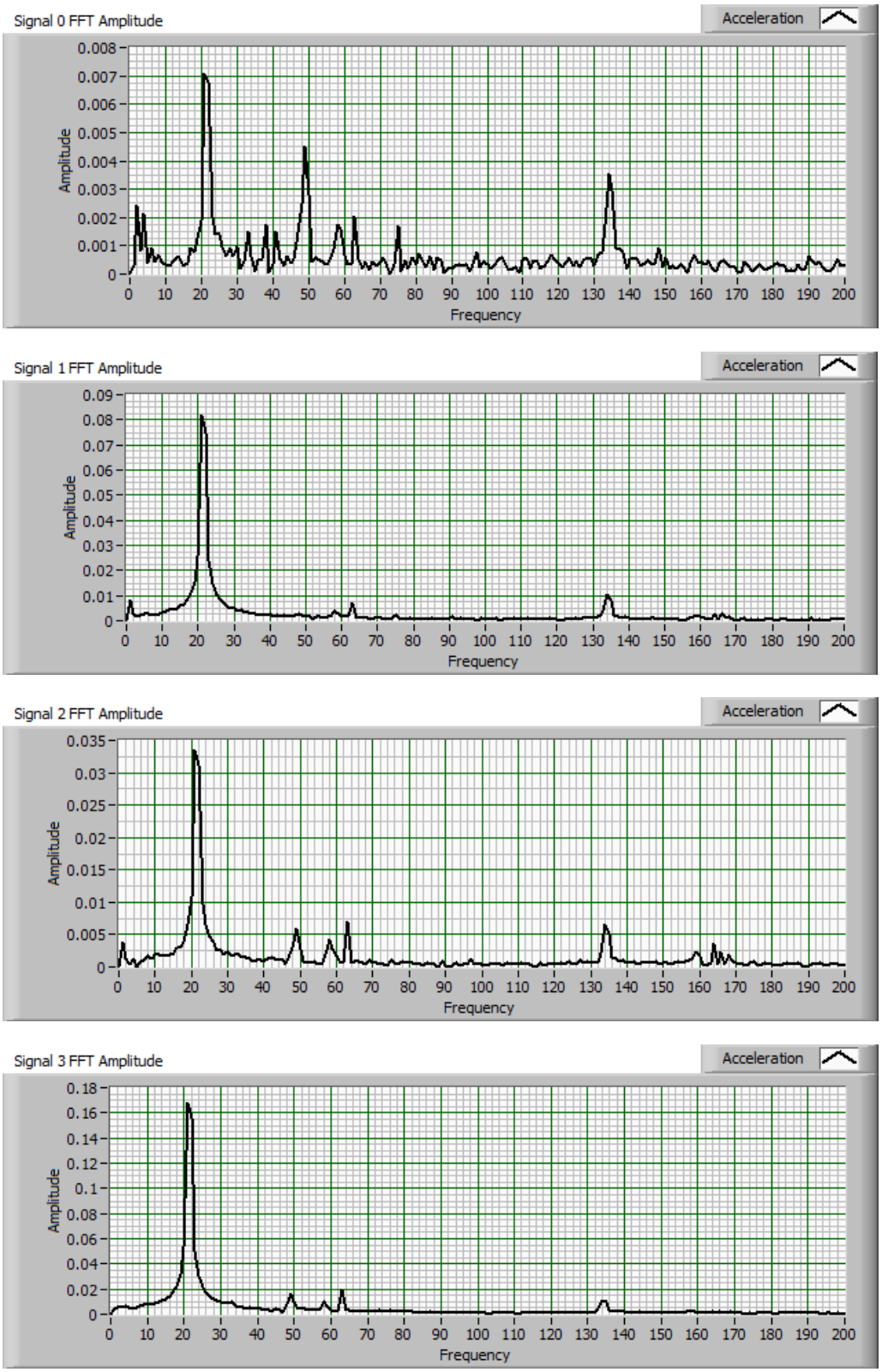

Fig. 18 - Free vibrations spectra – strong tightening

CONCLUSIONS

The paper analyzed the vibrations of a system of superposed bars, used as a model for a leaf spring.

The eigenfrequencies of the bar system were computed numerically for two cases: the case in which the bars can slide on one another and the case in which the system is rigid. In the first case two modalities were proposed for the computation of the influence coefficients, the modalities

CONCLUZII

Articolul a analizat vibrațiile unui sistem de bare suprapuse, utilizat ca model pentru un arc lamelar.

Au fost calculate numeric frecvențele proprii ale sistemului de bare în două cazuri: cel în care barele pot aluneca între ele, respectiv cel în care sistemul este rigid. În primul caz au fost propuse două modalități de determinare a coeficienților de influență, modalitățile furnizând rezultate

providing very close results.
The eigenfrequencies of the bar system were identified also by spectral analysis of the signal measured on an experimental model, for the two above mentioned cases: weak and strong tightening, respectively.
The fundamental eigenfrequency is of a particular interest, as it can lead to the resonance phenomenon, undesirable for transportation means.
By comparative analysis of the numerical and experimental results, respectively, it can be observed that the fundamental frequency determined numerically is very close to the value obtained from spectra, if the bars are superposed with weak tightening. In the case of the strong tightening, the fundamental frequency shown by the spectra is higher, however without reaching the values determined numerically for the rigid model.
The measurements validate the proposed model, for the fundamental frequency, and show that the band in which the fundamental frequency can be identified is situated in the neighborhood of the numerically determined value, translated with a larger value as the rigidity of the leaf spring is greater.
It can be concluded that the eigenfrequencies of a leaf spring depend essentially on the way in which the strips can slide on one another, thus on their state of wear, as well as on their tightening system.

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foarte apropiate.
Frecvențele proprii ale sistemului de bare au fost determinate şi prin analiza spectrală a semnalului măsurat pe un model experimental, în cele două cazuri menționate: strângere slabă şi puternică.
Frecvența proprie fundamentală prezintă un interes deosebit, deoarece poate conduce la fenomenul de rezonanță, nedorit pentru mijloace de transport.
Analiză comparativă a rezultatelor numerice şi a celor experimentale conduce la concluzia că frecvența fundamentală determinată numeric este foarte apropiată de valoarea obținută din spectre, dacă barele sunt suprapuse cu strângere slabă. În cazul strângerii puternice, frecvența fundamentală indicată în spectre are o valoare mai ridicată, dar nu atinge valoarea determinată numeric pentru modelul rigid.
Măsurătorile validează modelul propus, pentru frecvența fundamentală şi arată că banda în care poate fi identificată frecvența fundamentală este situată în vecinătatea valorii determinate numeric, deplasată cu atât mai mult cu cât rigiditatea arcului lamelar este mai mare.
Se poate concluziona că frecvențele proprii ale un arc lamelar depind în mod esențial de felul în care pot aluneca relativ între ele foile arcului, deci de starea lor de uzură, precum şi de sistemul de strângere.

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HYDROLYSIS AND SEPARATION OF LIGNOCELLULOSIC BIOMASS IN A SULPHITE PROCESS TO VALORISE THE MAIN FRACTIONS WITHIN THE BIOREFINERY CONCEPT

HIDRÓLISIS Y SEPARACIÓN DE BIOMASA LIGNOCELULÓSICA EN UN PROCESO AL SULFITO CON EL OBJETO DE VALORIZAR LAS PRINCIPALES FRACCIONES DENTRO DEL CONCEPTO DE BIO-REFINERÍA

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Abstract: *Physico-chemical and biological processes can be used to transform different pulp and paper industries through integrated forest biorefineries in order to valorise all of the main fractions of the lignocellulosic biomass (cellulose, hemicellulose and lignin). In this work, hydrolysis and fractionation processes have been studied in a sulphite pulp mill to obtain not only dissolving pulp from the cellulose but also lignosulphonates from the lignin and fermentation products from the hemicellulose. Delignification and hydrolysis experiments have been carried out at laboratory scale in order to increase the valorisation opportunities and trying to decrease the inhibitors in the final by-product. In addition, detoxification or separation treatments have been developed in order to separate the lignosulphonates and other inhibitors from the sugar substrate.*

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Keywords: *biorefinery, sulphite pulping, hydrolysis, lignosulphonates, sugars, detoxification.*

INTRODUCTION

Biorefinery is the sustainable processing of biomass into a spectrum of marketable products (food, feed, materials, and chemicals) and energy (fuels, power, heat) via biochemical, thermo-chemical, chemical or mechanical processes [14]. In this sense, lignocellulosic biomass, consisting of three major fractions: cellulose (35-50% dry weight), hemicelluloses (20-35%) and lignin (10-25%) [4], shows a high interest in biorefinery and several related industries as pulp and paper mills can be transformed into forest biorefineries [11].

Among the pulping processes, the acid sulphite process is based on the extraction of cellulose by the attack under acidic conditions (pH of 1.35 ± 0.15) in the presence of excess free SO_2 [14]. The main advantages of this process are (i) the production of a high-purity cellulose (dissolving pulp) for not only textile fibre production but also for high value-added films, plastics and coatings among others [14], and (ii) the possibility to obtain a high separation of all of the main components, cellulose, hemicellulose and lignin [7]. In addition, lignosulphonates are formed during the process, showing several applications as plasticizers and additives in construction.

During the first step of the process, due to the

Resumen: *Diferentes procesos físico-químico y biológicos se pueden utilizar para transformar la industria de la pasta y celulosa en bio-refinerías forestales integradas, con el objetivo de valorizar las principales fracciones de la biomasa lignocelulósica (celulosa, hemicelulosa y lignina). En este trabajo se han utilizado diferentes procesos de hidrólisis y fraccionamiento en una industria de pasta celulósica con el fin de obtener no solo la pasta dissolving sino también lignosulfonatos procedentes de la lignina y productos de fermentación de la hemicelulosa. Se han llevado a cabo diferentes experimentos de hidrólisis y deslignificación a escala laboratorio para aumentar las oportunidades de valorización y tratando de disminuir la producción de inhibidores en los sub-productos. Además, se han desarrollado diferentes procesos de detoxificación o separación con el objeto de separar los lignosulfonatos y otros inhibidores del sustrato de azúcar.*

Palabras claves: *bio-refinería, pasteado al sulfito, hidrólisis, lignosulfonatos, azúcares, detoxificación.*

INTRODUCCIÓN

Bio-refinería se conoce como la transformación sostenible de biomasa en un espectro de productos comerciales (alimentos, materiales y productos químicos) y energía (combustibles, electricidad, calor) por medio de procesos mecánicos, químicos. termo-químicos y bio-químicos [14]. En este sentido, la biomasa lignocelulósica que consiste en tres principales fracciones: celulosa (35-50% en masa seca), hemicelulosa (20-35%) y lignina (10-25%) [4], muestra un elevado interés en bio-refinería y muchas industrias como las del sector de pasta y celulosa, pueden ser transformadas en las llamadas bio-refinerías forestales [11].

Entre los procesos de pasteado, el proceso al sulfito ácido está basado en la extracción de celulosa en condiciones ácidas (pH de 1,35±0,15) en presencia de SO_2 libre en exceso [14]. Las principales ventajas de este proceso son (i) la producción de una celulosa de alta pureza (dissolving) que puede utilizarse para la producción de fibras textiles así como para plásticos, films y revestimientos entre otros [14], y (ii) la posibilidad de obtener una gran separación de los principales componentes, celulosa, hemicelulosa y lignina [7]. Además, durante el proceso se forman lignosulfonatos, mostrando diversas aplicaciones como plastificantes y aditivos en construcción.

Durante la primera etapa del proceso, debido a la

heterogeneous nature of the lignocellulosic biomass, in addition to sugars, other decomposition products can be obtained and they can act as inhibitors in the fermentation process. Therefore, detoxification processes should be added to the process to valorise all of the fractions and to decrease the quantity of inhibitors [4].

In this work, a sulphite pulp mill is studied in order to be transformed into a forest biorefinery. Delignification, hydrolysis and detoxification processes have been developed in order to separate the three main fractions: lignosulphonates from the lignin, dissolving pulp from the cellulose and sugars from the hemicellulose.

MATERIALS AND METHODS

Industrial samples from a sulphite pulp mill in the north of Spain (Torrelavega) have been used. Free, total and combined SO_2 were determined according to the titration method Tappi T604 with iodine and sodium hydroxide. Sugar content (glucose, xylose, arabinose, rhamnose and galactose), acids (acetic, levulinic and formic) and other decomposition products (furfural and hydroxymethyl furfural) were measured by a Shimadzu Prominence HPLC with SHODEX SH1011 and CHO-782 columns and Refraction Index detector according to Llano et al. [7] method using 0.5mL/min of 0.005M H_2SO_4 as a mobile phase, 60ºC in the oven and 198 psi of column pressure. Metals Mg^{+2} and Ca^{+2} were analysed by flame atomic absorption spectrometer; and UV-Vis spectrophotometer was used for low molecular phenolics and lignosulphonates. All samples were analysed in triplicate.

Hydrolysis and delignification experiments were carried out in 1-liter digesters. Overliming experiments with $Ca(OH)_2$ or NH_4OH were conducted in 250 mL erlenmeyer flasks at different pHs, times and temperatures. Granular activated carbon and powdered black carbon were used in the adsorption treatments. On the other hand, Dowex 50WX2 cation exchange resin in H^+ form and Amberlite IRA-96 anion exchange resin in OH^- form were used according to Fernandes et al. [11]. Experiments were carried out at batch mode in a rotary shaker at 60 rpm, room temperature at different settling times.

RESULTS AND DISCUSSION

Figure 1 shows the chemical characterisation of the spent liquor obtained in the factory as a first step to study the possibilities to be transformed in a forest biorefinery [13]. The liquor is composed mainly of lignosulphonates (~60%) and sugars (~35%). Based on the obtained chemical composition of the spent liquor, a literature search was carried out to establish the possible valorisation options. According to the studied references, the detoxification methods and the current processes, the main valorisation options for the spent liquor are the production of lignosulphonates, xylitol, ethanol, polyhydroxybutyrate, polybutylene-succinate, furfural and/or hydrogen. In addition, other minority alternatives can be acetic acid, methanol and vanillin [13].

naturaleza heterogénea de la biomasa lignocelulósica, además de azúcares, se forman otros productos de descomposición que pueden actuar como inhibidores en el proceso de fermentación. Por lo tanto, con el objeto de valorizar las principales fracciones, se deben añadir diferentes procesos de detoxificación para disminuir la cantidad de inhibidores [4].

En este trabajo se ha estudiado la transformación de una empresa de celulosa al sulfito en una bio-refinería forestal. Para ello, se han estudiado diferentes procesos de detoxificación, hidrólisis y deslignificación, con el objetivo de separar las tres fracciones principales: lignosulfonatos de la lignina, pasta dissolving de la celulosa y azúcares de la hemicelulosa.

MATERIALES Y MÉTODOS

Las muestras industriales se han obtenido de una empresa de celulosa en el normte de España (Torrelavega). SO_2 total, libre y combinado se ha determinado a través del método Tappi T604 de titración con hidróxido sódico y yodo. El contenido en azúcares (glucosa, xilosa, arabinosa, ramnosa y galactosa), ácidos (acético, levulínico y fórmico) y otros productos de descomposición (furfural e hidroximetilfurfural) fueron analizados mediante HPLC Schimadzu Prominence utilizando columnas SHODEX SH1011 y CHO-782 y con detector de índice de refracción, de acuerdo al procedimiento de Llano et al. [7], utilizando 0.005M H_2SO_4 a 0.5 mL/min como fase móvil, 60ºC de temperatura y 198 psi de presión en la columna. Los metales Mg^{+2} y Ca^{+2} fueron analizados por absorción atómica y los lignosulfonatos y compuestos fenólicos de bajo peso molecular mediante espectrofotometría UV-Visible. Todas las muestras fueron analizadas por triplicado.

Los experimentos de hidrólisis y deslignificación fueron llevados a cabo en digestores de 1 litro. En el caso de los experimentos de overliming con $Ca(OH)_2$ o NH_4OH, se utilizaron frascos Erlenmeyer de 250 mL a diferentes pHs, tiempos y temperaturas. Los tratamientos de adsorción fueron realizados con carbón activo granular y negro de humo. Por otro lado, como resinas de intercambio se utilizaron Dowex 50WX2 para el intercambio catiónico en forma de H^+ y Amberlite IRA-96 para el intercambio aniónico en forma OH^-, basándose en los resultados de Fernandes et al. [11]. Todos los experimentos fueron realizados en modo batch en un equipo de rotación de laboratorio a 60 rpm, temperatura ambiente y a diferentes tiempos de mezclado.

RESULTADOS Y DISCUSIÓN

La Figura 1 muestra la caracterización química del licor gastado obtenido en la fábrica, como primer paso para el estudio de las posibilidades de ser transformar la fábrica en una bio-refinería forestal [13]. El licor está compuesto principalmente por lignosulfonatos (~60%) y azúcares (~35%). Posteriormente se llevó a cabo un estudio bibliográfico para establecer las posibles vías de valorización basado en esta composición química. De acuerdo a las referencias estudiadas, las principales opciones de valorización del licor gastado son la producción de lignosulfonatos, xylitol, etanol, polihidroxibutiratos, polibutileno-succinatos, furfural y/o hidrógeno. Además, otras alternativas minoritarias pueden ser el ácido acético, metanol y vainillina [13].

In order to optimise the valorisation options of the factory, the second step was the study of the delignification process, maximising the quantity of sugars and lignosulphonates and minimising the inhibitors in the spent liquor. A set of digestion experiments were carried out at laboratory scale in 1-liter digesters. Different process variables were modified with this purpose: total SO_2 content of fresh liquor, fresh liquor-to-wood ratio, heating rate and maximum temperature. Heating rate affects the depolymerisation grade and the sugars content in spent sulphite liquors, whereas total SO_2 and maximum temperature affect the delignification grade and consequently the lignosulphonates of the liquor.

Con el objetivo de optimizar las opciones de valorización de la fábrica, el Segundo paso fue el estudio del proceso de deslignificación, maximizando la cantidad de azúcares y lignosulfonatos y minimizando los inhibidores del licor gastado. Para ello, se llevaron a cabo diferentes experimentos de digestión a escala de laboratorio en reactores de 1 litro. Las variables que fueron modificadas en el proceso son: el contenido en SO_2 del licor fresco, la relación licor-madera, la curva de calentamiento y la temperatura máxima. La curva de calentamiento afecta al grado de despolimerización y el contenido de azúcares del licor, mientras que la máxima temperatura y el SO_2 afectan el grado de deslignificación y, por tanto, la cantidad de lignosulfonatos en el licor.

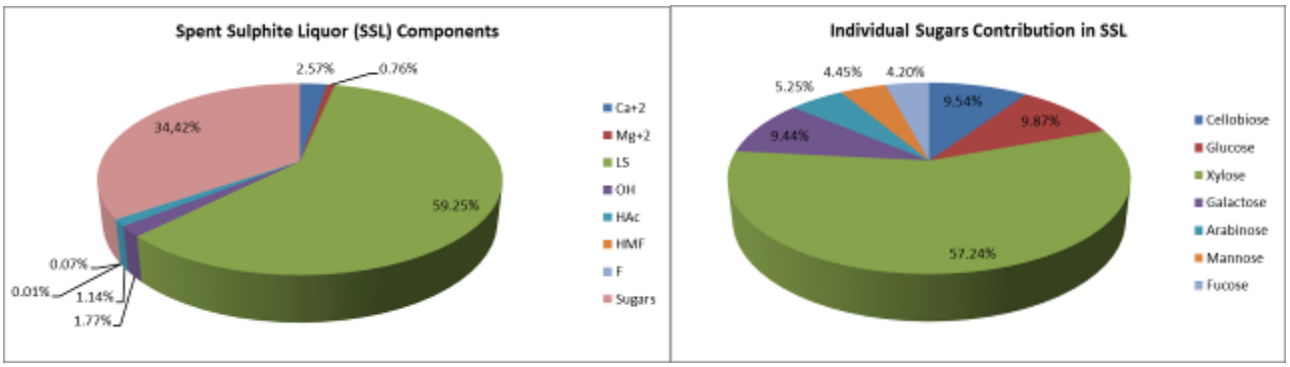

Fig. 1 – Characterisation of the spent sulphite liquor (% w/w). LS (lignosulphonates), OH (phenolics), HAc (acetic acid), HMF (Hydroxymethilfurfural), F(furfural).

The best results were obtained at 150ºC and 20-1 liquor-to-wood ratio, low heating rates and using a total SO_2 content of 6.20% [7, 10]. Once the main variables were optimised, a model of the digestion process was carried out. Maximum release of sugar and the time necessary to obtain it are shown in table 1 with and without pulp with desired quality results. If the digestion process is carried out without obtaining pulp, the maximum release are 49.41% at 130ºC, 37.11% at 140ºC and 32.62% at 150ºC; however, the necessary time for each temperature decrease a lot among them, from 2920 minutes to 770 minutes. On the other hand, to optimise the industrial process it is necessary to use conditions, which do not degrade the pulp and obtain the maximum sugar content in the spent liquor. Therefore, if 150ºC is used as temperature of work, the maximum conversion in total sugar found in the spent liquor would be 19.22%. If the temperature of work is 140ºC the release would be 17.30% and finally for 130ºC would be 21.08% [13].

Los mejores resultados fueron a 150ºC y con una relación licor-madera de 20-1, bajas curvas de calentamiento y utilizando una cantidad de SO_2 inicial de 6,20 % [7, 10]. Una vez que las variables fueron optimizadas, se llevó a cabo el modelado del proceso de digestión. Los resultados de la cantidad de azúcares y el tiempo necesario se muestran en la tabla 1, con y sin obtención de pasta celulosa dissolving de calidad adecuada. Si el proceso de digestión se lleva a cabo sin la obtención de esta pasta, se aumenta hasta un 49,41% a 130ºC, 37,11% a 140ºC y hasta un 32,62% a 150ºC la cantidad de azúcares: sin embargo, el tiempo de proceso necesario para cada temperatura disminuye enormemente entre ellos, desde 2920 minutos hasta 770 minutos. Por otro lado, para optimizar el proceso industrial es necesario utilizar condiciones en las que no se degrade la pasta obtenida y generando la mayor cantidad de azúcares. Por tanto, si se usa 150ºC como temperatura de trabajo, la máxima conversión fue del 19,22%. Si la temperatura es de 140ºC sería de 17,30% y finalmente para 130ºC podría ser de un 21,08% [13].

Table 1

Results of sugar release according to the simulation process

T (ºC)	SUGAR RELEASE (%)	
	With pulp	**Without pulp**
150	19.22 (200min)	32.62 (770min)
140	17.30 (300min)	37.11 (1410min)
130	21.08 (600min)	49.41 (2920min)

Once the digestion process was optimise, the third step was the study of a possible external hydrolysis of

Una vez que el proceso de digestión fue optimizado, el tercer paso fue el estudio de un posible proceso de

the liquor in order to increase the quantity of monomers from the hemicellulose content. In this case, a factorial design of a total of 24 experiments and 3 central points was carried out. Total sugar was calculated as the sum of glucose, xylose, arabinose, mannose and galactose. Inhibitors were weak acids and furfurals [7]. A multiple regression analysis was carried out to obtain the relation among all the variables. The obtained equations were the following: (i) Sugars (g/L)=26.5+0.017·A-13.5·B-0.0053·C-0.0029·D; (ii) Inhibitors (g/L)=8.4+0.036·A-4.41·B+0.0057·C-0.0006·D; (iii) LS (g/L)=96.8-0.0292·A-74.2·B+0.327·C-0.024·D, where A is temperature, B is liquid-to-wood ratio, C is the concentration of SO2 and D time. The regression coefficients were R^2= 92.50%, 90.79% and 84.04%, respectively [7].

Finally, the last step of this work was to study different detoxification options in order to separate both lignosulphonates and sugars and to give a lower concentration of inhibitors in the sugar substrate. Overliming, Ionic exchange resins and adsorption methods were used. Figure 2 shows a comparison among all of the processes. Regarding the total inhibitor removal, most promising techniques are anionic resins at 1.5 mL/g whereas the best selectivity and therefore sugars-to-inhibitors ratio were found using overliming or anionic resin at 6 mL/g. Separation by ionic resins was proposed as the best solution, using a maximum of 6 cycles of regeneration. However, depending on the fermentation process, overliming and/or adsorption techniques can be used [8]. In this sense, an economic evaluation of the processes was performed following standard methods described by Peters et al. [9] and Turton et al. [15]. Table 2 shows the obtained results. The overliming does not appear in the table because its capital investment is low compared to the rest of techniques. It requires a tank which promotes the homogenisation of the $Ca(OH)_2$ and the liquor. According to the Fixed Capital Invested (FCI) results, resins are the best alternative; however, the Manufacturing Costs (COM) are higher when resins are used than adsorption.

hidrólisis externa del licor con el objetivo de aumentar la cantidad de monómeros del contenido de hemicelulosa. En este caso, se realizó un análisis factorial de 24 experimentos y 3 puntos centrales. El contenido de azúcar fue calculado como la suma de glucosa, xilosa, arabinosa, manosa y galactosa y como inhibidores ácidos débiles y furfurales [7]. Para obtener la relación entre las variables, se realizó un análisis de regresión múltiple. Las ecuaciones obtenidas fueron las siguientes: (i) Azúcares (g/L)=26.5+0.017·A-13.5·B-0.0053·C-0.0029·D; (ii) Inhibidores (g/L)=8.4+0.036·A-4.41·B+0.0057·C-0.0006·D; (iii) LS (g/L)=96.8-0.0292·A-74.2·B+0.327·C-0.024·D, donde A es la temperatura, B es la relación líquido-madera, C es la concentración de SO_2 y D el tiempo. Los coeficientes de regresión fueron R^2= 92.50%, 90.79% y 84.04%, respectivamente [7].

Finalmente, la última etapa del trabajo fue el estudio de diferentes opciones de detoxificación para separar los lignosulfonatos de los azúcares y disminuir la cantidad de inhibidores en el sustrato de azúcares. Para ello se utilizaron los procesos de overliming, resinas de intercambio iónico y adsorción. La Figura 2 muestra una comparación de todos los procesos. Teniendo en cuenta la eliminación total de inhibidores, las técnicas más prometedoras son las resinas de intercambio aniónico a 1,5 mL/g mientras que la mayor selectividad y por tanto, la mejor relación azúcares-inhibidores se obtienen utilizando overliming o también resinas de intercambio aniónico pero a 6 mL/g. La separación con resinas fue propuesta como mejor alternativa, utilizando un máximo de 6 ciclos de regeneración de la resina. Sin embargo, dependiendo del proceso de fermentación, overliming o adsorción pueden ser también buenas alternativas [8]. En este caso, se llevó a cabo la evaluación económica de acuerdo a los métodos descritos por Peters et al. [9] y Turton et al. [15]. La Tabla 2 muestra los resultados obtenidos. El proceso de overliming no aparece en los costes fijos porque su coste es mucho menor que el resto, requiriendo únicamente un tanque de homogeneización del licor y el $Ca(OH)_2$. De acuerdo a los costes fijos (FCI), las resinas son la mejor alternativa; sin embargo, sus costes de operación (COM) son mayores que en adsorción.

Table 2

Economical results of the detoxification/separation processes

Detoxification/Separation process	FCI (M€)	COM (M€/year)
Anionic Resins	1.08	5.48
Black Carbon	2.06	2.35
Activated Charcoal	1.55	2.24
Overliming	--	0.11

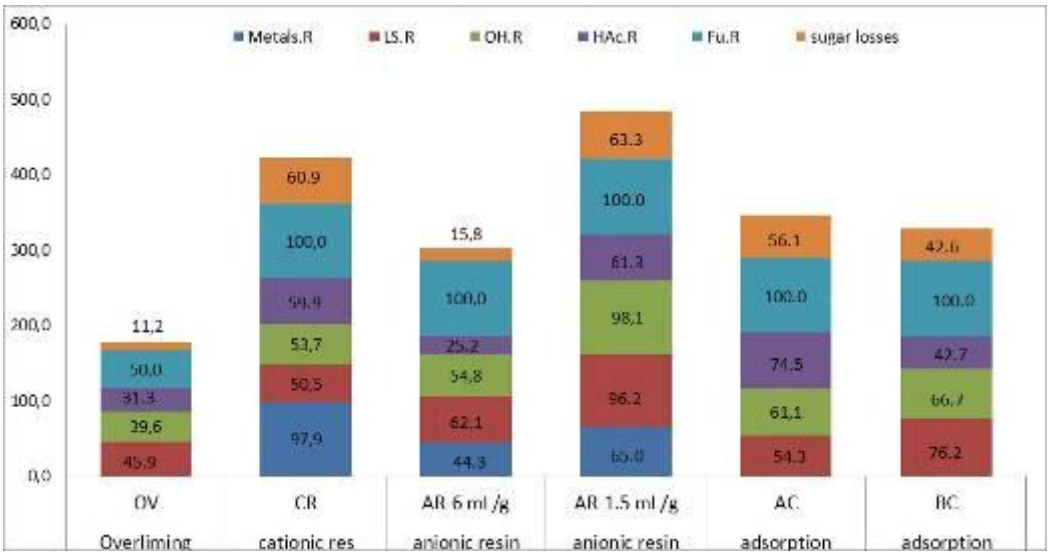

Fig. 4 – Results of detoxification/separation processes
OV (overliming), CR (cationic resin), AR (anionic resin), AC (activated carbon), BC (black carbon)

CONCLUSIONS

In this work, an acid sulphite pulping process has been studied in order to be integrated in a forest biorefinery, obtaining dissolving pulp from the cellulose, lignosulphonates from the lignin and sugars from the hemicellulose. Delignification and hydrolysis experiments have been optimised increasing the valorisation options and decreasing the inhibitors in the liquor. On the other hand, ionic exchange resins are proposed as the best solution to detoxify the sugar substrate and to separate the lignosulphonates; however, an optimisation of the manufacturing costs is recommended in this case.

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CONCLUSIONES

En este trabajo se ha estudiado un proceso al sulfito ácido con el objetivo de ser integrado en una bio-refinería forestal, obteniendo pasta dissolving procedente de la celulosa, lignosulfonatos de la lignina y azúcares de la hemicelulosa. Se han optimizado los procesos de hidrólisis y deslignificación, incrementando las opciones de valorización y disminuyendo los inhibidores en el licor residual. Por otro lado, se propone el uso de resinas de intercambio iónico como mejor opción para la detoxificación del sustrato de azúcares y separación de los lignosulfonatos; sin embargo, se recomienda una optimización de los costes de proceso en este caso.

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PLANNINING OF INTEGRATED SYSTEMS FOR SUPPLY OF NATURAL WATER AND UNCONVENTIONAL RESOURCE IN AGRICULTURE: THE FEASIBILITY OF MUNICIPAL SECONDARY EFFLUENTS REUSE IN IRRIGATION DISTRICTS OF APULIA REGION

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PIANIFICAZIONE DI SISTEMI INTEGRATI PER L' APPROVVIGIONAMENTO DI ACQUE NATURALI E RISORSE IDRICHE NON CONVENZIONALI IN AGRICOLTURA: LA FATTIBILITA' DEL RIUSO DI EFFLUENTI SECONDARI URBANI IN DISTRETTI IRRIGUI DELLA PUGLIA

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Abstract: *Municipal wastewater reuse represents a topic of real interest due to the potential for environmental impact reduction and the availability of "unconventional" water resource. This paper examines some of the main aspects involved in the planning of the reuse of trated secondary effluents in irrigation supply systems which use a primarily "conventional" natural source (surface water and groundwater). To evaluate the feasibility of such an action, the main aspects to be investigated are both tecnhical-operative and economical. In order to make evidence the critical issue and the real potential reuse finalized to supply irrigation district which are localised in semi-arid climate in Mediterranean areas, based on a large review of research described in scientific literature concerning treatment process, three case studies in Apulia region (Southern Italy) have been described and analysed.*

Keywords: *municipal wastewater; secondary effluent; reuse; irrigation; planning; treatment; storage; discharge.*

Sommario: *Il riutilizzo delle acque reflue rappresenta una pratica di attuale interesse per la riduzione dell'impatto ambientale e la disponibilità di risorse idriche non convenzionali. Il presente articolo esamina alcuni dei principali aspetti connessi alla pianificazione del riutilizzo degli effluenti urbani secondari nei sistemi di approvvigionamento irriguo che utilizzano quale risorsa primaria acque naturali estratte dai corpi idrici superficiali e dalla falda. Per valutare la fattibilità di tali interventi, gli aspetti principali da approfondire sono sia tecnico-operativi che economici. Al fine di rendere evidenti le problematiche e le reali potenzialità degli interventi finalizzati ad implementare i distretti di approvvigionamento irriguo localizzati nell'area mediterranea a clima semi-arido, sulla base di un'ampia revisione della letteratura scientifica riguardanti i processi di affinamento, sono stati descritti ed esaminati tre casi di studi in Puglia.*

Keywords: *acque reflue; effluenti secondari; riutilizzo; irrigazione; pianificazione; affinamento; scarico; accumulo.*

INTRODUCTION

Municipal wastewater reclamation represents a real option in water resource management in agriculture, mainly in the country of Mediterranean area, even though it does not make a final contribution to the resolution of the satisfaction of increasing irrigation water demand. In large parte of Southern Italy it has not been widely used due to the availability of good quality water from conventional natural water sources collected in artificial reservoirs and extracted by groundwater.

Irrigation by reuse of treated municipal secondary effluent can be applied by different treatment process and several systems properly distributing water on the agricultural land surface, surface sub-soil and cultivated plants [1, 5, 21]. The most part have been based on the „direct use" of daily effluent flow subject to a tertiary treatment, combined with balance tanks or operating seasonal storage in artificial reservoirs or stabilisation ponds (**Fig. 1**). In this scenario, the integration of municipal wastewater in the water irrigation supply sistems, which use natural water as primary source, assumes an important role. From this perspective, the discharge in surface water bodies and on the surface layer of the soil, in the permitted cases by the law, the seasonal storage in reservoirs with natural water, and the groundwater recharge, constitute an indirect utilisation of

INTRODUZIONE

Il riutilizzo delle acque reflue urbane rappresenta un'efficace pratica nella gestione della risorsa idrica in agricoltura principalmente nei paesi dell'area mediterranea, pur non fornendo un contributo risolutivo per il soddisfacimento della crescente domanda irrigua totale. In ampie parti dell'Italia meridionale, tale risorsa „non convenzionale" non trova utilizzo per la grande disponibilità di acqua di buona qualità provvista dalla risorsa idrica naturale „convenzionale" raccolta e accumulata negli invasi articifiali ed estratta dalla falda.

L'irrigazione mediante il riutilizzo degli effluenti urbani secondari puo' essere appliciato attravers differenti processidi trattamento and diversi sistemi che distribuiscono in maniera adeguata le acque sulla superficie del suolo agricolo e negli strati superficiali del suolo o sulle piante [1, 5, 21]. La gran parte di essi sono basati sull'utilizzo diretto delle portate giornaliere degli effluenti soggetti ad un trattamento di affinamento, combinato con vasche di equalizzazione o operando l'accumulo stagionale in serbatoi artificiali o bacini di stabilizzazione (**Fig. 1**). In questo scenario, assume un ruolo importante l'integrazione delle acque reflue nei sistemi di approvvigionamento irriguo che utilizzano acque naturali quale risorsa idrica primaria. Da questo punto di vista, lo scarico nei corpi idrici superficiali e sugli strati superficiali del suolo, nei casi permessi dalla normativa, l'accumulo stagionale in invasi articiali con acque naturali e le pratiche di ricarica della falda, costituiscono un riuso indiretto delle acque reflue trattate.

treated wastewater. In this case, the consequent degradation of the original water quality must be careflully verified.

The main objective is to maintain standards of safe of public health and to protect operators from infection and illness and to preserve the natural state of water, soil and crops. Considering that the water quality level for reuse is presently determined by normative, in Italy is regulated by *D.M. 185/2003 [7]*, the planning and operation of the municipal wastewater reclamation plants should prevent the control of health and environmental risks [3, 6].

The sanitary risks to health and to the community, can occur when watering is prolonged, is conducted with wastewater with not suitable quality and food crops are irrigated without implementing specific preventive actions. The main health risks are caused by infections caused by pathogens (viruses, bacteria, protozoa and nematodes), and by the accumulation of toxic and harmful substances in products (micro-organic and inorganic pollutants) that enter into the food chain. In order to reduce these risks, even irrigation techniques have to be applied adequately to different crops [10, 14]. The contamination of natural surface waters and groundwater, can be the consequence of spilling or the accumulation of chemical pollutants in soil (nitrates and heavy metals), the eutrophication, creating habitats favorable to the development of diseases.

In order to evaluate the feasibility of an irrigation system based on the reuse of municipal effluents, the cost of infrastructure for wastewater treatment, the daily balance, the eventually seasonal storage and the distribution must be estimated, specifically with the aim to evaluate available alternative sources. The treatment cost is a primary factor to be evaluated but we should consider also the aspects connected to make available the water resource in the agricultural area. Regarding this aspect, it is significant to verify the fraction of total irrigation water demand which can be covered by reused wastewater.

MATERIAL AND METHOD

INNOVATION IN WASTEWATER TREATMENT FOR REUSE IN AGRICULTURE

The choice of treatment processes to be taken depends on the type of pollutants present in the wastewater under the technic and economic point of view. Currently the treatment layout is still widely operated in water treatment systems based on activated sludge in which conventional pollutants are removed (such as total suspended solids, BOD, COD, macro-nutrients, colloidal solids, bacteria, cysts, protozoa, viruses). In order to allow the irrigation reuse, the configurations of secondary effluent treatment involve the use of stages in series of tertiary treatments such as chemical precipitation, flocculation, sand filtration adsorption on active carbon microfiltration, reverse osmosis [8, 18]. The applications of advanced techniques introduce technical solutions that employ processes of membrane filtration [2, 11, 16] and advanced oxidation and disinfection [13, 15, 17].

Regarding to the definition of the optimal treatment,

In questi casi, la degradazione della qualità delle acque naturali va attentamente esaminata.

Il principale obiettivo è mantenere gli standard di sicurezza della salute pubblica e proteggere gli operatori da infezioni e malattie e preservare lo stato naturale delle acque, dei suoli e delle coltivazioni. Considerato che il livello di qualità per il riutilizzo è prescritto sul territorio nazionale dalla normativa vigente (*D.M. 185/2003*) [7], le pratiche di riutilizzo dei reflui urbani devono prevenire il rischio igienico-sanitario e ambientale oltreche rispondere alle questioni impiantistiche e tecnico-gestionali [3, 6].

I rischi igienico-sanitari per la salute e per le comunità, possono presentarsi quando l'irrigazione è prolungata, viene condotta con acque reflue di qualità non idonea e le colture alimentari sono irrigate senza attuare specifiche azioni di prevenzione. I principali rischi sanitari sono causati dalle infezioni causate da agenti patogeni (virus, batteri, protozoi e nematodi), e dall'accumulo nei prodotti coltivati di sostanze tossiche e nocive (micro-inquinanti organici e inorganici) che entrano nella catena alimentare. Al fine di ridurre questi rischi, anche le tecniche di irrigazione devono essere applicate adeguatamente alle differenti coltivazioni [10, 14]. La contaminazione delle acque naturali, superficiali e sotterranee, puo' avvenire in seguito allo sversamento e all'accumulo di inquinanti chimici nel suolo (nitrati e metalli pesanti), l'eutrofizzazione delle acque, la creazione di habitat favorevoli allo sviluppo di malattie.

Al fine di valutare la fattiblità di un sistema di irrgazione basato sull'utilizzo degli effluenti urbani, i costi delle infrastrutture per i trattamenti, l'equalizzazione delle portate giornaliere, l'eventuale accumulo stagionale e di distribuzione devono essere stimati, in particolare in funzione di valutare soluzioni alternative basate su altre risorse disponibili. Il trattamento, la cui soluzione impiantistica dipende dalla qualità richiesta negli effluenti dalla normativa, è senza dubbio l'aspetto primario ma non vanno trascurati gli aspetti connessi a rendere effettivamente disponibile la risorsa idrica. A tal riguardo è significativo verificare la frazione della domanda irrigua complessiva e l'area agricola che il volume dei reflui utilizzabili contribuisce a soddisfare e irrigare.

MATERIALI E METODI

INNOVAZIONE NEL TRATTAMENTO DEI REFLUI URBANI PER IL RIUTILIZZO IRRIGUO

La scelta dei processi di trattamento da adottare dipende dal tipo di inquinanti presenti nel refluo e dalla convenienza tecnico-economica. Il trattamento ai fini dello smaltimento in corpo idrico ricettore viene ancora oggi diffusamente operato in impianti di depurazione basati su schemi a "fanghi attivi" nei quali sono rimossi gli inquinanti convenzionali (solidi sospesi totali, BOD, COD, macro-nutrienti, solidi colloidali, batteri, cisti, protozoi, virus). Al fine del riutilizzo irriguo, le configurazioni di trattamento degli effluenti secondari prevedono l'utilizzo di stadi in serie di trattamenti terziari quali chiariflocculazione precipitazione chimica, filtrazione su sabbia adsorbimento su carboni attivi microfiltrazione osmosi inversa [8, 18]. Le applicazioni delle tecniche avanzate introducono soluzioni impiantistiche che impiegano processi di filtrazione su membrane [2, 16] e processi avanzati di ossidazione e disinfezione [13, 15, 17].

Riguardo la definizione ottimale del trattamento, si deve evidenziae che, oltre i composti patogeni e nocivi per l'ambiente, i processi di trattamento comunemente applicati tendono a rimuovere la sostanza organica e gli

we must consider that, besides the pathogens and harmful compounds to the environment, treatment processes commonly applied tend to remove the organic substance and the macro-nutrients elements (nitrogen, phosphorus), useful to the practice of ferti-irrigation. In this respect, the irrigation using municipal wastewater can replace or partially reduce the practice of use the industrial fertilizers. The current legislation provides that in the case of recovery the wastewater for irrigation, the nutrients such as nitrogen and phosphorus, can find only a partial abatement instead of a strong removal to the levels requested for the direct discharge to surface water bodies, in order to prevent the eutrophication. This aspect allows a simplification of secondary treatments with the review process of nitro-denitro and chemical precipitation.

For the removal of non-conventional pollutants (VOC, metals, surfactants, total dissolved solids, refractory organic substances) further processes such as adsorption on activated carbon, ion exchange, desorption of gas, distillation, are used. The problems more recently highlighted are connected to the recognition in the wastewaters of emerging pollutants (drugs and antibiotics, sex hormones, steroids, drugs, detergents, endocrine disruptors). In this regard, only just over 60% of drugs residues present in urban effluents are removed in the activated sludge process, generating a growing level of alarm. Contaminants such as xenobiotic compounds (or ECDs) can cause diseases of the endocrine system. Several processes can be applied in order to treat these pollutants, although the yields of removal should be determined with specific investigations.

elementi macro-nutrienti (azoto, fosforo), utili alla pratica della ferti-irrigazione. A tal merito, si osserva che l'irrigazione con ii reflui urbani puo' sostituire o parzialmente ridurre la pratica di impiego di fertilizzanti industriali. La normativa piu' recente prevede che nel caso di recupero irriguo delle acque reflue, le sostanze, nutritive quali azoto e fosforo, possono trovare una parziale riduzione, invece, che essere rimosse ai livelli richiesti per lo scarico nei corpi idrici superficiali ai fini della prevenzione dei fenomeni di eutrofizzazione. Cio' consente una semplificazione dei trattamenti secondari con la revisione dei processi nitro-denitro e di precipitazione chimica.

Per la rimozione di inquinanti non convenzionali (VOC, metalli; tensioattivi; solidi totali disciolti; sostanze organiche refrattarie) trovano applicazione ulteriori processi quali l'adsorbimento su carboni attivi, lo scambio ionico, il desorbimento dei gas, la distillazione. Le problematiche evidenziate piu' di recente sono tuttavia connesse al riconoscimento nelle acque di inquinanti emergenti (farmaci e antibiotici; ormoni sessuali; steroidi; droghe; detersivi; prodotti industriali; distruttori endocrini). A tal riguardo, si rileva che solo poco più del 60% dei farmaci residui presenti neglie effluenti urbani sono rimossi nel processo a fanghi attivi, generando un crescente livello di allarme. Contaminanti quali i composti xenobiotici (o ECDs) sono causa di malattie del sistema endocrino. Numerosi processi possono applicarsi per il trattamento di questi inquinanti, seppure i rendimenti di rimozione vadano determinati con indagini specifiche.

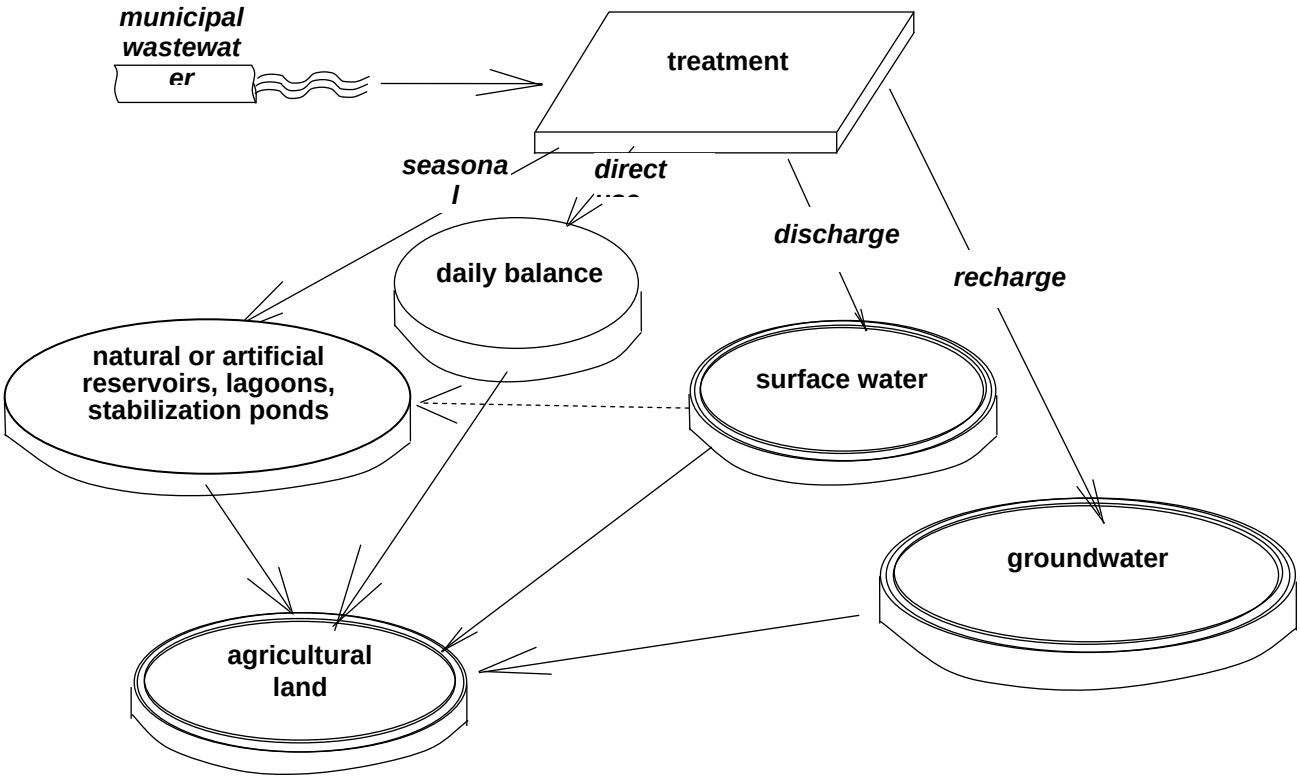


Fig. 1 - Patterns for municipal wastewater recovered for agricultural land.

INTEGRATED SYSTEMS FOR AGRICULTURAL REUSE OF MUNICIPAL SECONDARY EFFLUENT

SISTEMI INTEGRATI PER IL RIUSO AGRICOLO DEGLI EFFLUENTI URBANI SECONDARI

In the Mediterranean EU Countries, the WWTPs have usually a medium-low capacity, up to 40,000-50,000 eq. inhab. The reuse of water resources in agriculture using the treated effluents is often limited by a scale effect which does not make it economically sustainable, in particular when the WWTPs are located far from each other.

The integration of the volumes of urban wastewater in irrigation systems can behave locally, considering a stage of refinement at the service of the individual treatment plants. On a wider regional scale, when in a local site the treated wastewater is not convenient, the return of the wastewater to the environment, through an appropriate work discharge to surface water bodies can be expected, and a suitable controlled catchment downstream system through a monitoring of water quality can be implemented.

In other way, when the WWTPs are not far each other and the altimetric elevations are suitable, the common reuse using a single site where convey all treated effluent may be convenient. The realization of such a system requires high costs of investment and operation for the hydraulic infrastructures related to the adduction of wastewater, in addition to the problems connected to the treatment for achieve the required levels of effluent quality. When, in order to provide greater volumes of useful resource to be allocated to the agricultural reuse, we operate a seasonal accumulation of wastewater in the irrigation period, we can have the problems related to the maintenance of a proper water quality in the infrastructures for storage, transport and distribution of water.

These systems become particularly feasible when the seasonal increase in potential due to the accumulation of the wastewater in the periods without irrigation can be obtained by arranging a storage capacity in the agricultural areas. In that case, during irrigation periods the practical solution provides that refined wastewater are directly used, while in the non irrigation periods, the secondary effluents, also not refined, are stored in the reservoir. In this case we have to consider and compare the opportunity to treat the effluent in centralized WWTPs instead of to treat these waste in single municipal plants.

At local scale, in the case of small WWTPs with low capacity, not more than 20000 eq. inhab., for the irrigation of selected crops the use of installations which operate secondary effluent treatment and which can allow to combine the functions of offsetting daily flow of wastewater can be foreseen [4, 9, 12, 19, 20]. These plants consist of channels in series, in which are conducted chemical and physical processes of clear-flocculation and disinfection by chlorination, with the addition of hypochlorite or chlorine gas, or UV radiation (**Fig. 2a**).

These channels are made up of a series of appropriately water proofed excavated or banked channels provided with proper electro-mechanical facilities. The channels have a volume useful to balance the daily wastewater flow.

The secondary effluent arrives in a small tank where is a reagent mixing before coagulation; effluents pass in the first channel in which are carried out the flocculation and

Nei paesi comunitari delle aree mediterranee, gli impianti di depurazione presentano potenzialità medio-basse, fino a 40.000-50.000 a.e.. Il riuso in agricoltura della risorsa idrica costituita dagli effluenti trattati di questi impianti è spesso limitata da un effetto scala che non rende economicamente sostenibile l'intero sistema infrastrutturale. Tale situazione è talvolta resa piu' complessa dipsersione di questi impianti sul territorio.

L'integrazione dei volumi di acque reflue urbane nei sistemi irrigui puo' condursi localmente, prevedento uno stadio di affinamento a servizio dei singoli impianti di depurazione. Su una scala territoriale piu' ampia, allorquando l'utilizzo in un sito locale non sia conveniente, puo' prevedersi la restituizione delle acque reflue all'ambiente, mediante un'idonea opera di scarico nei corpi idrici superficiali e puo' pianificarsi un opportuno sistema controllato di captazione a valle attraverso un'attività di monitoraggio della qualità delle acque. In altra maniera, presentandosi distanze non elevate tra piu' impianti di depurazione e avendosi quote altimetriche idonee, può risultare conveniente un riuso congiunto utilizzando un unico sito sul quale convogliare tutti gli effluenti trattati per il riuso. La realizzazione di un tale sistema richiede costi elevati di investimento e di esercizio per le infrastrutture idrauliche di adduzione dei reflui, oltre alle problematiche connesse al trattamento per il raggiungimento dei livelli richiesti di qualità degli effluenti. Allorquando, al fine di disporre di maggiori volumi utili della risorsa da destinare al riuso, si operi un accumulo stagionale delle acque reflue nel periodo non irriguo, si presentano le problematiche correlate al mantenimento della qualità delle acque idonea nelle opere di trasporto, accumulo e distribuzione. Questi sistemi diventano particolarmente fattibili quando l'incremento di potenzialità derivante dall'accumulo stagionale dei reflui nei periodi non irrigui possa ottenersi disponendo di una capacità di invaso nell'areee agricole. In tal caso, la soluzione operativa prevede che nei periodi irrigui i reflui affinati vengano impiegati direttamente mentre nei periodi non irrigui gli effluenti secondari, anche non affinati, siono accumulati nell'invaso. A tal fine, si evidenzia che deve analizzarsi l'opportunità di effettuare il trattamento di affinamento in impianti centralizzati ovvero presso i singoli impianti comunali.

A scala territoriale locale, nel caso di piccoli impianti di depurazione di bassa potenzialità, non superiore a 20000 a.e., per l'irrigazione di coltivazioni selezionate può prevedersi l'utilizzo di impianti che operano il trattamento degli effluenti secondari e che possono consentire di combinare le funzioni di compenso delle portate giornaliere dei reflui [4, 9, 12, 19, 20]. Questi impianti sono costituiti da canali in serie, nei quali sono condotti processi chimico-fisici di chiari-flocculazione e disinfezione mediante clorazione, con aggiunta di ipoclorito o cloro gas, o radiazioni UV (**Fig. 2a**).

I canali sono provvisti di volumi idonei a realizzare le funzioni di equalizzazione e accumulo giornaliero; costruiti in scavo o in rilevato, sono opportunamente impermeabilizzati e adeguatamente provvisti delle necessarie opere elettro-meccaniche.

L'effluente secondario giunge in una vasca di piccole dimensioni dove si opera il mescolamento dei reagenti di coagulazione; i reflui passano nel primo canale nel quale si opera la flocculazione e la sedimentazione; nel secondo canale le acque sono chiarificate e si opera la raccolta dei fanghi sedimentati estratti mediante tubazioni forate disposte sul fondo collegate ad una pompa pneumatica; nel terzo canale si opera la fase di disinfezione; nel caso della clorazione la zona iniziale del

sedimentation; in the second channel the waters are clarified and the settled sludge are collected using perforated pipes laid on the bottom connected to a pneumatic pump; in the third channel there is the disinfection phase; in the case of chlorination the initial zone of the third channel operates as a tub of contact and in the terminal part the extraction of the effluent by means of a lifting plant is carried out. Effluent is supplied to the irrigation network.

The feasibility of these systems requires careful consideration. A convenient application of these effluents can be obtained in irrigation systems that operate the sub-irrigation and can find a proper application for irrigation of golf grounds. These plants constitute a control stage of the efficiency of treatment made by WWTPs and can be conveniently used as recovery plants [7].

Such a plant could be used also as post-treatment of secondary effluent at the discharge site where a proper land surface and soil morphology is available. The channels can be positioned in a cascade mode. Also, a sand infiltration basin of suitably dimension could be evaluated after a clariflocculation stage (**Fig. 2b**).

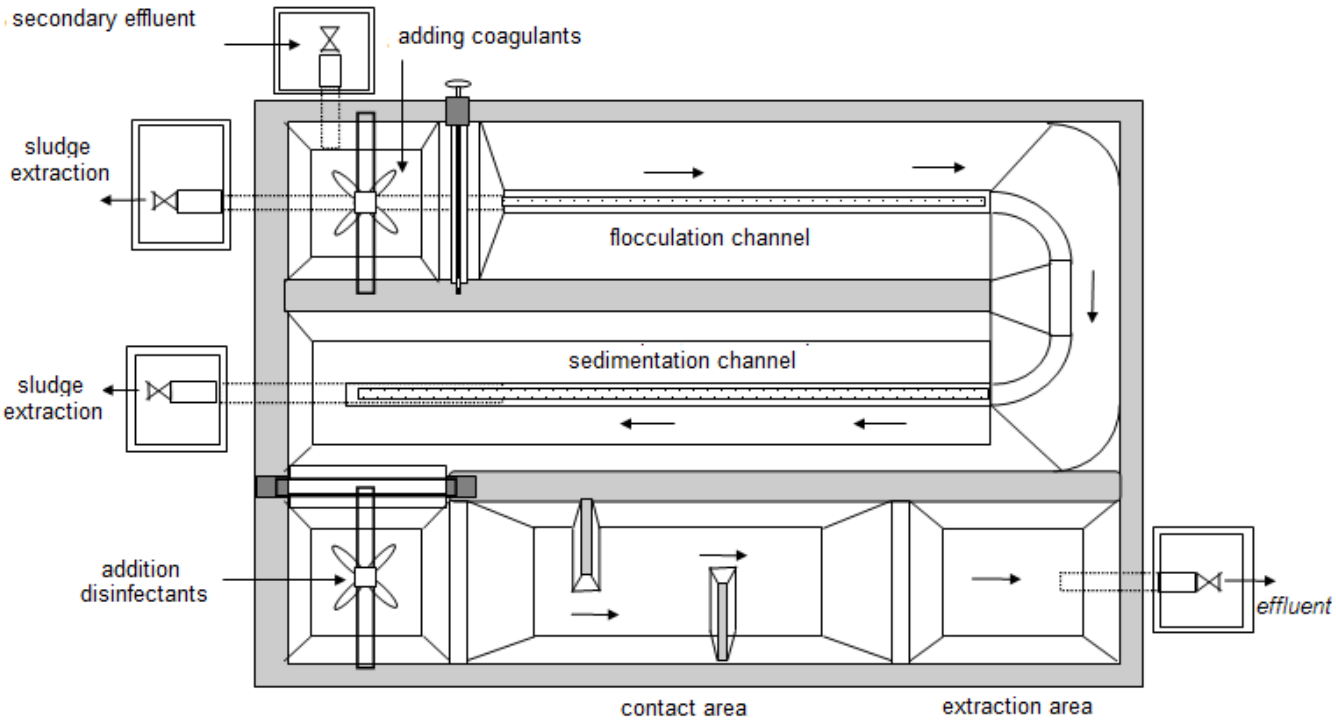
The inclusion of phytoremediation units that perform processes of phytoremediation with superficial or subsurface flow, can be considered in order to give suitable characteristics to the discharge and to maintain an adequately good quality status of the water body to be used for irrigation.

terzo canale opera come vasca di contatto e nella parte terminale si effettua l'estrazione dell'effluente mediante un impianto di sollevamento. L'effluente è quindi alimentato alla rete di distribuzione.

La fattibilità di questi impianti va attentamente valutata. Una conveniente applicazione degli effluenti può essere ottenuta in sistemi irrigui che operino la sub-irrigazione e possono trovare utilizzo per l'irrigazione di campi da golf. Questi impianti costituiscono uno stadio di controllo dell'efficienza di trattamento dell'impianto di depurazione e possono essere convenientemente utilizzati in impianti a recupero [7].

Una tale soluzione impiantistica potrebbe essere valutata anche come post-trattamento degli effluenti secondari a valle dell'opera di scarico, laddove una idonea superficie e un'adeguata morfologia del terreno è disponibile. I canali possono essere disposti in una configurazione a cascata. Anche un bacino di infiltrazione su sabbia potrebbe essere previsto a valle di uno stadio di chiari-flocculazione (**Fig. 2b**).

L'inserimento di unità che realizzano processi di fito-depurazione, a flusso superficiale o a flusso sommerso, puo' essere esaminato al fine di conferire agli effluenti urbani caratteristiche idonee allo scarico e a mantenere opportunamente un buono stato di qualità del corpo idrico ricettore ai fini dell'estrazione da esso di opportuni volumi a fini irrigui.



(*a*)

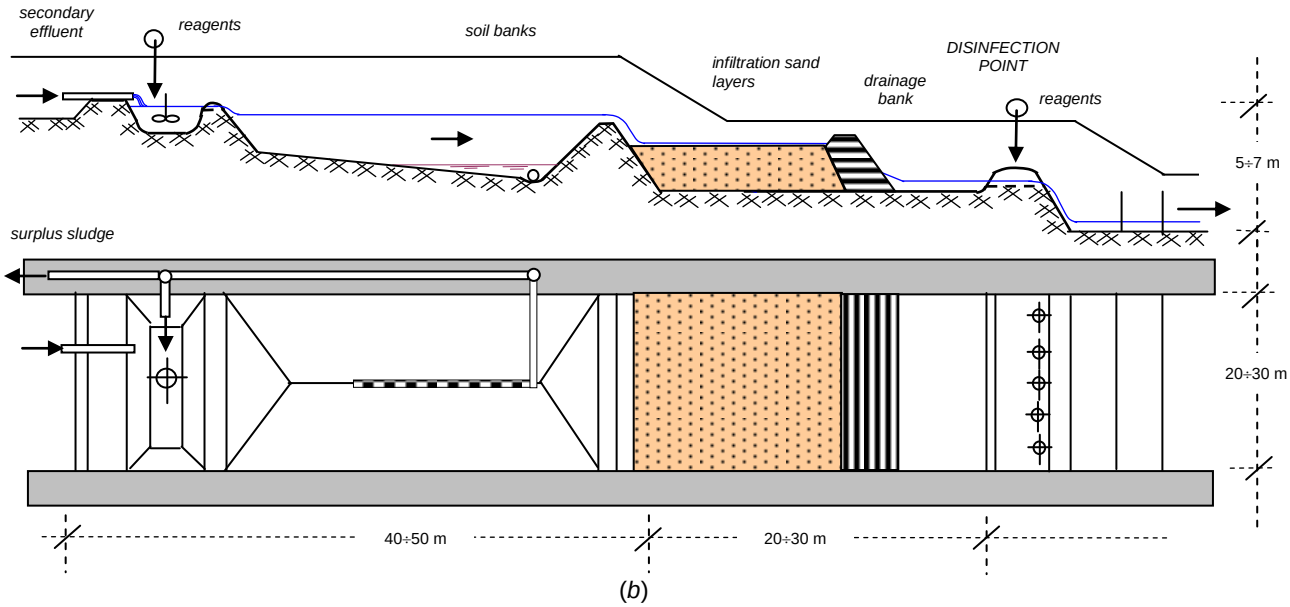


Fig. 2 - Combined plant with channels in series for post-treatment of municipal secondary effluent: (a) plant for irrigation reuse; (b) plant for surface water discharge [5].

RESULTS
REUSE OF TREATED MUNICIPAL WASTEWATER IN IRRIGATION DISTRICT IN APULIA REGION

Reuse of treated municipal effluents in large irrigation district of Tavoliere delle Puglie

Tavoliere delle Puglie is a vast plain located in the province of Foggia, in the north of Apulia region (Southern Italy) with a population of around 500,000 inhabitants. It is one of the main agricultural zone of the country covering a surface of more than 400,000 hectares. Irrigated crops represents the principal sector of the local economy in terms of both agricultural production and employment.

The satisfaction of the increasing water demand, will pose an important challenge for local planning authorities. *Tavoliere delle Puglie* constitutes a typical Mediterranean area and the water resource management should take in account scarcity of natural surface water and rainfall in spring and summer.

Main water source of potable and irrigation uses is represented by accumulation of natural water in the numerous articificial reservoirs: Occhito along the Fortore river, Capacciotti" and Osento in the watershed of the Ofanto River and along the Celone river. Locally, groundwater is diffusely used by farmers and for limitated industrial uses.

Many vegetal species and crops have been cultivated: arboriculture is applied with olive, grape and peache, and some herbaceae are very diffuse. The industrial transformation and commercial distribution of agricultural products involves intensive cultivation of spring-summer crops such as tomatoes, sugar cane, pepper and water melons, and vegetables such as cauliflowers, brussels sprouts, celery, fennel and lettuce produced in autumn-winter. Perennial crops include asparagus and artichokes.

At the present, in the area which is managed by the main operator, the Consorzio di Bonifica della Capitanata, an area of 140.000 hectares have been served by irrigation works, realized in two districts: the larger district, "Fortore", in the north with a 102,000 hectares irrigated surface; the water resource is mainly consituted by the Occhito reservoir; in the south, the district "*Sinistra Ofanto*", with 38,000 hectares irrigated surface, utilising

RESULTATI
RIUTILIZZO DI REFLUI URBANI TRATTATI IN DISTRETTI IRRIGUI DELLA PUGLIA

Riuso degli effluenti urbani trattati in grandi distretti irrigui del Tavoliere delle Puglie

Il *Tavoliere delle Puglie* è una vasta pianura situata nella provincia di Foggia, nel nord della Puglia con una popolazione di oltre 500000 abitanti e costituisce una delle principali zone agrigole del paese estendendosi per una superficie di oltre 400000 ettari. Le coltivazioni irrigue rappresentano il principale settore dell'economia locale in termine di produzione agricola e impiego.

Il soddisfacimento della crescente domanda irrigua, impone un importante sfida" will per le autorità locali e di gestione del territorio. Il *Tavoliere delle Puglie* rappresenta una tipica area mediterraneo e la gestione della risorsa idrica deve rispondere alla scarsità di acque naturali superficiali e delle precipitazioni nel periodo primaverile-estivo.

Le principali risorse idriche per l'utilizzo potabile e irriguo sono rappresentate dalle acque naturali accumulate nei numerosi bacini articificiali: gli invasi di Occhito lungo il fiume Fortore, Capacciotti and Osento nel bacino del fiume Ofanto e lungo il torrente CeloneLocalmente, la fada idrica è sfruttata dagli agricoltori e per i limitati usi industriali.

Molte specie vegetali sono coltivate: l'arboricoltura è presente principalmente con olivo, vite e pesche, e molto diffusa è la coltivazione delle erbaceae. Le attività di trasformazione industriale e la commercializzazione dei prodotti agricoli interessa le raccolte primaverili-estive di colture itnensive quali pomodori, peperoni, meloni e canna da zucchero, e autunnali-invernali degli ortaggi quali cavolfiore, cavoletti di brussels, sedano, finocchio e lattuga. Le tipiche coltivazioni annuali includono l'asparago e il carciofo.

Attualmente, nell'area gestita dal principale gestore, il Consorzio di Bonifica della Capitanata, gli impianti irrigui servono un area di circa 140.000 ettare, organizzati in due distetti: il piu' grande, denominato "Fortore" nel nord, ha una superficie irrigabile di circa 100.000 ettari e utilizza acque provenienti dall'invaso di Occhito; nel sud, il

water from the watershed of Ofanto River. A third district is under construction to operate , the district *Carapelle*. The distribution network develops for approximately 8,000 km and is a system under pressure constructed with adduction pipe in reinforced concrete and PVC pipes for water distribution.

The irrigation is operated usually from March to November. In the "Fortore" district, 75 % of demand is concentrated in June, July and August, in 75 days; while in the "Sinistra Ofanto" district, water demand is distributed substantially over the entire irrigation period. Yearly water demand is evalauted about 280 Mm^3. Water demand varies in relation to the different cultivation in use. An average amount demand can be estimated about 2,000 m^3 per irrigable hectare. The present annual water deficit with regard to the primary resource is estimated at 110 Mm^3.

Planning of an integrated supply system for combined use of natural waters and municipal wastewater

About 70 % population living in the Tavoliere delle Puglie is concenrated in 10 urban centres having more than 10,000 inhabitants. The municipal plants operating in the larger urban centres with a capacity higher than 30,000 a.e. (Foggia, San Severo, Cerignola, Manfredonia, Lucera and Margherita di Savoia) constitutes about 80 % of the annual volume available in the area of Tavoliere delle Puglie. As showed by Table 1, the evaluation of amount of municipal wastewater makes evident that they can represent a fraction of about 23% of total irrigation water demand.

distretto "Sinistra Ofanto" ha una superficie irrigabile di 38,000 ettari e utilizza acque provenienti dal bacino del fiume Ofanto e dai suoi affluenti. Un terzo distretto è in costruzione, il distretto Carapelle. La rete irrigua si sviluppa per circa 8.000 km ed è costituita da un sistema in pressione realizzato con condotte di adduzione in cemento armato e tubazioni in PVC per la distribuzione.

L'irrigazione è usualmente condotta da Marzo e Novembre. Nel distretto "Fortore", il 75 % della domanda irrigua è concentrata nei mesi di giugno, luglio e agosto, in circa 75 giorni, mentre nel distretto "Sinistra Ofanto", la domanda è distribuita praticamente nell'intero periodo irriguo. La domanda irrigua annua è oggi valutata in circa 280 Mm^3. La domanda irrigua varia in relazione alle differenti coltivazioni in uso. Una domanda irrigua media stagionale per superficie irrigabile puo' essere stimata in circa 2.000 m3/ha. L'attuale deficit idrico annuo relativo alle risorse primarie è stimato in 110 Mm.

Pianificazione di un sistema integrato per l'utilizzo combinato di acque naturali e reflui urbani trattati

Circa il 70 % della popolazione del tavoliere delle iving in the Tavoliere delle Puglie è concentrata in 10 centri urbani che hanno piu' di 10.000 abitanti. Gli impianti di depurazione urbani che servono i centri maggiori (Foggia, San Severo, Cerignola, Manfredonia, Lucera and Margherita di Savoia) presentano potenzialità superiori a 30.000 a.e. e costituiscono circa l'80 % of the yearly volume available in the Tavoliere delle Puglie. Come mostra Tabella 1, la valutazione dei quantitativi dei reflui urbani evidenzia che essi rappresentano una frazione della domanda irrigura totale non superiore al 23%.

Table 1

Municipal wastewater and water demand in the urban areas and irrigation districts of *Tavoliere delle Puglie*.

Irrigation district	Watershed or receiver water body	Municipal plans and irrigation area	Population	Specific water demand	Wastewater volume	Irrigable surface	Irrigation water demand	Wastewater from water demand rate
			*10^3*inhab.*	*m^3/inhab*day*	*Mm^3/year*	*10^3xha*	*Mm^3/year*	*%*
"FORTORE"	***Artificial channel "della Contessa"***	**Foggia**	157.7	0.30	17.3	22.8	45.6	37.9
	Triolo	**San Severo**	54.9	0.25	5.0	27.0	54.0	9.2
		Torremaggiore	17.1	0.20	1.2	12.3	24.5	4.9
	Celone	**Lucera**	33.3	0.20	2.4	7.4	14.8	16.2
		Troia	8.4	0.20	0.6	3.0	6.0	10.0
	Gargano area	**Manfredonia**	53.1	0.25	4.8	2.6	5.3	90.5
		San Giovanni Rotondo	21.5	0.20	1.6	2.1	4.2	38.1
		San Marco in Lamis	16.3	0.20	1.2	1.6	3.3	36.4
		Apricena	14.1	0.20	1.0	6.5	13.0	7.7
"SINISTRA OFANTO", "CARAPELLE"	***Carapelle, Ofanto river***	**Cerignola**	54.3	0.25	13.6	20.4	40.8	33.3
		Margherita di Savoia	21.6	0.20	1.6	1.4	2.8	57.1
		San Ferdinando	12.7	0.20	2.5	3.5	7.0	35.7
		Orta Nova	12.9	0.20	2.6	8.2	16.4	15.8
		Total	477.9	---	55.4	118.8	237.7	23.3

The municipal wastewater treatment plants operate a secondary treatment by activated sludge provided of a pre-denitrification stage (*Ludzach-Ettinger* process). Tertiary treatment for reuse of secondary effluents is provided by clariflocculation, filtration and disinfection by chlorine.

An optimal reuse of treated municipal should operate the accumulation of wastewater during non-irrigation period. One or more artificial reservoirs could provide the volume to store treated effluents from the main rurban

Questi impianti operano un trattamento secondario a fanghi attivi provvisto di stadio di pre-denitrificazione (*Ludzach-Ettinger* process). Il trattamento terziario degli effluenti secondari è realizzato mediante chiari-flocculazione, filtrazione e clorazione.

Un sistema di riutilizzo ottimale potrebbe operare l'accumulo degli effluenti urbani trattati durante il periodo non irriguo. Nel caso in esame, uno o piu' invasi artificiali potrebbero fornire il necessario volume per accumulare i reflui trattati prodotti dai principali centri urbani e una

centers, Foggia, and a pumping station should allow to transport waters to irrigation networks.

With this aim, stabilization ponds could be realized properly. The effluents from the plants working at several small urban centres find disposal discharged in the Candelaro river. The residual polluting load should be reduced preliminarly by disharge in stabilisation ponds which can provide a proper volume for accumulation of these waters.

Integrated purification systems for irrigation reuse of treated municipal effluents accumulated in a reservoir

A system using water treated by different wastewater treatment plants operating in the proximity of the province of Bari (**Fig. 3**) was implemented with the aim at the irrigation In the area Alta Murgia, close to the Sagliocca reservoir, with a storage capacity of about 1.8 million m^3: Altamura, 70,000 equivalent inhabitants, Gravina 45,000 eq.inhab. and Santeramo in Colle 25,000 eq. inhab.

stazione di sollevamento permetterebbe il sollevamento alle reti irrigue.

All'uopo potrebbe risultare conveniente anche la realizzazione di bacini di stabilizzazione. Gli effluenti di diversi impianti a servizio di diversi piccoli abitati trovano smaltimento con lo scarico nel fiume Candelaro. Il carico inquiannte residuo di queste acque potrebbe essere ridotto preliminarmente in bacini di stabilizzazione che potrebbero fornire un idoneo volume per l'accumulo.

Sistema integrato di impianti di depurazione per il riuso dei reflui urbani trattati accumulati in un invaso artificiale

E' stato previsto un sistema che opera l'impiego irriguo dei reflui trattati da piu impianti di depurazione a servizio di alcuni comuni limitrofi nella provincia di Bari (**Fig. 3**), nell'alta Murgia, localizzati in prossimità dell'invaso del Sagliocca che ha una capacità di accumulo di circa 1.8 m^3: Altamura 70000 a.e., Gravina 45000 a.e e Santeramo in Colle 25000 a.e..

Fig. 3. - Wastewater reuse in urban areas of Alta Murgia (Apulia region).
Legend: urban area; purification plants; artificial reservoir; lifting plants; supply pipelines; irrigation works; monitoring; irrigated area.

The system has a capacity of about 130,000 eq. inhab. for a given daily flow rate of about 20,000 m^3. The secondary effluents are treated in each of the individual WWTP with activated sludge scheme pre-denitrification and refining phase with flocculation, filtration and chlorination. Effluents refined are conveyed through supply pipelines and distributed to crops during the irrigation period and raised in the artificial reservoir in the non irrigation period. The inclusion in the scheme of the Saglioccia reservoir and the subsequent use of the water accumulated allows to increase the irrigable area up to 2200 hectares. In this case, the waste are raised in the artificial mainly in the period not irrigated; the reservoir provides the volume of monthly compensation during the irrigation period. The main problems are associated with maintaining the quality of water retained in the spring and summer periods and the efficiency of the system of transportation and distribution of wastewater.

Reuse by post-treatment of ~~municipal~~ secondary

Il sistema ha una potenzialità di circa 130.000 a.e. per una una portata calcolata di circa 20.000 m^3/giorno. Gli effluenti secondari sono trattati in ognuno dei singoli impianti di depurazione a fanghi attivi con schema di pre-denitrificazione ed affinati mediante chiariflocculazione, filtrazione su sabbia e clorazione. Gli effluenti affinati sono convogliati mediante condotte di adduzione e distribuiti alle coltivazioni nel periodo irriguo. L'inserimento nello schema dell'invaso del Saglioccia e il conseguente utilizzo delle acque accumulate consente di incrementare la superficie irrigabile fino a 2200 ettari. In tal caso, i reflui sono sollevati nell'invaso artificiale principalmente nel periodo non irriguo; l'invaso fornisce il volume di compenso mensile nel periodo irriguo. In questo schema di funzionamento le principali problematiche sono connesse al mantenimento della qualità delle acque invasate e nelle opere di trasporto nel periodo primaverile-estivo e all'efficienza della rete di distribuzione dei reflui.

Riutilizzo degli effluenti urbani secondari trattati in

urban effluent in a combined process plant in channels

A system of reuse the secondary urban effluent was realized downstream of the purification plant of Fasano town ~~of~~ (provincia di Bari) in *Contrada Forcatella*. The climate in this area is semi-arid: in the period from April to September the monthly average of temperature vary in the range 22°-26 °C, and total rainfall height is approximately 200 mm. An high tourist flux is observed in the urbanized area during the summer.

The extraction of groundwater, by wells realized by local farmer, satisfies the water demand for agriculture-use.

The project aims to reduce the use of groundwater subject to a diffuse phenomena of sea intrusion, intervening on an agricultuiral area with a surface of about 800 ha. Cultivated crops are arboricultural: olive, almond, pistachio and fig. The irrigation period starts in April and ends in September.

In order to estimate the water leakage a rate equal to 20 % was applied and the irrigation demand was calculated 1.9 Mm^3/year. The water demand was distributed during the irrigation season according to the following monthly rates: april 0.07, may 0.157, june 0.225, july 0.255, august 0.253, and september 0.04.

The water sources available to satisfy the irrigation water demand is constituted by the treated municipal wastewater produced by the residential population, which increases during the summer due to the tourist population, and groundwater supplied from wells. The capacity of municipal sewage plant is about 40000 a.e.. The volume of wastewater secondary effluents availablein the year was estimated about 2 Mm^3/year, estimating a daily water flow per capita of 0.2 m^3/day*inhabitant and a loss factor of 0.7). The flux of the tourist population during the summer increases the residential population to ~~of~~ 60, 70 e 75 % respectively in the month of June, July and August.

The groundwater is extracted by four ~~4~~ wells and supplied to irrigation network esclusively during periods of high water demand, according to an highest flow of 40 l/sec.

In order to satisfy the irrigation water demand in the period of highest water demand during the summer, the monthly water balance of the project makes evident the need to use both integrate municipal wastewater and groundwater (**Fig. 4**).

The secondary municipal effluents are treated in a plant operating a combined physico-chemical process in a serie of channels (*see parargaph* 3 *and figure* 2a).

In order to analyse and verify the quality and the state of groundwater, a monitoring system was realized: sampling and analysis of the groundwater and measurements with multi-parameters probes are periodically carried out in 10 wells.

More recently was positively evaluated and tested the reuse of treated municipal effluents for irrigation of a golf course.

un impianto a processi combinati in canali

Un sistema di riutilizzo degli effluenti urbani secondari è stato realizzato a valle dell'impianto di depurazione della città di Fasano (provincia di Brindisi) in *Contrada Forcatella*. Il clima in questa zona è semi-arido: nel periodo da aprile a settembre le medie mensili di temperatura variano nell'intervallo 22-26 °C, e l'altezza di pioggia è circa 200 mm. Durante l'estate si osserva nell'area urbanizzata un intenso flusso turistico.

Lo sfruttamento della falda idrica per mezzo di pozzi realizzato dagli agricoltori, soddisfa la domanda idrica per gli usi agricoli.

Il progetto intende ridurre lo sfruttamento della falda già soggetta ad una diffusa intrusione marina, intervenendo su un area irrigua con una superficie di circa 800 ha. Le colture irrigue sono prevalentemente arboricole: olivo, mandorlo, pistacchio e fichi. Il periodo irriguo parte ad aprile per terminare a settembre.

Al fine di stimare le perdite idrauliche un tasso del 20% è stato considerato e la domanda irrigua è stata calcolata pari a 1.9 Mm^3/year. La domanda idrica si distribuisce nella stagione irrigua in accordo ai seguenti tassi di utilizzo: aprile 0.07, maggio 0.157, giugno 0.225, luglio 0.255, agosto 0.253 e settembre 0.04.

La risorsa idrica disponibile per soddisfare la domanda irrigua è costituita dai reflui urbani trattati, prodotti dalla popolazione residente dagli afflussi turistici estivi, e dalla falda. La potenzialità dell'impianto urbano di depurazione è circa 40.000 a.e.. Il volume degli effluenti secondari disponibili nell'anno è stimato in circa 2 Mm^3/anno, sulla base di una dotazione idrica specifica pari a 0.2 m^3/giorno*ab. e un fattore di perdita pari a 0.7. Il flusso turistico nel periodo estivo incrementa la popolazione di crica il 60, 70 e 75 % rispettivamente dei mesi di giugno, luglio e agosto.

Le acque di falda sono estratte mediante quattro pozzi e sono alimentate alla rete di irrigazione esclusivamente durante i periodi di maggiore domanda idrica in base ad una portata massima di 40 l/sec.

Al fine di soddisfare la domanda irrigua nei periodi della piu' alta domanda idrica durante l'estate, il bilancio idrico mensile rende evidente la necessità di utilizzare congiuntamente i reflui urbani trattati e le acque di falda (**Fig. 4**).

Gli effluenti urbani secondari sono trattati in un impianto a processi combinati fisico-chimico in canali in serie (*vedi paragrafo* 3 *e figura* 2a).

Un sistema di monitoraggio è stato realizzato per comprendere le variazioni quali-quantitative delle acque di falda; il campionamento e l'analisi delle acque e le misure con sonde multi-parametriche sono effettuate periodicamente in 10 pozzi.

Piu' recentemente è stato valutato positivamente e testato il riuso degli effluenti urbani trattati per l'irrigazione di un campo da golf.

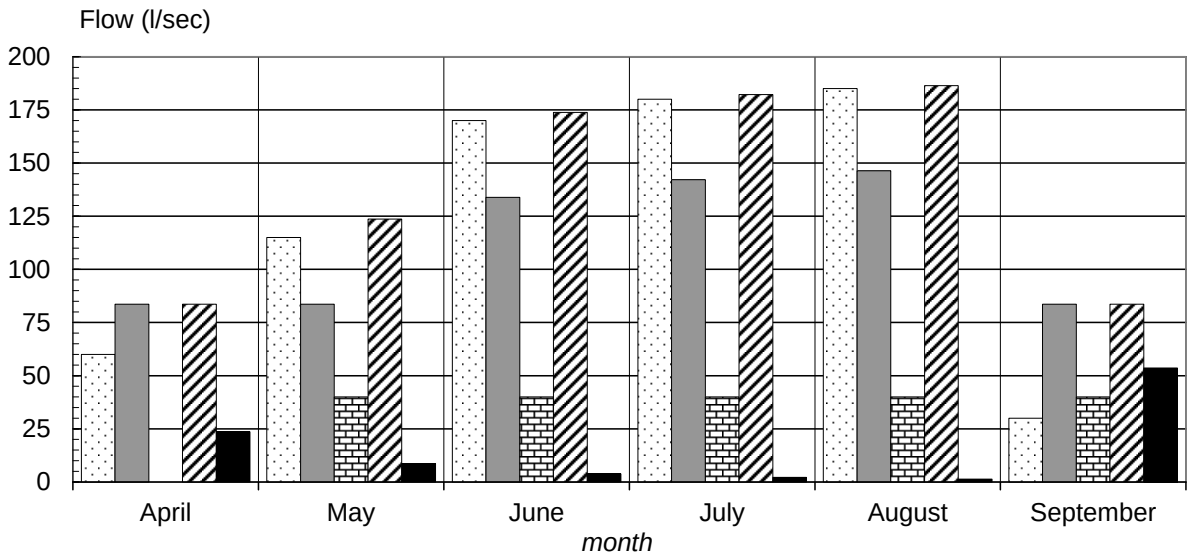


Fig. 4 Monthly water balance of the integrated system of reuse of treated municipal wastewater at "*Contrada Forcatelle*". *Legend*: water irrigation demand; wastewater produced by residential population; wastewater produced by tourist population; groundwater; residual wastewater.

CONCLUSIONS

In order to support the water demand in agricultural, the integration of secondary municipal effluent in supply systems which use natural water as primary source represents a real option in irrigation districts. The feasibility of this option requires yet a proper analysis to be planned. Although the treatment phase plays a fundamental role to make the water quality suitable for the use, as well as to prevent both health and environmental risk, the economic costs and energy consumption which are required to realize the infrastructure which provide seasonal storage, balance and distribution, and environmental monitoring, cannot be negligible.

The works of three irrigation districts in the Apulia region wich is expected to reuse ~~of~~ municipal effluents as integration of natural source (surface water and groundwater) have been described and examined.

The examined cases make evident that the yearly volume of treated municipal wastewater covers a fraction not higher than 25 % of total irrigation water demand and that seasonal storage can double the volume of unconventional water resource.

Even the secondary effluents can find a suitable treatment by the use of processes such as membrane filtration, in MBR schemes, or as tertiary stage, and disinfection by chlorination or UV, further research efforts are required to determine the optimal solution to plan and operate reuse systems sustainable by agricultural economy and making available the use of large volume of treated municipal effluents.

With this aim, the application of plants operating natural processes or using combined physical-chemical processes combined in integrated channels may constitute a potential solution, in particular, suitable to realize the balance of daily flow and the correct insertion in natural environment.

Seasonal storage of wastewater in reservoirs, which allows the increase of available non conventional water

CONCLUSIONI

Al fine di contribuire al soddisfacimento della domanda di acqua nel comparto agricolo, l'integrazione dei volumi di effluente urbani secondari nei sistemi di approvvigionamento che utilizzano acque naturali come fonte primaria rappresenta una reale opzione nei distretti irrigui. La fattibilità di questa opzione richiede tuttavia una idonea analisi per essere pianificata. Sebbene la fase di trattamento giochi un ruolo fondamentale per rendere la qualità dell'acqua idonea all'uso, nonché per prevenire sia il rischio sanitario che ambientale, i costi economici e i consumi energetici necessari per costruire le infrastrutture necessaria che forniscono stagionale stoccaggio, equilibrio e distribuzione, e ambientale monitoraggio, non possono essere trascurati.

Le opere di tre distretti irrigui operanti in Puglia in cui è previsto il riutilizzo delle acque reflue comunali quale risorsa integratativa alle acque naturali (acque superficiali e sotterranee) sono state descritte ed esaminate.

I casi studiati rendono evidente che il volume annuale di acque reflue urbane trattate copre una frazione non superiore al 25% della domanda idrica per l'irrigazione e che lo stoccaggio stagionale può raddoppiare il volume della risorsa idrica non convenzionale.

Pur se gli effluenti secondari possono trovare un adeguato trattamento mediante l'uso di processi come la filtrazione a membrana, in schemi MBR, o come stadio terziario, e la disinfezione mediante clorazione o UV, ulteriori sforzi di ricerca sono necessari per determinare la soluzione ottimale per realizzare e gestire sistemi di riutilizzo sostenibile dall'economia agricola e consentire l'uso di grandi quantitativi di effluenti urbani trattati.

A questo scopo, l'applicazione di impianti che operano processi naturali in bacini o utilizzano processi fisico-chimici combinati in canali integrati può costituire una soluzione potenziale, in particolare atta a realizzare le funzioni di compenso giornaliero e il corretto inserimento nell'ambiente naturale.

Lo stoccaggio stagionale dei reflui in invasi artificiali,

resource and the irrigated surface, requires however, in particular, the study of the problems related to maintain the good state of water quality ~~of~~ in reservoir and the works of supply and distribution.

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che consente l'incremento della risorsa utilizzabile e quindi delle superfici irrigabili, richiede tuttavia, in particolare, l'approfondimento delle problematiche connesse al mantenimento delle qualita' delle acque nell'invaso e nelle opere di adduzione e distribuzione.

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TiO_2 PHOTOCATALYST FOR WASTEWATER TREATMENT APPLICTIONS - REVIEW / *FOTOCATALIZATORUL TiO_2 UTILIZAT IN EPURAREA APELOR* - REVIEW

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Abstract: *Recently semiconductor photocatalytic processes have shown a huge potential for using within the wastewater treatment technologies, being considered as clean "zero" waste technologies. The review focuses on presenting the background and principles of using TiO_2 semiconductor as photocatalyst in advanced oxidation process applied for treatment of wastewater containing organic pollutants.*

Keywords: *TiO_2, photocatalysis, wastewater treatment*

INTRODUCTION

Addressing current and future problems such as:
a) 3.8 billions human beings that have limited or no access to water sources and millions that have succumbed to diseases caused by pollutants from water;
b)rapid urbanization and industrialization;
c) population growth;
d) quantitatively and qualitatively changes of the pollutants found in water;
d) existence of new chemical compounds with pollutant activity found in water, knowing that more than 300 new chemical compounds are obtained every year as a result of high- tech industry and the diversification of industry,
require new technologies of wastewater treatment with high efficiency and no environmental impact [9,11,12, 14].

One of the new technologies is based on advanced oxidation process implying the use of a TiO_2 semiconductor as photocatalyst for the depollution of water containing organic pollutants.

Photocatalytic oxidation using TiO_2 nanoparticles takes place under the light irradiation and consists in the total mineralization or decomposition of the organic pollutants from water into inorganic molecules, that are harmless (carbon dioxide, CO_2 and water, H_2O). When is used solar light in photocatalysis treatment of polluted water, the technology is called "clean and green" [3].

In practice, till now, TiO_2 has been the most promising photocatalyst [10]. Its multiple applications are sustained by the a lot of features such as those presented in Table 1.

TiO_2 particles naturally crystallize in three forms: rutile, anatase and brookite. Rutile is the most common, most stable, chemically inert and can be excited by both visible and ultraviolet (UV) light (wavelengths smaller than 390 nm) [7,6].

Anatase is only excited by UV light and can be transformed into rutile at high temperatures. Both rutile and anatase have a tetragonal crystal system but have different space group lattices. Brookite is not excited by UV light but its orthorhombic crystal system can be transformed into rutile with the application of heat.

Rezumat: *Recent, procesele fotocatalitice pe bază de semiconductori au arătat un potențial crescut de utilizare în cadrul tehnologiilor de epurare a apei, fiind considerate tehnologii curate din care nu rezultă deşeuri. Lucrare se axează pe prezentarea principiilor care stau la baza utilizării semiconductorului TiO_2 ca fotocatalizator în procesul de oxidare avansată aplicat în scopul epurării apei uzate care conține poluanți de natură organică.*

Cuvinte cheie: *TiO_2, fotocataliză, epurarea apelor.*

INTRODUCERE

Abordarea problemelor actuale şi viitoare, cum ar fi:
a) 3,8 miliarde de oameni care nu au acces sau au acces limitat la sursele de apă şi milioane de oameni care au murit de boli cauzate de poluanții din apă;
b) urbanizarea rapidă şi industrializarea;
c) creşterea populației;
d) modificările cantitative şi calitative ale poluanților care se găsesc în apă;
d) existența în apă a unor compuşi chimici noi cu acțiune poluantă, cunoscându-se că mai mult de 300 de noi compuşi chimici se obțin în fiecare an, ca urmare a industriei supra-tehnologizate şi a diversificării industriei,
necesită noi tehnologii de epuare a apelor uzate cu eficiență ridicată şi fară împact asupra mediului înconjurător [9, 11,12,14].

Una dintre noile tehnologii se bazează pe procesul de oxidare avansată, care implică utilizarea semiconductorului TiO_2, ca fotocatalizator pentru depoluarea apei care conține poluanți organici.

Oxidarea fotocatalitică folosind nanoparticulele de TiO_2 are loc sub radiația luminii şi constă în mineralizarea totală sau în descompunerea poluanților organici din apă, în molecule anorganice care sunt inofensive (dioxid de carbon, CO_2 şi apă, H_2O). Când se foloseşte lumina solară în scopul tratamentului prin fotocataliză a apei, tehnologia se numeşte „ecologică şi verde" [3].

În practică, până în prezent, TiO_2 a fost fotocatalizatorul cel mai promițător [10]. Multiplele sale aplicații sunt sustinute de multe caracteristici, cum ar fi cele prezentate în tabelul 1.

Particulele de TiO_2 se cristalizează în mod natural sub trei forme: rutil, anatas şi brookit. Rutilul este cel mai răspândit, cel mai stabil, inert din punct de vedere chimic şi poate fi excitat atât de lumina vizibilă cat şi de lumina ultravioletă (UV)-(cu lungimi de undă mai mici de 390 nm) [7,6].

Anatasul este excitat doar de lumina UV şi se poate transforma în rutil la temperaturi înalte. Atât rutilul cât şi anatasul au o rețea cristalină tetragonală, dar au unități spațiale de rețea diferite. Brookitul nu este excitat de lumina UV, dar structura sa cristalină octorombică poate fi transformată în rutil prin aplicarea tratamentului termic.

Table 1

Some of the advantages and disadvantages of using TiO_2 as photocatalyst in wastewater treatment plants [10, 16]

Crt. No.	*Advantages*	*Disadvantages*
1.	It is a very stable chemically and photochemically catalyst. It does not degrade itself because of the corrosion degradation and it is resistant against acids and alkalis actions.	- Limited UV lamp life.
2.	It is being certified for having a strong oxidation power due to which is capable to decompose recalcitrant substances.	-recovery facility when using powder.
3.	It can be industrially produced in large quantities.	
4.	It can handle safely and non-toxic.	
5.	It is Inexpensive.	
4.	It can decompose non biodegradable organic compounds during the wastewater treatment process.	
5.	It has low operational and installation cost.	
6.	It does not involve sludge treatment costs.	
7.	It can cause microbial inactivation and organic mineralization without secondary pollution.	

Photocatalysis may be described as a photoinduced reaction which is accelerated by the presence of a catalyst and is initiated by a photon with sufficient energy (equal or higher than the band gap energy of the catalyst).

The semiconductors have the valence band (VB) occupied with stable energy electrons and empty higher energy conduction band (CB).

In the case of using TiO_2 in photocatalysis, the process could be explained as follows: when irradiated with adequate and enough sufficiently $h\nu \geq E_g$ (band gap energy), one electron moves from the valence band (VB) to the conduction band (CB), and simultaneously a hole (vacancies left by electrons) created in the valence band (VB). These electron/holes pairs migrate to the surface where they participate to the redox reaction with adsorbed substances (organic pollutants) on the TiO_2 surface (Fig. 1) [4].

In the case of TiO_2 nanoparticles, the band gap energies are 3.2 eV for anatas and 3 eV for rutile, and the corresponding wavelengths are 388 nm and 413 nm respectively. This mean that UV light irradiation with wavelengths lower than that corresponding to band gap begins the photoreaction. The electron is photoexcited to the CB in fentoseconds [5].

Fotocataliza poate fi descrisă ca fiind o reacție fotoindusă care este accelerată de prezența unui catalizator şi este inițiată de un foton cu energie egală sau mai mare decăt energia benzii interzise a catalizatorului.

Semiconductor au banda de valență (VB) ocupată cu electroni ce au energie stabilă şi o banda de conducție de energie înaltă (CB).

În cazul utilizării TiO2 în fotocataliză, procesul ar putea fi explicat după cum urmează: când este iradiat cu energie corespunzătoare $h\nu \geq E_g$ (energia benzii interzise), electronul se mută din banda de valență (VB) în banda de conducție (CB) şi in acelaşi timp se crează goluri (vacanțe lăsate de electroni) în banda de valență (VB). Aceste perechi de electroni/goluri migrează spre suprafață, unde participă la reacții redox cu substanțele adsorbite (poluanți organici) pe suprafațaTiO_2 (Fig. 1) [4].

În cazul nanoparticulelor de TiO_2, energia benzii interzise este 3.2 eV pentru anatas şi 3 eV pentru rutil, iar lungimile de undă corespunzătoare sunt 388 nm, şi respectiv 413 nm. Acest lucru înseamnă că la iradierea cu lumină UV, cu lungime de undă mai mică decât cea corespunzătoare benzii interzise, se inițiază fotoreacția. Electronul este fotoexcitat spre banda de conducție (CB) în fentosecunde [5].

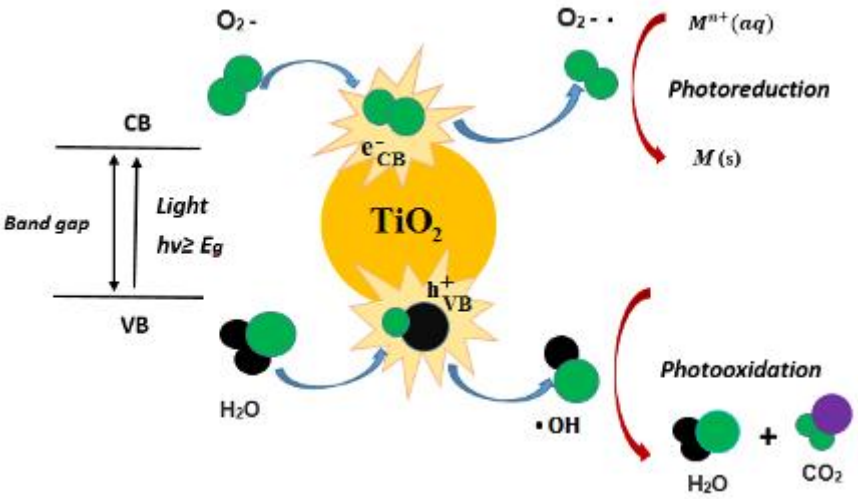

Fig.2 – Schematic diagram of photocatalysis with TiO_2 nanoparticles

The photon energy below 400 nm corresponds to a thermal energy of higher 30000 ^oC. Therefore, when TiO_2 surface is irradiated with UV light below 400 nm, the extremely high temperature achieved more than 30,000 ^oC oxidizes all organic compounds by completely decomposision into water and carbon dioxide [11].

Energia fotonului sub 400 nm corespunde unei energii termice mai mari de 30000 °C. Prin urmare, atunci când suprafața TiO_2 este iradiată cu lumină UV sub 400 nm, atinge temperaturi extrem de ridicată, având valori mai mari de de 30000 °C care oxidează toți compuşii organici şi îi descompune complet formându-se apă si

When applying UV light radiation to the surface of the TiO_2 catalysts particles suspended in water, two processes take place from which result two very important active species: a) photoreduction processes sustained by the photo-induced electrons in CB which react with dissolved oxygen in air forming the superoxide radical anions ($O_2^{\cdot-}$); b) photooxidation processes conducted by the photo-induced holes in the VB which diffuse to the particle surfaces of TiO_2 and react with adsorbed water molecules, forming hydroxyl radical ($OH^{\cdot}$) [8,13]. This photo-induced mechanism of the electron–hole pair formation in the TiO_2 is usually described as follows [2]:

dioxid de carbon [11].

La aplicarea radiației luminii UV pe suprafața particulelor de catalizatorTiO_2, suspendate în apă au loc două procese în urma cărora rezultă două specii active importante: a) procesul de fotoreducere realizat de electromii fotoinduşi în CB care reacționeză cu oxigenul dizolvat în aer formând anionul radical superoxide ($O_2^{\cdot-}$); b) procesul de fotooxidare efectuat de golurile foto-induse în VB care difuzează la suprafața particulelor de TiO_2 şi reacționează cu moleculele de apă absorbite, formând radicalul hidroxil ($OH^{\cdot}$) [8, 13]. Acest mecanism fotoindus de formare a perechii de electron- gol a TiO_2 este de obicei descries după cum urmează [2].

Photo-excitation: $TiO_2 + h\nu \rightarrow e^- + h^+$ (1)
Charge-carrier trapping of e−: $e^-_{CB} \rightarrow e^-_{TR}$ (2)
Charge-carrier trapping of h^+ : $h^+_{VB} \rightarrow h^+_{TR}$ (3)
Electron-hole recombination : $e^-_{TR} + h^+_{VB}\ (h^+_{TR}) \rightarrow e^-_{CB} + e^-_{CB}$ + heat (4)
Photoexcitede scavening: $(O_2) + e^- \rightarrow O_2^{-\cdot}$ (5)
Oxidation of hydroxyls: $OH^- + h^+ \rightarrow OH^{\cdot}$ (6)
Photodegradation by $OH^{\cdot}$: $R - H + OH^{\cdot} \rightarrow R'^{\cdot}\ H_2O$ (7)
Direct photoholes : $R + h^+ \rightarrow R^{+\cdot}$ (8)
→Intermediate(s)/ final degradation products
Protonation of superoxides: $O_2^{\cdot-} + OH^{\cdot} \rightarrow HOO^{\cdot}$ (9)
Co-scavenging of e⁻⁻ : $HOO^{\cdot} + e^- \rightarrow HO_2^-$ (10)
Formation of H_2O_2 : $HOO^- + H^+ \rightarrow H_2O_2$ (11)

where:
e^-_{TR} and h^+_{TR} represent the surface trapped VB electron and CB hole, respectively.

As presented in literature TiO_2 nanoparticles were already used with success to prototype wastewater treatment plants [1, 15, 5]. Some examples of organic pollutants that can successfully be removed from water are presented in Table 2.

Aşa cum este prezentat în literatura de specialitate, nanoparticulele de TiO_2 au fost folosite deja cu succes în prototipuri de stații de epurare [1, 15, 5]. Câteva exemple de poluanțiii de natură organică care se pot îndepărtați cu succes din apă sunt prezentați in Tabelul 2.

Table 2

Examples of non-biodegradable organic pollutants decompose by TiO_2 photocatalyst

Formula	Name	Formula	Name
CH_3CHO	*Acetaldehyde*	$C_6H_4(CH_3)OH$	*Cresol*
CH_3COOH	*Acetic acid*	$Cl_2C_6H_3OH$	*Dichlorophenol*
CH_3COCH_3	*Acetone*	$C_{12}H_{10}Cl_2N_2$	*Dichlorobenzidine*
C_3H_4O	*Acrolein*	$(CH_3)_2NNO$	*Dimethylnitrosamine*
$C_3H_4O_2$	*Acrylic acid*	$C_{12}H_4Cl_4O_2$	*Dioxin*
C_6H_6	*Benzene*	CCl_4	*Carbon tetrachloride*
C_6H_5COOH	*Benzoic acid*	$CHCl_3$	*Chloroform*
$CH_3CH_2CH_2COOH$	*Butyric acid*	CH_3Cl	*Chloromethane*
$C_6H_4(CH_3)_2$	*Xylene*	$C_{10}H_7Cl$	*Chloronaphthalene*
$C_6H_5CH_3$	*Toluene*	$C_{10}H_8$	*Naphthalene*
$Cl_2C_5CCl_2$	*Tetrachloroethylene*	CH_2Cl_2	*Methylene Chloride*
C_6H_5OH	*Phenol*	$C_8H_6O_4$	*Isophthalic acid*
$C_{14}H_{10}$	*Phenanthrene*	N_2H_4	*Hydrazine*
$C_6H_5NO_2$	*Nitrobenzene*	C_6Cl_6	*Hexachlorobenzene*
$C_3H_5(NO_3)_3$	*Nitroglycerine*	$HCOOH$	*Formic acid*
H_2NNO_2	*Nitroamine*	$HCHO$	*Formaldehyde*
$C_{12}Cl_xH_{10-x}$	*Polychlorinated biphenyl (PCBs)*	$(HO_2CCH_2)_2NCH_2CH_2N(CH_2CO_2H)_2$	*Ethylenediaminetetraacetic acid (EDTA)*

CONCLUSIONS

The utilization of TiO_2 photocatalyst within advanced oxidation technology for the wastewater treatment is very prominent owing to its low cost, nontoxicity, high photocatalytic activity, etc.,. In addition to the decomposition of organic pollutants, the photocatalytic activity of the TiO_2 leads to the inactivation of microorganisms existing in wastewater.

CONCLUZII

Utilizarea fotocatalizatorului TiO_2 în cadrul tehnologiei de oxidare avansata aplicată epurării apelor este foarte promițătoare datorită costului redus, netoxicității, activității fotocatalitice ridicate etc.. În plus fată de descompunerea poluanților organici, activitatea fotocatalitică a TiO_2 conduce la inactivarea microorganismelor prezente în apă.

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EVALUATION OF WASTE BIOMASS FROM OAT CULTIVATION FOR ENERGY
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YULAF YETİŞTİRİCİLİĞİNDE ATIK BİYOKÜTLENİN ENERJİ OLARAK DEĞERLENDİRİLMESİ

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Abstract: *Energy demand of the world is increasing day by day as the population increases. Plant origin agri-wastes have an important energy potential, and are environmental friendly with low emission values. Solid biofuels from agri-wastes in the form of briquettes can be a good alternative renewable energy resource to fossil fuels. In this study, biomass waste from oat cultivation were dried till 10-14 % moisture content and chopped till 10 mm particle size and converted to briquettes by a hydraulic press under 240 MPa pressure. Some parameters for briquettes like density, breaking resistance (shatter index), shaking resistance (tumbler index), moisture resistance of briquettes, water intake resistance, ash content, calorific values and chimney gas emission values were determined.*

Key words: Biomass, agricultural residue, energy, oat.

Özet: *Dünya Enerji talebi nüfus arttıkça her geçen gün artmaktadır. Bitki kökenli tarımsal atıklar sahip oldukları düşük emisyon değerleri ile önemli bir enerji potansiyeline sahiptirler. Tarımsal atıklardan elde edilen briket formundaki katı biyoyakıtlar fosil yakıtlara iyi bir alternatif yenilenebilir enerji kaynağı olabilir. Bu çalışmada, yulaf yetiştiriciliğinden elde edilen biyokütle atığı % 10-14 nem aralığına kadar kurutulmuş ve ortalama 10 mm parçacık boyutuna sahip olacak şekilde parçalanarak, bir hidrolik pres ile 240 MPa basınç altında preslenerek, briketlere dönüştürülmüştür. Briketlere ait yoğunluk, kırılma dayanımı (kırılma indeksi), titreşim dayanımı (titreşim indeksi), briketlerin neme dayanımı, su almaya karşı dayanımı, kül içeriği, kalorifik değerleri ve baca gazı emisyon değerleri gibi bazı parametreler belirlenmeye çalışılmıştır.*

Anahtar Kelimeler: *Biokütle, tarımsal atık, enerji, yulaf*

INTRODUCTION

Biomass is the name to given all Earth's living matter. Biomass is general term for material derived from growing plants or from animal manure which is effectively a processed form of plant material such as wood from natural forests, waste from agricultural and forestry processes, and industrial, human or animal wastes. The stored energy in the plants and animals, or the waste that they produce is called biomass energy [14]. Energy production from biomass is becoming very important since there's a huge potential on the world, especially from agricultural production. Biomass energy potential of Turkey is estimated as 32 Mtoe [4], [17] and the total recoverable potential was estimated to be about 16.9 Mtoe [4], [15].

Side products from agricultural production are a very good source of alternative energy. Some of these side products such as residues or wastes from a particular crop can be converted to biofuels but, the productivity of agricultural resources used for production of biomass for energy purposes depends on the further development of biomass conversion technologies. Besides, the use of biomass resources which are defined as ''CO2 neutral'' [6] in the energy sector is important for Turkey to fulfil the possible future commitments based on the Kyoto Protocol.

Moreover, the use of indigenous resources such as coal and bio wastes for energy production is of critical importance in reducing energy imports. Among the combustion technologies, fluidized-bed technology has become more important because of its ability to burn different types of fuels due to the good mixing in the combustor and the high combustion efficiency achieved with less air given into the combustor [5], [16]. So, the potential to build power plants using coal as main fuel and various biomasses as supplementary fuel appear to be a promising choice for Turkey. Thus, the disposal of biowastes will be achieved and the energy content of the biowastes will be used beneficially in the country's energy

GİRİŞ

Biyokütle; dünyadaki yaşayan tüm canlı unsurlara verilen genel bir isimdir. Biyokütle bitkilerden yada hayvan gübresinden elde edilmiş bitki, doğal orman ürünleri, tarım ve orman faaliyetlerinin sonucu elde edilen atıklar, endüstriyel, insan ya da hayvan atıklarından oluşabilen faydalı olacak şekilde işlenmiş ürünlere verilen genel bir terimdir. Bitki ve hayvanlar tarafından depolanan enerji ya da bunların ürettikleri atıklardan elde edilen enerji biyokütle enerjisi olarak adlandırılır [14]. Dünyamızda tarımsal üretimin sahip olduğu yüksek biyokütle potansiyelden dolayı biyokütleden enerji üretimi önemli bir hale gelmiştir. Türkiye'nin sahip olduğu biyokütle enerjisi potansiyeli 32 Mtoe [4], [17] ve toplam geri kazanılabilir enerji potansiyeli yaklaşık 16.9 Mtoe olarak tahmin edilmektedir [4], [17].

Tarımsal üretim esnasında elde dilen yan ürünler iyi bir alternatif enerji kaynağıdır. Belirli bir tarımsal üründen elde edilen atık ve artıklar biyoyakıtlara dönüştürülebilir fakat enerji eldesi amacına yönelik olarak kullanılan tarımsal kaynakların verimliliği biokütle dönüşüm teknolojilerinin ileri düzeyde gelişimine bağlıdır. Bunun yanı sıra, enerji sektöründe 'CO_2 nötral'' [6] olarak tanımlanan biokütle kaynaklarının kullanımı, Türkiye açısından Kyoto protokolüne dayalı olarak gelecekteki taahhütlerini yerine getirmek adına da ayrıca önem arz etmektedir.

Ayrıca, bu tür enerji üretimi için kömür ve biyoatıklar olarak yerli kaynakların kullanımı, enerji ithalatını azaltmak için kritik önem taşımaktadır. Yanma teknolojileri arasında, akışkan yatak teknolojisi, yanma odası içerisinde iyi bir karıştırma sağlanmasından dolayı farklı tipte yakıtların yakılabilmesi ve daha az hava ile elde edilen yüksek yanma etkinliği nedeniyle daha da önem kazanmıştır [5], [16]. Türkiye açısından potansiyel olarak ana yakıtın kömür ve ek yakıt kaynağının biokütle olduğu enerji santrallerinin kurulması umut verici bir seçenek olarak görülmektedir. Böylece, biyoatıkların

production.

Briquetting is the process of conversion of agricultural waste into uniformly shaped briquettes that are easy to use, transport and store. The briquetting of biomass improves its handling characteristics, increase the volumetric calorific value, reduces transportation costs and makes it available for a variety of application.

The aim of this study is to investigate utilization possibilities of biomass residue from oat cultivation for energy in the form of solid biofuel. Some parameters of oat residues briquettes such as; density, breaking resistance (shatter index), shaking resistance (tumbler index), moisture resistance of briquettes, water intake resistance, ash content, calorific values and chimney gas emission values of oat straw briquettes were determined.

MATERIAL AND METHOD

This study was conducted in laboratory of Ondokuz Mayıs University Agriculture Faculty, Agriculture Machinery and Technologies Engineering Department in Samsun, Turkey. Cultivation residues of oat biomass were used as material. The material was dried in natural conditions until the moisture contents of 10-14%.

Material was primarily chopped and grinded by a hammer mill to 10 mm particle sizes. Then the dried and milled materials were briquetted by a hydraulic type press under 240 MPa pressure without using any adhesive. Heating values of the samples were determined according to European Committee for Standardization [13]. Before testing, the moisture contents of the milled samples were determined according to [10], and [11].

Before briquetting, material was filled in a certain capacity container from a certain height (about 4 cm) to determine the density of the material and the filled material was recorded by weighing. The material density was calculated by dividing the material weight by the volume of the container. Hectoliter and precision scales were for measuring briquette's volume weight. To determine briquette density, water flooding method was applied. Briquettes were covered with stretch film to prevent water absorption (Figure 1). The mass of covered briquettes were recorded. By dipping the covered briquettes into water container, volumes of briquettes were calculated.

imhası sağlanmış olacak ve biyoatıklarda elde edilecek enerji ülkenin enerji üretiminde yararlı bir şekilde kullanılmış olacaktır.

Briketleme, tarımsal atıkların, depolanması, taşınması ve kullanımı kolay olan düzenli briket formundaki yapılara dönüşümü işlemidir. Biokütlenin briket haline getirilmesi onun taşıma-boşaltma özelliklerini geliştirip, hacimsel ısısal değerini yükselttiği gibi, taşıma maliyetlerini azaltarak uygulama çeşitliliğini mümkün kılmaktadır.

Bu çalışmanın amacı, yulaf yetiştiriciliğinde atık biokütlenin katı yakıt enerjisi olarak kullanım olanaklarının araştırılmasıdır. Bu kapsamda, b*riketlere ait yoğunluk, kırılma dayanımı (kırılma indeksi), kopma dayanımı (kopma indeksi), briketlerin neme dayanımı, su almaya karşı dayanımı, kül içeriği, kalorifik değerleri ve yulaf atıklarından imal briketlere ait baca gazı emisyon değerleri gibi bazı parametreler belirlenmeye çalışılmıştır.*

MATERYAL VE YÖNTEM

Bu çalışma, Türkiye'de Samsun ilinde, Ondokuz Mayıs Üniversitesi Ziraat Fakültesi Tarım Makineleri ve Teknolojileri Mühendisliği Bölümüne ait laboratuvarlarda yürütülmüştür. Materyal olarak yulaf yetiştiriciliğinden arta kalan biyokütle kullanılmıştır. Materyal, % 10-14 oranında nem içeriğine kadar doğal koşullarda kurutulmuştur.

Materyal önce parçalanmış ve 10 mm parçacık büyüklüğüne gelinceye kadar çekiçli değirmen ile öğütülmüştür. Daha sonra, kurutulmuş ve öğütülmüş olan materyal herhangi bir yapıştırıcı malzeme kullanılmadan 240 MPa basınç altında hidrolik bir pres ile briket haline getirilmiştir. Örneklere ait ısıl değerler Avrupa Birliğinin standardına göre belirlenmiştir [13]. Testlerden önce örneklere ait nem içerikleri [10] ve [11] standartlarına göre belirlenmiştir.

Briketlemeden önce, materyal yoğunluğunun belirlenmesi için malzeme, kapasitesi belirli olan bir kap içine belirli bir yükseklikten (yaklaşık 4 cm) doldurulur ve ağırlığı tartılarak yoğunluğu belirlenir. Materyal yoğunluğu malzeme ağırlığının, kap hacmine oranlanmasıyla hesaplanmıştır. Briket yoğunluğunun belirlenmesi için hassas terazi ve hektolitre kullanılmıştır. Briket yoğunluğunun belirlenmesinde su taşırma yöntemi kullanılmıştır. Briketler su alımının önlenmesi için streç filmle kaplanmıştır (Şekil 1). Streçle çevrili briketlerin kütleleri kayıt altına alınmıştır. Su dolu kaplara briketler daldırılarak briketlere ait hacim değerleri hesaplanmıştır.

Fig. 1 - Briquettes from oat biomass

For shatter resistance, briquettes weights were recorded before testing than the briquettes were dropped from a certain height (1-1.8 m) to hard ground for 10 times and the weights were recorded again. The shatter resistance was calculated as a percent (Figure 2).

Briketlerin kırılma direnci hesaplanırken, işlemden önce briketlerin ağırlıkları belirlenmiş ve sonrasında belirli bir yükseklikten (1-1.8 m) 10 kez sert bir zemin üzerine serbest olarak bırakılmıştır. Briket ağırlıkları tekrar ölçülerek % olarak kırılma dirençleri hesaplanmıştır. (Şekil 2).

Fig. 2 - Shatter test

For determining Tumbler resistance 5 briquettes were weighed before settled test apparatus according to in ASAE S269.4 standards [3]. Then briquettes were placed test apparatus and rotated 40 min^{-1} for 3 minutes. At the end of rotation, briquettes were weighed again. Tumbler resistance was calculated as a percentage depending on the weight loss that occurs during the test.

Water intake resistance is a measure of the percentage of absorbed water by briquette immersed water. In this test each briquette weight before immersion in water was weighted and recorded. Then, each briquette was weighted and recorded again about 11 °C by immersion in normal tap water, with 30 second intervals for a total period of two minutes. Water intake resistance, depending on the increase in weight was calculated as a percentage.

The ash content was determined according to EN14775 standard [12] results are given in Table 1. Emission measurement contains measurements of exhaust gases discharged into the atmosphere as a result of various activities. Briquettes was measured with flue gas temperature flue gas analyser to determine flue gas emission values burned in conventional type stove used in household heating and flue gas emission values (O_2, CO, CO_2, SO_2, NO_x) coming out as a result of burning (Figure 3).

Titreşim dayanımının belirlenmesi amacıyla ASAE S269.4 [3] standardına uygun olarak testten önce rastgele seçilen 5 briketin ağırlıkları belirlenmiştir. Daha sonra test düzeneğine yerleştirilen briketler 3 dakika süresince 40 d/d dönecek şekilde teste tabi tutulmuştur. Testin sonucunda briketlerin ağırlıkları tekrar belirlenmiştir. Titreşim dayanımı test sürecince parçalanmaya bağlı olarak gerçekleşen ağırlık kaybının % ifadesi şeklinde oransal olarak hesaplanmıştır.

Su alma direnci, suya daldırılmış briketlerin su tutma yüzdesinin ölçüsüdür. Bu testten önce her briketin ağırlığı suya daldırılmadan önce ölçülmüştür. Daha sonra briketler suya daldırılmış ve iki dakika test süreci boyunca 11 ^{0}C sıcaklığındaki şebeke suyunda 30 saniyelik aralıklarla tekrar ölçülmüştür. İki dakikalık süre sonunda briketlerin su almaya karşı direnci başlangıç ve son durumdaki briket ağırlıklarının birbirlerine oranlanması ile % değer olarak hesaplanmıştır.

Kül içeri değerleri EN14775 standardına göre hesaplanmıştır [12]. Sonuçlar Tablo 1'de verilmiştir. Emisyon ölçümü, çeşitli faaliyetler sonucu atmosfere yayılan egzoz gazlarının ölçümlerini içerir. Briketler ev ısıtmasında da kullanılan geleneksel tip bir sobada yakılmış ve yanma sonucu açığa çıkan O_2, CO, CO_2, SO_2, NO_x gazlarına ait emisyon değerleri baca gazı analizörü ile ölçülmüş ve ayrıca baca gazı sıcaklık değerleri belirlenmiştir (Şekil 3).

Fig. 3 - Gas emission measurement test

At the beginning of combustion carbon monoxide (CO) and carbon dioxide (CO_2) emissions were increased rapidly because of the decrease in oxygen content (O_2). Then CO and CO_2 emissions began to decline with the increase of O_2 content in the combustion chamber as a result of steady-state the combustion process. Similar results were achieved with the research of [8], [7], [1].

RESULTS and DISCUSSION

At the end of the study, briquettes having lengths from 75 to 95 mm long and 50 mm diameter without central hole were produced. It's observed that well shaped briquettes were produced under high pressure values by hydraulic type briquetting machine. Selected particle size and moisture content of material were suitable for briquetting. Average density of obtained briquettes were suitable as a briquette (higher than 1000 kg/m^3 which given in literature). This was proved by the results of Shatter and Tumbler tests. Water intake resistance of briquettes was not so good, because they started to dissolve in the water at the second attempt. Ash content of the oat biomass briquettes was good enough for a solid biofuel according to [12] EU Standard. Heating value of briquettes were higher than normal wood and gas emission values were below the allowed limits given in Heating Air Pollution Control Regulations. Some parameters of oat biomass in the form of briquettes were given in Table 1.

Yanma olayı başlangıcında oksijen (O_2) içeriğindeki düşüşten dolayı, karbon monoksit (CO) ve karbon dioksit (CO_2) yayılımında hızlı bir artış gerçekleşmiştir. Daha sonra oksijen (O_2) içeriğindeki artışla beraber yanma olayının daha kararlı bir hale gelmesiyle karbon monoksit (CO) ve karbon dioksit (CO_2) emisyonları azalmaya başlamıştır. Benzer sonuçlara, [8], [7], [1], yaptıkları çalışmalarda da ulaşılmıştır [8], [7], [1].

SONUÇLAR ve TARTIŞMA

Çalışmanın sonucunda uzunluğu 75-90 mm aralığında değişen, içi dolu 50 mm çapında briketler üretilmiştir. Bu materyal ile hidrolik tip briketleme makinesinde yüksek basınç değerleri altında düzgün briketler elde edildiği görülmüştür. Seçilen parçacık boyutu ve nem içeriği değerlerinin yulaf atıklarının briketlenmesi açısından uygun olduğu görülmüştür. Üretilen briketlerin yoğunlukları literatürde briketler için verilen 1000 kg/m^3 değerinden yüksek olduğu için uygundur. Bu tespiti briketlerin kırılma ve titreşim dirençleri test sonuçlarıda desteklemektedir. Briketlerin su alma dayanımlarının iyi olmadıkları, ikinci denemeden itibaren briketlerin su içerisinde dağıldıkları gözlenmiştir. EN14775 AB stadartlarında belirtiliği gibi yulaf biyokütlesinden üretilen briketlerin kül içeriği değerleri katı biyoyakıt olarak kullanıma uygun olduğu görülmüştür [12]. Briketlerin ısıl değerleri odunundinden yüksek çıkmıştır ve yakma sonucu açığa çıkan gaz emisyon değerleri Hava Kirliliği Kontrolü Yönetmeliğinde verilen sınır değerlerinin altında gerçekleşmiştir. Yulaf biokütlesinden imal edilmiş briketlere ait bazı parametreler Tablo 1'de verilmiştir.

Table 1

Some parameters of oat biomass

Specification	Unit	Value
Density of material	(kg/m^3)	45.55
Density of briquettes	(kg/m^3)	1044.37
Ash content	(%)	9.32
Heating value	(cal/g)	4250
CO	(ppm)	1982

NO_x	(ppm)	136.33
SO_2	(ppm)	0
CO_2	(%)	4.65
O_2	(%)	7.6
Tumbler index	(%)	17.91
Shatter index	(%)	4.72
Water intake resistance	(%)	Dissolved

CONCLUSIONS

The results showed that, heating values and ash contents of briquettes were appropriate to be used as a solid biofuel according to [9]. This means that oat biomass obtained after harvesting can be effectively used as an alternative energy source in combustion systems. Briquettes of oat biomass after burning in a traditional stove remained below the specified limit values determined by Heating Air Pollution Control Regulation [2]. It is seen that oat biomass is very suitable for briquetting without the use of any adhesive material with a hydraulic type briquetting machine.

This study supported that converting agricultural residues/wastes to solid biofuels is an effective way of creating environmental friendly alternative energy sources. The last but not least, the number of such researches must be increased to stress on this energy potential.

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SONUÇ

Sonuçlar, EN14961-3 standardına göre ısıtma değerleri ve briket kül içeriği değerlerinin yulaf atıklarından üretilen briketlerin katı biyoyakıt olarak kullanılması açısından uygun olduğunu göstermiştir [9]. Bu durum hasat sonrası yulaf atıklarından elde edilen biokütlenin alternatif bir enerji kaynağı olarak yakma sistemlerinde kullanılabileceğini göstermektedir. Yulaf biyokütlesinden üretilen briketlerin geleneksel sobada yakılması Hava Kirliliği Kontrolü Yönetmeliğinde verilen değerlere uygun olduğu görülmüştür [2]. Yulaf biokütlesinin herhangi bir yapıştırıcı materyal kullanımına ihtiyaç olmaksızın hidrolik tip bir briket makinasında briketleme açısından uygun bir malzeme olduğu görülmüştür.

Bu çalışma, katı biyoyakıt açısından tarımsal artık ve atıkların dönüştürülmesinin çevre dostu alternatif enerji kaynakları yaratma açısından etkili bir yol olduğunu desteklemektedir. Sonuç olarak, bu tip enerji potansiyeline dikkat çekmek açısından benzer araştırmaların sayısının artırılması gerekmektedir.

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COMPARATIVE STUDY ON PIGMENT BIOSYNTHESIS BY 4 MONASCUS MUTANT STRAINS IN SUBMERGED CULTURE ON MINIMAL MEDIUM

STUDIU COMPARATIV PRIVIND BIOSINTEZA DE PIGMENTI IN 4 TULPINI MUTANTE DE MONASCUS IN CULTURA SUBMERSA PE MEDIU MINIMAL

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Abstract: *Among natural color additives with tinctorial properties and considerable stability, the pigments of Monascus are metabolites that can be synthesized in liquid media with relatively low price. 4 mutant strains obtained by gamma and electron beam irradiation have been tested compared to the parental strain in terms of biosynthesis of yelow and red pigments on a minimal medium containing glucose and mineral salts. The analysis of characteristic absorbances demonstrated that the M2 and M5 mutants produced at least 7 times more red pigment than the control under the conditions of the experiment.*

Keywords*: Monascus, pigments, minimal medium, submerged culture*

Rezumat: *Între aditivii naturali de culoare cu proprietăți tinctoriale şi stabilitate considerabile, pigmenții din Monascus sunt metaboliți ce pot fi sintetizați în medii lichide cu preț relativ scăzut. 4 tulpini mutante obținute prin iradiere gamma şi în fascicul de electroni au fost testate comparativ cu tulpina parentală din punct de vedere al biosintezei de pigmenți roşii şi galbeni pe un mediu minimal cu glucoză şi săruri minerale. Determinarea absorbanțelor caracteristice a demonstrat că două tulpini mutante M2 şi M5 au produs de minim 7 ori mai mult pigment roşu decât martorul în condițiile experimentului.*

Cuvinte cheie: *Monascus, pigmenți, mediu minimal, cultură submersă*

INTRODUCTION

High pressure of public opinion for the use of natural food additives has resulted in continuous replacement of synthetic colorants with new sources such as those from *Monascus purpureus*, known for their staining power and the relatively high degree of stability.

Monascus species are known as producers of various secondary metabolites with polyketide structures, and the well-known ones are monacolin, pigments, and citrinin [8, 11].

The genus *Monascus* comprises species that synthesize al least 6 types of pigments: 2 yellow (monascin and ankaflavin), 2 orage (rubropunctatin and monascorubrin) and 2 red (rubropunctamin and monascorubramin). It has been demonstrated that in fact the oxygen atom of pyranic ring of orange pigments rubropunctatin and monascorubrin is replaced with the -NH- group at high pH to form the red pigments monascorubramin and rubropunctamin. The orange pigments produced by the fungus react thus with -NH- groups in the mycelium to produce the red color of ang-kak (red rice) [7, 8].

The biosynthetic pathway of *Monascus* pigments has received much attention because of their wide applications and various biological activities. Based on previous reports, a schematic of metabolic routes for the biosynthesis of *Monascus* pigments is described. 1 mol of acetate and 5 mol of malonate are condensed to form a hexaketide chromophore through the polyketide biosynthetic pathway. On the other branch, a medium-chain fatty acid, for example octanoic acid, from the fatty acid biosynthetic pathway, is further synthesized to *β*-keto acid. The binding of *β*-keto acid to the chromophore structure by a trans-esterification reaction leads to the formation of the orange pigment monascorubrin (or rubropunctatin by binding with hexanoic acid) [7, 8, 11].

The fungi belonging to the genus *Monascus* have been used in the traditional way for centuries in Asian countries for coloring some foods, to prepare red rice

INTRODUCERE

Presiunea crescută a opiniei publice pentru folosirea aditivilor alimentari naturali a determinat înlocuirea coloranților de sinteză cu noi surse de pigmenți cum sunt cei din *Monascus purpureus*, cunoscuți pentru puterea tinctorială şi gradul relativ crescut de stabilitate.

Speciile de *Monascus* produc diferiți metaboliți secundari cu structura poliketidică din care cei mai cunoscuți sunt monacolina, pigmenții şi citrinina [8, 11].

Genul *Monascus* cuprinde specii care sintetizează cel puțin 6 tipuri de pigmenți: 2 compuşi galbeni (monascina şi ankaflavina), 2 oranj (rubropunctatina şi monascorubrina) si 2 roşii (rubropunctamina şi monascorubramina). S-a demonstrat cã, de fapt atomul de oxigen din inelul piranic al pigmenților oranj monascorubrina şi rubropunctatina este înlocuit cu gruparea -NH- la pH ridicat, pentru a forma pigmenții roşii monascorubramina şi rubropunctamina. Pigmenții oranj produşi de fung reacționează deci cu grupãrile -NH- în miceliu pentru a da naştere la culoarea roşie tipicã din ang-kak (orezul rosu) [7, 8].

Calea de biosinteză a pigmenților din *Monascus* fost studiată cu atenție datorită aplicațiilor numeroase şi activității biologice diverse. Pe baza studiilor efectuate a fost descrisă o schemă a căilor metabolice de biosinteză a pigmenților din *Monascus*. 1 mol de acetat şi 5 moli de malonat se condensează pentru a forma un cromofor hexaketidic pe calea biosintezei polyketidice. În cealaltă ramură a căii metabolice, un acid gras cu lanț de lungime medie, de exemplu acidul octanoic din reacțiile de biosinteză a acizilor graşi este transformat în *β*-ceto acid. Legarea acestuia la structura cromoforului printr-o reacție de trans-esterificare determină formarea pigmentului oranj monascorubrina (sau rubropunctatina prin legare de acidul hexanoic) [7, 8, 11].

Fungii aparținând genului *Monascus* au fost utilizați în mod tradițional de secole în țările din Asia pentru colorarea unor alimente, obținerea vinului roşu de orez sau a altor băuturi. Principalele utilizări ale pigmenților

wine or other beverages. The main uses of *Monascus* pigments both in the form of red rice or extract refers to the following products: meat products, fermented fish paste, Asian traditional products named "surimi", "mirin", "hoi-sin" sauce, "miso" paste, soy sauce, soy paste, "tofu", ketchup, banana sauce, rice wine ("shaoxin"), brandy, winegar from rice wine, pickles, snacks, cereals, beverages, cosmetics [2, 5].

Moreover, *Monascus* pigments also possess a broad range of biological functions, such as anticancer, antimicrobial, and antimutagenic properties, and potential antiobesity activities [4, 7, 8].

According to studies, the pigments from *Monascus* can be synthesized on solid media in SSF system (solid state fermentation) and also in submerged, shaken cultures, in appropriate media containing a carbon source, a nitrogen source and minerals. The biosynthesis is influenced by the type of nutrients, dissolved oxygen, pH, temperature, stimulating growth factors [3, 6, 9].

The pigments are synthesized both intracellular and extracellular, being secreted along the hyphae in the culture medium or can remain inside the hyphae and conidiospores, where they can be extracted with different solvents.

Monascus spp., a type of filamentous fungi, were first studied in red mold rice (RMR) and characterized by van Tieghem (1884) [10]. *Monascus purpureus* belongs to the family *Monascaceae*, the order *Eurotiales*, the subclass *Eurotiomycetidae*, and the class *Eurotiomycetes* [1].

MATERIAL AND METHOD

Fungal strains

The production of pigments was performed in liquid culture media using 5 *Monascus purpureus* strains, 4 of them being high productive mutants and 1 – the parental strain, from Mycotheque of Catholic University of Louvain with the indicative MUCL 28962. The mutant strains M1 and M2 are obtained by gamma irradiation and M4 and M5 by electron beam treatment.

Culture media

Potato dextrose agar and malt extract agar culture media have been used for the maintenance and preservation of fungal strains. The cultures have been grown at 30 ^{o}C for 5-7 days until complete sporulation then kept at 4°C before use. The growth rate of fungal strains has been determined by measuring the diameter of *Monascus* colonies on potato dextrose agar in Petri dishes for 7 days and calculated as the ratio between the diameter of colony (cm) and time (days).

A minimal medium with well known composition that allows the determination more precise of fungal growth and pigments accumulation have been used for the cultivation on orbital shaker. The medium contains $NaNO_3$ 0.3 g/L, KH_2PO_4 0.1 g/L, $MgSO_4{\cdot}7H_2O$ 0.05 g/L, NaCl 0.05 g/L, $FeSO_4{\cdot}7H_2O$ 0.01 g/L, glucose 1 g/L and were sterilized 15 minutes at 121°C. The cultures were carried out in 500 mL Erlenmeyer flasks with 200 mL liquid medium. The culture parameters were: temperature 30°C, 150 rpm, pH 6.5, time 5 days. The samples were collected daily and the absorbance corresponding at red and yellow pigments were measured at a spectrophotometer UV Vis T92+.

din *Monascus* atât sub formă de orez roşu cât şi sub formă de extract se referă la următoarele produse: produse din carne, pastă de peşte fermentat, produse tradiționale asiatice denumite "surimi", "mirin", sos "hoi-sin", pastă "miso", sos de soia, pastă de soia, "tofu", ketchup, sos de banane, vin de orez ("shaoxin"), brandy, oțet din vin roşu de orez, murături, snacks-uri, cereale, băuturi de toate tipurile, produse cosmetice [2, 5].

În plus, pigmenții din *Monascus* posedă un spectru larg de funcții biologice având proprietăți anticancerigene, antimicrobiene şi antimutagene precum şi activitate potențială antiobezitate [4, 7, 8].

Conform studiilor, pigmenții din *Monascus* pot fi sintetizați atât pe medii solide în sistem SSF (solid state fermentation) cât şi în submers, cu agitare, în medii corespunzătoare, conținând o sursă de carbon, o sursă de azot şi săruri minerale. Biosinteza este influențata de tipul nutrienților, prezența oxigenului dizolvat, pH, temperatură, utilizarea unor factori stimulatori ai creşterii [3, 6, 9].

Pigmenții sunt sintetizați atât extracelular, fiind secretati de-a lungul hifelor în mediul de cultură sau pot ramâne în interiorul hifelor sau conidiosporilor, de unde pot fi extraşi cu diferiți solventi.

Monascus spp., din categoria fungilor filamentoşi a fost studiat pentru prima oară în orezul roşu fermentat (RMR) şi caracterizat de van Tieghem (1884) [10]. *Monascus purpureus* face parte din familia *Monascaceae*, ordinul *Eurotiales*, subclasa *Eurotiomycetidae*, şi clasa *Eurotiomycetes* [1].

MATERIAL ŞI METODĂ

Tulpini fungice

Producția de pigmenți a fost realizată în medii de cultură lichide utilizând 5 tulpini de *Monascus purpureus*, 4 dintre ele fiind mutante înalt productive iar una tulpina parentală, provenită din colecția Micotecii Universității Catolice din Louvain, cu indicativul MUCL 28962 Tulpinile mutante M1 şi M2 sunt obținute prin iradiere gamma iar M4 şi M5 prin iradiere cu electroni.

Medii de cultura

Pentru întreținerea şi conservarea tulpinilor s-au folosit mediile potato dextrose agar şi maltz extract agar în tuburi. Culturile au fost crescute la 30 ^{o}C timp de 5-7 zile, până la sporularea completă, apoi păstrate la 4 ^{o}C până la utilizare. Viteza de creştere a tulpinilor fungice a fost determinată prin măsurarea diametrului coloniilor de *Monascus* dezvoltate în cutii Petri pe mediul potato dextrose agar timp de 7 zile şi calculată ca raportul dintre diametrul coloniei (cm) şi timp (zile).

Pentru cultivarea pe incubatorul orbital s-a utilizat un mediu minimal cu compoziție bine determinată care permite urmărirea mai precisă a creşterii şi acumulării de pigmenți. Mediul conține $NaNO_3$ 0.3 g/L, KH_2PO_4 0.1g/L, Mg $SO_4{\cdot}7H_2O$ 0.05 g/L, NaCl 0.05 g/L, Fe $SO_4{\cdot}7H_2O$ 0.01 g/L, glucoza 1 g/L şi a fost sterilizat prin autoclavare, 15 minute la 121°C. Culturile au fost efectuate în flacoane Erlenmeyer de 500 mL în care s-au introdus 200 mL mediu lichid. Parametrii de cultivare au fost: temperatura 30°C, 150 rpm, pH 6,5, durata de dezvoltare 5 zile. Probele au fost recoltate zilnic şi s-a determinat absorbanța corespunzătoare pigmenților roşii şi galbeni la un spectrofotometru UV Vis T92+.

RESULTS

On potato dextrose agar in Petri dishes *Monascus* forms red colonies with velvet or fluffy appearance, uniform margins, do not produce exudates (fig 2a). The determination of growth rate demonstrated that the parental strain forms the largest colonies on this medium (8.5 cm and 1.2 cm/day growth rate).The mutant colonies are smaller and different in morphological aspect. M1 has 0.5 cm/day growth rate, M2 0.7, M4 0.4 and M5 0.6 (fig 1). It seems that the pigmentation on this agar medium is directly related with the growth rate: M4 forms the most colored colonies and has the smaller growth rate.

On microscopic plates it can be seen septate hypha, conidiospores in germination stage and spherical asce with ascospores (fig 2b).

REZULTATE

Pe potato dextrose agar in cutii Petri *Monascus* formează colonii roşii cu aspect catifelat sau pufos, margini uniforme, nu produce exudate (fig 2a). Determinarea vitezei de creştere a demonstrat că tulpina parentală formează cele mai mari colonii pe acest mediu (8,5 cm şi 1,2 cm/zi viteza de creştere). Coloniile mutante sunt mai mici şi diferite ca aspect morfologic. M1 are o viteză de creştere de 0,5 cm/zi, M2 0,7, M4 0,4 şi M5 0,6 (fig 1). Se pare că pigmentația pe acest mediu agarizat este direct corelată cu viteza de creştere: M4 formează cele mai colorate colonii şi are cea mai mică viteza de creştere.

Pe preparatele de microscop se pot vedea hife septate, conidiospori în stadiul de germinație şi asce sferice cu ascospori (fig 2b).

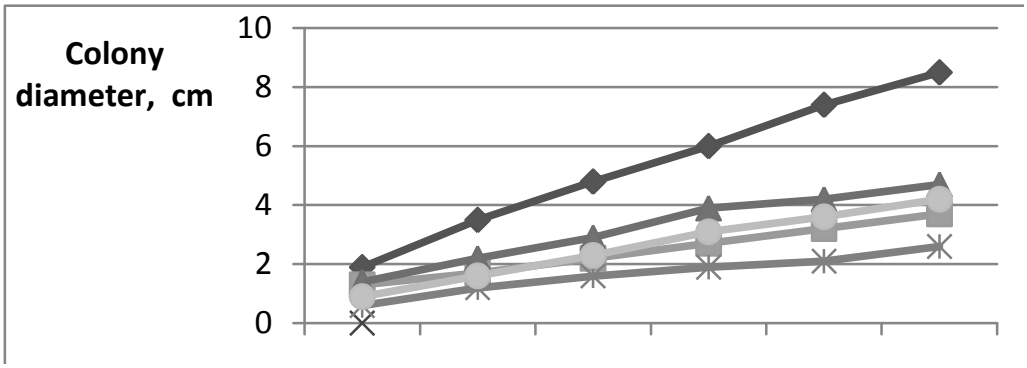


Fig. 1 – The diameters of *Monascus* colonies (parental and mutant strains) on potato dextrose agar medium

In order to compare the production of red and yellow pigments, the absorbance in samples collected from culture media were analyzed and the visible spectra were recorded (fig. 4).

In the first 3 days the fungal biomass was accumulate in all the cultures. The mold forms small pellets of hyphae (fig. 2) and then the pigments begin to synthesize..

Pentru a compara producția de pigmenți roşii şi galbeni s-a analizat absorbanța în probele recoltate din mediul de cultură şi s-au înregistrat spectrele de absorbție in vizibil (fig. 4).

În primele 3 zile în toate culturile s-a acumulat biomasa fungică. Mucegaiul formează mici pelete din hife (fig. 2) şi apoi pigmenții încep să se sintetizeze.

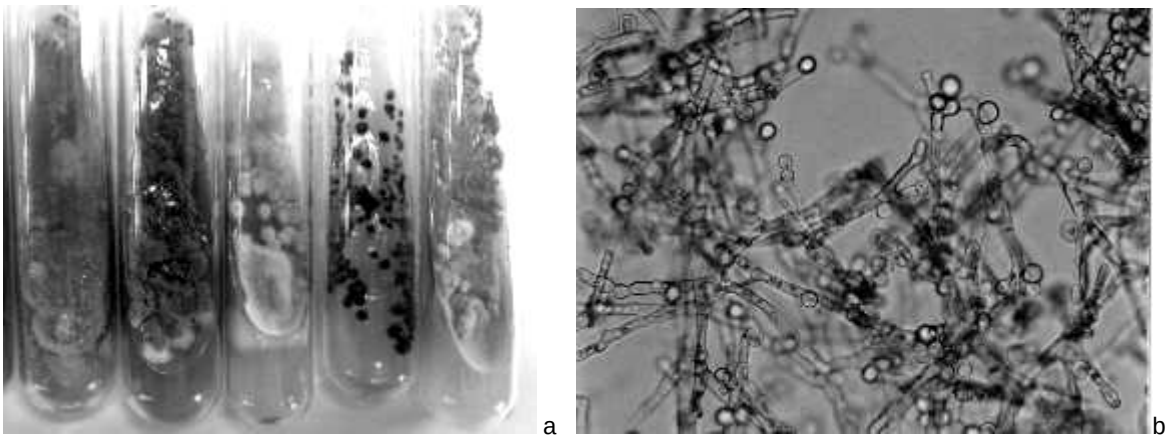


Fig. 2 – The morphological aspect of *Monascus* colonies - a) (parental and mutant strains) on potato dextrose agar medium and b) hyphae and conidiospores on microscopic plates

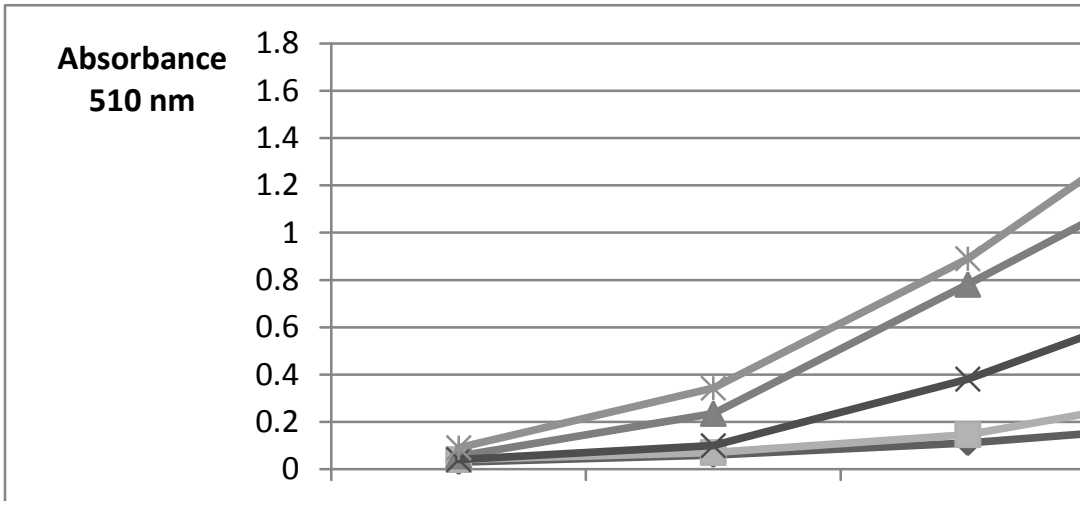
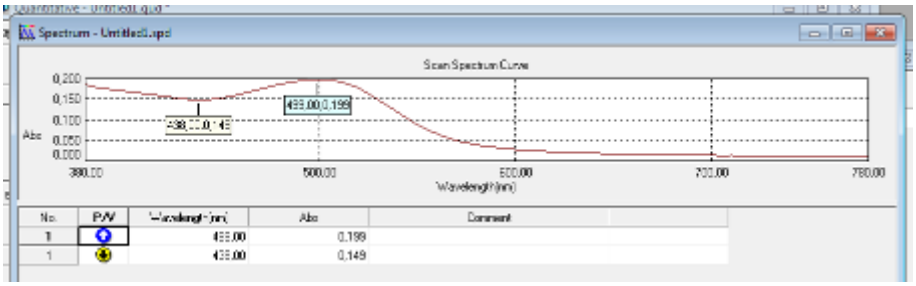


Fig. 3 - Absorbance values for red pigments in minimal culture medium after 5 days



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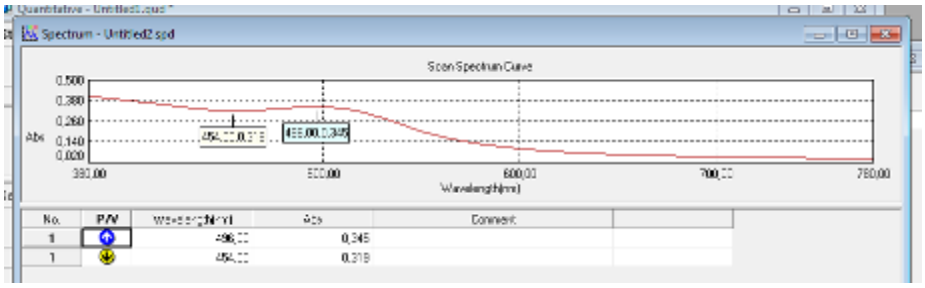

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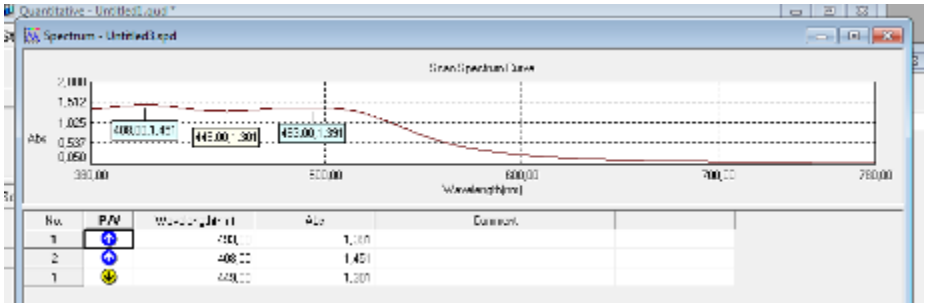

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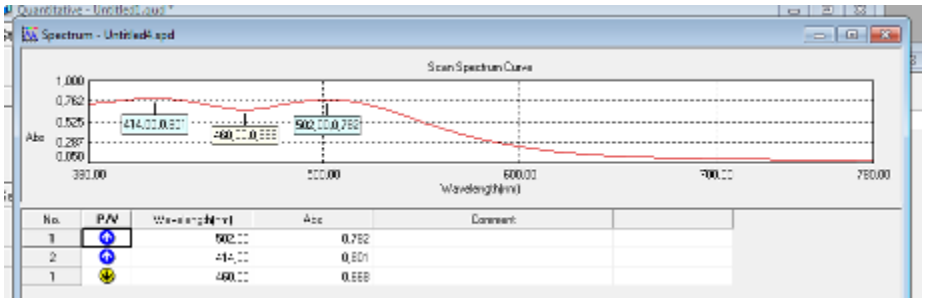

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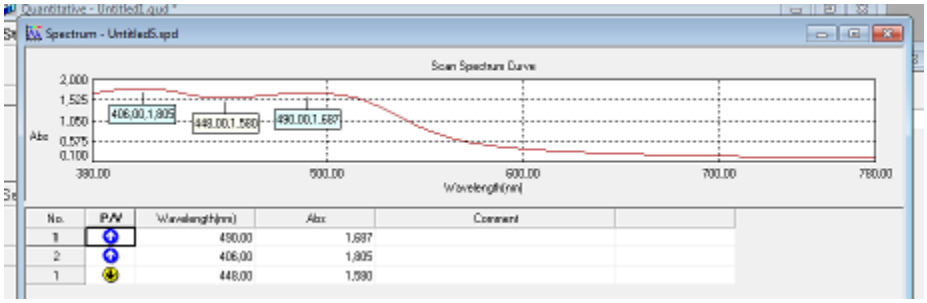

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Fig. 4 Visible spectra for pigment mixture in culture media after 5 days on orbital shaker a) parental strain; b) M1 c) M2 d) M4 e) M5

The absorbance values at 540 nm determined during the experiment are shown in figure 3 and demonstrate that the extracellular red pigments begin to accumulate after 3 days, and the M5 was the most productive strain.

After 5 days the values of absorbances at 400 and 510 nm for yellow and red pigments were compared (table1). All mutant strains synthesized higher amounts of pigments but the M5 mutant was the most productive. The absorbance value of M5 characteristic for the red component was 8 time higher than the absorbance for parental strain. M2 was another strain that produces 7 times larger amounts of pigments. M4 had a smaller productivity than M5 and M2 probably because of its low growth rate, but had the best nuance of red, the most interesting dye for food industry.

Valorile absorbanțelor la 540 nm determinate pe parcursul experimentului sunt prezentate în figura 3 şi demonstrează că pigmenții roşii extracelulari încep să se acumuleze din a treia zi, iar M5 este tulpina cea mai productivă.

După 5 zile de dezvoltare, valorile absorbanțelor la 400 şi 510 nm pentru pigmenții galbeni şi roşii au fost comparate (tabelul1). Toate tulpinile mutante au sintetizat cantități mai mari de pigmenți dar mutanta M5 a fost cea mai productivă. Valoarea absorbanței tulpinii M5 caracteristică pentru componenta roşie a fost de 8 ori mai mare decât absorbanța pentru tulpina parentală. M2 a fost altă tulpină care a produs de 7 ori mai multă cantitate de pigmenți. M4 a avut o productivitate mai mică decât M5 şi M2 probabil din cauza vitezei mici de creştere, dar a avut cea mai bună nuanța de roşu, cel mai intereant colorant pentru industria alimentară.

Table 1

The absorbance values of yellow and red pigments for parental and mutant strains

Absorbance	Parental strain	M1	M2	M4	M5
Abs 400 nm	0.171	0.382	1.439	0.782	1.791
Abs 510 nm	0.194	0.336	1.346	0.774	1.633
Maximum, nm	499nm	496 nm	493 nm, 408 nm	502 nm, 414 nm	490 nm, 406 nm
Abs max	0.199	0.345	1.391, 1,451	0.782, 0.801	1.687, 1.805
Nuance, Abs510/Abs400	1.13	0.88	0.93	0.99	0.91

CONCLUSIONS

4 mutant radioinduced strains of *Monascus purpureus* were tested in terms of red and yellow pigments production. All the 4 mutant strains of *Monascus* produced larger amonts of polyketide pigments in minimal culture medium containing glucose and salts after 5 incubation days at 30 ^{o}C, 150 rpm in Erlenmeyer flasks.

CONCLUZII

4 tulpini mutante de *Monascus purpureus* au fost testate din punct de vedere al producției de pigmenți roşii şi galbeni. Toate cele 4 tulpini mutante de *Monascus* au produs cantități mai mari de pigmenți poliketidici în mediu de cultură minimal conținând glucoză şi săruri după 5 zile de incubare la 30 ^{o}C, 150 rpm in flacoane Erlenmeyer.

Compared to a control strain the mutants had also lower growth rate on potato dextrose agar and different morphocolonial characteristics. The most productive strains were M5 and M2 that produced more than 7 times pigments than the control strain.

The use of *Monascus* pigments in food industry represents a natural alternative to the synthetic dyes that can be toxic and unhealthy.

Also found in the form of a dietary supplement, red yeast rice extract is recognized as a natural cholesterol-lowering agent, provides benefits in cardiovascular disorders, in other blood circulation problems, in anthrax, bruises, diarrhea, dysentery, indigestion, stomach problems.

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Comparativ cu tulpina martor, mutantele au de asemenea o rată de creştere mai scazută şi caractere morfologice diferite pe potato dextrose agar. Cele mai productive tulpini au fost M5 şi M2 care au produs de 7 ori mai mult pigmenți decât martorul.

Utilizarea pigmenților din *Monascus* în industria alimentară reprezintă o alternativă naturală la coloranții sintetici care pot fi toxici şi nesănătoşi.

Găsit de asemenea şi sub formă de supliment alimentar, orezul roşu este recunoscut ca agent natural anti-colesterol, cu beneficii în tulburările cardiovasculare, în alte probleme circulatorii, în antrax, contuzii, diaree, dizenterie, indigestii, probleme ale stomacului.

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THE DETERMINATION OF THE INTERDEPENDENCE BETWEEN THE AMOUNT OF FREE RESIDUAL CHLORINE AND THE AMMONIA COMPOUNDS LOAD TO THE DISINFECTION OF A MICROBIAL CONTAMINATED WASTEWATER
/
DETERMINAREA INTERDEPENDENȚEI DINTRE CANTITATEA DE CLOR REZIDUAL LIBER ŞI CONȚINUTUL DE COMPUŞI AMONIACALI LA DEZINFECTAREA UNEI APE UZATE CONTAMINATĂ MICROBIOLOGIC

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Abstract: *In the paper is presented an experimental study for the interdependence between the amount of free residual chlorine and the ammonia compounds load to the disinfection of the wastewater resulted from the manufacturing process of biological products (vaccines, sera, diagnostic reagents) in the National Society " PASTEUR INSTITUTE" S.A. of Bucharest. During the experiments, in the water flow submitted to the chlorination treatment (90 m^3/h), there were introduced progressive chlorine doses between 50-200 g/h for a period of 8 hours, registering for each chlorine dose the microbial load, the content of ammonia compounds and the pH/temperature of the influent and of the effluent, respectively the residual chlorine (free and chemically bonded) content of the effluent. In the paper there are indicated and described the methods used for the determination of the contents of free and total chlorine and ammonia compounds from the waste water, for the determination of the pH of the waste water and there are presented and discused the results of the experimental study.*

Keywords: *Microbial Contaminated Wastewater, Disinfection, Residual Chlorine, Ammonia Compounds, pH / temperature*

INTRODUCTION

The National Society "PASTEUR INSTITUTE" S.A. of Bucharest is an institution wherein are held research and development activities and manufacturing of a wide range of veterinary pharmaceutical products, mainly biologicaly active products (vaccines, sera, diagnostic reagents). From these activities, microbial contaminated wastewater results, which must be evacuated in the central sewerage system of Bucharest city.

In order to respect the Romanian legal prescriptions concerning the quality of the effluent discharged into urban sewarages (NTPA 013, HG 567/2006), the National Society " PASTEUR INSTITUTE" S.A. of Bucharest has a local wastewater treatment plant in which the wastewater resulted from the company's activity are mechano-chemical treated (it must be mentioned that in this plant reach both the wastewater resulted from the technological processes and the rainwater colected by the local sewerage system).

In an anterior paper there were described [5] the construction and the operation of the chlorine dosing and injection installation and it was presented the experimental study to determine the optimal dose of chlorine for the disinfection of a microbiologically contaminated wastewater, indicating the laboratory analyzes which were done for the determination of the microbial load of the wastewater samples and the methods for the determination of the residual free

Rezumat*: În lucrare este prezentat studiul experimental de determinare a interdependenței dintre cantitatea de clor rezidual liber şi conținutul de compuşi amoniacali la dezinfectarea apei uzate contaminată microbiologic rezultată din procesul de fabricatie a produselor biologice (vaccinuri, seruri, reagenți de diagnostic) in Societatea națională "INSTITUTUL PASTEUR" S.A. din Bucureşti. În timpul experimentelor s-au introdus în curentul de apă supus tratamentului de clorinare (cu debitul de 90 m^3/h), doze progresive de clor între 50-200 g/h, pe perioade de câte 8 ore, înregistrându-se pentru fiecare doză de clor în parte încărcarea microbiologică, conținutul de compuşi amoniacali ai influentului şi efluentului, pH-ul/ temperatura influentului şi efluentului, respectiv conținutul de clor rezidual al efluentului (liber şi legat chimic). În lucrare sunt indicate şi descrise metodele utilizate pentru determinarea clorului liber si clorului total, determinarea conținutului de compuşi amoniacali din apa uzată, pentru determinarea pH-ului apei uzate şi sunt prezentate şi analizate rezultatele studiului experimental.*

Cuvinte cheie: *Apă uzată contaminată microbiologic, Dezinfectare, Clor rezidual, Compuşi amoniacali, pH/Temperatură*

INTRODUCERE

Societatea națională "INSTITUTUL PASTEUR" S.A. din Bucureşti este o instituție în care se desfăşoară activități de cercetare-dezvoltare şi de fabricare a unei game largi de produse farmaceutice de uz veterinar, preponderent produse biologic active (vaccinuri, seruri, reagenți de diagnostic). În urma acestor activități rezultă apă uzată contaminată microbiologic, care trebuie evacuată către sistemul centralizat de canalizare al municipiului Bucureşti.

În scopul respectării prevederile legale româneşti privind calitatea apelor deversate în canalizările orăşeneşti (Normativ NTPA 013, HG 567/2006) Societatea națională "INSTITUTUL PASTEUR" S.A. din Bucureşti este dotată cu o stație locală de epurare, în care se tratează mecano - chimic apele uzate rezultate din activitatea societății (de menționat că în stația de epurare locală ajung atât apele uzate rezultate din procesele tehnologice cât şi apele meteorice captate de sistemul local de canalizare).

Într-o lucrare anterioară [5] au fost descrise construcția şi funcționarea instalației de injectare a clorului gazos şi a fost prezentat studiul experimental de determinare a dozei optime de clor pentru dezinfectarea apei uzate contaminate microbiologic, cu indicarea metodelor de analiză de laborator utilizate pentru determinarea încărcării microbiologice, respectiv cu indicarea metodelor utilizate pentru determinarea conținutului de clor rezidual din efluentul instalației de

chlorine from the effluent.

MATERIAL AND METHOD

For the determination of the interdependence between the amount of free residual chlorine and the ammonia compounds load to the disinfection of the microbial contaminated wastewater, an experimental study was conducted as follows:

- it was made permanent chlorination of the wastewater per period of 8 hours (the duration of a shift of work) with progressive chlorine doses between 50 – 200 g Cl_2/h (during a chlorination period the chlorine dose being maintained constant);
- the flow of wastewater submitted to the chlorination treatment (90 m^3/h) was maintained constant for the entire duration of the experimental study;
- during all the duration of the study, samples were taken every 2 hours from both the influent and effluent (namely at the point of discharge of the effluent in the urban sewerage) of the disinfection installation for the determination of the microbial load, the ammonia compounds content, the pH / temperature and the residual chlorine;
- laboratory analyzes were made for the determination of the microbial load, the ammonia compounds content, the pH / temperature and the residual chlorine of the taken samples, using the analysis referential presented in table 1 (it is mentioned that there were used both classical methods [1, 2] stipulated by the Romanian standards and methods currently used in Europe and wide world);

dezinfectare.

MATERIAL ŞI METODĂ

În vederea determinării interdependenței dintre cantitatea de clor rezidual şi conținutul de compuşi amoniacali la dezinfectarea apei uzate contaminate microbiologic a fost realizat un studiu experimental condus astfel:

- s-a efectuat clorinarea permanentă a apei uzate pe perioade de câte 8 ore (un schimb de lucru) cu doze progresive de clor între 50 – 200 g Cl_2/h (în timpul unei perioade de clorinare doza de clor fiind menținută constantă);
- debitul de apă uzată supusă tratamentului de clorinare (90 m^3/h) a fost păstrat constant pe toată durata studiului;
- pe toată durata studiului, din 2 în 2 ore, s-au prelevat probe atât din influentul, cât şi din efluentul (în punctul de deversare a efluentului în canalizarea urbană) instalației de dezinfectare prin clorinare pentru determinarea încărcării microbiologice, conținutului de compuşi amoniacali, pH-ului / temperaturii si conținutului de clor rezidual;
- au fost efectuate analize de laborator pentru determinarea încărcării microbiologice, conținutului de compuşi amoniacali, a pH-ului (implicit şi a temperaturii) si al clorului residual, liber şi legat, din probele prelevate, utilizându-se referențialul de analiză indicat în tabelul 1 (de menționat că au fost utilizate atât metodele clasice [1, 2] prevăzute de standardele româneşti, cât şi metodele prevăzute actualmente pe plan european şi mondial);

Table 1

Microbial load, ammonia compound content, pH / temperature and residual chlorine analysis referential and maximum permissible limit values

The analyzed parameter [Unit]	Analysis referential	Maximum permissible limit values
Total number of mesophilic bacteria that grow at 37°C	SR EN ISO 8199/2008	-
Probable number of total coliforms bacteria [no. /100ml]	SR EN ISO 9308-2:2014	5000
Probable number of faecal coliforms bacteria [no. /100ml]	SR EN ISO 9308-2:2014	2000
Probable number of faecal streptococcus Bacteria [no. /100ml]	SR EN ISO 7899-2:2002	1000
Escherichia coli	SR EN ISO 8199/2008	0
Clostridium perfringens	Method L458/2002 (consolidated form in 2011)	0
Pseudomonas aeruginosa	pr EN ISO 6222	0
Salmonella	Pre-enrichment, enrichment, dispersion and isolation on selective media and biochemical and serological confirmation ISO 19250:2013	0
Residual chlorine [mg/l]	SR EN ISO 7393/2/2002	0.50
Ammonia compounds (expressed as ammonium ions) [mg/l]	Spectrometric method SR ISO 7150/1/2001	30
pH / temperature [°C]	Electrochemical probe measuring SR ISO 10523/2012	6.5 - 8.5

- because of the wide variety of wastewater microbial load, for the microbiological control of the

- din cauza marii varietăți a încărcării microbiene a apei uzate, la controlul microbiologic al probelor, pe

samples, in addition to the routine analysis required by the Romanian and European standards, there were added additional complementary analysis [5];

- for the determination of the content of free residual chlorine and total residual chlorine in the samples, it was used the colorimetric method with N, N-diethylphenylene - 1,4-diamine; the free chlorine, in form of hypochlorous acid, hypochlorite ion and dissolved elemental chlorine, was determined by spectrophotometry at 510 nm measurement of the red compound, resulted from the reaction with N, N-diethylphenylene - 1,4-diamine, at a pH value between 6.2 and 6.5; the total chlorine, present in form of free chlorine and bound chlorine in chloramines and in organic chloramines, was determined by spectrophotometry at 510 nm measurement in the presence of an excess of potassium iodide [3]; the calculation of the concentration of free chlorine and total chlorine was made by applying the correction of the interference due to the presence of the oxidized manganese [4]; the bound chlorine was determined by the difference between the total residual chlorine and the free chlorine; for the validation of the results obtained from the determination of free and bound chlorine, there were also used the titrimetric method, using methyl orange, and the spectrophotometric method, using o-tolidine [5];

lângă analizele curente obligatorii, prevăzute de normativele româneşti şi europene s-au adaugat suplimentar şi analize complementare [5];

- pentru determinarea conținutului de clor rezidual liber si clor rezidual total din probe s-a utilizat metoda colorimetrica cu N,N – dietilfenilen – 1,4 diamina; clorul rezidual liber, prezent sub forma de acid hipocloros, ion hipoclorit si clor elementar dizolvat, a fost determinat prin măsurarea spectrometrică la 510 nm a compusului de culoare rosie, rezultat din reacția cu N, N – dietilfenilen – 1,4 diamina, la valori ale pH - ului cuprinse între 6,2 si 6,5; clorul rezidual total, prezent sub forma de clor liber şi clor legat în cloramine şi cloramine organice, a fost determinat prin reacția cu N,N – dietilfenilen – 1,4 diamina, în prezenta unui exces de iodură de potasiu [3] şi măsurarea spectrometrică la 510 nm; calculul concentrației de clor rezidual liber şi clor rezidual total, s-a făcut aplicând corecția interferenței datorate prezenței manganului oxidat [4]; clorul legat chimic s-a determinat prin diferența dintre clorul rezidual total şi clorul rezidual liber; pentru validarea rezultatelor obținute la determinarea conținutului de clor rezidual liber şi clor rezidul legat chimic, au mai fost utilizate metoda titrimetrică, utilizând metil oranj, şi metoda spectrofotometrică, utilizând o-tolidină [5].

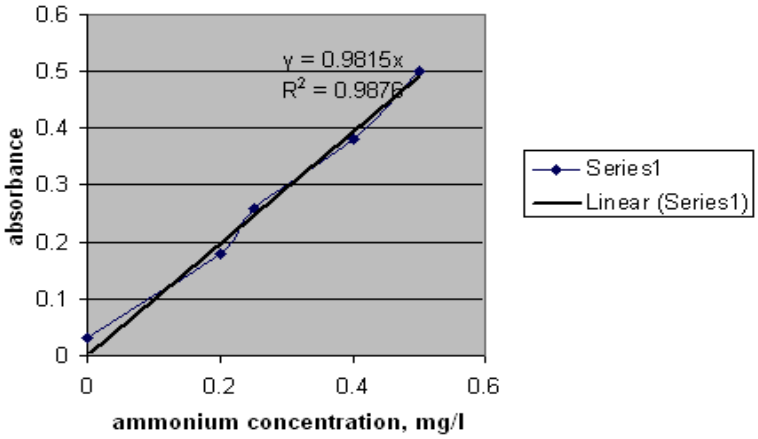

Fig. 1 – The calibration curve of the spectrophotometric method (the absorbance in relation with the ammonium ions concentration [mg/l])

- for the determination of the content of ammonia compounds (in the form of NH_4^+ ions) in the samples, it was conducted a spectrometric measurement at about 650 nm of the blue compound resulted from the reaction of ammonia with the salicylate and hypochlorite ions, in the presence of sodium (III) nitrosopentacyanoferrate (sodium nitroprusside); the hypochlorite ions are generated by the alkaline hydrolysis of the sodium salt of N,N'-dichloro-1,3,5-triazine-2,4,6(1H, 3H, 5H)-trione (sodium dichloroisocyanurate); the reaction of chloramine with sodium salicylate takes place at pH 12.6 in presence of sodium nitroprusside; the added sodium citrate masks the interference given by the cations, in particular of calcium and magnesium; the methodology used was as follows: it was taken a 10 ml sample of wastewater and filtered through a glass fiber filter, it was brought to a volume of 40 ml and it was formed the absorbing compound by the addition of 4 ml color reagent (sodium salicylate, trisodium citrate and sodium (III) nitrosopentacyanoferrate) and 4 ml of sodium dichloroisocyanurate, the pH of the obtained solution was 12,68; after 60 minutes of thermostatting at

- pentru determinarea conţinutului de compuşi amoniacali (sub formă de ioni de NH_4^+) din probe, s-a efectuat măsurarea spectrometrică, la aproximativ 650 nm a compusului albastru rezultat din reacția amoniului cu ionii de salicilat şi hipoclorit în prezența nitrozopentacianoferatului (III) de sodiu (nitroprusiat de sodiu); ionii de hipoclorit sunt generați prin hidroliza alcalină a sării de sodiu a N,N'-dicloro-1,3,5-triazina-2,4,6(1H,3H,5H)-triona (dicloroizocianurat de sodiu); reacția cloraminei cu salicilatul de sodiu are loc la un pH cu valoarea de 12,6 în prezenta nitroprusiatului de sodiu; citratul de sodiu adăugat maschează interferența dată de cationi, în special de calciu si magneziu; metodologia utilizată a fost următoarea: s-a prelevat o probă de 10 ml de apă uzată, filtrată printr-un filtru de fibră de sticlă, s-a adus la volumul de 40 ml şi s-a format compusul absorbant prin adaugarea a 4 ml de reactiv colorat (salicilat de sodiu, citrat trisodic şi nitrozopentacianoferat (III) de sodiu) şi 4 ml de soluție de dicloroizocianurat de sodiu, pH-ul soluției obținute a avut valoare de 12,68; după 60 minute de termostatare la o temperatură de 25ºC, s-a măsurat absorbanța

25° C, the absorbance was measured at 655nm in a cell with appropriate optical path and it was drawn the calibration curve (see Figure 1), in order to determine the absorbance in relation with the weight of ammonium nitrate, for each optical path of the cell (it is mentioned that, in a sample, the ammoniacal nitrogen concentration of 0.777 mg/l corresponds to a concentration of 1mg/l ammonium ions) [6];

- the determination of the pH of the wastewater samples is based on the measurement of the potential difference of an electrochemical cell, using a suitable pHmeter; all pH determinations are accompanied by the temperature at which the measurement is made (because the pH of a sample is dependent on the temperature, due to the dissociation equilibrium); the parameter pH of the wastewater is not as itself a contaminant of them, but is considered as an important parameter for characterizing wastewater, depending on its value it will be established the appropriate structure of the wastewater treatment or the right way of discharging the wastewater to the public sewage, with or without a neutralization treatment;

- it is mentioned that the sampling of wastewater was performed according to ISO 5667/10/1995 and conservation of the samples was performed according to ISO 5667/3/2004.

RESULTS AND DISCUSSION

In table 2 there are presented the values ranges of the microbiological parameters, the ammonia compounds content, the pH / temperature and the residual chlorine in the influent samples resulted from the experimental study.

soluției la 655nm, într-o cuva cu drum optic adecvat şi s-a trasat curba de etalonare (vezi figura 1), în scopul determinării absorbanței în funcție de masa de azot amoniacal, pentru fiecare drum optic al cuvei (se menționează că o concentrație de azot amoniacal de 0,777 mg/l în probă corespunde la o concentrație de1mg/l ioni amoniu în probă) [6].

- determinarea valorii pH-ului probelor de apă uzată se bazează pe măsurarea diferenței de potential a unei celule electrochimice utilizând un pH-metru adecvat; toate determinarile de pH sunt insoțite de temperatura la care se efectuează măsurarea (se menționează că pH-ul probelor este dependent de temperatură, datorită echilibrului de disociere); parametrul pH al apelor uzate nu reprezintă prin el însuşi un contaminant al acestora, însă se constituie ca un parametru important de caracterizare a apelor uzate, în funcție de valoarea acestuia stabilindu-se structura adecvată a procesului de epurare la care vor fi supuse, sau modul de evacuare a apelor uzate în canalizarea orăşenească, cu sau fără aplicarea unui tratament de neutralizare.

- de menționat că prelevarea tuturor probelor de apă a fost efectuata conform standardului ISO 5667/10/1995, iar conservarea tuturor probelor a fost efectuata conform standardului ISO 5667/3/2004.

REZULTATE ŞI DISCUȚII

În tabelul 2 sunt prezentate domeniile de valori ale parametrilor microbiologici, a conținutului de compuşi amoniacali, a pH-ului / temperaturii si conținutului de clor rezidual din probele prelevate din influent, rezultate în urma studiului experimental.

Table 2

Microbial load, ammonia compound content, pH / temperature and residual chlorine values ranges resulted from the experimental study

The analyzed parameter [Unit]	Values range
Total coliforms [no. /100ml]	8100 - 7900
Faecal coliforms [no. /100ml]	3700 - 3500
Faecal Streptococi [no. /100ml]	2800 - 2500
Escherichia coli	0
Clostridium perfringens	0
Pseudomonas aeruginosa	0
Salmonella	0
Residual choline [mg/l]	0,03 - 0,05
Ammonia compounds (expressed as ammonium ions) [mg/l]	10,88
pH / temperature [°C]	7,9 - 8,2 / 25ºC

Table 3 presents the values resulted from the experimental study of the microbiological parameters, free and chemically bound residual chlorine, ammonium ion content, pH / temperature from the samples of effluent taken at point of discharge into the urban sewage.

Analyzing the results from table 3 it can be observed that, from the point of view of a suitable disinfection of the effluent, the optimal dose of chlorine is 100 gCl_2/h, where both the microbiological parameters and the free residual chlorine reside freely within the permissible limits. It is mentioned that, in the case where a chlorine dose of 50 gCl_2/h is administrated, some of the microbiological parameters exceed the permissible limits, while in the case where chlorine doses of 150 and 200 gCl_2/h are administrated, the free residual chlorine exceeds the permissible limit (in table there are marked the values of parameters which are not included in the permissible limits).

În tabelul 3 sunt prezentate valorile parametrilor microbiologici, clorului rezidual liber şi legat chimic, conținutului de ioni de amoniu, pH-ului / temperaturii din probele prelevate din efluent, la punctul de deversare în canalizarea urbană, rezultate în urma studiului experimental.

Analizând rezultatele din tabelul 3 se observă că din punct de vedere al dezinfectării corespunzătoare a efluentului, doza optimă de clor este de 100 g Cl_2/h, la care atât parametrii microbiologicii cât şi clorul rezidul liber se încadrează în limitele admisibile. Se menționează că în cazul administrării unei doze de clor de 50 g Cl_2/h, unii dintre parametri microbiologici depăşesc limitele admise, în timp ce în cazul administrării unor doze de clor de 150 şi 200 g Cl_2/h, clorul rezidul liber depăşeste limita admisă (în tabel sunt marcate valorile parametrilor care nu se încadrează în limitele admise).

Table 3

Values resulted from the experimental study of the microbiological parameters, free and chemically bound residual chlorine, ammonium ion content, pH / temperature from the samples of effluent taken at point of discharge into the urban sewage

The analyzed parameter [Unit]	The chlorine doze [g/h]															
	50				100				150				200			
	Chlorination period [h]				Chlorination period [h]				Chlorination period [h]				Chlorination period [h]			
	2	4	6	8	2	4	6	8	2	4	6	8	2	4	6	8
NTG 37°C	2380	2300	2100	1300	6	7	7	8	2	2	3	3	<0,5	<0,5	<0,5	0,5
Total coliforms [no. /100ml]	2300	2280	2080	1180	0	0	0	0	0	0	0	0	0	0	0	0
Faecal coliforms [no. /100ml]	390	300	256	189	0	0	0	0	0	0	0	0	0	0	0	0
Faecal Streptococi [no. /100ml]	1890	1670	1400	1030	0	0	0	0	0	0	0	0	0	0	0	0
Escherichia coli	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clostridium Perfringens	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudomonas Aeruginosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salmonella	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Free residual choline [mg/l]	0,11	0,08	0,04	0	0,28	0,20	0,19	0,15	0,58	0,51	0,42	0,40	0,64	0,62	0,57	0,50
Bound residual choline [mg/l]	0,15	0,22	0,28	0,30	0,18	0,27	0,32	0,32	0,28	0,36	0,40	0,41	0,35	0,41	0,50	0,50
Ammonium ions [mg/l]	10,3	10,1	9,2	8,4	10,4	9,1	8,5	8,6	9,2	7,9	7,3	7,1	7,8	7,2	6,4	6,1
pH / temp °C	8,17 / 16,2	8,17 / 16,2	8,19 / 16,3	8,10 / 16,3	8,12 / 16	7,97 / 16,1	8,10 / 16,2	7,88 / 16,3	8,17 / 16.1	7,97 / 16,2	8,19 / 16,2	8,10 / 16,3	8,1 / 16,1	7,9 / 16,1	7,9 / 16,2	7,8 / 16,2

Regarding the content of the effluent in residual chlorine, free and chemically bonded, there are observed the following:

- higher is the dose of injected chlorine, higher is the content of chemically bonded chlorine in the effluent;
- for a certain dose of chlorine injected, longer the period of administration, the content of chemically bonded residual chlorine of the effluent tends to increase;
- for a certain dose of chlorine injected, longer the period of administration, the content of free residual chlorine of the effluent tends to decrease.

From the point of view of the content of ammonia compounds (expressed as ammonium ions) of the effluent, there are observed the following:

- higher the dose of injected chlorine is, lower the content of ammonium ions in the effluent;
- for a certain dose of chlorine injected, longer the period of administration is, the ammonium ions content of the effluent tends to decrease;
- the ammonium ions content in all the effluent samples does not exceed the permissible limits.

From the point of view of the pH of the effluent, the results were relatively constant (around 8), and fall within the range of admissible values.

CONCLUSIONS AND FUTURE WORK

The paper presents an experimental study to determine the interdependence between the amount of free residual chlorine and the ammonia compounds load

Din punct de vedere al conținutului de clor rezidual liber şi legat chimic al efluentului, se observă următoarele:

- cu cât doza de clor injectată este mai mare, cu atât conținutul de clor legat chimic este mai mare;
- pentru o anumită doza de clor injectată, cu cât perioada de timp de administrare este mai mare, cu atât conținutul de clor legat chimic are tendința să crească;
- pentru o anumită doza de clor injectată, cu cât perioada de timp de administrare este mai mare, cu atât conținutul de clor liber are tendința să scadă.

Din punct de vedere al conținutului de compuşi amoniacali al efluentului (exprimat prin conținutul de ioni de amoniu), se observă următoarele:

- cu cât doza de clor injectată este mai mare, cu atât conținutul de ioni de amoniu din efluent este mai redus;
- pentru o anumită doza de clor injectată, cu cât perioada de timp de administrare este mai mare, cu atât conținutul de ioni de amoniu din efluent tinde să se reducă;
- conținutul de ioni de amoniu din toate probele de efluent nu depăşeste limita admisă.

Din punct de vedere al pH-ului efluentului, rezultatele au fost relativ constante (în jurul valorii 8) şi s-au încadrat în domeniul de valori admisibile.

CONCLUZII ŞI CERCETĂRI VIITOARE

În lucrare este prezentat un studiu experimental

to the disinfection of the microbial contaminated wastewater.

From the experimental results it is observed that the level of ammonia compounds in the water submitted to a disinfection treatment depends on the injection of chlorine gas, and implicitly, on the chemically bonded chlorine concentration in the form of chloramines from the effluent; lower the free residual chlorine is, higher becomes the total residual chlorine; higher the total residual chlorine becomes, implicitly in form of chloramines ($NH_3 + OCl^- \rightarrow NH_2Cl + HO^-$), lower the ammonium ions concentration in the effluent becomes, at values of pH≈8.

In the future, experimental studies will be carried out in order to determine the varieties of the residual bonded chlorine, as monochloramine, dichloramine or nitrogen trichloride.

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pentru determinarea interdependenței dintre cantitatea de clor rezidual şi conținutul de compuşi amoniacali la dezinfectarea apei uzate contaminate microbiologic.

Din rezultatele experimentale obținute se observă că nivelul concentrației compuşilor amoniacali în apa supusă tratamentului de dezinfectare depinde de injecția de clor gazos şi implicit de concentrația clorului rezidual legat sub formă de cloramine din efluentul rezultat; cu cât scade clorul rezidual liber, clorul rezidual total creşte; cu cât creşte clorul rezidual total, implicit clorul legat sub forma de cloramine (NH_3+ $OCl^- \rightarrow NH_2Cl + HO^-$), concentrația ionilor de amoniu scade, la o valoare inregistrată de pH ≈ 8.

În viitor se preconizează efectuarea unor studii experimentale pentru determinarea separată a clorului combinat de tip monocloramină, dicloramină si triclorură de azot.

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ENERGY ANALYSIS OF MANUFACTURING PROCESS OF BIODEGRADABLE AGRICULTURAL FILMS

ANALIZA ENERGETICĂ A PROCESULUI DE FABRICAȚIE A FOLIILOR AGRICOLE BIODEGRADABILE

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Abstract: Lately in the agricultural sector the amount of low density polyethylene film (PV) non biodegradable, used annually has increased considerably. Thus worldwide have intensified research to obtain biodegradable agricultural films produced from renewable agricultural sources. The paper presents a method of energy analysis of the manufacturing process of biodegradable agricultural film. It also presents the results obtained by applying this method for a technologie for new biodegradable films products, for agriculture, from renewable resources, developed at INMA Bucharest, Branch of Cluj-Napoca.

Keywords: energy analysis, agricultural film, biodegradable, renewable resources, the manufacturing process, energy consumption, extrusion lamination.

INTRODUCTION

Worldwide, the volume of films used in agriculture has greatly increased in the last 10 years. The latest data shows that agriculture and horticulture are responsible for approximately 1.5 million t consumption of annual production of polymers in Europe. In the case of the thin films, in Europe are consumed more than 72,000 t / year direct coating floor in rows, over 75 000 t / year films for culture in small tunnels and more than 130 000 t / year mulching films [5].

Currently, the market is still dominated by agriculture films obtained from low-density polyethylene (PE). These films have two major disadvantages: they are manufactured from petroleum based raw materials and produce a large amount of waste that needs to be removed from the field and destroyed [3]. Also in their manufacturing process consuming large amounts of energy that comes from conventional sources. So besides the fact that is an important source of waste with negative environmental impact, producing low density film it is also conventional primary resource consuming [6].

An alternative solution to agricultural polyethylene film is the development and use of biodegradable plastics, from renewable agricultural resources and which break down completely in contact with microorganisms found in the soil [3]. In this way we solve two problems of great importance for the environment: saves fossil resources and reduce emissions of greenhouse gases (GHG) [1, 4]. However the problem of energy consumption for producing films remains a problem because in this case too, both in the extraction of raw materials process and in the manufacturing process the energy consumed comes also from fossil sources.

In this context, the main objective of the work was to develop a theoretical mathematical model of analysis of energy consumption in the production process of agricultural biodegradable films and its application to determine maximum energy consumption of the production process of agricultural biodegradable films using corn starch as raw material and the technology

Rezumat: În ultima perioadă în sectorul agricol cantitatea de folie din polietilenă de joasă densitate (PV), nebiodegradale, utilizată anual a crescut considerabil. Astfel pe plan mondial s-au intensificat cercetările de obținere a foliilor agricole biodegradabile produse din surse agricole regenerabile. În lucrare se prezintă o metodă de analiză energetică a procesului de fabricație a foliilor agricole biodegradabile. De asemenea sunt prezentate şi rezultatele obținute în urma aplicării metodei asupra unei tehnologii de realizare de produse noi, biodegradabile, tip folii, pentru agricultura, din resurse regenerabile, dezvoltate la INMA Bucureşti, Filiala Cluj-Napoca.

Cuvinte cheie: *analiză energetică, folii agricole biodegradabile, resurse regenerabile, proces de fabricație, consum energetic, extrudare, laminare.*

INTRODUCERE

Pe plan mondial, volumul foliilor pentru utilizare in agricultura a crescut foarte mult in ultimii 10 ani. Cele mai recente date arata ca agricultura si horticultura sunt responsabile pentru un consum de aproximativ 1.500.000 t din productia anuala de polimeri din Europa. În ceea ce priveste categoria foliilor subtiri, în Europa sunt consumate peste 72.000 t/an folii pentru acoperire directa pe randuri, peste 75 000 t / an folii pentru culturi in tunele mici si mai mult de 130 000 t / an folii de mulcire[5].

În prezent, piața este încă dominată de folii pentru agricultura obținute din polietilenă de joasa densitate (PE). Aceste folii au doua mari dezavantaje: sunt fabricate din materii prime pe baza de titei si produc o mare cantitate de deseuri care necesita a fi inlaturate de pe camp si distruse [3]. De asemenea in procesul de fabricare a acestora se consuma cantitati insemnate de energie care provine din surse surse conventionale. Asadar pe langa faptul ca este o importanata sursa de deseuri cu impact negativ asupra mediului, producerea foliilor de joasa densitate este si consumatoare de resurse primare conventionale [6].

O solutie alternativa viabila la foliile agricole din polietilena o constituie dezvoltarea si utilizarea plasticelor biodegradabile, provenite din resurse agricole regenerabile si care sa se descompuna complet in contact cu microorganismele aflate in sol [3]. In acest fel se rezolva doua probleme de mare importanta pentru mediu: se economisesc resursele fosile si se reduc emisiile de gaze cu efect de sera (GES) [1, 4]. Totusi problema consumului de energie pentru producerea foliilor ramane o problema, deoarece si in acest caz atat in procesul de extractie a materiei prime cat si in procesul de fabricatie energia consumata provine tot din surse de energie fosile.

In acest context, obiectivul principal a lucrarii a fost de a realiza un model matematic teoretic de analiza a consumului energetic al procesului de fabricatie a foliilor agricole biodegradabile si aplicarea acestuia pentru

developed by INMA Bucharest, Branch of Cluj-Napoca. Thus in this paper have been developed a theoretical model for analyzing energy consumption using systemic analysis method, applying mathematical model to determine the maximum consumed the energies in the manufacture of agricultural films from corn starch.

MATERIAL AND METHOD

To develop theoretical mathematical model for determining the energy consumption in the manufacturing process of biodegradable agricultural film was used systemic analysis. The manufacturing process was considered as a whole system (MPF) and the phases were considered as subsystems of the considered system (MPF.Fi) (Fig.1). The total energy consumed (E_{MPF}) in manufacturing process of films is determined by the relationship 1.

determinarea consumului energetic maxim al procesului de producere a foliilor agricole biodegradabile utilizand ca materie prima amidon de porumb si tehnologia dezvoltata în acest sens de catre INMA Bucuresti, Sucursala Cluj-Napoca. Astfel in lucrare s-a dezvoltat un model teoretic de analiza a consumului energetic utilizand metoda analizei sistemice, aplicarea modelului matematic pentru determinarea enegiei maxime consumate in procesul de fabricare a foliilor agricole din amidon de porumb.

MATERIAL ŞI METODĂ

Pentru dezvoltarea modelului matematic teoretic de determinare a consumurilor energetice a procesului de fabricare a foliilor agricole biodegradabile s-a utilizat analiza sistemica. Procesul de fabricatie a fost considerat ca un intreg sistem (MPF), iar fazele procesului au fost considerate ca subsisteme ale sistemului considerat ($MPF.F_i$) (fig.1). Energia totala consumata (E_{MPF}) in procesul de fabricatie a foliilor se determina cu relatia 1.

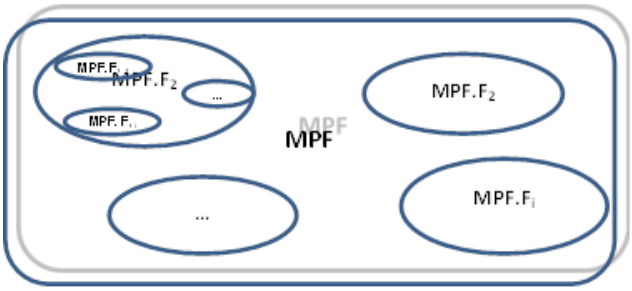

Fig. 1 – Abstractiion of manufacturing process by systemic analysis: MPF – manufacturing process system; $MPF.F_i$ – subsystems of manufacturing process

$$E_{MPF} = \sum_{i=1}^{n} E_{MPF.F_i} \qquad (1)$$

$$E_{E_{MPF.F_i}} = \sum_{j=1}^{k} E_{MPF.F_{i.j}} \qquad (2)$$

Where:

E_{MPF} - total energy consumed in manufacturing process of biodegradable agricultural film [kWh / kg];

$E_{MPF.Fi}$ - energy consumed during *i* stage of the manufacturing process [kWh / kg];

i = 1 ... n stages of production.

By systemic analysis of the manufacturing process stages, each term of relationship 1 is divided into subterms lower grade. The division of the terms in terms of the lower level is performed in accordance with the stages, respective the activities of the technological process [7, 8] until results the final relationships to determine the energy consumption (relation 2), which allow absolute quantification of energy consumption.

Where:

$E_{MPF.Fi,j}$ - energy consumed during the stage i, activity j of manufacturing process [kWh / kg]; j = 1 ... k activities of stage i of the process of production.

Unde:

E_{MPF} - energia totală consumată în procesul de fabricare a foliilor agricole biodegradabile [kWh/kg];

$E_{MPF.Fi}$ – energia consumată în faza *i* a procesului de fabricare [kWh/kg];

i=1…n fazele procesului de fabricatie.

Prin analiza sistemică a fazelor procesului de fabricație, fiecare termen a relației 1, se divide in subtermeni de grad inferior. Divizarea termenilor în termeni de grad inferior se realizează în concordanță cu fazele respectiv activitățile procesului tehnologic [7, 8] până când rezulta relațiile finale de determinare a consumurilor energetice (relația 2), care să permită cuantificarea consumurilor energetice în valoare absolută.

Unde:

$E_{MPF.Fi,j}$ - energia consumată în faza i, activitatea j a procesului de fabricație [kWh/kg]; j=1…k activitățile fazei i a procesului de fabricatie.

To determine the components of relationship 2 it is necessary to analyze the technological process for manufacturing renewable agricultural film (Figure 2).

After analyzing the technological process, relationship 1 became relation 3:

Pentru determinarea componentelor relației 2 este necesară analiza procesului tehnologic de fabricație a foliilor agricole din surse regenerabile (Figura 2).

În urma analizei procesului tehnologic relația 1 devine relația 3:

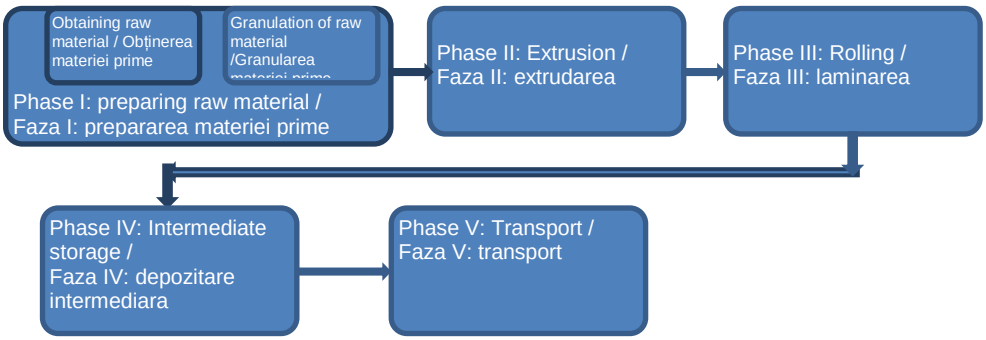

Fig. 2 – Chart of technological process for manufacturing renewable agricultural film

$$E_{MPF.F} = E_{MPF.F_1} + E_{MPF.F_2} + E_{MPF.F_3} + E_{MPF.F_4} + E_{MPF.F_5} \quad (3)$$

$$E_{MPF.F_2} = E_{MPF.F_{2.1}}. + E_{MPF.F_{2.2}} + E_{MPF.F_{2.3}} \quad (4)$$

Where:

$E_{MPF.F1}$ - energy used for preparing raw material [kWh / kg];

$E_{MPF.F2}$- energy consumed in the process of dispensing, extrusion and widening the extruded material [kWh / kg];

$E_{MPF.F3}$ - the energy consumed in the process of rolling [kWh / kg];

$E_{MPF.F4}$ - energy consumed for intermediate storage [kWh / kg];

$E_{MPF.F5}$ - energy consumption in intermediate transport phase (in manufacturing) and final (to the beneficiary) [kWh / kg].

The term 2 of relation 3 will further divide in terms of order 3 (relation 4).

Where:

$E_{MPF.F2.1}$ - the energy used for dosing raw materials [kWh / kg];

$E_{MPF.F2.2}$ - energy used for extrusion [kWh / kg];

$E_{MPF.F2.3}$ - the energy consumed by widening matrix [kWh / kg].

Energy consumption for raw material dosage can be expressed by a final relation (relation 5):

Unde:

$E_{MPF.F1}$- energia consumată pentru prepararea materiei prime [kWh/kg];

$E_{MPF.F2}$ – energia consumată în procesul de dozare, extrudare şi lățirea materialului extrudat [kWh/kg];

$E_{MPF.F3}$ - energia consumată în procesul de laminare [kWh/kg];

$E_{MPF.F4}$ – energia consumată pentru depozitare intermediară [kWh/kg];

$E_{MPF.F5}$ – energia consumată aferentă fazei de transport intermediar (în procesul de fabricație) şi final (la beneficiar) [kWh/kg].

Termenul 2 al relației 3 se va divide în continuare în termeni de ordinul 3 (relația 4).

Unde:

$E_{MPF.F2.1}$- energia consumată pentru dozarea materiei prime [kWh/kg];

$E_{MPF.F2.2}$ - energia consumată pentru extrudare [kWh/kg];

$E_{MPF.F2.3}$ - energia consumată de matricea de lățire [kWh/kg].

Energia consumată pentru dozarea materiei prime poate fi exprimată printr-o relație finală (relația 5):

$$E_{MPF.F_{2.1}}. = \frac{E_d}{C_d} \quad (5)$$

$$E_{MPF.F_{2.2}}. = E_{MPF.F_{2.2.1}}. + E_{MPF.F_{2.2.2}}. + E_{MPF.F_{2.2.3}}. \quad (6)$$

$$E_{MPF.F_{2.2.1}} = \sum_{m=1}^{p} E_{MPF.F_{2.2.1.m}} \quad (7.1)$$

$$E_{MPF.F_{2.2.1 \cdot m}}. = f(C_{ma}; C_{ex}; C_{hex}) \quad (7.2)$$

$$E_{MPF.F_{2.2.1}}. = \frac{C_{hc}}{D_{hex}} \quad (7.3)$$

where E_d is hourly energy consumption of the dispenser [kWh]; C_d - hourly production capacity of the dosing feeder [kg / h].
The energy consumed by the extrusion equipment will divide in terms of lower order (relation 6).

Where: $E_{MPF.F2.2.1}$ is the energy used to run the extrusion screws [kWh / kg]; $E_{MPF.F2.2.2}$ - energy consumed by heating system [kWh / kg]; $E_{MPF.F2.2.3}$ - energy consumed by cooling system [kWh / kg]. Terms from relation 6 are divided further in lower order terms (relations 7.1; 7.2, 7.3, 8, 9)

Where: $E_{MPF.F2.2.1.m}$ is energy consumed per each area of the extruder cylinder [kWh / kg]; m = 1...p – identify coefficient of extruder cylinder areas [kWh / kg]. Also in relation 7.2:

C_{ma} is dependence coefficient on thermo-physics characteristics of the material;

C_{ex} - coefficient depending on the characteristics of the extrusion cylinder; C_{hex} - the productivity of the extruder [kg / h]; T_{ex} - Extrusion temperature [C°];

T_{ex} = f(C_{ma}).

The relation 7.1 can be quantified by relation 7.3, where:

C_{hc} – total energy consumption for driving extrusion screws [kWh];

The energy consumed by the heating system $E_{MPF.F2.2.2}$, and cooling system $E_{MPF.F2.2.3}$ is influenced by extrusion tempperature and technical characteristics of the plants (relation 8.1), and can be quantified using relations 9.1, 9.2, where

unde: E_d este consumul energetic orar al dozatorului [kWh]; C_d – capacitatea de producție orară a dozatorului [kg/h].

Energia consumată de echipamentul de extrudare se va divide în termeni de ordin inferior (relația 6).

Unde: $E_{MPF.F2.2.1}$ este energia consumată pentru acționarea melcilor de extrudare [kwh/kg]; $E_{MPF.F2.2.2}$ - energia consumată de instalația de încălzire [kwh/kg]; $E_{MPF.F2.2.3}$ - energia consumată de instalația de răcire [kwh/kg].

Termenii relației 6 se divid in continuare in termeni de ordin inferior (relațiile 7.1; 7.2, 7.3; 8, 9):

Unde: $E_{MPF.F2.2.1.m}$ este energia consumată pe fiecare zonă a cilindrilor extruderului [kwh/kg]; m=1..p – coeficient de identificare a zonelor cilindrilor de extrudare [kwh/kg]. De asemenea in relatia 7.2:

C_{ma} este coeficent de dependență de caracteristicile termo-fizice ale materialului; C_{ex} - coeficent de dependență de caracteristicile cilindrilor de extrudare; C_{hex} – productivitatea extruderului [kg/h]; T_{ex} – temperatura de extrudare [°C]; T_{ex}= f(C_{ma}).

Relația 7.1 se poate cuantifica prin relația 7.3, unde:

C_{hc} – consumul orar total de energie pentru antrenarea melcilor de extrudare [kwh];

Energia consumată de instația de încălzire $E_{MPF.F2.2.2}$, respectiv răcire $E_{MPF.F2.2.3}$ este influențată de temperatura de extrudare şi caracteristicile tehnice ale instalațiilor (relația 8.1) şi se poate cuantifica utilizand relațiile 9.1, 9.2, unde:

$$E_{MPF.F_{2.2.2,3}.} = f(T_{ex}, C_i) \quad (8.1)$$

$$E_{MPF.F_{2.2.2}.} = \frac{C_{hi}}{D_{hex}} \quad (9.1)$$

$$E_{MPF.F_{2.2.2}.} = \frac{C_{hr}}{D_{hex}} \quad (9.2)$$

$$E_{MPF.F_{2.3}.} = \frac{C_{hml}}{D_{hml}} \quad (10)$$

C_i - coefficient depending on the characteristics of the heating / cooling system;

C_{hi} - hourly energy consumption of the heating system [kWh];

C_{hr} - hourly energy consumption of the cooling system,[kWh].

The energy consumed by the widening area can be quantified using the relationship 10, where:

C_{hml} -hourly electricity consumption for the widening matrix [kWh];

D_{hml} - hourly production capacity for widening matrix [kg / h].

C_i – coeficient de dependență de caracteristicile instalației de încălzire/răcire;

C_{hi} – consumul de energie orar al instalației de încălzire [kwh];

C_{hr} – consumul orar de energie al instalației de răcire [kwh].

Energia consumată de matricea de lățire se poate cuantifică utilizând relația 10, unde:

C_{hml} este consumul orar de energie electrică a matricei de lățire [kWh];

D_{hml} – capacitatea de producție orară a matricei de lățire [kg/h].

$$E_{MPF.F_{3}.} = E_{MPF.F_{3.1}.} + E_{MPF.F_{3.2}.} + E_{MPF.F_{3.3}.} \quad (11)$$

$$E_{MPF.F_{3}.} = \frac{C_{hv} + C_{hli} + C_{hlr}}{D_{hl}} \quad (12)$$

$$E_{MPF.F_{4}} = \frac{N_d \cdot C_d}{M_d} \quad (13)$$

$$E_{MPF.F5.} = \frac{N_t \cdot C_{cb} \cdot H_{cb}}{M_f.} \quad (14)$$

The energy consumption of the rolling equipment $E_{MPF.F3}$ will divide in terms of lower order (relation 11), where:
$E_{MPF.F3.1}$ -is energy consumed by driving laminating rollers [kWh];
$E_{MPF.F3.1}$ respectively $E_{MPF.F3.3}$ - the energy consumed for heating or cooling system [kWh].
The relationship 11 can be quantified by the equation 12, where:
C_{hv} -hourly electricity consumption for laminating rollers [kWh];
C_{hli} - hourly electricity consumption of the heating system of the rolling equipment [kWh];
C_{hl} - hourly electricity consumption for cooling system of the rolling equipment [kWh];
D_{hml} - rolling equipment hourly production capacity [kg /h].
Energy for intermediate storage is determined by the relation 13, where:
N_d - it is number of storage days;
C_d - energy requirement for optimal warehouse $C_d = C_{d1} + C_{d2}$ [kWh]; C_{d1} - energy consumed to illuminate the deposit [kWh]; C_{d2} - energy consumed for heating deposit [kWh]; M_d - total amount of deposited material [kg / h]
Energy for transport is determined by the relation 14, where:
N_t – is transport distance [km];
C_{cb} – fuel consumption [l / km]; H_{cb} - calorific value of the fuel [kW / l]; M_f - the amount of material transported [kg].

Energia consumată de echipamentul de laminare $E_{MPF.F3}$ se va divide în termeni de ordin inferior (relația 11), unde:
$E_{MPF.F3.1}$ -este energia consumată cu antrenarea valțurilor de laminare [kWh]; $E_{MPF.F3.1}$ şi respectiv $E_{MPF.F3.3}$ – energia consumată de instalația de încălzire respectiv răcire [kWh].
Relația 11 poate fi cuantificată prin relația 12, unde:
C_{hv} este consumul orar de energie electrică a valțurilor de laminare [kWh]; C_{hli} - consumul orar de energie electrică a instalației de încălzire a laminatorului [kWh]; C_{hl} - consumul orar de energie electrică a instalației de răcire a laminatorului [kWh]; D_{hml} – capacitatea de producție orară a laminatorului [kh/h].
Energia consumată cu depozitarea intermediară se determină cu relația 13, unde:
N_d -este numărul de zile de depozitare; C_d – energia necesară funcționării optime a depozitului $C_d = C_{d1} + C_{d2}$ [kWh]; C_{d1} – energia consumată pentru iluminarea depozitului [kWh]; C_{d2} – energia consumată pentru încălzirea depozitului [kWh]; M_d – cantitatea totală de material depozitată [kg/h]
Energia consumată cu transportul se determină cu relația 14, unde:
N_t -este distanța de transport [km]; C_{cb} – consumul de carburant [l/km]; H_{cb} – puterea calorică a carburantului [kW/l]; M_f – cantitatea de material transportată [kg].

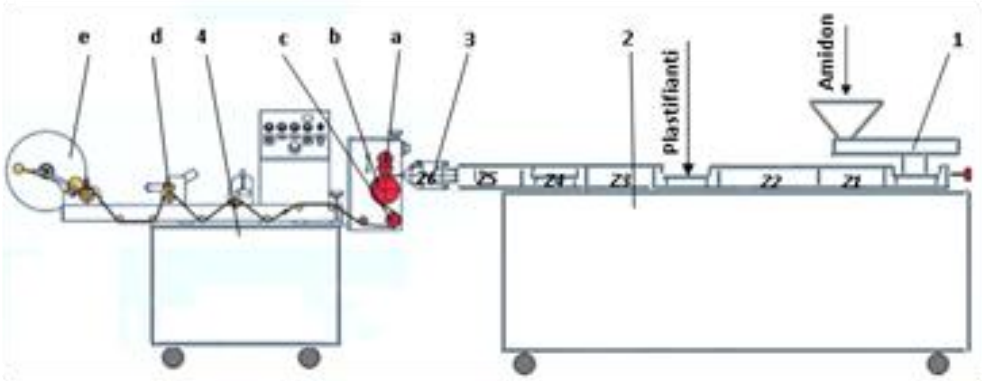

Fig. 3 –Installation for extrusion and rolling

RESULTS AND DISSCUSION

General mathematical method developed was applied to determine the energy consumption of manufacture of biodegradable agricultural film using the system developed for this purpose by INMA Bucharest, Branch of Cluj-Napoca (fig.3). To determine the energy consumption of the process, will apply simplified mathematical model taking into account only the actual two phases of the manufacturing process: extrusion and laminating respectively.

The manufacturing process of biodegradable agricultural film which has applied mathematical method developed was conducted under the following conditions: raw material used was a mixture of starch, glycerol and water. Corn starch used had the water content on wet basis of 10.76%, particle sizes between 2.3 and 37.3 mm, and a density of 0.561 g / cm^3; glycerin had a concentration of 99.5% and a density of 1.262 g / cm^3.

REZULTATE ŞI DISCUȚII

Metoda matematică generală elaborată a fost aplicată la determinarea consumurilor energetice a procesului de fabricație a foliilor agricole biodegradabile utilizând instalația dezvoltată în acest sens de către INMA Bucureşti, Sucursala Cluj-Napoca (fig.3). Pentru determinarea consumurilor energetice a procesului, se va aplica un model matematic simplificat luându-se în calcul doar cele două faze efective ale procesului de fabricație: extrudarea şi respectiv laminarea.

Procesul de fabricație al foliilor agricole biodegradabile pentru care s-a aplicat metoda matematică dezvoltată s-a desfăşurat în următoarele condiții: materia primă utilizată a fost amestec de amidon, glicerina si apa. Amidonul de porumb utilizat a avut umiditatea raportată la substanta umeda de 10,76%, dimensiunile particulelor între 2,3 şi 37,3 µm si densitatea de 0,561 g/cm^3; glicerina a avut o concentratie de 99,5 % si o densitate de 1,262 g/cm^3

. The water used was from the water supply system.. Starch was introduced into the extruder by means of the dispenser and the plasticizers with a peristaltic pump. In order to use a single metering pump, the two plasticizers, glycerol and water, beeing miscible, were mixed in the proportions of the formulation and introduced into tank plasticizers. The feed rate with raw material was 12 kg / h. Temperatures in the five zones of the extruder were 30^0C, 50^0C, 100^0C, 130^0C, 150^0C and the temperature in the mold was 150^0C.

The main parts of the installation are: dispenser -1; extruder-2, widening matrix-3 and the rolling equipment -4.

Extrusion equipment used was a laboratory twin-screw extruder with co-rotating intermeshing screws, with a productivity of 12 kg/h, screw diameter D=25 mm, screw lenght L=30xD and screw speed of 400 rpm. The extruder cylinder is modular and has 5 zones, each zone having independent heating and cooling. Each of the 5 zones,Z1-Z5, is equiped with one temperature sensor that measures temperature and controls starting or stoping of the heaters or fans to maintain the temperature set in each zone.

Dosage of powder materials in the extruder hopper was achieved using twin screw dispenser and dispensing components in the Z2area will be done using metering pumps.

The results obtained by applying the mathematical method developed are presented in Table 1.

. Apa utilizata a fost apa de la retea. Amidonul a fost introdus în extruder cu ajutorul dozatorului iar plastifianții cu ajutorul pompei peristaltice. În scopul utilizării unei singure pompe dozatoare, cei doi plastifianți, glicerina şi apa, fiind miscibili, au fost amestecați în proporția din rețetă şi introduşi în rezervorul pentru plastifianți. Debitul de alimentare cu materie primă 12 kh/h. Temperaturile în primele cinci zone ale extruderului au fost 30^0C, 50^0C, 100^0C, 130^0C, 150^0C iar temperatura în zona matriței a fost de 150^0C.

Elementele principale ale instalatie sunt: Dozatorul **1**, Extruderul **2**, Matrita de latire **3** si Echipamentul de laminare **4.**

Echipamentul de extrudare folosit a fost un extruder cu doi melci modulari corotativi, cu o productivitate de 12 kg/h, diametrul melcilor: D=25 mm, lungimea melcilor: L=30xD, turatia melcilor 400 rot/min. Cilindrul extruderului este modular si are 5 zone, fiecare zona avand încălzire si racire independenta. Fiecare dintre primele 5 zone, **Z1-Z5**, este prevazuta cu cate un senzor de temperatura care masoara temperaturile si comanda pornirea sau oprirea incalzitoarelor sau ventilatoarelor pentru mentinerea temperaturilor reglate pe fiecare zona.

Dozarea materialelor pulverulente in palnia extruderului s-a realizat cu ajutorul dozatorului cu doi melci iar dozarea componentilor in zona ***Z2*** se va face cu ajutorul cu ajutorul unor pompe dozatoare.

Rezultatele obținute în urma aplicării metodei matematice dezvoltate sunt prezentate în tabelul 1.

Table 1

Energy consumption divided on biodegradable agricultural film manufacturing phases / stages

Parameter	Notation /U.M.	*Value*
Material flow	D_m [kg/h]	12.00
Energy consumption of the dispenser	$E_{MPF.F2.1}$ [kwh/kg]	0.05
Total energy consumption of extruder	$E_{MPF.F2.2}$ [kwh/kg]	0.90
Energy consumption of extrusion screws	$E_{MPF.F2.2.1}$ [kwh/kg]	0.43
Energy consumption of heating system	$E_{MPF.F2.2.2}$ [kwh/kg]	0.37
Energy consumption of cooling system	$E_{MPF.F2.2.3}$ [kwh/kg]	0.10
Energy consumption of widening matrix	$E_{MPF.F2.3}$ [kWh/kg]	0.42
Total energy consumption of rolling equipment	$E_{MPF.F3}$ [kWh/kg]	1.20
Energy consumption for driving laminating rollers	$E_{MPF.F3.1}$ [kWh/kg]	0.03
Energy consumption for heating	$E_{MPF.F3.2}$ [kWh/kg]	0.50
Energy consumption for cooling	$E_{MPF.F3.3}$ [kWh/kg]	0.67
Total energy consumption for the proces	E_{MPF} [kWh/kg]	2.57

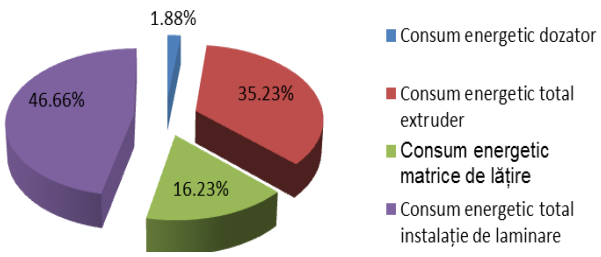

Fig.4 – The structure of energy consumption divided into phases of the manufacturing process of biodegradable agricultural film

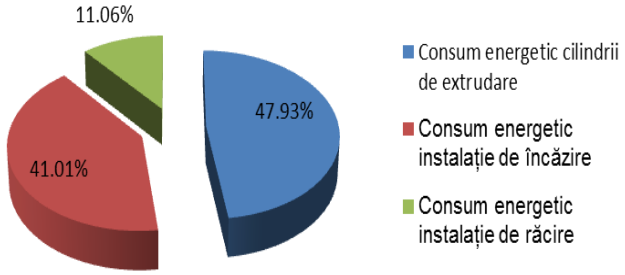

Fig.5 – The structure of energy consumption divided into stages of extrusion phase of biodegradable agricultural film

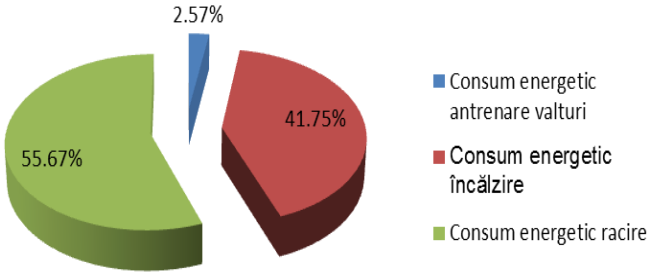

Fig.6 – Energy consumption structure divided into stages of rolling phase of biodegradable agricultural film

The analysis of energy consumption (Fig. 4) shows a maximum power consumption (46.66%) during the rolling, followed by energy consumption in the extrusion phase (35.23%), the phase of widening (16, 23%) and the dispenser (1.88%).

In the extrusion phase of the material (Fig. 5) The maximum power consumption due to the operation of the extrusion screws, followed by the heating (41.01%) and the cooling (11.06%). The energy required to drive the extrusion screws is influenced primarily by the extrusion screws speed which depends on the physical characteristics of the material and structural transformations that occur in the five phases of extrusion phase. Also, the energy consumption for the heating or cooling systems, depends on the working temperature in the 5 zones of the extruder which are determined based on the thermophysical characteristics (glass transition temperature and the melting temperature) of the processed mixtures.

Energy-intensive stage of rolling is due to the cooling equipment (consuming about 55.67% of this total energy consumed in this phase of the process (Fig. 6), followed by heating equipment (41.75%) and driving the laminating rollers (2.57%).

The analysis of energy consumption in the manufacturing process for the respective phases of biodegradable agricultural film allows to identify equipment with high energy consumption. Thus, we can achieve energy optimization of the manufacturing process so that the energy consumed in the process to be minimized, thus ensuring a positive effect on the environment and optimum use of resources.

CONCLUSIONS

Determining the energy consumption of the manufacturing process for biodegradable films produced from renewable sources, for agriculture is important both in terms of environmental impact and in terms of the use of energy resources needed. Such general mathematical method developed in this paper allows the determination of both total energy consumption of the manufacturing process of biodegradable agricultural film using various raw

Analiza structurii consumurilor energetice (fig.4) arată un consum maxim de energie (46,66%) în faza de laminare a materialului, urmat de consumul energetic din faza de extrudare (35,23%), a fazei de lățire (16,23%) şi respectiv al dozatorului (1,88%).

În faza de extrudare a materialului (fig.4) consumul energetic maxim se datorează acționării melcilor de extrudare, urmat de instalația de încălzire (41,01%) şi respectiv instalației de răcire (11.06%). Energia necesară pentru acționarea melcilor de extrudare este influențată în primul rând de turația melcilor de extrudare care depinde de caracteristicile fizice ale materialului şi transformările structurale care au loc pe parcursul celor 5 etape ale fazei de extrudare. De asemenea energia consumată de instalațiile de încălzire, respectiv răcire, este dependentă de temperatura de lucru pe cele 5 zone ale extruderului care se determină funcție de caracteristicile termofizice (temperatura de tranzitie vitroasa si temperatura de topire) ale amestecurilor procesate.

Consumului energetic ridicat în etapa de laminare se datorează echipamentului de răcire (acesta consumând circa 55,67% din energia totală consumată în această fază a procesului (fig.5), urmată de echipamentul de încălzire (41,75%) şi respectiv antrenarea valțurilor de laminare (2,57%).

Analiza structurii consumurilor energetice în fazele respectiv etapele procesului de fabricare a foliilor agricole biodegradabile permite identificarea echipamentelor cu consum energetic ridicat. Astfel putându-se realiza o optimizare energetică a procesului de fabricație astfel încât energia consumată în proces să fie cat mai redusă, asigurându-se astfel un efect pozitiv asupra mediului inconjurător şi o utilizare optimă a resurselor.

CONCLUZII

Determinarea consumurilor energetice a procesului de fabricație a foliilor biodegradabile obținute din surse regenerabile, pentru agricultură este importantă atât din punct de vedere a impactului asupra mediului cât şi din punct de vedere a utilizării resurselor energetice necesare. Astfel metoda matematică generală dezvoltată în cadrul lucrării permite atât determinarea consumului

materials and to identify the main energy consumers, thus enabling optimization of the process energetically. This involves beneficial effects on the environment by saving resources, and an economic efficiency of the process.

Applying mathematical method for energetically analysis of manufacturing process for biodegradable agricultural film from renewable materials, using innovative technology developed by INMA Bucharest, Branch of Cluj-Napoca allowed assessment in terms of energy of the technology, on the one hand and on the other side identification of rolling phase as the main consumer of energy.

Further development of the mathematical method proposed according to the specific manufacturing technology used will also allow the study of the influence of the mixtures physical-thermal characteristics from renewable material used as raw materials on the energy consumption of the phases or stages of the manufacturing process.

Acknowledgement

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energetic total al procesului de fabricație a foliilor agricole biodegradabile utilizând diverse materii prime, cât şi identificarea principalilor consumatori energetici, permițând astfel optimizarea procesului din punct de vedere energetic. Aceasta implicând efecte benefice atât asupra mediului înconjurător prin economie de resurse, cât şi o eficientizare economică a procesului.

Aplicarea metodei matematice în vederea analizei energetice a procesului de fabricare a foliilor agricole bidegradabile din surse regenerabile utilizând tehnologia inovativă dezvoltată de INMA Bucureşti, Sucursala Cluj-Napoca a permis evaluarea din punct de vedere energetic al tehnologiei pe de o parte iar pe de altă parte a identificarea fazei de laminare ca fiind principalul consumator de energie.

Dezvoltarea în continuare a metodei matematice propuse în concordanță cu specificul tehnologiilor de fabricație utilizate va permite de asemenea şi studiul influenței caracteristicilor fizico-termice ale amestecurilor din surse regenerabile utilizate ca materie primă asupr consumurilor energetice ale fazelor respectiv etapelor procesului de fabricație.

Mulțumiri/Recunoştință

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ECONOMIC ASPECTS OF PHYTOSANITARY CONTROL WITH NONPOLLUTING SUBSTANCES IN ORCHARDS
/
ASPECTE ECONOMICE ALE COMBATERII FITOSANITARE CU SUBSTANȚE NEPOLUANTE ÎN LIVEZI

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Abstract: *Growing of fruit trees is of particular importance in terms of food and pharmacy. Fruit trees and fruit shrubs is one of the healthiest food sources for the human body. The installation of pest resistance to chemical pesticides and the environmental degradation have imposed the research and promotion of selective and biodegradable pesticides. The use of unpolluting phytopharmaceutical substances is an important trend in fruit growing due to the advantages it presents: reduction of environmental and food pollution, avoiding the emergence of control resistant pest populations, possibility of using unqualified staff under total security. The main direction for improving the application of phytosanitary treatments technologies and for designing the appropriate technical equipment is to increase the quality of treatment by carrying out environmentally friendly work processes that lead to environmental remediation and healthy products. Applying the new technology will lead to the reduction of environmental pollution by the gradual replacement of pesticides, the natural technique of working with organic products and the development of advanced technological equipment that can perform treatments with lower consumption of active substance at the same time with the increasing of the area treated and the reduction of working time. The present paper aims to achieve a Cost-Benefit Analysis of phytosanitary treatments by means of nonpolluting substances in orchards. The main performance indicators used in the Cost-Benefit Analysis are: Net Present Value (NPV), Internal Rate of Return (IRR) and the Benefit-Cost Ratio (B/C).*

Keywords: *phytosanitary treatments, orchards, clean substances, cost benefit analysis, financial net present value, internal rate of return, benefit/cost ratio*

INTRODUCTION

Pesticides, also known as phytosanitary substances are chemical or natural plant compounds used to destroy parasites and animal pest that attack crops. Depending upon which group of organisms, pesticides are grouped into: acaricides, insecticides, fungicides, herbicides, nematicides.

The European Union has developed a strategy on the use of pesticides and a Directive to reach the goals. In this context, the European Commission proposed a new regulation that will govern the use of plant protection products. European Commission wants to reduce the risk to people and the environment through the use of pesticides, to replace hazardous substances with safer alternatives (other than those chemical substances). It also aims at reducing or eliminating the use of chemical pesticides and encouraging organic farming.

The need to increase efficiency in all sectors of the economy makes economic and financial analysis to play an increasingly role, as it can highlight strengths and weaknesses, including the

Rezumat: *Cultura pomilor fructiferi reprezintă o importanță deosebită din punct de vedere alimentar şi farmaceutic. Fructele pomilor şi arbuştilor fructiferi constituie unul din alimentele cele mai sănătoase pentru organismul uman. Instalarea fenomenului de rezistență a dăunătorilor la pesticide chimice şi degradarea mediului au impus cercetarea şi promovarea unor pesticide selective şi biodegradabile. Folosirea substanțelor fitofarmaceutice nepoluante constituie o orientare importantă în pomicultura actuală datorită avantajelor pe care le prezintă: reducerea poluării mediului şi a alimentelor, evitarea apariției populațiilor de dăunători cu rezistență la tratamentele de combatere, posibilitatea utilizării de personal necalificat în condiții de totală securitate. Principala direcție de perfecționare a tehnologiilor de aplicare a tratamentelor fitosanitare şi de elaborare a echipamentelor tehnice adecvate o constituie creşterea calității tratamentelor prin realizarea unor procese de lucru nepoluante care sa conducă la reabilitarea mediului si obținerea unor produse sănătoase. Aplicarea noii tehnologii va avea ca efect diminuarea poluării mediului, datorită înlocuirii treptate a pesticidelor şi a tehnicii fizice de lucru cu produse ecologice, precum şi cu realizarea de echipamente tehnologice performante ce pot realiza tratamente cu consumuri mai mici de substanță activă, odată cu mărirea suprafeței tratate şi reducerea timpilor de lucru. Actuala lucrare îşi propune să efectueze o analiză economica privind combaterea fitosanitară cu substanțe nepoluante în plantațiile pomicole. Indicatorii necesari pentru testarea performanțelor financiare ale proiectului sunt valoarea financiară netă actualizată a proiectului (VFNA), rata internă de rentabilitate financiară (RIRF) şi raportul Beneficiu/Cost (B/C).*

Cuvinte cheie: *tratamente fitosanitare, livezi, substanțe nepoluante, analiză cost-beneficiu, valoarea financiară netă actualizată, rata internă de rentabilitate, raport beneficiu/cost*

INTRODUCERE

Pesticidele, cunoscute şi sub denumirea de substanțe fitosanitare, sunt compuşi chimice sau naturali, folosiți pentru distrugerea paraziților vegetali şi dăunatorilor animali care atacă plantele de cultură. În funcție de grupul de organisme asupra căruia acționează, pesticidele se grupează în: acaricide, insecticide, fungicide, erbicide, nematocide.

Uniunea Europeană a elaborat o strategie referitoare la utilizarea pesticidelor şi o Directivă pentru atingerea obiectivelor Strategiei [6]. În acest context, Comisia Europeană a propus şi un nou Regulament, care va reglementa utilizarea produselor pentru protecția plantelor. Comisia Europeană doreşte să reducă riscul asupra populației şi mediului datorită folosirii de pesticide, să înlocuiască substanțele periculoase cu alternative mai sigure (alte substanțe în afară celor chimice). De

effectiveness of the application of phytosanitary treatments with nonpolluting substances to combat pest in orchards. The analysis plays an important role in assessing, adjusting and improving equipment performance in this area.

The main objectives pursued in this paper are:
- Evaluation of investment costs involved in combating by clean phytosanitary substances;
- Evaluation of operating costs and total revenues;
- Calculation of financial performance indicators;
- Evaluation of risk levels

In order to achieve these objectives will be developed an Excel model of administration of phytosanitary substances, based on cost-benefit analysis, which will use as inputs investments, operating costs, residual value, etc.

MATERIAL AND METHOD

Cost-benefit analysis is the best known technique for rational allocation of resources. This method of evaluation of expenditure programs is an attempt to measure the costs and gains. Cost-benefit analysis (CBA) is emerging as an economic and mathematical tool designed to facilitate funding decisions, and hence the allocation of economic resources currently in the hope of future economic and social benefits. CBA analyze, describe and assess, in terms of costs, alternatives and potential benefits.

The first step in the financial analysis is to estimate the *investment costs*. Investment costs can be planned for an initial period and should therefore be defined the time horizon, ie the maximum number of years for which forecasts are provided.

The second step is the calculation of *operating costs*. Operating costs include all information about the payments provided for the purchase of goods and services which are not by nature of investment costs.

Once the data were collected on the investment costs, operating costs and revenues, the next logical step is the evaluation of *financial profitability* on investment.

Relevant indicators are *financial net present value* of the project (FNPV), *internal rate of return* (IRR) and the *Benefit / Cost ratio* (B / C).

Financial net present value is defined as the amount that results when the expected investment and operating costs of the project shall be deducted from the present value of expected revenues (1):

asemenea, se urmăreşte reducerea sau eliminarea folosirii pesticidelor chimice şi încurajarea agriculturii ecologice.

Necesitatea creşterii eficienței în toate ramurile economiei face ca analiza economico-financiară să joace un rol din ce în ce mai pregnant deoarece astfel se pot evidenția punctele tari şi slabe, inclusiv în privința eficienței aplicării de tratamente fitosanitare cu substanțe de combatere nepoluante în plantațiile pomicole. Analiza are un rol important în evaluarea, reglarea şi îmbunătățirea performanțelor echipamentelor din acest domeniu.

Principalele obiective urmărite în cadrul lucrării sunt:
- Evaluarea costurilor de investiție implicate de combaterea cu substanțe fitosanitare nepoluante;
- Evaluarea costurilor de operare şi a veniturilor totale;
- Calcularea indicatorilor de performanță financiară;
- Evaluarea nivelurilor de risc

În vederea atingerii acestor obiective se va elabora un model Excel al procesului de administrare a substanțelor fitosanitare, bazat pe analiza cost-beneficiu, care va folosi ca date de intrare investițiile, costurile de operare, valoarea reziduală, etc.

MATERIAL ŞI METODĂ

Analiza cost-beneficiu reprezintă cea mai cunoscută tehnică de alocare rațională a resurselor. Această modalitate de evaluare a programelor de cheltuieli reprezintă o încercare de a măsura costurile şi câştigurile. Analiza cost beneficiu (ACB) se conturează ca un instrument economico-matematic menit să faciliteze luarea unor decizii de finanțare, şi implicit de alocare a unor resurse economice în prezent, în speranța obținerii unor beneficii economice şi sociale viitoare.

Primul pas în ACB este să se estimeze *costurile de investiț ie*. Costurile de investiț ie pot fi planificate pentru o perioadă iniț ială , de aceea trebuie definit orizontul de timp, adică numă rul maxim de ani pentru care previziunile sunt furnizate.

Al doilea pas este calculul *costurilor de operare*. Costurile de operare cuprind toate datele cu privire la pl ă ț ile prevă zute pentru achiziț ionarea de bunuri ş i servicii care nu sunt costuri de natura investiț iilor.

Odat ă ce au fost colectate datele referitoare la costurile de investiț ie, costurile de operare ş i venituri, urmă torul pas logic este de evaluare a *rentabilit ă ț ii financiare*.

Indicatorii relevanți sunt *valoarea financiar ă net ă actualizat ă* a proiectului (VFNA), *rata intern ă de rentabilitate financiar ă* (RIRF) şi *raportul Beneficiu/Cost* (B/C) [1, 3].

Valoarea financiar ă net ă actualizat ă este definit ă ca suma care rezult ă atunci când investiț ia preconizat ă ş i costurile de operare ale proiectului se deduc din valoarea actualizat ă a veniturilor aş teptate (1):

$$VFNA = \sum_{i=0}^{n} a_t S_t = \frac{S_0}{(1+i)^0} + \frac{S_1}{(1+i)^1} + \ldots + \frac{S_n}{(1+i)^n} \quad (1)$$

where S_t is the balance of cash flow at time t and a_t the financial factor chosen for update at time t, $a_t = (1 + i)^{-t}$, where t is time and i is the discount rate.

A positive FNPV means that the project generates a net benefit (as the weighted sum of the flows of costs and benefits is positive) and is generally desirable from a financial standpoint.

The internal rate of return (IRR) is defined as the discount rate that produces a zero FNPV (2):

unde S_t este soldul fluxului de numerar la momentul t ş i a_t factorul financiar ales pentru actualizarea la momentul t, $a_t = (1 + i)^{-t}$, unde t este timpul şi i este rata de actualizare.

O VFNA pozitivă înseamnă că proiectul generează un beneficiu net (deoarece suma ponderată a fluxurilor de costuri şi beneficii este pozitivă) şi este în general dezirabilă din punct de vedere financiar.

Rata intern ă de rentabilitate financiar ă (RIRF) este definit ă ca rata de actualizare care produce o VFNA egală

cu zero (2):

$$VFNA = \sum_{i=0}^{n} a_t S_t = \frac{S_0}{(1+i)^0} + \frac{S_1}{(1+i)^1} + \ldots + \frac{S_n}{(1+i)^n} = 0 \quad (2)$$

The internal rate of return is a measure of the relative efficiency of investment. IRR contains useful information about the overall economic value. An advantage of IRR is that is a pure number, making it easy to carry comparing similar projects.

The Benefit / Cost ratio (B / C) is financial net present value of project benefits divided by the financial net present project costs (3):

Rata internă de rentabilitate financiară este un indicator al eficienței relative a investiției. Un avantaj al RIRF este acela că reprezintă un număr pur, ceea ce face să se realizeze uşor compararea proiectelor similare.

Raportul Beneficiu/Cost (B/C) este valoarea financiară net ă actualizată a beneficiilor proiectului împărțită la valoarea financiară netă actualizată a costurilor proiectului (3):

$$B/C = VA(I)/VA(O) \quad (3)$$

where I are inputs and O are outputs. If B / C> 1 the project is suitable because the benefits outweigh the costs.

The assumptions and the conditionalities used are:

- It is envisaged a time horizon of 10 years;
- The economic life is considered to be 20 years;
- Duration of the project is 12 months;
- Time reference point for prices is December 2014;
- The discount rate is 5%;
- Diverse and unpredicted expenses are eligible expenditure;
- Expenditures for capital revisions are made at regular intervals;
- Residual value is the value of potential sales. Given the estimated life and the low impact of obsolescence, it can be considered a residual value of 40% of the investment.

unde I sunt intrările şi O sunt ieşirile. În cazul în care B/C > 1 proiectul este corespunzător deoarece beneficiile sunt mai mari decât costurile.

Ipotezele şi condiționalitățile folosite sunt:

- Se are în vedere un orizont de timp de 10 ani;
- Durata economica de viață este considerată a fi 20 de ani;
- Durata de realizare a proiectului este de 12 luni;
- Momentul de referință pentru prețuri este decembrie 2014 ;
- Rata de actualizare este 5%;
- Cheltuielile diverse şi neprevăzute sunt considerate cheltuieli eligibile;
- Cheltuielile pentru revizii capitale se realizează la intervale regulate;
- Valoarea reziduală este valoarea potențiala de vânzare. Dată fiind durata de viață estimata şi impactul redus al uzurii morale, se poate considera o valoare reziduală de 40% din valoarea investiției.

RESULTS

Machines for treating orchards are performing in space, not on the surface, as in field crops, representing a combination of hydraulic and pneumatic dispersion. The phytosanitary solution is dispersed by means of nozzles and air flow is generated by a fan, providing a very fine spray droplets in transport to the place of treatment. A machine with hydropneumatic dispersion is the high precision machine for the application of phytosanitary treatments in orchards, MSL, designed and worked out by The National Institute of Research - Development for Machines and Installations designed to Agriculture and Food Industry - INMA (fig. 1).

REZULTATE

Maşinile destinate plantațiilor pomicole realizează tratarea în spațiu, nu pe suprafață, ca la culturile de câmp, constituind o combinație între cele cu dispersie hidraulică şi cele cu dispersie pneumatică. Soluția fitosanitară este dispersată cu ajutorul duzelor în curentul de aer generat de ventilator, asigurând o pulverizare foarte fină şi transportul picăturilor până la locul tratamentului. O maşină cu dispersie hidropneumatică este Maşina pentru aplicarea cu precizie ridicată a tratamentelor fitosanitare în plantațiile pomicole, MSL, proiectată şi realizată de Institutul Național de Cercetare - Dezvoltare pentru Maşini şi Instalații destinate Agriculturii şi Industriei Alimentare - INMA (fig. 1) [2].

Fig. 1 – The high precision machine for the application of phytosanitary treatments in orchards, MSL, in aggregate with tractor

The main components of the machine MSL are: frame, with rolling system; spraying system, consisting of axial fan and nozzles; installation of

Principalele părți componente ale maşinii MSL sunt: cadrul, cu sistem de rulare; dispozitivul de pulverizare, alcătuit din ventilator axial şi duze;

liquid, composed of tanks and pump; angular gear; detection system of the canopy of the tree, consisting of ultrasonic sensors; automatic control system, consisting of PLC. Investment costs are summarized in table 1.

instalația de lichid, compusă din rezervoare şi pompă; transmisia cardanică; sistemul de detectare a coroanei pomului, alcătuit din senzori ultrasonici; sistemul automat de comandă, alcătuit din automat programabil. Costurile de investiție sunt defalcate în tabelul 1.

Table 1

Investment costs [lei]

Nr.	Component	M.U.	Cant.	Unit price	Total price
1	Tractor	pc.	1	60.000	60.000
2	Frame, with rolling system	pc.	1	5.000	5.000
3	Axial fan	pc.	1	2.200	2.200
4	Nozzles	pc.	12	80	960
5	Solution tank	pc.	1	2.000	2.000
6	Clean water tank	pc.	1	200	200
7	Liquid pump	pc.	1	3.400	3.400
8	Angular gear	pc.	1	120	120
9	Ultrasonic sensors	pc.	6	1500	9.000
10	PLC	pc.	1	4.100	4.100
11	Accesories	pc.	1	1.500	1.500
	TOTAL				**88.480 lei**

Operating cost categories are the following:

1. The costs of fuel. For an average parcel, with length between 600 and 800 meters and height of trees between 4 and 6 meters, the tractor has an hourly fuel consumption of 3.2 l/ha. The annual consumption of diesel is 8704 l. The average price of Standard diesel is 5 lei / l. Total cost of diesel is 43,520 lei.
2. Personnel costs. The average salary of a tractor operator is 1.800 lei / month. So in the 3,85 months of working in the field of phytosanitary treatments is paid with 6.930 lei.
3. The cost of the active substance. The amount of active substance used per hectare, at a norm of 187 liters and an average concentration of 0.5% is 0.935 l (kg). At an average price of 440 lei / l (kg) results an annual consumption of 2543 l, totaling 1.131.724 lei.
4. Current maintenance costs are those costs that arise as a result of normal wear and tear of equipment. These costs are estimated at 13.000 lei / equipment / year.
5. Periodic repair costs are those costs incurred to replace functional components due to optimum operating time expiration. These costs are estimated at 9.500 lei / equipment / 3 years.
6. Replacement costs of components are those costs that arise as a result of normal wear and aging time. These costs are estimated at 4.800 lei / equipment / 4 years.
7. Diverse and unpredicted costs are caused by premature wear and vandalism and is estimated at 5% of the average annual total recurrent costs for routine maintenance, periodic repair and replacement.

These cost categories are summarized in table 2.

Since phytosanitary treatments, at trees maturation, costs about 480 lei per hectare and the equipment can deserve 2.720 hectares annually, operating income amounts to 1.360.000 lei.

Financial performance indicators (FNPV, IRR and B/C) are calculated using Excel programme, from Microsoft Office 2003 suite, having as input the

Categoriile de costuri de operare sunt urmatoarele:

1. Costurile combustibilului. Pentru o parcelă medie, cu lungimea între 600 şi 800 de metri şi înălțimea pomilor între 4 şi 6 metri, tractorul are un consum orar de 3,2 l/ha. Astfel, consumul anual de motorină este 8704 l. Prețul mediu al motorinei Standard este de 5 lei/l. Costul total al motorinei este de 43.520 lei.
2. Costurile cu personalul. Salariul mediu al unui tractorist este de 1.800 lei/lună. Deci, în cele 3,85 luni în care munceşte în domeniul tratamentelor fitosanitare este plătit cu 6.930 lei.
3. Costurile substanței active. Cantitatea de substanță activă folosită la hectar, în condițiile unei norme medii de 187 de litri şi al unei concentrații medii de 0,5% este 0,935 l(kg). La un preț mediu de 440 lei / l(kg), rezultă un consum anual de 2543 l, în valoare totală de 1.131.724 lei.
4. Costurile de întreținere curentă sunt acele costuri care apar ca urmare a uzurii normale a echipamentelor. Se estimează aceste costuri la 13.000 lei/echipament/an.
5. Costurile cu reparațiile periodice sunt acele costuri generate de înlocuirea unor componente funcționale datorita expirării timpului optim de funcționare. Se estimează valoarea acestor costuri la 9.500 lei/echipament/3 ani.
6. Costurile de înlocuire a componentelor sunt acele costuri care apar ca urmare a uzurii normale şi îmbatrânirii în timp. Se estimează valoarea acestor costuri la 4.800 lei/echipament/4 ani.
7. Costurile diverse şi neprevăzute sunt provocate de uzura prematură şi vandalizări şi se estimează la nivelul de 5% din media tuturor costurilor recurente anuale pentru întreținere curentă, reparație periodică şi de înlocuire.

Aceste categorii costuri sunt sintetizate în tabelul 2.

Având în vedere că pentru un hectar de pomi ajunşi la maturitate tratamentele fitosanitare costă aproximativ 480 lei şi că echipamentul poate asigura tratarea a 2.720 de hectare anual, veniturile din exploatare anuale se cifrează la 1.360.000 lei.

Indicatorii de performanță financiară (VFNA, RIRF şi B/C), calculați cu ajutorul programului Excel, din Suita Microsoft Office 2003, având ca date de intrare cele expuse mai sus, sunt prezentați în tabelul 2.

above data. These are presented in table 2.

Financial net present value is 644,941 lei. Being positive, does not require structural funding. The internal rate of return is 120.05%. The Benefit/Cost ratio is 1.079. Being higher than one, it means that the project is profitable, revenue generator.

Valoarea financiară netă actualizată este 644.941 lei. Fiind pozitivă, nu necesită finanțare din fonduri structurale. Rata internă de rentabilitate financiară este 120,05 %. Raportul Beneficiu/Cost este 1,079. Fiind supraunitar, înseamnă că proiectul este rentabil, generator de venituri.

Table 2

Financial performance indicators

	Investment	Operating costs								
Year	0	1	2	3	4	5	6	7	8	9
	88,480	1,184,174	1,184,174	1,184,174	1,184,174	1,184,174	1,184,174	1,184,174	1,184,174	1,184,174
Overhauls	0	0	0	9.500	0	0	9.500	0	0	-35.392
Current maintenance	0	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000	13,000
Replacements	0	0	0	0	4,800	0	0	0	4,800	0
Diverse and unpredicted	0	650	650	1,125	890	650	1,125	650	890	0
Total costs	**88,480**	**1,197,824**	**1,197,824**	**1,207,799**	**1,202,864**	**1,197,824**	**1,207,799**	**1,197,824**	**1,202,864**	**1,161,782**
Financial factor	1.000	0.952	0.907	0.864	0.823	0.784	0.746	0.711	0.677	0.645
	88,480	1,140,785	1,086,462	1,043,342	989,599	938,526	901,278	851,271	814,146	748,895
Revenues	0	1,305,600	1,305,600	1,305,600	1,305,600	1,305,600	1,305,600	1,305,600	1,305,600	1,305,600
CF	-88,480	107,776	107,776	97,801	102,736	107,776	97,801	107,776	102,736	143,818
FNPV	**644,941**									
IRR	**120.05%**									
B/C	**1.079**									

A risk assessment consists of studying the probability that a project would achieve a satisfactory performance (for IRR or FNPV threshold values). In this context, the probability must be interpreted as an index where value 1 is the certainty that a prediction is confirmed, value 0 is the certainty that a prediction will be invalidated.

The sensitivity analysis imposes the determination of critical variables, those of which variations have the highest impact on financial performance. It is recommended to consider these variables for which a 1% variation compared to best estimation creates a corresponding variation of at least 1% of FNPV and IRR.

The sensitivity index shows how many percents the studied parameter varies when the critical variable is modified by one percent. If the index is higher than one, this variable is risk-bearing.

The critical index, SV (Switching Value) or changeover value is that value that the variable should be modified so that the financial net present value become 0. Low value of the critical index shows that the variable presents a high risk, a small deviation being able to transform a cost-effective investment in an unprofitable one.

To determine the sensitivity, the following critical variables were taken into account: investment costs (CI) and operating costs (CO).

Sensitivity analysis results, obtained by means of Microsoft Excel programme, are presented in Tables 3 and 4. Aforementioned general criterion was applied: a variation of 1% of critical variable corresponds to at least one percentage point variation of financial indicators FNPV and IRR. Given the reduced level of investment costs compared to the operating costs, has been established a variation interval of {+ 10%; + 50%} for investment costs and an interval of {+ 1%; + 5%} for the operating costs.

In relative values, FNPV and IRR lowering (%), due

O evaluarea a riscurilor constă în studierea probabilității ca un proiect să atingă o performanță satisfăcătoare (pentru valori prag ale RIR sau VFNA). În acest context, probabilitatea trebuie interpretată drept un index în care valoarea 1 reprezintă certitudinea că o predicție va fi confirmată, valoarea 0 reprezintă certitudinea că o predicție va fi infirmată.

Analiza de senzitivitate impune determinarea variabilelor critice, cele ale căror variații au cel mai mare impact asupra performanței financiare. Se recomandă să se ia în considerare aceste variabile pentru care o variație de 1% față de cea mai bună estimare dă naştere la o variație corespunzătoare de minimum 1% a VFNA şi RIR [4].

Indicele de senzitivitate arată cu cate procente se modifică parametrul studiat în cazul modificării cu un procent a variabilei critice. Dacă indicele este supraunitar, respectiva variabilă este purtătoare de risc.

Indicele critic, SV (Switching Value) sau valoarea de comutare este acea valoare cu care ar trebui să se modifice variabila astfel încât valoarea financiară netă actualizată să devina 0. O valoare mică a indicelui critic arată că acea variabilă prezintă un risc mare, o abatere mică putând să transforme investiția din rentabilă în nerentabilă.

Pentru determinarea senzitivității au fost luate în calcul următorele variabile critice: costurile investiționale (CI) şi costurile de operare (CO).

Rezultatele analizei de senzitivitate, obținute cu ajutorul programului Microsoft Excel, sunt prezentate în tabelele 3 şi 4. S-a aplicat criteriul general menționat anterior: o variație de 1% a variabilei critice corespunde cel puțin unui punct procentual de variație a indicatorilor financiari VFNA şi RIR. Având în vedere nivelul redus al costurilor investiționale față de cele de operare, s-a stabilit un interval de variație {+10%; +50%} pentru costurile investiționale şi un interval {+1%; +5%} pentru cele de operare.

În valori relative, scăderea VFNA şi a RIR (%),

to IC and OC growth are expressed as follows (4):

$$\frac{FNPV_{REF} - FNPV}{FNPV_{REF}} ; \frac{IRR_{REF} - IRR}{IRR_{REF}} \quad (4)$$

where $FNPV_{REF}$ = 644,961lei şi IRR_{REF} = 120.05%

datorate creşterii CI şi CO, se exprimă astfel (4):

unde $VFNA_{REF}$ = 644.961lei şi RIR_{REF} = 120,05%

Table 3

Sensitivity analysis in relation to investment costs, IC [%]

IC Growth	10	20	30	40%	50%
VFNA Lowering	1,31	2,61	3,92	5,22	6,53
IRR Lowering	9,22	16,92	23,44	29,03	33,89

Table 4

Sensitivity analysis in relation to operating costs, OC [%]

OC Growth	1	2	3	4	5
VFNA Lowering	12,57	25,14	37,72	50,29	62,86
IRR Lowering	11,66	23,34	35,11	46,67	58,32

The sensitivity index - At a rise of 1% of the investment costs, FNPV decreases on average by 1.37% and IRR decreases on average by 0.84%. At a 1% increase of operating costs FNPV, decreases on average by 1.43% and IRR decreases on average by 1.31%.

The critical index – At an increase of over 86.5% of the investment costs or at an increase of 7.95% of operating costs, FNPV becomes negative and the IRR drops below the discount rate, the investment become inefficient.

Once the critical variables have been identified, the probability distributions are defined for each variable, in a precise range of values around the best estimation basis, in order to calculate the expected financial performance indicators.

There are two main categories of probability distributions: discrete distribution and continuous distribution. Gaussian (or normal) is the most important and most used. This distribution is fully defined by two parameters: mean and standard deviation. The degree of dispersion of possible values around the mean value is measured by standard deviation.

It was considered that the normal distribution describes more accurately the variation of investment costs and operating costs around the estimated values. Probability distributions for these two variables are shown in figures 2 and 3. The standard deviation (Std. Dev. - Standard Deviation) was postulated to be 10% of the average value (Mean - Mean Value) in both cases.

Indicele de senzitivitate - La o creştere cu 1% a costurilor investiţionale, VFNA scade în medie cu 1,37%, iar RIR scade în medie cu 0,84%. La o creştere cu 1% a costurilor de operare VFNA scade în medie cu 1,43%, iar RIR scade în medie cu 1,31%.

Indicele critic - La o creştere cu peste 86,5% a costurilor investiţionale sau la o creştere cu peste 7,95% a costurilor de operare, VFNA devine negativă, iar RIR coboară sub nivelul ratei de actualizare, investiţia devenind neperformantă.

Odată ce variabilele critice au fost identificate, se definesc *distribuţiile de probabilitate* pentru fiecare, într-o gamă precisă de valori în jurul celei mai bune estimări, în scopul de a calcula valorile aşteptate ale indicatorilor de performanţă financiară.

Există două categorii principale de distribuţii probabilistice: distribuţia discretă şi distribuţia continuă. Distribuţia gaussiană (sau normală) este cea mai importantă şi mai des utilizată. Această distribuţie este integral definită de doi parametri: media şi deviaţia standard. Gradul de dispersie al posibilelor valori în jurul mediei este măsurat prin deviaţia standard.

S-a considerat că distribuţia normală descrie cu cea mai mare acurateţe variaţia costurilor investiţionale şi a costurilor de operare în jurul valorilor estimate. Distribuţiile de probabilitate pentru aceste două variabile sunt prezentate în figurile 2 şi 3. Abaterea medie pătratică (Std. Dev. – Standard Deviation) a fost postulată ca fiind 10% din valoarea medie (Mean – Mean Value) în ambele cazuri.

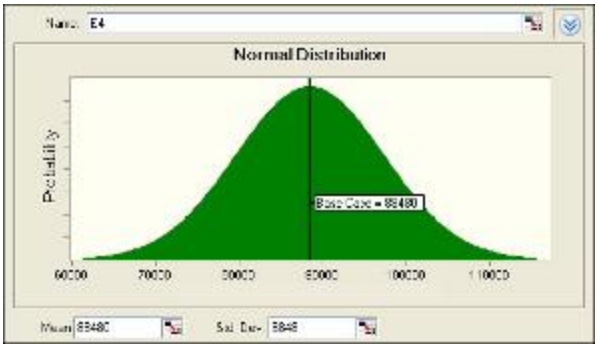

Fig. 2 – Probability distribution for the investment costs

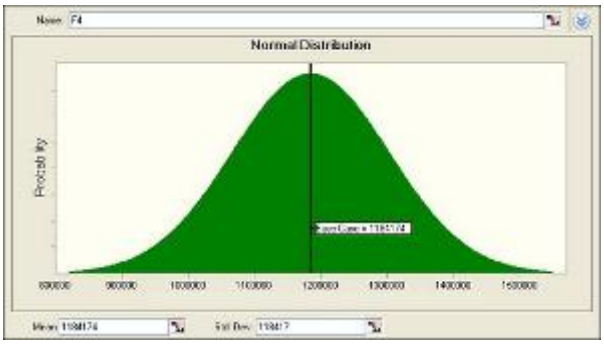

Fig. 3 – Probability distribution for the operating costs

Assessing the level of risk is performed by numerical means, generally by the method of Monte Carlo simulation (MCS - Monte Carlo Simulation) because of the advantages recognized both by practitioners as well as by academic community. The distribution of possible results of an event is generated by analyzing a model several times, each time using randomly select input values from probability distributions of critical variables.

The simulation was performed using Crystal Ball software from Oracle, obtaining the probability distributions for FNPV (Financial Net Present Value) and B/C (Benefit/Cost ratio). There have been carried out as many as 2,000 iterations.

The probability distribution for FNPV is shown in figure 4.

Evaluarea nivelului de risc se efectuează prin mijloace numerice, în general prin metoda de simulare Monte Carlo (MCS – Monte Carlo Simulation), datorită avantajelor recunoscute atât de practicieni cât şi de comunitatea academică [5]. Distribuția rezultatelor posibile ale unui eveniment este generată prin analizarea unui model de mai multe ori, de fiecare dată utilizându-se valori de intrare selectate întâmplător din distribuțiile de probabilitate ale variabilelor critice.

Simularea s-a efectuat cu ajutorul programului Crystal Ball, de la Oracle, obținându-se distribuțiile de probabilitate pentru VFNA (Valoarea financiară netă actualizată) şi B/C (Raportul beneficiu/cost). S-au efectuat câte 2.000 de iterații.

Distribuția de probabilitate pentru VFNA este prezentată în figura 4.

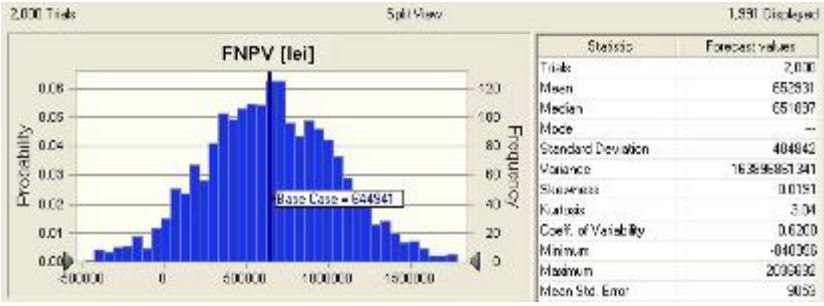

Fig. 4 – The probability distribution for FNPV

The probability that FNPV to be above the reference value (644,941 lei) is 50.73% (figure 5).

Probabilitatea ca VFNA să se situeze peste mărimea de referința (644.941 lei) este de 50,73% (figura 5).

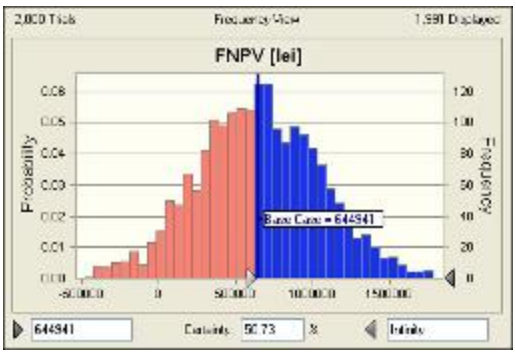

Fig. 5 – The probability that FNPV to be above the reference value

The probability that B/C to be higher than one is 95.08% (figure 6).

Probabilitatea ca B/C să fie supraunitar este 95,08% (figura 6).

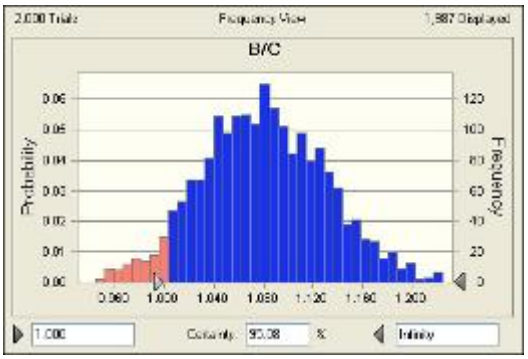

Fig. 6 – The probability that B/C to be higher than one

CONCLUSIONS

The indicators obtained in Cost-Benefit Analysis inforces the idea that the technology is self-sustaining, requiring no structural funding and has revenue-generating potential. The results of the paper can be extrapolated successfully in phytosanitary treatments in vineyards, field crops and greenhouses.

Acknowledgement

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CONCLUZII

Indicatorii obţinuţi în Analiza Cost-Beneficiu impun ideea că tehnologia este autosustenabilă, nu necesită fonduri structurale şi are potenţial generator de venituri. Rezultatele obținute în cadrul lucrării pot fi extrapolate cu succes şi în domeniul tratamentelor fitosanitare în vii sau culturi de câmp, precum şi în sere.

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MONITORING WIND SPEED AT DIFFERENT HEIGHTS FROM THE GROUND IN BUCHAREST

MONITORIZAREA VITEZEI VANTULUI LA DIFERITE INALTIMI FATA DE SOL IN ORASUL BUCURESTI

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Abstract: *This paper presented the main theoretical and practical aspects related to wind speed at different heights from the ground. The calculations were performed based on statistical analysis of weather station recorded wind speed by choosing the maximum and average values of wind speed, knowing the station recorded wind speed at 10 m height and the wind profile parameter by category stability, in this case urban forestry will calculate the wind speed at different heights from the ground (20, 30, 40, 50, 60 m). In this paper the wind speed is monitored by the city of Bucharest weather station in 2010-2013. We calculated parameter of the wind profile at the height of 10-60 m, depending on wind speed by statistical analysis for the years 2010 to 2013 in Bucharest. Wind speed measured at 10 m height above ground is estimated at 60 meters height that supposedly will position aerogeneratorul*

Keywords: *Wind speed, wind profile parameter, weather station.*

INTRODUCTION

Atmospheric air is in constant motion, both horizontal (advection movement) and vertical (convective motion) in relation to the earth's surface. and the movement of air masses printing a look weather in those regions. Through the phenomenon of shifting pressure to a region of low atmospheric pressure. The main reason is the difference in atmospheric pressure will formation between two regions. Hot air being lighter rises producing a minimum pressure will be taken place by air masses from the cold (maximum air pressure) until it is equal to the pressure difference between the two regions [9].

It is very important to know the wind speed at various heights above the ground, since action on buildings, flora and fauna. Wind speed has been investigated by other authors in their works. [4,5].

With increasing negative effects of fossil fuels on environment, using renewable energy sources. Nowadays, the fastest developing and most common used energy source is the wind energy. Wind energy is a clean and renewable alternative source of energy potential to fossils based energy sources polluting the lower layer atmosphere. Energy is a clean and renewable energy, systems transforming wind power to electrical energy has been developing quite fast. The most important parameter of the wind energy is the wind speed. For this reason, an accurate determination of probability distribution of wind speed values is very important in evaluating wind speed energy potential of a region. Wind energy potential can be determined by wind measurements of a certain investigation region depending on years [1, 11].

Knowledge of all parameters involved in wind speed makes possible the proper placement of a wind turbine. Bucharest.

Rezumat: *Aceasta lucrare, prezinta principalele aspecte teoretice şi practice legate de viteza vântului la diferite înălțimi fata de sol. Calculele au fost efectuate pe baza analizei statistice a valorilor vitezei vântului înregistrate de stația meteo, prin alegerea valorile maxime şi medii ale vitezei vântului, ştiind viteza vântului la 10 m înălțime, a fost calculat şi parametrul de profil al vântului in functie de categoriile de stabilitate, în acest caz, se va calcula viteza vântului la diferite înălțimi fata de sol (20, 30, 40, 50, 60 m). În această lucrare, viteza vântului este monitorizată de stația meteo in oraşul Bucureşti în perioada 2010-2013. S-a calculat parametrul de profil al vântului la doua înălțimi de 10 si 60 m, în funcție de viteza vântului inregistrata de statia meteo in anii 2010-2013, în Bucureşti. Viteza vântului masurata la înaltimea de 10 m deasupra solului este estimata la 60 de metri, înaltime la care se presupune ca se va pozitiona aerogeneratorul*

Cuvinte cheie: *viteza vantului, parametru de profil al vantulu, statie meteo.*

INTRODUCERE

Aerul atmosferic se află într-o permanență mişcare, atât pe orizontală (mişcare de advecție), cât şi pe verticală (mişcare de convecție) în raport cu suprafața Pământului, iar deplasarea maselor de aer imprimă un anumit aspect vremii din regiunile respective.

Cauza principală a formării vântului este diferența presiunii între două regiuni. Aerul cald fiind mai uşor se înalță producându-se un minim de presiune, locul lui va fi preluat de masele de aer din zona rece (maxim de presiune atmosferică), până când se va egala diferența de presiuni dintre cele două regiuni. [9].

Este foarte importanta cunoasterea vitezei vantului la diferite inaltimi deasupra solului, avand in vedere actiunea sa asupra cladirilor, florei si faunei.

Viteza vântului a fost investigata si de alți autori în lucrările lor. [4,5].

Odată cu creşterea efectelor negative ale combustibililor fosili asupra mediului, a inceput utilizarea surselor regenerabile de energie.

Energia eoliană este o sursă alternativă curată şi regenerabilă de energie, sistemele de transformare a energiei eoliene în energie electrică s-au dezvoltat destul de rapid. Cel mai important parametru al energiei eoliene este viteza vântului. Din acest motiv, o determinare exactă a distribuției valorilor vitezei vântului este foarte importanta în evaluarea potențialului energetic al unei regiuni.

Potențialul energiei eolian poate fi determinat prin măsurători ale vântului[1,11].

Cunoaşterea tuturor parametrilor care intervin în viteza vântului face posibilă amplasarea corectă a unei turbine eoliene.

MATERIAL AND METHOD

Wind speed was monitored weather station Biotechnical Faculty of Engineering.

The System for Environmental and Meteorological Monitoring mod AWS/EV Engineering Faculty of Biotechnical automatically registers: air temperature, wind speed and direction, air humidity, solar radiation, rainfall

The system is composed of a data acquisition control box, several environmental sensors, the software enabling the remote monitoring and the data processing and all the mechanical accessories necessary to scarry out a proper installation [12].

It is a complete system that enables to acquire the wished environmental parameters and to memorize them to prevent their scattering.

It is possible to monitor in real time the acquired data directly on the control board.

Or, with external PC, it is possible to monitor the acquired data directly as well as to carry out their processing.

For this last possibility, it is necessary to transfer the data from the control box to an external PC, using one of the following procedures: connecting an external PC, to the control board, connecting a modem .

Wind speed measurement range: 0-50 [m/s]; resolution: 0.1 [m/s]; sensitivity: 0.25 [m/s] [8].

Other authors have their work monitored wind [4, 5].

RESULTS

Weather Station AWWS/EV measuring the wind speed at 10 m from the ground, to calculate the wind speed at other heights above the ground using the following formula [6]:

MATERIAL ŞI METODĂ

Viteza vantului a fost monitorizată cu Stația meteo de la Facultatea de Ingineria Sistemelor Biotehnice.

Stația meteo: AWS/EV de la Facultatea Ingineria Sistemelor Biotehnice, înregistrează automat: temperatura atmosferică, direcția şi viteza vântului, umiditatea atmosferică, radiația solară, cantitatea de precipitatii.

Sistemul este compus dintr-o cutie de achiziție a datelor, mai mulți senzori de mediu, software-ul care permite monitorizarea de la distanță şi prelucrarea datelor şi toate accesoriile mecanice necesare pentru o instalare adecvată [12].

Este un sistem complet care permite să achiziționeze parametrii de mediu şi să le memoreze. Este posibil să monitorizeze în timp real datele obținute direct de pe panoul de control.

Sau, cu PC extern, este posibil să se monitorizeze datele achiziționate direct, precum şi să efectueze procesarea lor.

Pentru această ultimă posibilitate, este necesar să se transfere datele de la panoul de comandă la un PC extern, utilizând unul dintre următoarele proceduri: Conectarea unui PC extern, la placa de control, conectarea unui modem. Viteza vântului domeniul de măsură: 0 la 50 m /s; rezoluție: 0,1 m/s; sensibilitate: 0,25 m / s. [8].

Viteza vantului a fost studiata si de alti autori [4,5].

REZULTATE

Viteza vantului a fost masurata la 10 m fata de sol, de statia meteo. Pentru a calcula viteza vantului la alte inaltimi fata de sol se foloseste urmatoarea formula [6]:

$$u(z) = u_{10} \cdot \left(\frac{z}{10}\right)^m \quad (1)$$

In the equation (1) shows the time profile of the parameter *m* that represents the wind and atmospheric stability based on the group set out in Table 1,2,3,4, u_{10} station recorded wind speed at 10 m height, while *u(z)* is the speed we wish to estimate at different heights above the ground. [6].

For strength calculations of the constructions, for reasons of caution, this formula is used to estimate the wind speed at a certain height.

In ecuatia (1) apare termenul *m* care reprezinta parametrul de profil al vantului, si este functie de categoria de stabilitate atmosferica prezentat in tabelele 1, 2, 3, 4, u_{10} viteza vantului inregistrata de statie la 10 m inaltime, in timp ce *u(z)* reprezinta viteza pe care dorim sa o estimam la diferite inaltimi deasupra terenului [6].

Pentru calculele de rezistenta a constructiilor, din motive de precautie, este folosita aceasta formula pentru a estima viteza vântului la o anumita înaltime.

Table 1

Wind profile parameter depending on the category of stability

Stability category	m
A	0,10
B	0,10
C	0,16
D	0,16
E	0,30
F	0,30

Table 2

Estimation of atmospheric stability category

Day time	Winter		Spring		Summer		Fall	
	8-16	17-7	7-17	18-6	6-18	19-5	7-17	18-6
Wind speed [m/s]								
u<2	C	F	C	F	B	F	C	F
2<u<3	C	E	C	E	C	E	C	E
u>3	D	D	D	D	D	D	D	D

Table 3

The values of the parameter *m* depending on the soil and atmospheric stability conditions

Area	Stability class

	A	B	C	D	E	F
Seas and lakes	0,03	0,05	0,06	0,08	0,10	0,12
Agricultural land	0,10	0,15	2,20	0,25	0,35	0,40
Urban forestry	0,16	0,24	0,32	0,40	0,56	0,64

Table 4

The values of the parameter *m* depending on the soil and atmospheric stability conditions

Wind speed [m/s]	**Day time conditions (solar irradiation)**			**Conditions night (Cloud)**	
	strong	**moderately**	**small**	**>4/8 clouds of low altitude**	**<3/8**
<2	A	A-B	B	-	-
2-3	A-B	B	C	F	F
3-5	B	B-C	C	D	E
5-6	C	C-D	D	D	D
>6	C	D	D	D	D

Stability of the class: [9] A – very unstable, B- moderately unstable, C- slightly unstable, D – neutral, E, –moderately stable, F – stable Caracteristicile categoriilor de stabilitate [9]: A – foarte instabilă, B – moderat instabilă, C – uşor instabilă, D – neutră, E – moderat stabilă, F- stabila.

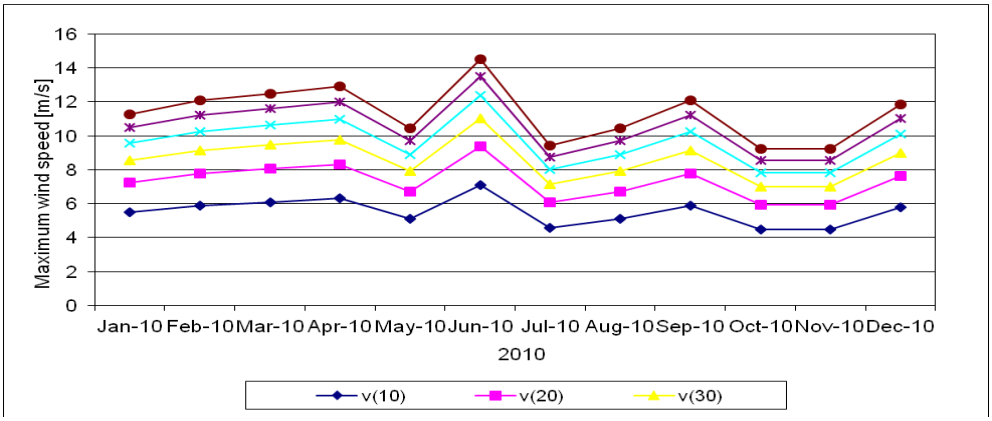

Fig. 1 - Wind profile parameter studied in height 10-60 m, depending on wind speed for the year 2010

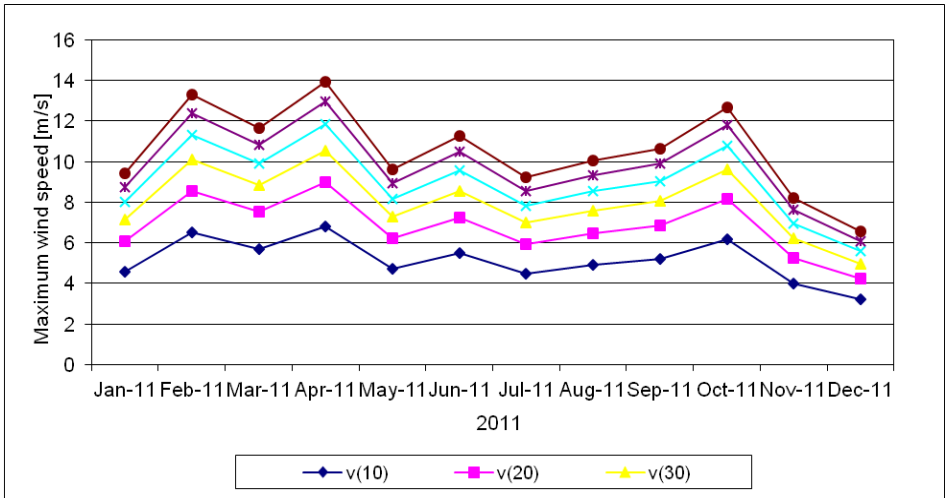

Fig. 2 - Wind profile parameter studied in height 10-60 m, depending on wind speed for the year 2011

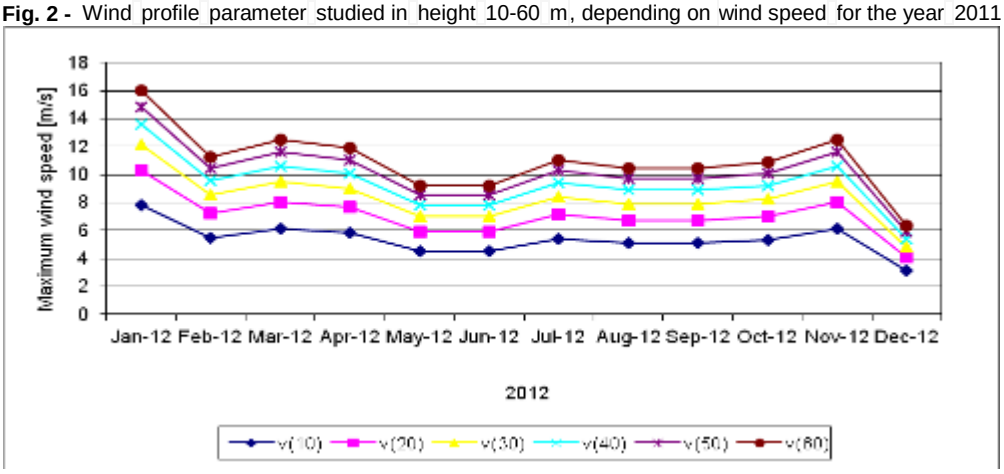

Fig. 3 - Wind profile parameter studied in height 10-60 m, depending on wind speed for the year 2012

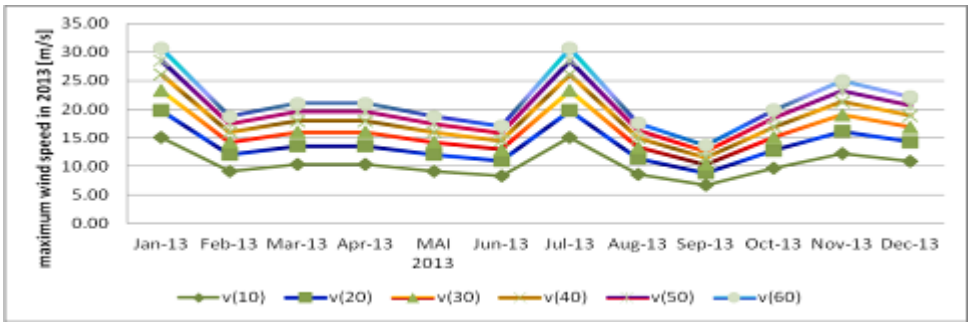

Fig. 4 - Wind profile parameter studied in height 10-60 m, depending on wind speed for the year 2013

For statistical analysis we obtained wind speed highs reaching levels of 14.1 [m/s] in 2010, 14 [m/s] in 2011, 15.2 [m/s] in 2012, 30.72 and 2013 to 60 [m] above the ground. For statistical analysis we obtained wind speed highs reaching levels of 9.76 [m/s] in 2010, 3.01 [m/s] in 2011, 9.76 [m/s] in 2012, 12.24 and 2013 to 10 [m] above the ground.

It is noted that the higher the wind speed measured by the weather station was 12.24 m / s recorded in 2013, the mean wind speed are commonly found in 4.0 [m / s].

Average wind speed Territory University Polytechnic Bucharest where the weather station is located with which we monitored wind speed presented in this work and its surrounding areas surrounded by forests has a normal circulation of air masses, particularly conductive to the maintenance of a relatively stable atmosphere.

Din analiza statistică am obținut maximele vitezei vântului atingând cote de 14,1 [m/s] în anul 2010, 14 [m/s] în anul 2011; 15,2 [m/s] în anul 2012; 30.72 [m/s] in 2013 la 60 m față de sol; respectiv: 9,76 [m/s] în anul 2010, 3.01 [m/s] în anul 2011, 9.76[m/s] în anul 2012; 12,24 [m/s] in anul 2013 la 10 m față de sol.

Se observă că cea mai mare valoare a vitezei vantului masurată de statia meteo a fost de 12,24 m/s inregistrata in anul 2013, valorile medii ale vitezei vantului frecvent intalnite sunt sub 4.0 [m/s].

Viteza medie a vântului

Teritoriul Universitatii Politehnica Bucuresti si zonele sale limitrofe inconjurate de păduri beneficiaza de o circulatie normala a maselor de aer, deosebit de favorabila mentinerii unei atmosfere relativ stabile.

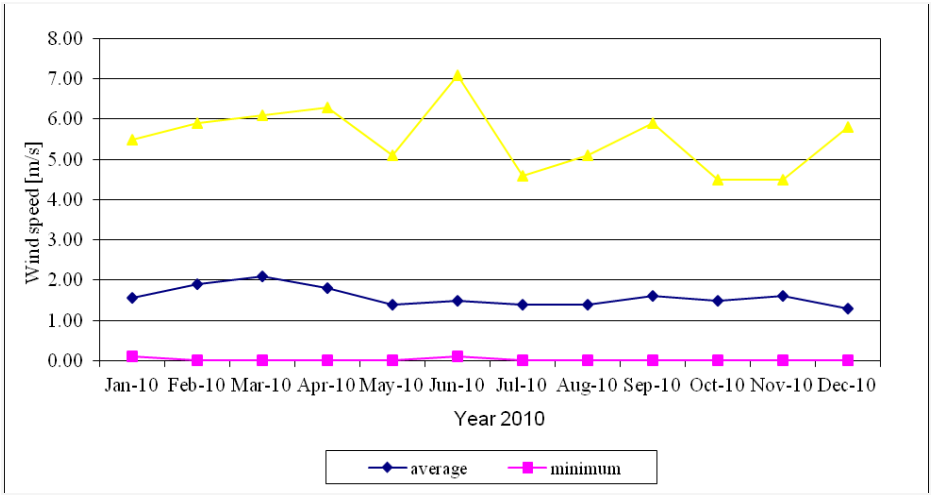

Fig. 5 - Monthly average wind speed of 10 m to 60 m, calculated for 2010

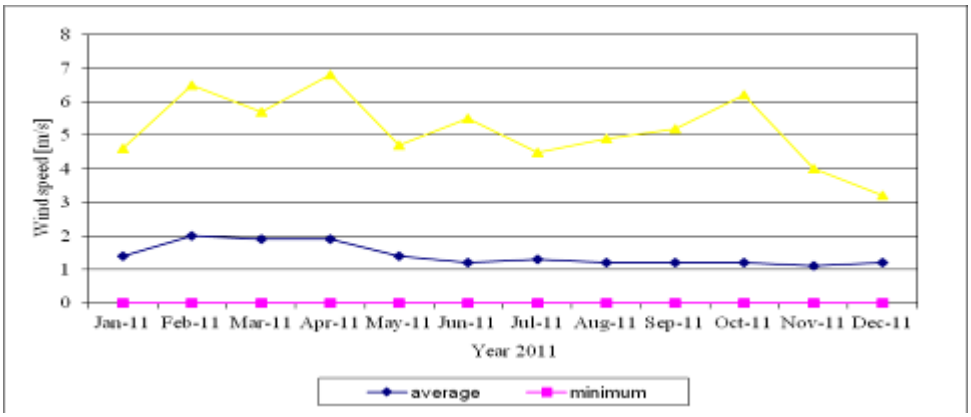

Fig. 6 - Monthly average wind speed of 10 m to 60 m, calculated for 2011

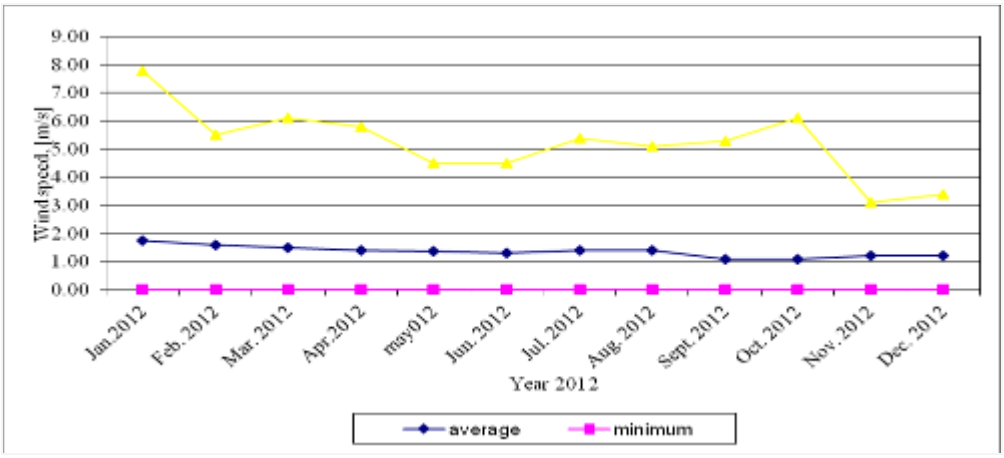

Fig. 7 - Monthly average wind speed of 10 m to 60 m, calculated for 2012

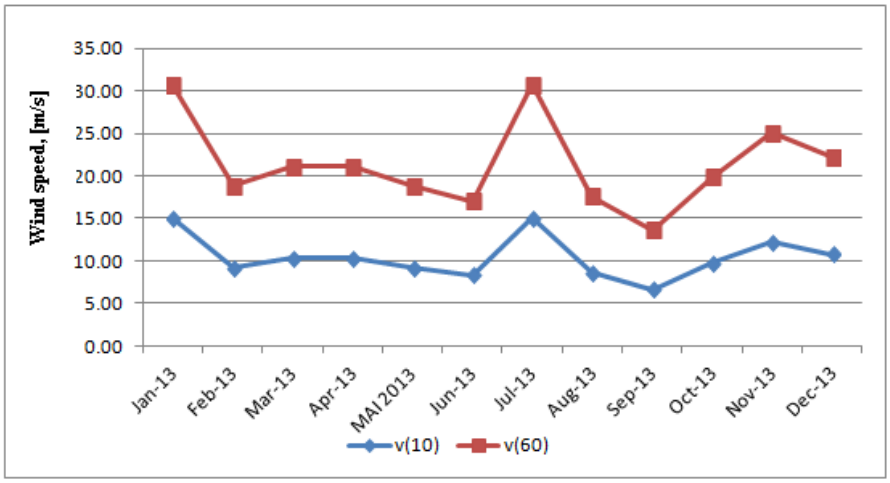

Fig. 8 - Monthly average wind speed of 10 m to 60 m, calculated for 2013

It is observed that the wind was relatively close to the average values in the period under review.

CONCLUSIONS

In this paper they were presented theoretical and practical aspects on wind speed at various heights from the ground. The calculations were performed for average and maximum wind speed, wind speed recorded knowing station at 10 m height and wind profile parameter in the

Se observă că vântul a avut valorile medii relativ apropiate în intervalul analizat.

CONCLUZII

In prezenta lucrare au fost prezentate aspectele teoretice si practice privind viteza vantului la diferite inaltimi fata de sol. S-au efectuat calcule pentru viteza medie şi maximă a vântului, cunoscând viteza vîntului înregistrată de stație la 10 m înălțime şi parametrul de

category of stability, in case the urban area and forest. City falls in moderate continental climate transition characteristic SE part of the Pannonian Plain, with some Mediterranean influences.

Its general features are marked by diversity and irregularity of atmospheric processes.

The movement of air masses from the west persists both in the cold and in the warm seasons and is characterized by mild winters, often with liquid precipitation. Frequently, even in winter, arriving from humid Atlantic air masses, bringing significant rain and snow rarely cold waves.
By monitoring the wind speed in the city of Bucharest, characterized by a temperate climate, the Biotechnical Faculty of Engineering, the measurements took place, is an area protected from the strong winds.

Hence, although there is a wind potential, it is still considered a useful place for exploitation of other renewable energies.

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profil al vântului în funcție de categoria de stabilitate, în cazul de față zona urbana şi forestiera. Oraşul Bucureşti se încadrează în climatul temperat continental moderat de tranziție, caracteristic părții de SE a Câmpiei Panonice, cu unele influențe submediteraneene.

Trăsăturile sale generale sunt marcate de diversitatea şi neregularitatea proceselor atmosferice.

Masele de aer din circulația vestică persistă atât în perioada rece, cât şi în perioada caldă a anului şi se caracterizează prin ierni blânde, adeseori cu precipitații lichide. În mod frecvent, chiar în timpul iernii, sosesc dinspre Oceanul Atlantic mase de aer umed, aducând ploi şi ninsori însemnate, rar valuri de frig. Oraşul Bucureşti, caracterizat de un climat temperat, iar zona Facultății de Ingineria Sistemelor Biotehnice, în care au avut loc măsuratorile, este o zonă protejata de influența vânturilor puternice. Deşi nu este un loc cu potențial eolian, este totuşi un loc considerat util pentru exploatarea altor energii regenerabile.

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USING THE REVERSE OSMOSIS METHOD TO OBTAIN DRINKING WATER FROM NITRATE POLLUTED SOURCES FOR RURAL COMMUNITIES
/
UTILIZAREA PROCEDEULUI DE OSMOZA INVERSA PENTRU OBTINEREA DE APA POTABILA DIN SURSE POLUATE CU NITRATI PENTRU COMUNITATI RURALE

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Abstract: *Using reverse osmosis to obtain high quality drinking water, with no contaminants, has gone beyond the stage of special applications, such as space stations and spacecrafts, cruise ships or military applications; currently, reverse osmosis imposes itself as a water decontamination solution in agricultural areas polluted as a consequence of using chemical or organic fertilizers which contain nitrogen compounds.*

The facility presented, currently under development, consists of three main modules, of which the last one, the denitrification one, reduces the nitrate concentration in waste water down to the allowed limit (50 mg/l).

Advances in mechanical and chemical areas make reverse osmosis an accessible process for obtaining high quality drinking water, even in areas affected by the use of fertilizers in farming.

Keywords: *reverse osmosis, ultrafiltration, denitrifiction*

INTRODUCTION

Although the phenomenon of osmosis is known early since 1748 thanks to French physicist Jean Antoine Nollet, for nearly 200 years it has remained a phenomenon studied in the laboratory, without a practical application. In 1949, at University of Los Angeles, California (UCLA) foundations were laid for obtaining drinking water from seawater, by desalination; however, the first large-scale commercial applications have emerged in the 1970s.

Direct osmosis is a natural phenomenon of transfer of molecules between two liquids with different concentrations of ions, between which there is a semi-permeable membrane. Movement of molecules takes place from the lower concentration liquid towards the area with higher concentration of ions, until concentrations are balanced. This phenomenon is shown in the figure below.

Rezumat: *Folosirea osmozei inverse pentru obtinerea apei potabile de calitate superioara, fara contaminanti, a depasit faza aplicatiilor speciale, cum ar fi statiile si navele spatiale, vasele de croaziera sau aplicatiile militare; in prezent, osmoza inversa se impune ca o solutie pentru decontaminarea apei din zonele agricole poluate in urma utilizarii ingrasamintelor chimice sau organice care contin compusi ai azotului.*

Instalatia prezentata, in curs de realizare, se compune din 3 module principale, dintre care ultimul, cel de denitrificare, reduce concentratia de nitrati din apa reziduala pana la limita admisa (50 mg/l).

Progresele in domeniile mecano-chimic fac din osmoza inversa un procedeu accesibil pentru obtinerea apei potabile de calitate superioara, chiar si in zonele afectate de utilizarea ingrasamintelor in agricultura.

Cuvinte cheie: *osmoză inversă, ultrafiltrare, denitrificare*

INTRODUCERE

Desi fenomenul de osmoză este cunoscut inca din 1748, datorita fizicianului francez Jean Antoine Nollet, pentru aproape 200 ani a ramas la stadiul de fenomen cercetat in laborator, fara a avea o aplicatie practica. În 1949, la Universitatea din Los Angeles, California (UCLA) s-au pus bazele obtinerii apei potabile din apa de mare, prin desalinizare; totusi, primele aplicatii comerciale la scara mare au aparut in anii 1970.

Osmoza directa este un fenomen natural de transfer de molecule intre doua lichide cu concentratii diferite de ioni, intre care se afla o membrana semipermeabila. Circulatia moleculelor are loc dinpre lichidul cu concentratie mai mica spre zona cu concentratie mai mare de ioni, pana la egalizarea concentratiilor. Fenomenul este prezentat in figura de mai jos.

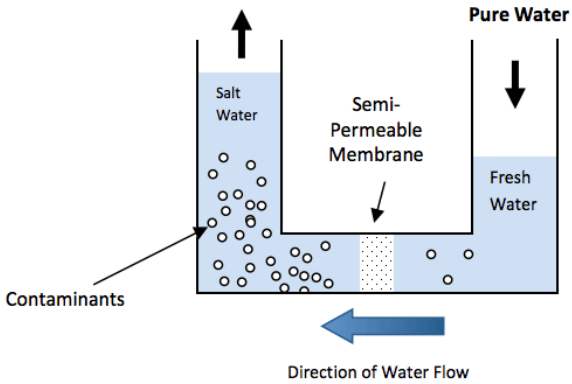

Fig. 1 – Direct osmosis process

Applications of direct osmosis are found in water treatment (mainly in pilot installations), food processing,

Aplicatiile osmozei directe se regasesc in tratarea apei (in principal in instalatii pilot), procesarea

generation of electricity, controlled release of drugs inside the body, etc. The main advantages are related to the low pressure at which the process occurs, removing a large number of contaminants, simplicity of the equipment.

In the case of **reverse osmosis**, the liquid in the more concentrated solution is forced, as a result of application of external pressure, to pass in the area with lower concentration. When filtering water with impurities, compounds that can be filtered are: arsenic, barium, cadmium, chromium (Cr3+/Cr6+), copper, lead, nitrates, nitrites, rhodium, selenium, ammonium, bicarbonates, bromide, free chlorine, chlorides, magnesium, sodium, sulfur, tannins, zinc, aluminum, turbidity, unpleasant taste and odor, microorganisms, etc.

alimentelor, generarea de energie electrica, eliberarea controlata in organism a medicamentelor, etc. Principalele avantaje sunt legate de presiunea joasa la care are loc procesul, inlaturarea unui numar mare de contaminanti, simplitatea echipamentelor.

In cazul **osmozei inverse**, lichidul din solutia mai concentrata este fortat, datorita aplicarii unei presiuni externe, sa treaca in zona de concentratie mai redusa. In cazul filtrarii apei cu impuritati, compusii care pot fi filtrati sunt: arseniu, bariu, cadmiu, crom (Cr3+/Cr6+), cupru, plumb, nitrati, nitriti, radiu, seleniu, amoniu, bicarbonati, bromuri, clor liber, cloruri, magneziu, sodiu, sulfati, tanin, zinc, aluminiu, turbiditate, gust neplacut si miros, microorganisme, etc.

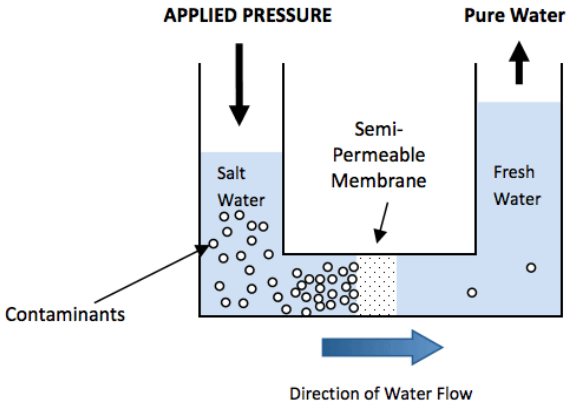

Fig. 2 – Reverse osmosis process

The process is achieved with a pressure applied to the high concentration liquid (generally 2...17 bar for regular water); if it is desired to obtain drinking water from seawater, one must consider the natural osmotic pressure which must be overcome (27 bar), in this case the working pressure rates being in the range 40…80 bar.

Using chemical or organic fertilizers containing nitrogen compounds has led in recent years to contamination of water sources.

In Romania there have been designated 1955 localities situated in 42 nitrate vulnerable zones, representing 57.8% of the country territory. In 11.5% of the groundwater monitoring sections there have been recorded exceeds in the allowed concentration (50 mg/l) of nitrates (NO3). [1, 2]

Procesul se realizeaza cu o presiune aplicata lichidului cu concentratie mare (in general 2…17 bar pentru apa obisnuita); daca se doreste obtinerea apei potabile din apa de mare, trebuie tinut cont de presiunea osmotica naturala care trebuie invinsa (27 bar), in acest caz presiunile de lucru fiind intre 40…80 bar.

Utilizarea ingrasamintelor chimice sau organice care contin compusi ai azotului a condus in ultimii ani la contaminarea surselor de apa.

In Romania au fost desemnate 1955 localitati aflate in 42 zone vulnerabile la nitrati, reprezentand 57,8% din teritoriul tarii. In 11,5% din sectiunile de monitorizare pentru ape subterane s-au inregistrat depasiri ale concentratiei de nitrati (NO_3) admis (50 mg/l). [1, 2]

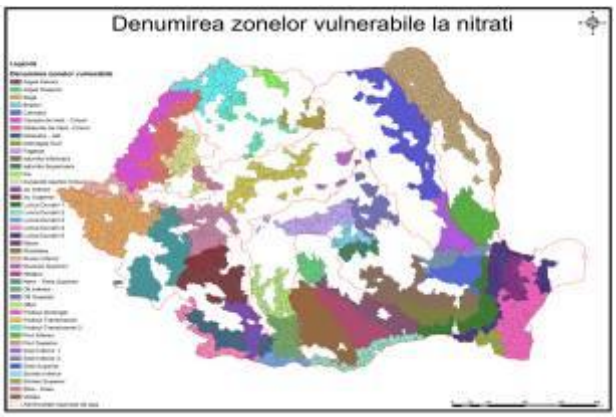

Fig. 3 – Nitrates vulnerable zones (2008-2011) [2]

Water consumption with high concentrations of nitrates has serious effects on health; from the syndrome of the blue baby to increase in high incidence of cancers; for this reason there is urgently needed the researching and development of equipment to provide drinking water for rural communities where deep or surface sources are polluted.

EQUIPMENT FOR WATER TREATMENT AND DENITRIFICATION OF CONCENTRATED WASTE RESULTED

The base technical solution chosen for the development of the filtration equipment - experimental model - is the reverse osmosis. The experimental model proposed on this base is expected to be developed in three modules (see Figure 4):

- the ultrafiltration module
- the reversis osmosis module
- the denitrification module

Consumul de apă cu concentrații ridicate de nitrați are efecte grave asupra sănătății; de la sindromul albastru al nou-născutului până la creşterea incidenței bolilor canceroase şi din acest motiv este imperios necesară cercetarea şi dezvoltarea unui echipament care să asigure apa potabilă pentru comunitățile rurale unde sursele de adâncime sau de suprafață sunt poluate.

DESCRIEREA ECHIPAMENTUI PENTRU TRATAREA APEI SI DENITRIFICAREA CONCENTRATULUI REZULTAT

Soluția tehnică aleasă pentru realizarea echipamentului de filtrare-model experimental este osmoza inversă. Echipamentul model experimental este prevăzut să fie realizat din trei module (vezi figura 4).

- modulul de ultrafiltrare
- modulul de osmoză inversă
- modulul de denitrificare.

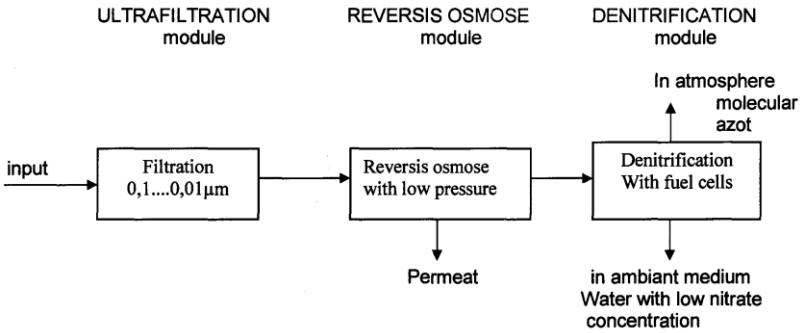

Fig. 4 – Hybrid system: reverse osmosis – denitrification with biofuel cells

Module 1 - ultrafiltration module

Before osmosis could be there the contaminated water must pass through a process microfiltration. Without this pre-filtration, the life of osmotic membrane is drastically reduced. The integral diagram of water filtration is presented in Figure 5.

Modulul 1 - modulul de ultrafiltrare

Înainte de a fi osmozată apa contaminată trebuie să treacă printr-un proces de microfiltrare.Fără această prefiltrare, „viața" membranei osmotice se reduce drastic. În figura 5 este prezentat tabloul integral al filtrării apei.

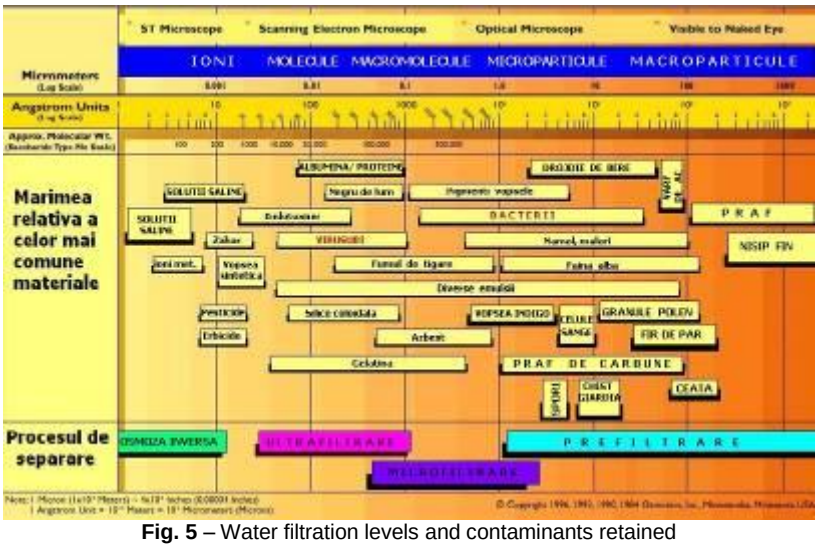

Fig. 5 – Water filtration levels and contaminants retained

Through microfiltration there are retained particles sized between 0.1 and 10µm. For microfiltration there are commonly used ceramic filters.

Ultrafiltration is carried out with ultrafiltration membranes that have the ability to retain particles with a size of 0.001 ÷ 0.1µm. Ultrafiltration is used as a pre-filtering for reverse osmosis.

Prin microfiltrare sunt reținute particule cu dimensiunea cuprinsă între 0,1 şi 10µm. Pentru microfiltrare se folosesc de obicei filtre ceramice.

Ultrafiltrarea se realizează cu membrane de ultrafiltrare care au capacitatea de a reține particulele cu dimensiuni de 0,001÷0,1µm. Ultrafiltrarea este utilizată ca prefiltrare pentru osmoza inversă.

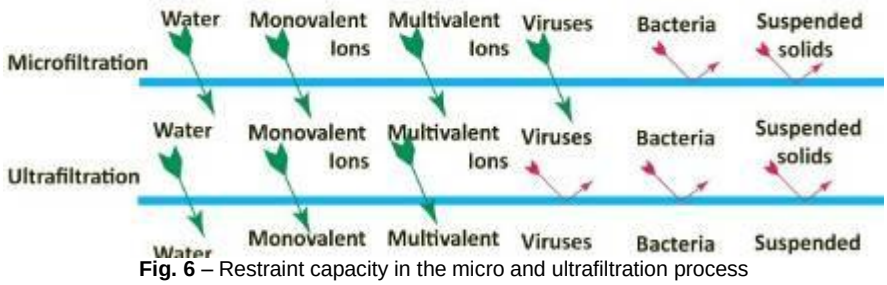

Fig. 6 – Restraint capacity in the micro and ultrafiltration process

Module 2 - reverse osmosis module

This module, having a high level of automation, is shown in figure 7, and it has in its structure:

Modulul 2 - modulul de osmoză inversă

Acest modul, cu un înalt grad de automatizare, este prezentata în figura 7 şi are în structura sa:

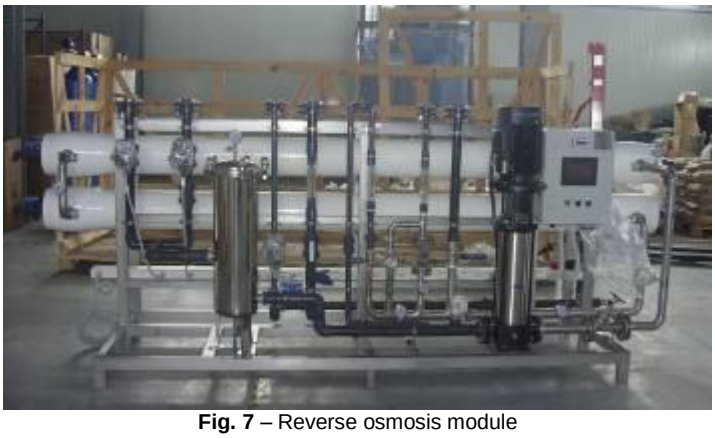

Fig. 7 – Reverse osmosis module

a) Dosing system of the antiscalant, which containts: ● dosing pump; ● chemical tank

b) Proper reverse osmosis system, having as components: ● cartridge filter; ● high pressure pump (HPP); ● reverse osmosis membranes; ● reverse osmosis vessel

c) Analyzer group with: ● permeate conductivity controller; ● permeate and concentrate flow meter; ● low and high pressure control; ● pressure gauges; ● autoflush unit; ● permeate rinsing unit.

d) Piping and valve groups of the unit with the main elements: ● valve group; ● piping group; ● system mount frame

e) Membrane cleaning system: ● washing pump; ● washing tank; ● pressure gauges; ● piping group; ● valve group; ● system frame

The "heart" of the equipment is the osmotic membrane (Figure 8).

a) Sistemul de dozare al antiscalantului, care contine: ● pompă dozatoare; ● rezervor chimic

b) Sistemul propriu-zis de osmoză inversă, avand in componenta: ● Cartuş filtrant; ● Pompa de inalta presiune; ● Membrane de osmoză inversă; ● Vas de osmoză inversă

c) Grupul analizor compus din: ● Controlerul de conductivitate permeat; ● Debitmetru permeat si concentrat; ● Aparatura pentru controlul presiunii; ● Conducte; ● Unitatea de autospălare; ● Unitatea de curățire a permeatului

d) Valve si țevi ale unității: ● Valve; ● Grup de pompare; ● Ansamblu cadru

e) Sistemul de curatire al membranelor, cuprinzand: ● Pompa de spalare; ● Rezervor de spalare; ● Conducte de presiune; ● Conducte; ● Supape; ● Cadru

„Inima" echipamentului este membrana osmotică (figura 8).

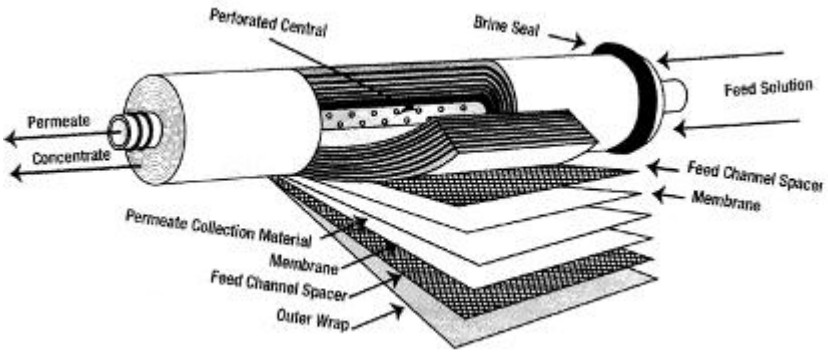

Fig. 8 – The reverse osmosis membrane

The reverse osmosis membranes are polymer membranes.

Filtering on the principle of reverse osmosis is performed with cylindrical filter cartridges in which are inserted osmotic filtering membranes (see Figure 8).

Module 3 - denitrification module

The denitrification module is intended for the post-treatment of the concentrate waste, in order to reduce the nitrate concentration to a level at least equal or lower than that recorded at the entry point of the reverse osmosis system.

The bio-fuel system will consist of two electrodes (an anode and a cathode) to be positioned as follows: the anode - on the bottom of the tank, and the cathode - at its surface, and will consist in grids supporting a carbon felt structure (Fig. 9). By polarizing the cathode electrode, namely by applying a potential for its activation, the electro-active bacteria existing in the waste water will attach to the electrode and will use it as the end acceptor of electrons, in order for them to capture nitrates and remove excess nitrogen.

The biological reduction of nitrate (NO_3^-) to molecular nitrogen (N_2) is called denitrification and is performed, generally, by facultative anaerobic bacteria. These require in their metabolic processes a source of carbon and oxygen, which they can take from the oxygen dissolved in water, or by taking it from the nitrate molecules. [5]

Denitrification occurs when the oxygen level in the solution is at minimum values or exhausted, and nitrates become the main source of oxygen for the microorganisms. The denitrification process is carried out under anoxic conditions, when the dissolved oxygen concentration is less than 0.5 mg/l, and ideally less than 0.2 mg/l [4]. Bacteria degrade nitrate to take up oxygen that occurs via a series of intermediates (oxides of nitrogen), necessary for their metabolism, which leads at the end to obtaining molecular nitrogen (N_2). This respiratory process for the nitric oxide reduction occurs in response to the oxidation of an electron donor (for example, organic matter). In terms of thermodynamics, the forms of nitrogen used by microorganisms as electron acceptors include: nitrate (NO_3^-); nitrite (NO_2^-); nitric monoxide (NO^-); nitrous oxide (N_2O), and eventually resulting in molecular nitrogen (N_2), thereby completing the nitrogen cycle in the microbial cells. As molecular nitrogen has a low solubility in water, it will pass into the atmosphere as gas, and since nitrogen is a major component of the air, this will not entail any environmental concerns. [3]

Membranele de osmoză inversă sunt membrane polimerice.

Filtrarea pe principiul osmozei inverse se realizează cu cartuşe filtrante cilindrice în care se introduce membranele osmotice filtrante. (vezi figura 8).

Modulul 3 - modulul de denitrificare

Modulul de denitrificare, destinat tratării post-epurare a reziduurilor concentrate în scopul reducerii concentrației de nitrați la un nivel cel puțin egal sau mai redus decât cel care a fost înregistrat la punctul de intrare în instalația de osmoză inversă.

Sistemul de biocombustie va consta în 2 electrozi (un anod şi un catod) care vor fi poziționați astfel: anodul – pe fundul bazinului şi catodul – la suprafața acestuia şi vor consta în grile care susțin o structură din pâslă carbonică (Fig. 9. Prin polarizarea electrodului catodic, adică prin aplicarea unui potențial de activare a acestuia, bacteriile electro-active existente în apa reziduală se vor ataşa de electrod şi îl vor folosi ca acceptor final de electroni cu scopul ca acestea să capteze nitrații şi să elimine azotul în exces.

Procesul de reducere biologică a nitraților (NO_3^-) la azot molecular (N_2) se numeşte denitrificare şi este realizat, în general, de bacterii facultativ anaerobe. Acestea, în procesele lor metabolice, necesită o sursă de carbon şi de oxigen pe care îl pot prelua din oxigenul dizolvat în apă sau preluându-l din moleculele de nitrați. [5]

Denitrificarea apare atunci când nivelul oxigenului în soluție este la valori minime sau epuizat, iar nitrații devin principala sursă de oxigen pentru microorganisme. Procesul de denitrificare este realizat în condiții anoxice, când concetrația de oxigen dizolvat este mai mică de 0,5 mg/l, ideal fiind sub 0,2 mg/l [3]. Bacteriile degradează nitrați pentru a-şi prelua oxigenul necesar în metabolismul propriu care apare printr-o serie de produşi intermediari (oxizi de azot), în final ducând la obținerea de azot molecular (N_2). Acest proces respirator de reducere a formelor oxidate de azot apare ca răspuns al oxidării unui donor de electroni (de exemplu, materie organică). Din punct de vedere preferențial termodinamic, formele de azot utilizate de microorganisme ca acceptori de electroni includ: nitrați (NO_3^-); nitriți (NO_2^-); monoxid de azot (NO^-); protoxid de azot (N_2O), iar în cele din urmă rezultând azot molecular (N_2), completând astfel ciclul azotului în celulele microbiene. Cum azotul molecular are o solubilitate mică în apă, acesta va trece în atmosferă ca gaz, iar având în vedere că azotul este o componentă principală a aerului, nu va atrage nici o altă preocupare asupra mediului înconjurator.[3],

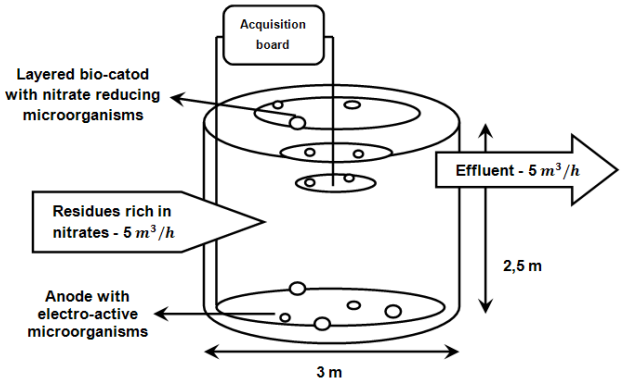

Fig. 9 – Wastewater denitrification using fuel cells

The chosen method is taken from the known experience of bio-fuel cells and the system model used will be one optimized for operation through consumption of organic matter present in the water through the use of microorganisms' species capable of reducing the toxic organic compounds from aqueous ecosystems. [4].

CONCLUSIONS

The equipment proposed in this paper solves the problem of drinking water in rural areas where the exposure of population to high nitrate concentrations increased the level of risk to public health on the medium and long term.

The solution chosen for purifying water - reverse osmosis - has the advantage over the other methods of low energy consumption and reasonable operating and implementation costs.

If many years ago, reverse osmosis was considered an expensive and highly technical purification process, nowadays, thanks to the ongoing development of mechanical-chemical techniques, we can say that it has become a process of elimination of impurities available to everyone.

In addition compared to other installations of the water purification, where waste water results from reverse osmosis process, which has a high concentration of nitrates and is discharged in ambient causing pollution, at the proposed equipment there is achieved reducing of nitrate concentrations of waste water up to the legal limit of 50mg/l accepted Romania.

Implementation of equipment in rural areas vulnerable to nitrates will be made by the public local authorities which will acquire the facility and will produce and distribute bottled drinking water to the population.

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Metoda aleasă este preluată din experința cunoscută a pilelor de bio-combustie, iar modelul de sistem utilizat va fi unul optimizat pentru a opera prin consumarea materiei organice prezente în apă prin utilizarea de specii de microorganisme capabile să reducă compuşii organici toxici din ecosistemele apoase [4].

CONCLUZII

Echipamentul propus în cadrul acestei lucrări rezolvă problema apei potabile în zonele rurale unde expunerea populației la concentrațiile ridicate de nitrați a crescut nivelul de risc asupra sănătății publice pe termen mediu şi lung.

Soluția aleasă pentru purificarea apei - osmoza inversă – are, față de alte procedee avantajul unui consum energetic redus şi al unor costuri de implementare şi exploatare rezonabile.

Dacă în urmă cu mai multi ani, osmoza inversă era considerate un procedeu de purificare scump de înaltă tehnicitate, în zilele noastre, grație dezvoltării continue a tehnicilor mecanico-chimice, se poate spune ca a devenit un procedeu de eliminare a impurităților la îndemâna tuturor.

În plus, față de alte instalații de purificare a apei la care apa reziduală rezultata din procesul de osmoza inversa, care are o concentrație ridicată de nitrați, este "deversata" in mediul ambiant producand poluare, la echipamentul propus se realizeaza reducerea concentratiei de nitrati a apei reziduale pana la limita legala acceptata in Romania de 50 mg/l.

Implementarea echipamentului in zonele rurale vulnerabile de nitrati se va face prin grija autoritatilor publice locale care vor achizitiona instalatia si vor produce, imbutelia si distribui catre populatie apa potabila.

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/
STUDII PRIVIND PRODUCEREA BIOGAZULUI DIN CULTURI ENERGETICE

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Abstract: *Obtaining biogas from biomass falls within the great actuality concerns in the field of renewable energies. The anaerobic digestion process is considered to be a key technology for the sustainable use of biomass composed of the organic fraction of municipal solid waste, animal manure, crop residues, aquatic biomass and energy crops suitable for this process. In this paper there are presented aspects regarding the biogas production from different energy crops used as substrate in anaerobic fermenters.*

Keywords: *biogas, anaerobic digestion, energy crops*

INTRODUCTION

The energy security, along with food security are two major challenges, both in the member states of the European Union as well as worldwide.

At the european level, the concept of energy security is well approached and highlighted in the Europe 2020 Strategy, where one of the objectives concerns to climate change and sustainable energy use, namely: reduction of greenhouse gas emissions by at least 20% (or by 30% if the conditions are right) compared to 1990 levels, increasing the share of renewable energy sources by 20% and achieving a 20% increase in energy efficiency [9].

The process of anaerobic digestion is considered to be a key technology for the sustainable use of biomass consisting of the organic fraction of municipal solid waste, animal manure, crop residues, aquatic biomass and energy crops suitable for this process [17]. Lately, anaerobic fermentation process has gained a particular attention because of the environment protection by reducing greenhouse gas emissions, but also the biogas generation which is a promising source of renewable energy. The benefits of anaerobic digestion technology are also reflected in the stability and agronomic quality of the obtained fertilizer.

This method of treating organic wastes is in accordance with the legislative previsions of the European Union, which require the decrease and recovery of waste, and the promotion of clean technologies [20].

The most used raw materials for biogas production coming primarly from agricultural sector, these being composed of waste from livestock (animal manure and sludge) and also from crop residues (straw, leaves, fruits etc.) [2, 22].

Animal manure contain the necessary nutrients for the growth of anaerobic microorganisms, but even so, because of the low concentration of total solids (usually <8%), these are mixed together with different crop residues or energy crops [19].

Lignocellulosic biomass is rich in carbon, therefore is very important that this material to be fermented with raw

Rezumat: *Obținerea biogazului din biomasă se încadrează în preocupările de mare actualitate din domeniul energiilor regenerabile. Procesul de fermentație anaerobă este considerat a fi o tehnologie cheie pentru utilizarea durabilă a biomasei constituită din fracția organică a deşeurilor solide municipale, dejecții animaliere, resturi vegetale, biomasa acvatică dar şi culturi energetice pretabile acestui proces. În lucrarea de față sunt prezentate aspecte cu privire la obținerea biogazului din diferite culturi energetice utilizate ca substrat în fermentatoarele anaerobe.*

Cuvinte cheie: *biogaz, fermentație anaerobă, culturi energetice*

INTRODUCERE

Securitatea energetică, alături de securitatea alimentară constituie două mari provocări, atât la nivelul țărilor membre ale Uniunii Europene cât şi la nivel mondial.

La nivel european, conceptul de securitate energetică este foarte bine abordat şi conturat în Strategia Europa 2020, în care, unul dintre obiectivele propuse se referă la schimbările climatice şi utilizarea durabilă a energiei, şi anume: reducerea cu 20% a emisiilor de gaze cu efect de seră (sau chiar cu 30%, în condiții favorabile) față de nivelurile înregistrate în 1990, creşterea ponderii surselor de energie regenerabile până la 20% şi creşterea cu 20% a eficienței energetice [9].

Procesul de fermentație anaerobă este considerat a fi o tehnologie cheie pentru utilizarea durabilă a biomasei constituită din fracția organică a deşeurilor solide municipale, dejecții animaliere, resturi vegetale, biomasa acvatică dar şi culturi energetice pretabile acestui proces [17]. În ultima perioadă, procesul de fermentație anaerobă a câştigat o deosebită atenție datorită protecției mediului prin reducerea emisiilor de gaze cu efect de seră, dar şi a generării de biogaz care este o sursă promițătoare de energie regenerabilă. Beneficiile tehnologiei fermentației anaerobe se reflectă de asemenea şi în stabilitatea şi calitatea agronomică a fertilizatorului obținut.

Această metodă de tratare este în concordanță cu prevederile Uniunii Europene care presupun diminuarea şi valorificarea deşeurilor, precum şi promovarea tehnologiilor curate [20].

Cele mai utilizate materii prime pentru producerea biogazului provin în primul rând din sectorul agricol, acestea fiind constituite din deşeuri rezultate din zootehnie (dejecții animaliere şi nămoluri) dar şi din resturi vegetale (paie, frunze, fructe etc) [2, 22].

Dejecțiile animaliere conțin nutrienții necesari pentru creşterea microorganismelor anaerobe, dar cu toate acestea, din cauza concentrației scăzute de solide totale (de obicei < 8%), se recurge la amestecul acestora cu diferite resturi de culturi agricole sau culturi energetice [19].

Biomasa lignocelulozică este bogată în carbon şi

materials rich in nitrogen to obtain an optimal C/N ratio, a good yield and an adequate stability in the anaerobic digester [21].

In Germany, the maize is the most used substrate in the anaerobic fermentation process of animal manure due to its low lignin content [5].

However, it is not suitable for long-term use in biogas plants because there is competition with food industry. Moreover, in this situation, maize crop is associated with soil erosion and compaction, as well as pesticide polution of soil and groundwater [10].

For this reason, the interest in using agricultural residues as a substrate in biogas plants has increased, residues coming from the food industry, but also from perennial crops (Miscanthus, energy willow, sorghum, alfalfa, barley, sunflower etc.) [16].

Among the various types of substrates suitable for anaerobic digestion, energy crops were intensively investigated, especially for their use together with animal manure in the co-digestion process [24].

In this paper there is presented a synthesis of some experimental results conducted in our country or abroad, regarding biogas production from energy crops used as substrate in anaerobic digestion process, mixed with animal manure or as monosubstrat.

MATERIAL AND METHOD

Co-digestion is an efficient process in terms of energy, that can improve the performance of anaerobic digestion by adding a secondary substrate which is rich in nutrients lacking from the initial feedstock [18].

It has been demonstrated that fermentation of several raw materials in the same bioreactor can establish a positive synergism, activating the microbial growth, necessary to conduct in optimal conditions the biogas obtaining process [14].

In the literature, several studies were conducted which show that a high concentration of methane in biogas production can be achieved by co-digestion of animal manure and energy crops or their residues [1, 6, 25].

Amon *et al.* [3] studied the optimisation of methane production from agricultural crops and residues. Thus, they developed a methane energy system in order to estimate the biogas production from different crops and the impact of harvest time. They reported that maize should be harvest in the vegetation stage milk to wax ripeness and the methane production that can be achieved is about 7500–10200 m^3_N ha^{-1}.

Assessing the potential for biogas production of different energy crops is very important, because lately it increased the interest in finding effective crops of biomass with a high energy yield, low production cost and minimal effects on the environment [23].

In table 1 [4] there are presented the measured and calculated values for methane yield, obtained from different types of crops used as substrate in plants for biogas production by anaerobic digestion process.

astfel este foarte important ca acest material să fie fermentat împreună cu materii prime bogate în azot pentru a se obține un raport C/N optim, un randament bun dar şi o stabilitate corespunzătoare în fermentatorul anaerob [21].

În Germania, porumbul este cel mai utilizat co-substrat în procesul de fermentație anaerobă a dejecțiilor, datorită conținutului scăzut de lignină [5]. Totuşi, acesta nu este adecvat pentru utilizarea pe termen lung în instalațiile de biogaz deoarece apare competiția cu industria alimentară. În plus, în acest context, cultura porumbului este asociată cu eroziunea şi compactarea solului, precum şi poluarea cu pesticide a solului şi pânzei freatice [10].

Din acest motiv, a crescut interesul pentru utilizarea ca substrat în instalațiile de biogaz a reziduurilor agricole, a resturilor din industria alimentară, dar şi a culturilor energetice (*Miscanthus*, salcia energetică, sorg, lucernă, orz, floarea soarelui) [16].

Printre tipurile variate de substrat adecvate procesului de fermentație anaerobă, culturile energetice au fost intens investigate în special pentru utilizarea lor împreună cu dejecțiile animaliere în procesul de co-digestie [24].

În această lucrare este prezentată o sinteză a unor rezultate experimentale realizate în țară şi în străinătate, cu privire la obținerea biogazului din culturi energetice, folosite ca substrat în procesul de fermentație anaerobă, în amestec cu dejecții animaliere sau ca substrat unic.

MATERIAL ŞI METODĂ

Co-digestia este un proces eficient din punct de vedere energetic, care poate îmbunătăți performanța fermentării anaerobe prin adăugarea unui substrat secundar bogat în nutrienți de care materia primă inițială este lipsită [18].

S-a demonstrat că fermentarea mai multor materii prime în acelaşi bioreactor poate stabili un sinergism pozitiv, activând creşterea microbiană necesară desfăşurării în condiții optime a procesului de obținere a biogazului [14].

În literatura de specialitate au fost realizate numeroase studii din care reise că o concentrație ridicată de metan în producția de biogaz poate fi obținută prin co-digestia dejecțiilor animaliere şi a culturilor energetice sau reziduurilor acestora [1, 6, 25].

Amon et al. [3] au studiat optimizarea producției de metan obținut din culturi agricole şi reziduuri. Astfel, aceştia au propus un sistem bazat pe energia metanului pentru a estima producția de biogaz care se poate obține din diferite culturi, precum şi influența recoltării acestora. Cercetătorii au raportat că porumbul ar trebui recoltat în faza de coacere în lapte până la coacerea în pârgă-ceară, iar producția de metan care poate fi obținută este de aproximativ 7500–10200 m^3N ha^{-1}.

Evaluarea potențialului pentru obținerea biogazului a plantelor energetice este foarte importantă, deoarece în ultima perioadă a crescut interesul pentru găsirea de culturi de biomasă cu un conținut de energie ridicat, cost de producere scăzut şi efecte minime asupra mediului înconjurător [23].

În tabelul 1 [4] sunt evidențiate valorile calculate şi măsurate pentru conținutul de metan, aferent mai multor tipuri de culturi utilizate ca substrat în instalațiile de producere a biogazului prin procesul de fermentație anaerobă.

Table 1

Measured and calculated methane yield from different crops [4]

Crop	Crop yield (t/ha)	Measured methane yield (m^3/t VS)	Calculated methane yield (m^3/ha)
Maize	9 - 30	397 - 618	3573 - 18540
Wheat	3.6 – 11.75	384 - 426	1382 - 5005
Miscanthus	8 - 25	179 – 218	1432 - 5450
Triticale	3.3 – 11.9	337 - 555	1112 - 6604
Sorghum	8 - 25	295 - 372	2360 - 9300
Alfalfa	7.5 – 16.5	340 - 500	2550 - 8250
Grass	12 - 14	298 - 467	3576 - 6538
Rye	2.1	283 - 492	594 - 1033
Barley	3.6 – 4.1	353 - 658	1271 – 2698
Sunflower	6 - 8	154 - 400	929 – 3200
Sugar beet	3 - 16	236 - 381	708 - 6096
Hemp	8 - 16	355 - 409	2840 - 6544
Oats	4.1 – 12.4	250 - 365	1025 - 4526

RESULTS

Regarding the use of energy crops in anaerobic fermenters for biogas obtaining, a group of researchers [15] assessed different energy crops (*Miscanthus x giganteus*, sorghum, sunflower, tall fescue, spelt, hemp, switchgrass and immature rye) as an alternative to the use of maize as substrate. Experimental results have shown that the perennial crop *Miscanthus x giganteus* is the most promising alternative to maize in anaerobic fermentation process, if it is harvested as green matter in autumn, with a production of biogas of 5.5 ± 1x 10^3 m^3 ha^{-1}, as compared to 5.3 ± 1x 10^3 m^3 ha^{-1} for maize. Figure 1 shows the methane production recorded for each type of plants studied, maize being control sample. It is also shown the methane production obtained from *Miscanthus x giganteus,* maize and sorghum, according to the year of harvest. Among the evaluated energy crops, maize harvested in autumn had the highest methane content, 6934±1850 m^3/ha, followed by *Miscanthus x giganteus* harvested in autumn with a methane production of 4468±1265 m^3/ha and sorghum harvested in autumn with a production of 4332±1175 m^3/ha.

REZULTATE

Referitor la utilizarea culturilor energetice în fermentatoarele anaerobe pentru obținerea biogazului, un grup de cercetători [15] au evaluat diferite plante energetice (*Miscanthus x giganteus*, sorg, floarea soarelui, păiuş înalt, secară albă, cânepă, iarbă, secară necoaptă) ca alternative la folosirea ca substrat a porumbului. Rezultatele experimentale au demonstrat că planta perenă *Miscanthus x giganteus* este cea mai bună alternativă a porumbului în procesul de fermentație anaerobă, dacă aceasta este recoltată toamna, ca substrat verde, înregistrând o producție de biogaz de 5.5 ± 1x 10^3 m^3 ha^{-1}, comparativ cu 5.3 ± 1x 10^3 m^3 ha^{-1} obținut în cazul porumbului. În figura 1 este prezentată producția de metan înregistrată pentru fiecare tip de cultură testat, porumbul fiind proba martor. De asemenea, este redată şi producția de metan obținută în urma experimentelor realizate utilizând ca substrat planta *Miscanthus x giganteus*, porumbul şi sorgul, în funcție de anul de recoltare. Dintre culturile energetice evaluate, porumbul recoltat toamna a înregistrat cea mai mare producție de metan, 6934±1850 m^3/ha, urmat de planta *Miscanthus x giganteus* recoltată toamna cu o producție de metan de 4468±1265 m^3/ha iar sorgul recoltat toamna înregistrând 4332±1175 m^3/ha.

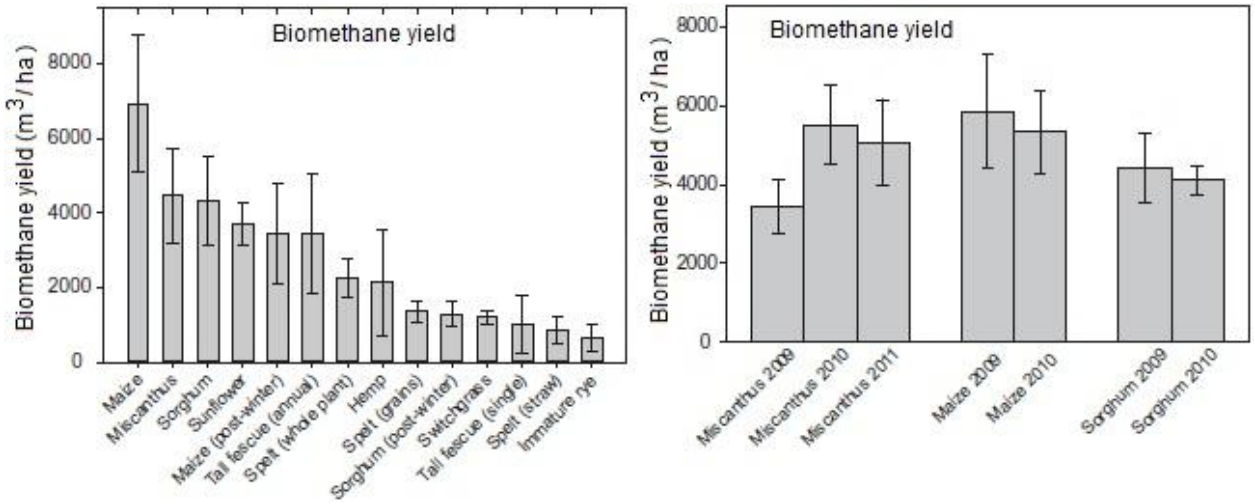

Fig. 1 – Biomethane production from different crop species [15]

Kalamaras and Kotsopoulos [11] tested sorghum silage, milk thistle silage and cardoon silage for the substitution of maize silage in biogas plants from South Europe.

Crop silages were used in the anaerobic co-digestion process with cattle manure, the mixture of manure with maize silage being used as a reference control. Results showed that maize silage and cardoon mixed with cattle manure (mixing ratio plants:manure being 40:60), had recorded the highest methane production of 267, respectively 308 L/kg VS.

In the case of mixture with sorghum silage, milk thistle silage, methane registered a production of 241, respectively 192 L/kg VS.

The quantity of biogas recorded during anaerobic fermentation process is shown in Figure 2. The cumulative biogas production was 5.5 L for the mixture of cattle manure with maize silage, 6.2 L for cardoon silage mixture, 4.6 L for sorghum silage and 3.8 L for the mixture with milk thistle silage.

Kalamaras şi Kotsopoulos [11] au testat sorgul siloz, armurariul siloz şi cardonul siloz pentru înlocuirea porumbului siloz utilizat ca substrat în instalațiile de biogaz din Europa de Sud.

Plantele au fost utilizate în procesul de co-digestie anaerobă cu dejecțiile bovine, amestecul dejecțiilor cu porumb fiind folosit ca substrat de referință. Rezultatele au arătat că porumbul siloz şi cardonul siloz în amestec cu dejecțiile bovine (raportul de amestec plante:dejecții fiind 40:60), au înregistrat cea mai mare producție de metan de 267, respectiv 308 L/kg VS.

În cazul amestecului cu sorg siloz şi armurariu siloz, metanul a înregistrat o producție de 241, respectiv 192 L/kg VS.

Cantitatea de biogaz înregistrată pe parcursul procesului de fermentație anaerobă este redată în figura 2. Producția totală de biogaz a fost de 5.5 L în cazul amestecului de dejecții cu porumb siloz, 6.2 L pentru amestecul cu cardon siloz, 4.6 L pentru amestecul cu sorg şi 3.8 L pentru amestecul cu armurariu.

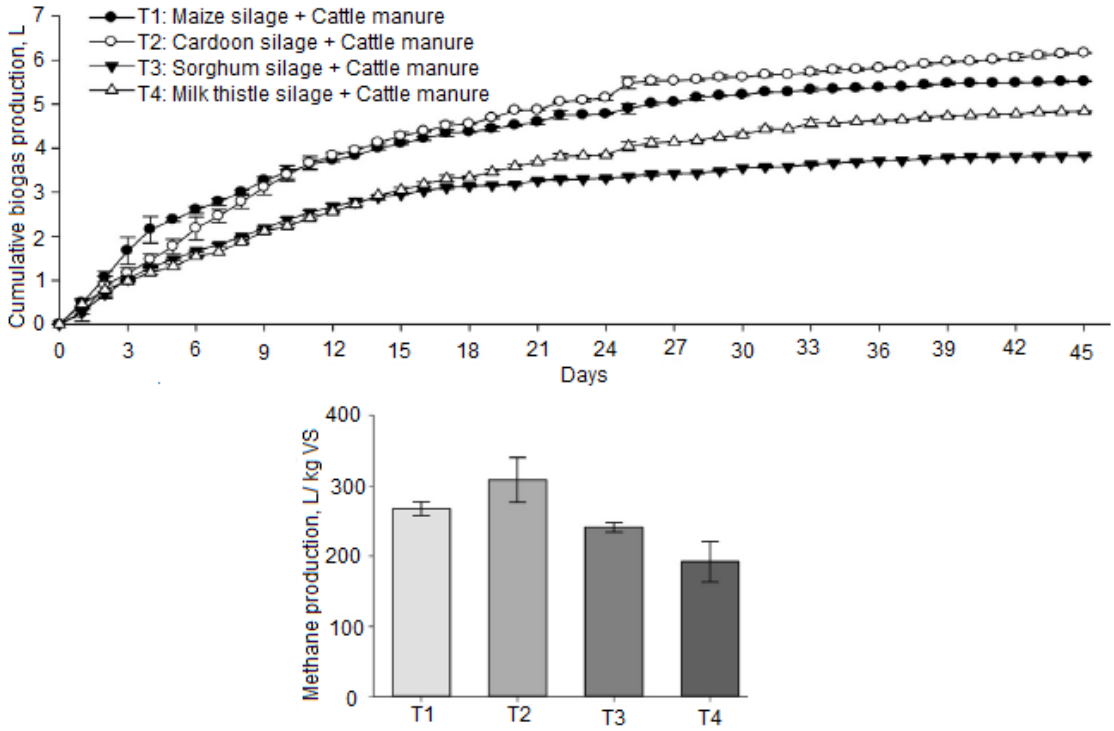

Fig. 2 – Biogas and methane production from cattle manure and different crop silages, [11]

Another kind of substrate used in the production of biogas from the anaerobic fermentation process is made up of rice straw. Li D. and co-workers [12] assessed the biogas production obtained from rice straw mixed with cow manure in anaerobic mesophilic co-digestion process (37°C±1).The substrate ratio were of 0:1, 1:2, 1:1, 2:1 and 1:0 (rice straw/cow manure).

The organic loading rate was of 3.0, 3.6, 4.2, 4.8, 6.0, 8.0 and 12.0 kg VS/(m^3 d).

Based on the results of the study, the highest amount of biogas of 383.5 L/kg VS (figure 3) with methane concentration of about 50 – 55%, was obtained for the mesophilic co-digestion of rice straw and cow manure, at a ratio of 1:1, for the organic loading rate of 6 kg VS/(m^3 d).

Un alt tip de substrat utilizat la obținerea biogazului prin procesul de fermentație anaerobă este format din paie de orez. Li D. şi colaboratorii [12] au evaluat producția de biogaz obținută din paiele de orez în amestec cu dejecțiile de vacă, în domeniul de temperatură mezofil (37°C±1). Proporțiile substratului au fost de 0:1, 1:2, 1:1, 2:1 şi 1:0 (paie de orez/dejecții de vaci). Rata de încărcare organică a fost de 3.0, 3.6, 4.2, 4.8, 6.0, 8.0, şi 12.0 kg VS/(m^3 d).

Cea mai mare cantitate de biogaz, de 383.5 L/kg VS (figura 3) cu o concentrație de metan cuprinsă între 50-55%, s-a obținut pentru co-digestia în domeniul mezofil a paielor de grâu şi dejecțiilor de vaci, în proporție de 1:1, pentru rata de încărcare organică de 6 kg VS/(m^3 d).

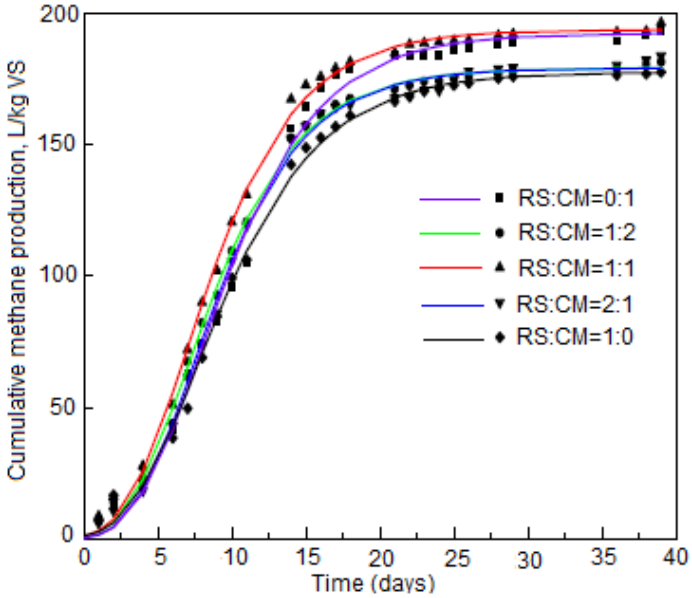

Fig. 3 – Methane production from co-digestion of cow manure and rice straw, [12]

In Figure 4 there are presented experimental data recorded after evaluation of maize silage and *Miscanthus x giganteus* energy plant used as substrate for biogas production in mixture with animal manure [7, 8]. Maize silage was mixed with cow and pig manure and *Miscanthus x giganteus* plant was mixed only with cow manure.

For the firts experiment, the largest amount of biogas (0.158 m^3) and the highest concentration of methane (56% v/v) were recorded on day 17. The total biogas production accumulated throughout the anaerobic digestion process was about 1.70 m^3/batch.

In the second experiment, was studied the production of biogas generated by the process of anaerobic digestion of cow manure mixed with *Miscanthus x giganteus* biomass. Results showed that the total biogas production was of 1.80 m^3/ batch. In this situation, the maximum concentration of methane of 56.8% v/v was reached on day 15.

În figura 4 sunt prezentate datele experimentale înregistrate în urma evaluării porumbului siloz şi a plantei energetice *Miscanthus x giganteus* utilizate ca substrat pentru obținerea de biogaz în amestec cu dejecții animaliere [7, 8]. Porumbul siloz a fost amestecat cu dejecții de porcine şi vaci iar planta *Miscanthus x giganteus* a fost amestecată numai cu dejecții de vaci. Pentru primul experiment, cea mai mare cantitate de biogaz (0.158 m^3) cu cea mai mare concentrație de metan (56% v/v) au fost înregistrate în ziua 17. Producția totală de biogaz acumulată pe parcursul perioadei de fermentație a fost de 1.70 m^3/şarjă [8].

În experimentul al doilea [7], s-a studiat producția de biogaz generată în urma procesului de fermentație anaerobă a dejecțiilor bovine în amestec cu planta energetică *Miscanthus x giganteus.* Rezultatele au arătat că producția totală de biogaz, a fost de 1.80 m^3/şarjă. În acest caz, concentrația maximă de metan de 56.8% v/v a fost înregistrată în ziua 15.

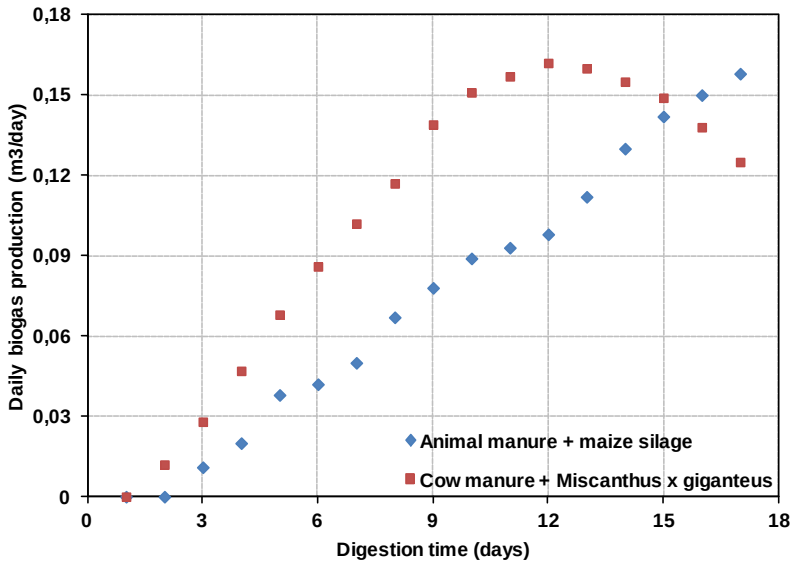

Fig. 4 – Daily biogas production from animal manure and different energy crops, [7,8]

Giant cane represents a promising non-food crop for biogas production through anaerobic digestion process.

In the experiment conducted by Luca C. et al. [13], giant cane and maize mixed with pig manure were used as substrate in anaerobic digester. The obtained results showed that giant cane produced less methane than maize,174±10 Nm^3 CH_4/Mg TS compared to 245±26 Nm^3 CH_4/Mg TS.

On the other hand, due to high biomass production, the biogas amount per hectare was higher for giant cane,12292 Nm^3 CH_4/ ha, than for that obtained from maize, 4549 Nm^3 CH_4/ha.

Trestia de zahăr gigant reprezintă o cultură nealimentară, promițătoare pentru obținerea biogazului prin procesul de fermentație anaerobă.

În experimentul realizat de Luca C. şi colaboratorii săi [13], a fost utilizat ca substrat în fermentatorul anaerob trestia de zahăr gigant şi porumbul în amestec cu dejecții de porci. Rezultatele obținute au arătat că trestia de zahăr gigant produce mai puțin metan decât porumbul, 174±10 Nm^3 CH_4/Mg TS față de 245±26 Nm^3 CH_4/Mg TS. Pe de altă parte, datorită producției mai mari de biomasă, producția de biogaz pe hectar a fost mai mare în cazul trestiei de zahăr gigant, 12292 Nm^3 CH_4/ ha, față de 4549 Nm^3 CH_4/ha obținut în cazul porumbului.

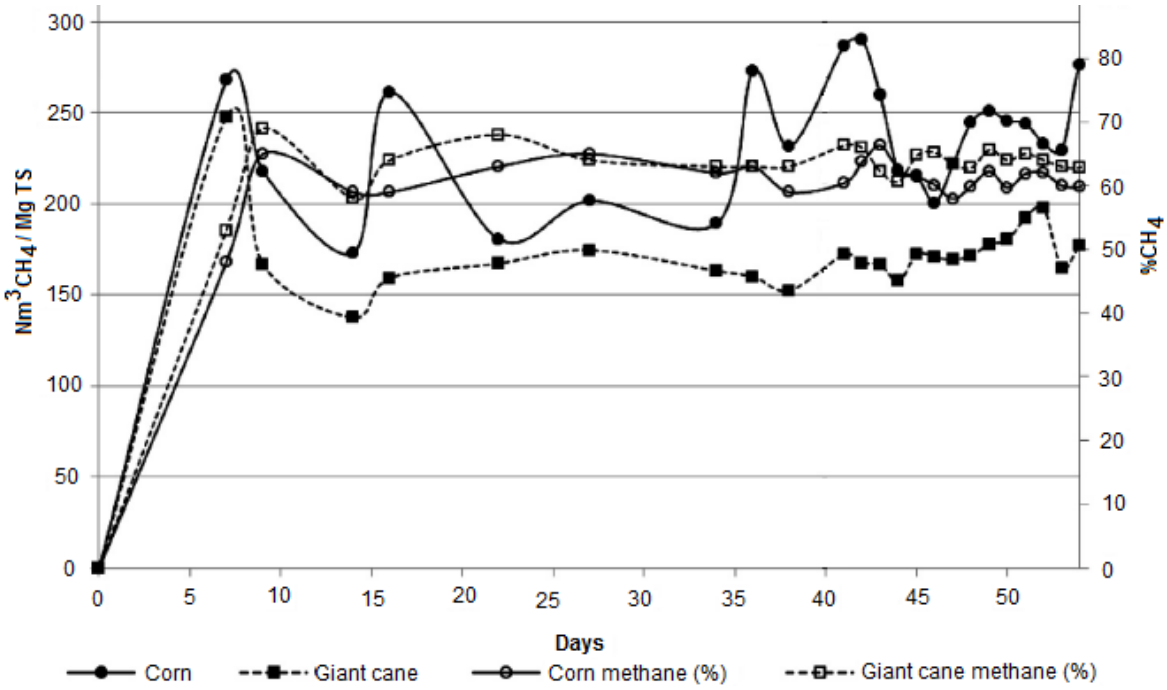

Fig. 5 – Methane production and content in biogas obtained from corn and giant cane, [13]

CONCLUSIONS

Assessing the potential for biogas production of different energy crops is very important, because lately it increased the interest in finding effective crops of biomass with a high energy yield, low production cost

CONCLUZII

Evaluarea potențialului pentru obținerea biogazului din diferite plante energetice este foarte importantă, deoarece în ultima perioadă a crescut interesul pentru găsirea de culturi de biomasă cu un conținut de energie

and minimal effects on the environment.

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AN INEXPENSIVE OPEN-SOURCE SYSTEM FOR MONITORING AND CONTROL ENVIRONMENTAL FACTORS IN GREENHOUSE
/
SISTEM OPEN-SOURCE CU COSTURI REDUSE PENTRU MONITORIZAREA ŞI CONTROLUL FACTORILOR DE MEDIU ÎN SERE

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Abstract: *This paper presents a system used to grow plants under controlled climatic conditions for optimum production. The system consists of Arduino Mega 2650 board type, air temperature and humidity, gas, temperature and soil moisture, light intensity, power sensors and relay has been implemented in an experimental greenhouse in rural areas. The achieved tests result concludes that the system is working properly. This research work would be helpful in designing a plastic cover greenhouse for growing vegetables to increase productivity levels with about 22% - 25%.*

Keywords: *greenhouse, network sensors, monitoring, temperature, humidity, drip irrigation.*

INTRODUCTION

Greenhouses form an important part of the agriculture and horticulture sectors in our country as they can be used to grow plants under controlled climatic conditions for optimum produce. An environmental control system will improve plant life within greenhouses by providing a constantly monitored atmosphere, producing a more uniform product (Clayton, 2014).

Classification of greenhouses can be made depending on the functions or utilities. Plastic covered greenhouses have proven very useful for growing early spring plants, and for producing vegetable or flower crops throughout the year (Sheldrake & Sayles, 1992).

In the current conditions of globalization and market economy throat competition, any aid offered to farmers should be considered. Farmers try to optimize utilization of agricultural resources to obtain good product having both quality and quantity. Plant growth under controlled conditions can help small producers of vegetables in our country to obtain optimal yields.

Monitoring and controlling environmental factors in greenhouse research have been carried out by various workers (Zhang *et al*., 2007; Ahonen *et al*., 2008; Fourati, 2007). Mirales *et al*. (2010) developed and tested a data acquisition and control system for managing control fertilization and irrigation. Shaker and Imran (2013) designed and implemented climate monitoring with irrigation control system based on Wireless Sensor Network (WSN) technology. Nugroho et al. (2012) proposed an intelligent control system for a greenhouse called “Agri-eye”, which covers monitoring and actuation system for agricultural facilities. Van Iersel et al. (2013) provides an overview of the most common sensors that can be used for large increases in irrigation efficiency and improve the profitability of ornamental production in greenhouses and nurseries.

Rezumat: *Această lucrare prezintă un sistem, cu un pret scăzut, utilizat în monitorizarea şi controlul factorilor de mediu din sere de dimensiuni mici şi medii. Sistemul compus din placa de tip Arduino Mega 2650, senzori de temperatură şi umiditate a aerului, gaze, temperatură şi umiditatea solului, intensitatea luminii, curent electric şi relee de acționare a fost implementat într-o seră experimentală din mediul rural. Rezultatul testelor realizate concluzionează că sistemul funcționează în mod corespunzător. Această lucrare ar putea fi de ajutor în proiectarea unor sere cu acoperiş din plastic utilizate în cultivarea legumelor pentru a creşte nivelul de productivitate cu aproximativ 22% - 25%.*

Cuvinte cheie: *sere, rețea senzori, monitorizare, temperatură, umiditate , irigare prin picurare.*

INTRODUCERE

Serele constituie o parte importantă a sectoarelor agricol şi horticol în țara noastră, deoarece acestea pot fi folosite pentru creşterea plantelor în condiții climatice controlate pentru producții optime. Un sistem de control al mediului va îmbunătăți viața plantelor în sere, oferind o atmosferă monitorizată în mod constant, obținând un produs mai uniform (Clayton, 2014).

Clasificarea serelor se poate face în funcție de funcțiile produsului sau utilități. Serele acoperite cu plastic s-au dovedit foarte utile la creşterea plantelor la începutul primăverii, şi pentru producerea de legume sau creşterea florilor pe tot parcursul anului (Sheldrake & Sayles, 1992).

În condițiile actuale ale globalizării şi competiței acerbe ale economiei de piață, orice ajutor oferit fermierilor trebuie luat in considerare. Fermierii încearcă să optimizeze utilizarea resurselor agricole pentru a obține un produs bun atât calitativ, cât şi cantitatativ. Creşterea plantelor în condiții controlate ii poate ajuta pe micii producători de legume din țara noastră la obținerea unor producții optime.

Cercetări cu privire la monitorizarea şi controlul factorilor de mediu în sere au fost realizate de numeroşi cercetători (Zhang et al., 2007; Ahonen *et al*., 2008; Fourati, 2007). Mirales *et al*. (2010) au dezvoltat şi testat un sistem de achiziție de date şi control pentru controlul fertilizării şi irigării. Shaker şi Imran (2013) au proiectat şi implementat un sistem de monitorizare climatic şi de control al irigării bazat pe o rețea wireless de senzori (WSN). Nugroho şi colab. (2012) au propus un sistem de control inteligent pentru o seră denumit " Agri-eye", care include sistemul de monitorizare şi acționare al instalațiilor agricole. Van Iersel şi colab. (2013) prezintă o privire de ansamblu asupra celor mai frecvent întâlniți senzori ce pot fi utilizați pentru creşterea eficienței de irigare şi îmbunătățire rentabilității producției ornamentale în sere şi pepiniere.

Fig. 1 - Experimental greenhouse

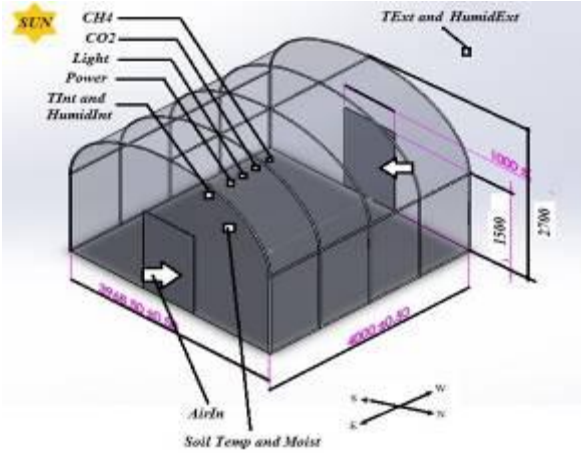

Fig. 2 - Schematic view of greenhouse

MATERIAL AND METHOD

A roof type round span greenhouse of 16 m^2 effective floor area was fabricated of PPR pipe and a UV film covering of 150 microns. The advantage of this greenhouse is the ease of building and covering. The central height and the walls were maintained as 2.7 m and 1.5 m respectively. Two doors of 1.5x1.25 m was provided on the front and back of the greenhouse for the natural convection experiments. A photograph of the experimental setup for greenhouse is shown in Fig. 1 and its schematic view is shown in Fig. 2.

Agreed requirements for our monitoring system have been: low unit cost; small form factor; non-intrusive in the domestic environment; robust.

Hardware components:

- *Arduino Mega 2650 Board;*
- *Arduino Ethernet shield;*
- *Sensors*: Air temperature and humidity sensor (AM2302); Soil temperature and moisture sensor (AM2302); Light intensity Sensor (BH1750FVI); Gas sensors (CO2-MQ135; CO-MQ7; CH4-MQ4); Current sensor (ECS1030-L72-max 30A); Liquid Flow sensor (TEM01071B-max 6L/min); MicroSD Card (C10-16GB); Digital Clock (DS3231);
- *Liquid Crystal Display* (Hitachi' s HD44780);
- *Actuators - Relays; solenoid valve;*
- *Power source (12V - 360W*);
- *Router wireless (ZyXEL NBG-418N V2)*;

The system installed in the greenhouse consists of a main controller board (ArduinoTM, a popular single-board microcontroller), environmental monitoring sensors (temperature, humidity, light intensity, CO2, CH4, soil moisture content, etc.), network devices, relay shield. The microcontroller ATmega2560 has 256 KB of flash memory for storing code (of which 8 KB is used for the bootloader), 8 KB of SRAM and 4 KB of EEPROM (which can be read and written with the EEPROM library). The main board can be programmed flexibly to provide specific features regarding requirement function in the intelligent system, such as data handling (averaging, calibrating and smoothing), data transfer (HTTP protocols) and SD-card storage [8]. The main controller board in which analog and digital I/O ports have been incorporated is connected directly to the Internet via a local area network (the Ethernet) in the greenhouse. Sensors are installed in the analog/digital input ports on the main controller board by using Ethernet shield. For monitoring and actuation system has been designed with additional modules such as RTC (real time clock), relay modules, and also connectors for sensors. Relay

MATERIAL ŞI METODĂ

O seră cu acoperiş tip rotund şi suprafaţa efectivă de 16 m^2 a fost realizată din ţeavă din PPR şi acoperită cu folie de polietilena UV de 150 de microni. Avantajele acestui tip de seră sunt uşurinţa construcţiei şi acoperirii. Înălţimea centrală şi pereţii au dimensiunile de 2.7 m şi respectiv,1.5 m. Două uşi de 1.5x1.25 m au fost realizate în partea din faţă şi din spate a serei pentru a asigura o ventilaţie naturală adecvată. O fotografie a modelului experimental al serei este prezentată în Fig. 1, iar în Fig. 2 este prezentată o vedere schematică.

Cerinţele necesare pentru sistemul de monitorizare au fost: preţ redus; factor de formă mic; non-invaziv în mediu; robust.

Părţi componente:

- *Arduino Mega 2850 Board;*
- *Arduino Ethernet shield*
- *Senzori*: Senzor temperatură şi umiditate aer (AM2302); Senzor temperatură şi umiditate sol (AM2302); Senzor intensitate lumină (BH1750FVI); Senzori gaz (CO2-MQ135; CO-MQ7; CH4-MQ4); Senzor curent (ECS1030-L72-max 30A); Senzor debit apă (TEM01071B-max 6L/min); MicroSD Card (C10-16GB); Digital Clock (DS3231);
- *Liquid Crystal Display* (Hitachi' s HD44780);
- *Actuators - Relee; valva solenoid;*
- *Sursa electrică (12V - 360W*);
- *Router wireless (ZyXEL NBG-418N V2)*;

Sistemul instalat în seră constă într-o placă de bază ArduinoMega 2560 (ArduinoTM, un microcontroler foarte popular), senzori de monitorizare a mediului (temperatură, umiditate, intensitatea luminii, CO2, CH4, conţinutul de umiditate a solului, etc.), dispozitive de reţea, relee de acţionare. Microcontrolerul ATmega2560 are 256 KB de memorie flash pentru stocarea codului sursă (din care 8 KB sunt utilizaţi pentru bootloader), 8 KB de SRAM şi 4 KB de EEPROM (care pot fi citiţi şi scrişi cu biblioteca EEPROM). Placa de bază poate fi programată flexibil pentru a asigura funcţii specifice necesare în sistemul inteligent, cum ar fi de manipulare a datelor (mediere, calibrare şi netezire), transfer de date (protocoalele HTTP) şi de stocare pe SD card [8]. Controlerul din placa de bază în care sunt încorporate porturi analogice şi digitale I/O este conectat direct la Internet printr-o reţea locală (Ethernet), în seră. Senzorii sunt montaţi în porturile de intrare analogice/digitale de pe placa de bază prin utilizarea plăcii Ethernet. Pentru monitorizare şi acţionare sistemul a fost conceput cu module suplimentare, cum ar fi RTC (ceas de timp real), module releu, şi, de asemenea, conectori de senzori.

actuation control greenhouse equipment (pump water for irrigation in this study) are connected to the digital output ports. The system also employs an simple LCD (text with 16 characters) to display information retrieved from sensors and continuously alerting the user about the condition inside the greenhouse. Mega2560 motherboard, Ethernet card and microSD card are used for a web server that hosts a web page on the SD card that allows starting and stopping of equipment over the Internet. When a browser requests a web page from the Arduino web server, the Arduino will fetch the web page from the SD card. Figure 3 shows the block diagram of the system.

Plants were grown in the greenhouse tomatoes, green peppers and eggplants, as are some of the most commonly grown by vegetable growers. Watering plants growing in the seven rows is done by drip tapes diameter 16 mm, the distance between holes 10 cm and a flow rate of 1L/h. Statistical analysis of measurement results was conducted by IBM SPSS Statistics V20 Software.

Releele de acționare pentru controlul echipamentelor în seră (pompa de apă pentru irigații în acest studiu), sunt conectate la porturile de ieşire digitală. Sistemul are, de asemenea, un ecran LCD (text cu 16 caractere) pentru afişarea informațiilor preluate de la senzori şi alertarea continuuă a utilizatorului despre starea din interiorul serei. Placa de bază Mega2560, placa Ethernet şi microcardul SD sunt utilizate pentru realizarea unui server web care găzduieşte o pagină web pe cardul SD ce permite pornirea şi oprirea unui dispozitiv prin Internet. Când un browser solicită o pagină web de pe web serverul Arduino, Arduino va deschide pagina web de pe cardul SD. Figura 3 prezintă schema bloc a sistemului.

Plantele cultivate în seră au fost roşiile, ardeiul verde şi vinetele, deoarece sunt unele dintre cele mai frecvent cultivate de legumicultori. Udarea plantelor cultivate pe şapte rânduri se face prin benzi de picurare cu diametrul de 16 mm, distanța dintre picurători de 10 cm şi un debit de curgere de 1L/h. Analiza statistică a datelor rezultate din măsuratori a fost realizată cu programul IBM SPSS Statistics V20.

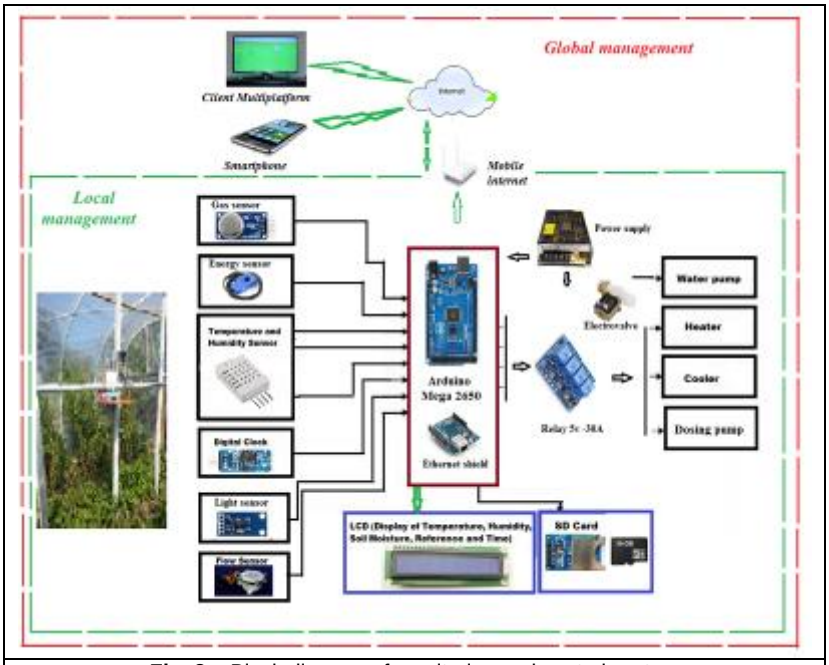

Fig. 3 - Block diagram of monitoring and control system

RESULTS AND DISCUSSION

Experimental data obtained with sidewalls open for increase natural ventilation of greenhouses on 17 August between the hours 10:05-13:50 are presented in Table 1. To evaluate the normality assumption we conduct a Kolmogorov-Smirnov test (2-sided) with significance level α=0.05. For most variables tested the p value is less than that of α chosen so that reject the null hypothesis and conclude that the population is non-normal.

AM2302 (Aosong) capacitive humidity sensing, digital temperature and humidity module is a good solution for the greenhouse environment due to fast response time, low power consumption and tolerance against moisture climate. Temperature accuracy of the sensor is ±0.3 °C and the accuracy of the relative humidity under ±2 %. The histogram of indoor greenhouse temperature values measured by AM2302 sensor are shown in figure 4 (17/08/2015; 10:05 -13.50). Mean temperature has a value of 29.8°C (stdv. 1.623 °C). Maximum temperature value of 33.0°C were strongly influenced by the sun and the natural air ventilation in greenhouse.

REZULTATE ŞI DISCUȚII

Datele experimentale obținute cu pereții laterali ridicați pentru creşterea ventilației naturale în seră în ziua de 17 Aug. în intervalul 10:05-13:50 sunt prezentate în tabelul 1. Pentru evaluarea ipotezei normalității datelor am efectuat un test Kolmogorov-Smirnov (2-parți) cu un nivel de semnificație α=0.05. Pentru majoritatea variabilelor testate valoarea lui *p* este mai mică decât *α* astfel încât respingem ipoteza nulă şi concluzionăm că distribuția este non-normală.

Senzorul de temperatură şi umiditate relativă AM2302 (Aosong), cu detectarea capacitivă a umidității, reprezintă o soluție bună pentru mediul din seră datorită timpului rapid de răspuns, consumului redus de energie şi toleranței la schimbările climatice. Precizia temperaturii senzorului este de ± 0,3 °C, iar a umidității relative sub ± 2%. Histograma valorilor de temperatură din seră măsurate cu senzorul AM2302 sunt prezentate în figura 4 (17/08/2015; 10:05 -13.50). Temperatura medie are o valoare de 29.8°C. Valoarea maximă a temperaturii de 33.0°C a fost puternic influențată de soare şi de ventilația

Fig. 5 shows the distribution of CH4 concentration in the air between the hours 10:05 - 1:50 p.m. on the day of 17/8/2015. CH4 concentration has a maximum value of 10.32 [ppm] corresponding to the maximum value of temperatures; average value of the measurements is 6.313 [ppm] with a standard deviation of ±0.765.

naturală a aerului din seră.

Fig. 5 prezintă distribuția concentrației de CH4 în aer în intervalul orar 10:05: - 13:50 in ziua de 17/8/2015. Concentrația de CH4 are o valoare maximă de 10.32 [ppm] corespunzând valorii maxime a temperaturii; valoarea medie a măsurătorilor este de 6.313 [ppm], cu o deviație standard de ± 0.765.

Table 1.

Descriptive statistics of environmental factors

Descriptive Statistics Date = 15 / 8 / 17 ; 10.05 - 13.50

	N	Minimum	Maximum	Mean	Std. Deviation	Variance	Skewness	Kurtosis
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic
TempInt [oC]	515	27.00	33.00	29.804	1.623	2.633	.023	-.933
UmidInt [%]	515	46.00	66.00	55.126	3.831	14.679	.261	-.169
TempEx [oC]	515	24.00	30.00	27.346	1.681	2.826	-.288	-.765
UmidEx [%]	515	53.00	74.00	62.118	4.804	23.081	.323	-.581
TempSol [oC]	515	23.00	26.00	24.355	0.891	.794	-.378	-1.060
UmidSol [%]	515	39.00	40.00	39.977	0.151	.023	-6.338	38.323
CO2 [ppm]	515	207.000	2115.000	1097.237	167.041	27902.547	1.131	6.019
CH4 [ppm]	515	1.000	10.000	6.313	0.765	.585	.320	6.889
PresBMP180 [Pa]	515	99192.0000	99456.0000	99318.291	64.641	4178.413	.499	-.671
Light [Lux]	515	2824	13703	8508.594	1687.713	2848374.502	-.571	2.437
Valid N (listwise)	515							

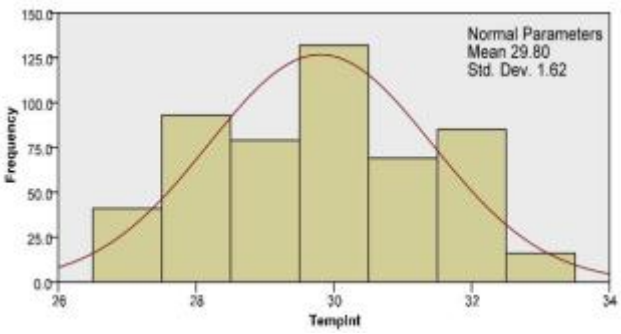

Fig. 4 - Air temperature histogram 17/08/2015

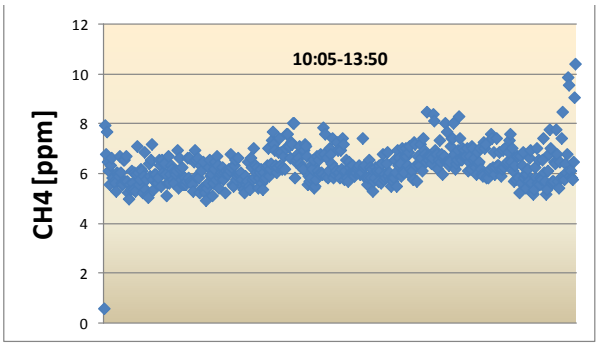

Fig. 5 - CH4 concentration in air 17/08/2015

Normally there are approximately 2 parts per million of CH4 in the atmosphere; plants help methane travel into the atmosphere—acting like inverted lightning rods as they direct the gas up through the soil and into the air. CH4 in air was measured with a MQ6 semiconductor type gas sensor. The sensor is composed by a micro AL2O3 ceramic tube, a Tin Dioxide (SnO2) sensitive layer, a measuring electrode and heater fixed into a crust made of plastic and stainless steel net. This sensor has different resistance value in different concentration.

Fig. 6 (left) shows the evolution of the CO_2 (ppm) in time between the hours 17:25-18:45 on the day of 11/8/2015. Parallel boxplots in figure 6 (right) provide information about CO2 distribution depending on temperature. In this figure most samples appear to be centered similar, except corresponding values of 31, 37 and 38 °C. The sample of corresponding value 37° C appears to have the greatest variability. Most samples are quite symmetrical, but the corresponding value of 31° C is skewed to the right. The measurements were carried out using MQ135 type gas sensor. The response of the CO2 sensor were highly consistent and correlated with much more expensive instruments.

În mod normal, concentrația de CH4 în atmosferă este de aprox. 2 ppm; plantele ajută deplasarea metanului în atmosferă acționând ca un paratrăsnet inversat, deoarece direcționează gazul în sus prin sol şi în aer. Metanul din aer a fost determinat cu un senzor semiconducor tip MQ4. Senzorul este compus dintr-un tub microceramic de AL2O3, un strat sensibil de dioxid de staniu (SnO2), un electrod de măsurare şi unul de încălzire fixați într-o crustă din plastic şi o plasă din oțel inoxidabil. Valorile rezistenței senzorului se modifică în funcție de diferitele concentrații.

Fig. 6 (stanga) prezintă evoluția CO_2 (ppm) în seră în data de 11/8/2015 în intervalul orar 17:25-18:45. Graficul cu căsuțe paralele din figura 6 (dreapta) furnizează informații despre distribuția CO2 în funcție de temperatură. În această figură majoritatea grupurilor par să fie centrate similar, cu excepția celor corespunzătoare valorilor de 31, 37 şi 38°C. Grupul corespunzător valorii de 37°C pare să aibă cea mai mare variabilitate. Majoritatea grupurilor sunt destul de simetrice, dar cel corespunzător valorii de 31°C este oblic spre dreapta. Măsuratorile au fost efectuate cu ajutorul senzorului de gaz tip MQ135. Răspunsul senzorului de CO_2 a fost extrem de consistent şi corelat cu instrumente mult mai scumpe.

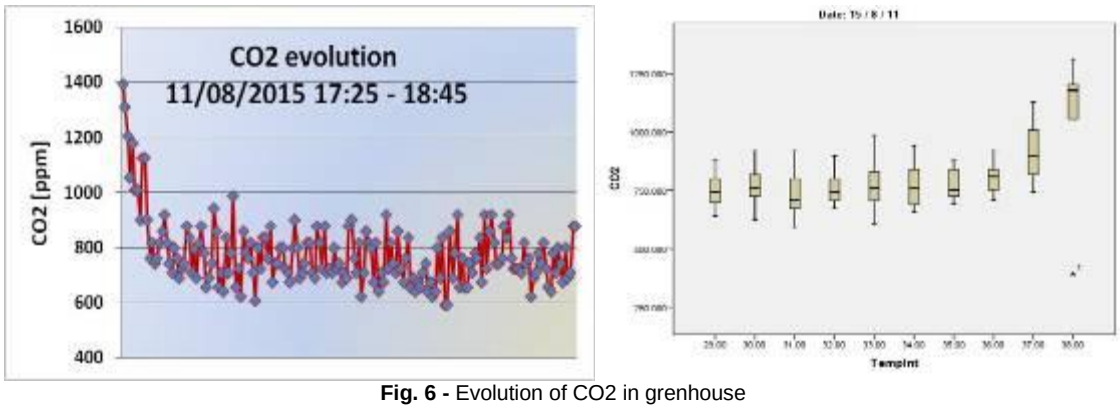

Fig. 6 - Evolution of CO2 in grenhouse

Figure 7 shows the comparative evolution of air temperature inside and outside the greenhouse, and soil temperature, in conditions of reduced natural ventilation, the side walls lowered. While the temperature inside remains constant at 38°C, outside temperature increases from 35 to 38°C due to strong sunlight. It finds that soil temperature is constant at a level relatively high to 32°C. Figure 8 shows the comparative evolution of the relative humidity inside and outside the greenhouse, and soil moisture, in the same conditions. Soil moisture remained constant at a value of 40%. From the figure can be seen that while outdoor humidity values varying between 35-40% indoor humidity increase to a value of 45%; minimum values of 35% is due to the wind that enters through doors left open in the greenhouse.

Fig. 7 prezintă evoluția comparativă a temperaturii aerului din interiorul şi în afara serei, şi temperatura solului, în condiții de ventilație naturală redusă, cu pereții laterali coborâți. În timp ce temperatura în interior rămâne constantă la aprox. 38°C, temperatura în exterior creşte de la 35 la 38°C datorită soarelui puternic. Se constată că temperatura solului este constantă, la o valoare destul de ridicată de 32°C. În figura 8 este prezentată evoluția comparativa a umiditatii relative a aerului în interiorul şi exteriorul serei, precum şi a umidității solului, în aceleaşi condiții. Umiditatea solului se menține constantă la o valoare de 40%. Din figură se poate observa că în timp ce umiditatea în exterior oscilează între valorile de 35 - 40%, în interior umiditatea creşte până la o valoare de 45 %; valorile minime de cc. 35% se datoreaza vântului ce pătrunde în seră prin uşile lăsate deschise.

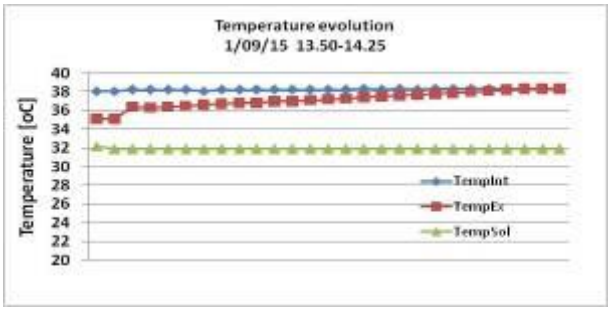

Fig. 7 - Air humidity evolution

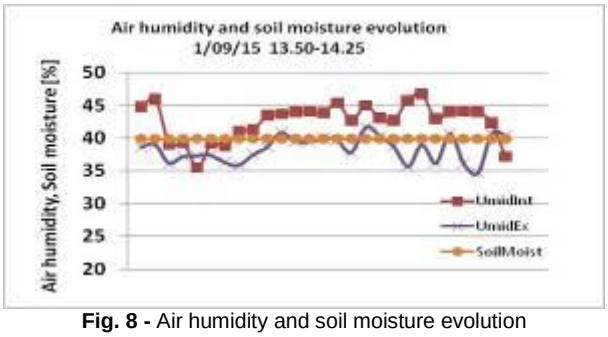

Fig. 8 - Air humidity and soil moisture evolution

Fig. 9 - Monitor evolution of grenhouse environment on Web Smart TV

Adequate ventilation and proper circulation of airflow in the greenhouse are essential in ensuring optimum plant growth parameters.

In figure 9 is shown watching website monitoring environmental parameters in the greenhouse on the screen of a Smart TV. The Arduino Web server hosting the web page displayed parameter values sensors. Also, the website allows control of external devices (dosing pump water or fertilizer, fan and radiator) by pressing buttons or checkboxes. We used JavaScript to implement Ajax for sending data to the Arduino from the web page and getting

Ventilația adecvată şi o circulatie corespunzătoare a fluxului de aer într-o seră sunt elemente esențiale în asigurarea parametrilor optimi de creştere a plantelor.

În figura 9 este prezentată vizionarea paginii web de monitorizare a parametrilor mediului din seră pe ecranul unui Smart TV. Web serverul Arduino găzduieşte pagina web pe care sunt afişate valorile parametrilor senzorilor. De asemenea, pagina web permite controlul aparatelor externe (pompa de apă sau dozare fertilizator, ventilator şi radiator) prin acționarea unor butoane sau casete de selectare. Instrucțiuni JavaScript au fost utilizate pentru

data back from the Arduino behind the scenes. Ajax enables parts of the web page to be updated. This reduces the amount of data that needs be sent from the Arduino making the updates faster because the entire web page does not need to be reloaded every time new data is to be displayed on it.

CONCLUSIONS

In light of the above development is needed technologies that are not expensive, can be realized with cheap materials and handy, but at the same time guarantee high productivity both quantitatively and qualitatively. The implementation of the monitoring and control system has been successfully tested for its validation. The performance of the system found to be satisfactory.

Aknowlegement

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implementarea aplicației Ajax în fluxul de transmitere a datelor între Arduino şi pagina web. Ajax permite ca numai anumite părți ale paginii web să fie actualizate. Acest lucru reduce cantitatea de date care trebuie trimise către Arduino, ceea ce conduce la actualizări mai rapide, deoarece nu trebuie să fie reîncarcată întreaga pagină web de fiecare dată când noi date trebuie să fie afişate.

CONCLUZII

Având în vedere aspectele menționate în cercetare, se impune dezvoltarea unor tehnologii care să nu fie costisitoare, să poată fi realizate cu materiale ieftine şi la îndemână, dar în acelaşi timp să asigure o productivitate ridicată atât cantitativ cât şi calitativ. Implementarea sistemului de monitorizare şi control a fost testată cu succes pentru validarea acestuia. Performanțele sistemului pot fi considerate ca fiind satisfăcătoare.

Aknowlegement

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THE INFLUENCE OF THE TEMPERATURE ON BIOGAS PRODUCTION IN A SMALL CAPACITY PLANT
/
INFLUENȚA TEMPERATURII ASUPRA PRODUCȚIEI DE BIOGAZ ÎNTR-O INSTALAȚIE DE CAPACITATE MICĂ

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Abstract: *Temperature has a major influence in biogas production obtain by anaerobic digestion. The temperature effect on biogas quantity obtain in a small capacity plant was studied in this paper. Experimens were done at a temperature of* 25°C, 35°C, *respectively 45°C.*

Keywords: *temperature, anaerobic digestion, biogas*

Rezumat: *Temperatura are o importanță majoră în obținerea de biogaz prin fermentare anaerobă. În această lucrare s-a studiat efectul temperaturii asupra cantității de biogaz obținută într-o instalație de capacitate mică. Testele au fost făcute la temperatura de* 25°C, 35°C, *respectiv 45°C.*

Cuvinte cheie: *substrat, fermentare anaerobă, biogaz*

INTRODUCTION

Biological fermentation represents one of the waste reciclying technologies that can withstands a higher degree of waste capitalisation. It can be applied on wastes with a high organic content and it is possible to obtain a gaseous fuel (biogas) with different uses: heating, cooking, electricity generation, the leftover residues that represents a non-polluting material can be used with great results in agriculture as fertilizer.

Biogas represents a gaseous mixture composed of methane (max. 80%), carbon dioxide (min. 20%) along with small quantities of hydrogen (H_2), hydrogen sulfide (H_2S), mercaptans and water vapors [5].

Microorganisms that can live only in environments lacking of oxygen are responsible for anaerobic fermentation. The four stages of organic wastes decomposition are hydrolysis, acidogenesis, acetogenesis and methanogenesis [1, 3].

The organic decomposable matter, in natural systems in which it can be found, is the bearer of a varied and active microflora. This mixed microflora ensures specific metabolic compounds for metanobacteria development.

A number of factors including the type and composition of the substrate, temperature, pH, moisture content and the structure of the bioreactor influence the yield of biogas. Some studies have shown that the substrate concentration at the outlet of the fermenter depends on the substrate concentration entering the bioreactor [10].

In the literature, a series of experiments were conducted on the effect of temperature on anaerobic fermentation process. Although, the process is well known in mesophilic and thermophilic domains, the current state of knowledge on biomethanisation process development in psychrophilic domain is not so developed. In nature, it was observed that methane can be otained at temperatures between 0 and 97°C. There are sufficient experimental evidences that methane can be produced at temperatures below 20°C due to the existence of psychrophilic methanogenic bacteria in the medium [4].

Anaerobic bacteria, especially metanogenic, are sensitive to medium conditions. Many reserchers evaluate the performance of an anaerobic system

INTRODUCERE

Fermentația biologică reprezintă una din tehnicile de reciclare a deşeurilor care comportă un înalt grad de valorificare a acestora. Se aplică deşeurilor cu un conținut organic ridicat şi are ca rezultat obținerea unui combustibil gazos (biogaz) cu largi utilizări: încălzire, prepararea hranei, generare de energie electrică, reziduurile rămase constituind un material nepoluant care se poate utiliza cu rezultate foarte bune în agricultură ca îngrăşământ.

Amestecul gazos format din metan (max. 80%) şi dioxid de carbon (min. 20%), alături de care se întâlnesc cantități mici de hidrogen (H_2), hidrogen sulfurat (H_2S), mercaptani, vapori de apă constituie biogazul [5].

Fermentarea anaerobă este realizată de microorganisme care nu pot trăi decât în medii lipsite de oxigen. Descompunerea deşeurilor organice se petrece în patru etape: hidroliza, acidogeneza, acetogeneza şi metanogeneza [1, 3].

În sistemele naturale în care se găseşte, materia organică decompozabilă este purtătoarea unei microflore foarte variate şi active. Aceasta microfloră mixtă asigură anaerobioza şi compuşii metabolici specifici dezvoltării metanobacteriilor.

Randamentul de biogaz este influențat de o serie de factori care includ tipul şi compoziția substratului, temperatura, pH-ul, umiditatea şi structura bioreactorului, etc. Unele studii au arătat că concentrația substratului la ieşirea din fermentator depinde de concentrația substratului care intră în bioreactor [10].

În literatura de specialitate au fost realizate o serie de experimente cu privire la influența temperaturii asupra procesului de fermentare anaerobă. Deşi în domeniul mezofil şi termofil, procesul este bine cunoscut, stadiul actual al cunoaşterii desfăşurării procesului în domeniul psihrofil asupra biometanizării nu este atât de dezvoltat. În natură, s-a observat că metanul se poate dezvolta la temperaturi cuprinse între 0 şi 97°C. Există suficiente dovezi experimentale că metanul se poate obține şi la temperaturi mai mici de 20°C datorată existenței unor bacterii metanogene psihrofile în mediul respectiv [4].

Microorganismele anaerobe, în special cele metanogene, sunt susceptibile la condițiile de mediu. Mulți cercetători evaluează performanța unui sistem anaerobic pe baza producției de biogaz deoarece metanogeneza este privită ca o limită în tratamentul

based on biogas production because mehanogenesys represents a limit in anaerobic treatment. Methanogenic organisms are very vulnerable and have a very low rate of growth therefore requires careful maintenance and monitoring of environmental conditions. A change in temperature or substrate concentration can lead to stopping the production of biogas [7].

Many researchers have observed that temperature has a significant influence on bacterial community, kinetic processes but also on the yield of methane. In the process of anaerobic digestion, low temperatures rfeduce the microbial culture, slow the rate of decomposition of the substrate and reduce production of biogas. On the other hand, higher temperatures result in reduced yield of biogas due to the volatile gas produced by the volatile acids such as ammonia that suppresses the activity of methanogenic bacteria.

In general, the process of anaerobic digestion, carried out in order to obtain biogas, takes place at mesophilic temperatures. Process development in the mesophilic domain is more stable and require less energy consumption. Experiments have shown that the optimum temperature for anaerobic fermentation process is 35°C, with a retention time in the fermenter of 18 days. In addition, a temperature in the range 35 - 37°C is considered optimal for the production of methane, and the changeover from the mesophilic to thermophilic temperature may cause a decrease in biogas production.

However, the thermophilic temperature presents a number of advantages, such as faster speed decomposition of the organic fraction, a higher production of biogas and the destruction of pathogens present in the substrate [5].

Anaerobic digestion of the substrate in order to obtain the biogas can be inhibited when changes in temperature exceed 1°C/day. To maintain a stable process, studies shown that changes in temperature should be less than 0.6°C/day [2].

MATERIAL AND METHOD

Experimental research presented in this paper aimed to analyze the influence of substrate temperature on biogas production and have been conducted on a small capacity pilot plant (Figure 1) belongs to the Department of Biotechnical Systems, Faculty of Biotechnical Systems Engineering from the University „Politehnica" of Bucharest [8].

The system has four main parts, namely:

- food compartment consists of biomass preparation system and a pump that transfers the material in the reactor;
- anaerobic digester;
- gas pipeline with relative treatment systems;
- a tank where the gas is stored prior to use.

In the stirring tank, the fermented material with water and a number of feed substances is inserted (Table 1). Each batch introduced into the tank is mixed with the water and feeding substances for 1 hour.

The material is separated into a liquid phase and a solid phase. Partially fermented liquid fraction is pumped from the stirring tank to the fermentation reactor with a piston pump which is operated from the console.

anaerobic. Organismele metanogene sunt foarte vulnerabile şi au o rată de creştere foarte redusă de aceea este necesară o întreţinere atentă şi o monitorizare a condiţiilor de mediu. O modificare în temperatură sau concentraţia substratului poate conduce la oprirea producerii de biogaz [7].

Mulţi cercetători au observat faptul că temperatura prezintă o influenţă semnificativă asupra comunităţii bacteriene, proceselor cinetice dar şi asupra randamentului de metan. În procesul de fermentare anaerobă, temperaturile scăzute produc o scădere a creşterii culturii microbiene, scăderea vitezei de descompunere a substratului precum şi scăderea producţiei de biogaz. Pe de altă parte, temperaturile ridicate conduc la scăderea randamentului de biogaz din cauza gazelor volatile produse de acizii volatili cum sunt amoniacul care suprimă activitatea bacteriilor metanogene.

În general, procesul de fermentare anaerobă desfăşurat în vederea obţinerii biogazului are loc la temperaturi din domeniul mezofil. Desfăşurarea proceselor în domeniul mezofil este mult mai stabilă şi necesită un consum mai mic de energie. Experimentele au demonstrat că temperatura optimă a procesului de fermentare anaerobă este de 35°C, cu un timp de retenţie în fermentator de 18 zile. De asemenea, o temperatură cuprinsă în intervalul 35 – 37°C este considerată optimă pentru producerea metanului, iar trecerea de la regimul de temperatură mezofil la cel termofil poate cauza o descreştere a producţiei de biogaz.

Totuşi, domeniul de temperatură termofil prezintă o serie de avantaje, cum sunt: o viteză de descompunere mai rapidă a fracţiei organice, o producţie mai mare de biogaz precum şi distrugerea germenilor patogeni prezenţi în substrat [5].

Fermentarea anaerobă a substratului în scopul obţinerii de biogaz poate fi inhibată atunci când variaţiile de temperatură depăşesc 1°C/zi. Pentru menţinerea unui proces stabil, studiile au demonstrat că modificările de temperatură trebuie să fie mai mici de 0,6°C/zi [2].

MATERIAL ŞI METODĂ

Cercetările experimentale prezentate în această lucrare au urmărit analiza influenţei temperaturii substratului asupra producţiei de biogaz şi au fost efectuate pe staţia pilot de capacitate mica (figura 1) care aparţine Departamentului de Sisteme Biotehnice a Facultăţii de Ingineria Sistemelor Biotehnice din cadrul Universităţii Politehnica din Bucureşti [8].

Instalaţia are patru părţi principale, şi anume:

- compartimentul de alimentare, constă din sistemul de preparare a biomasei şi o pompă ce transferă materialul în reactor;
- digestorul anaerob;
- conducta de gaz cu sisteme relative de tratare;
- un bazin unde gazul este stocat înainte de a fi utilizat.

În rezervorul de agitare se introduce materia supusă fermentării împreună cu apa şi o serie de substanţe de hrănire (tabelul 1). Fiecare şarjă introdusă în rezervor este amestecată cu apa şi substanţele de hrănire timp de 1 oră.

Materialul este separat într-o fază lichidă şi una solidă. Fracţia lichidă parţial fermentată este pompată din rezervorul de agitare în reactorul de fermentare cu ajutorul unei pompe cu piston ce este acţionată de la consolă.

Fermentation reactor is hermetically sealed to preserve substrate anaerobic conditions throughout the fermentation process. Inside the fermenter takes place temperature and pH control of the liquid sample. The liquid must have a pH around 7 (neutral), and if necessary is adjusted using acid or base solution contained in the two containers. It should be noted that during the process, the pH tends to became acidic and, hence, needs to be monitored.

Reactorul de fermentare este închis ermetic pentru păstrarea condițiilor anaerobe ale substratului pe tot parcursul procesului de fermentare. În interiorul fermentatorului are loc controlul temperaturii probei lichide şi controlul pH-ului. Lichidul trebuie să aibă un pH în jurul valorii 7 (neutru), iar dacă este necesar se reglează utilizând soluția bază sau acid, conținută în cele două recipiente. Trebuie remarcat faptul că în timpul procesului, pH-ul tinde să treacă la mediul acid şi, de aceea, trebuie monitorizat.

Fig. 1 - Small capacity plant for biogas production [8]

The sample subjected to fermentation is heated by a heating element. Fermented mass is taken by means of a pump from the bottom or the top of the reactor, where it is further heated by resistance.

Biogas production process begins after about a day. Before arriving in the storage tank, the gas passes through a series of treatment systems, namely activated carbon filter, drier filter and carbon dioxide separator. The amount of biogas can be read directly from the gasmeter or from the console.

Finally, the biogas is stored in the storage reservoir that consists of four stacked rubber rooms with 120 liter capacity, suitable for biogas storage at atmospheric pressure.

Before connecting the storage tank to the corresponding valve, it is recommended to remove the air contained in the tank. When the ball was emptied, biogas flows and fills it completely maintaining atmospheric pressure.

Proba supusă fermentării este încălzită cu ajutorul unei rezistențe. Masa fermentată este preluată prin intermediul unei pompe, fie de la partea inferioară, fie de la partea superioară a reactorului, de unde este mai departe încălzită de rezistență.

Procesul de producție a biogazului începe după aproximativ o zi. Înainte de a ajunge în rezervorul de stocare, gazul trece printr-o serie de sisteme de tratament, şi anume: filtru de carbon activ, filtru deshidrator şi separator de dioxid de carbon. Cantitatea de biogaz poate fi citită de la gazometru sau direct de pe consolă.

În final, biogazul este depozitat în rezervorul de stocare care este format din patru camere de cauciuc suprapuse, cu capacitate de 120 litri, potrivit pentru depozitarea biogazului la presiunea atmosferică.

Înainte de a conecta rezervorul de depozitare la valva corespunzătoare, este recomandat să se elimine din rezervor aerul conținut. Când balonul a fost golit, biogazul curge şi îl umple complet menținând presiunea atmosferică.

Table 1

Quantities of substances necessary for fermentation [8]

No.	Substance	Symbol	Quantity, g/100 L
1.	Glucose	$C_6H_{12}O_6$	6000
2.	Ammonium phosphate	$(NH_4)_2HPO_4$	91.1
3.	Ammonium chloride	NH_4Cl	56.6
4.	Potassium chloride	KCl	8
5.	Ferric chloride	$FeCl_3$	10
6.	Magnesium chloride	$MgCl_2 \cdot 6H_2O$	20
7.	Aluminum chloride	$AlCl_3 \cdot 6H_2O$	2.2
8.	Calcium chloride	$CaCl_2 \cdot 2H_2O$	2
9.	Magnesium sulphate	$MgSO_4 \cdot H_2O$	0.5
10.	Zinc chloride	$ZnCl_2$	0.04

11.	Ammonium molybdate	$(NH_4)_6MoO_{24}\cdot 4H_2O$	0.2

For the study was used the same substrate composed of the manure and feeding substances with a C/N ratio of 20.4 (Table 2), the pH was kept constant, and the retention time was one week (from the moment the imposed working parameters are reached) for the three experiments [8].

Pentru acest studiu a fost folosit acelaşi substrat compus din dejecţii animaliere şi substanţe de hrănire, cu raport C/N de 20,4 (tabelul 2), pH-ul a fost menţinut constant, iar timpul de retenţie a fost de o săptămână (din momentul atingerii parametrilor de lucru impuşi) pentru cele trei experimente [8].

Table 2

Composition and parameters of substrate [9]

Substrate	Quantity, kg	C/N Ratio	Dry matter, %	Umidity, %
Pig manure	2	13	13.5	86.5
Cattle manure	3	25	14	86
Water	150	-	-	-

Organic materials used as a substrate was weighed and placed in the mixing and homogenization tank. Then, the tank was filled with an amount of 150 L of water for fluidization of the substrate because the homogenisation of the substrate in the fermenter is done by recirculation. The substrate was kept under these conditions for two days during which the substrate partially disintegrate in water and begin the bacteria development needed in process of fermentation.

After two days, feeding substances were added in the resulting liquid, in the specified amounts by the plant manufacturer. All of these were mixed using the mixer inside the tank for one hour.

The feeding pump was powered from the control panel in order to transfer the liquid substrate in the fermenter. After filling the digester, the temperature and pH were kept constant automatically throughout the fermentation process. The liquid substrate was re-circulated to reach the required temperature and pH.

The data acquisition system was started to record the biogas flow, temperature and pH changes that occur during fermentation after the liquid meets the required conditions.

RESULTS

The values recorded during the experiments are shown in Table 3 and in Figures 2, 3 and 4 is represented the change in the production of biogas for the temperatures of 25°C, 35°C and 45°C.

Materialele organice utilizate ca substrat au fost cântărite şi introduse în sita rezervorului pentru amestecare şi omogenizare. Apoi rezervorul a fost umplut cu o cantitate de 150 L de apă în scopul fluidizării substratului deoarece amestecarea substratului în fermentator este de tip hidraulic. Substratul era menţinut în aceste condiţii timp de două zile în decursul cărora substratul se dezintegra parţial în apă şi începea dezvoltarea bacteriilor necesare procesului de fermentare.

După cele două zile, în lichidul rezultat erau adăugate substanţele de hrănire, în cantităţile specificate de producătorul instalaţiei. Toate acestea erau amestecate cu ajutorul amestecătorului din dotarea rezervorului timp de o oră.

Pentru a transfera substratul lichid în fermentator se comanda de la panoul de control pornirea pompei de alimentare. După umplerea fermentatorului, se setau temperatura şi pH care erau menţinute constante automat pe toată durata fermentării. Substratul lichid era recirculat pentru a ajunge la temperatura şi pH-ul impus.

Când lichidul îndeplinea condiţiile impuse, se pornea şi sistemul de achiziţiei de date pentru înregistrarea debitului de biogaz obţinut, precum şi variaţiile de temperatură şi pH care apăreau în timpul fermentării.

REZULTATE

Valorile înregistrate în decursul experimentelor sunt prezentate în tabelul 3, iar în figurile 2, 3 şi 4 este evidenţiată variaţia producţiei de biogaz pentru temperaturile de 25°C, 35°C şi 45°C.

Table 3

The biogas quantities for the studied temperatures [8]

Time, h	Biogas production, m^3/h			Time, h	Biogas production, m^3/h		
	for 25°C	for 35°C	for 45°C		for 25°C	for 35°C	for 45°C
4	0	0	0	88	0.015	0.03	0.024
8	0	0	0.0017	92	0.014	0.031	0.02
12	0	0.001	0.0025	96	0.015	0.03	0.019
16	0	0.0013	0.0036	100	0.015	0.029	0.021
20	0.001	0.002	0.0051	104	0.014	0.032	0.018
24	0.001	0.0026	0.0072	108	0.014	0.031	0.017
28	0.0013	0.0034	0.0089	112	0.013	0.029	0.018
32	0.0016	0.005	0.012	116	0.0125	0.027	0.0185
36	0.0016	0.0071	0.017	120	0.013	0.028	0.017
40	0.0025	0.0084	0.016	124	0.0125	0.026	0.015
44	0.0031	0.014	0.019	128	0.011	0.027	0.0155
48	0.0042	0.012	0.021	132	0.011	0.025	0.014
52	0.005	0.015	0.018	136	0.01	0.022	0.0145
56	0.0046	0.018	0.019	140	0.011	0.024	0.0132
60	0.0051	0.02	0.022	144	0.01	0.021	0.0139
64	0.006	0.022	0.024	148	0.009	0.02	0.0128
68	0.007	0.021	0.022	152	0.0084	0.022	0.012

72	0.009	0.024	0.024
76	0.011	0.027	0.023
80	0.013	0.027	0.021
84	0.012	0.029	0.022

156	0.0076	0.019	0.0125
160	0.007	0.016	0.012
164	0.0069	0.016	0.0115
168	0.006	0.015	0.011

Experimental data obtained from the fermentation of a mixture of pig and cattle manure at different temperatures in the pilot plant RE-biomass with continuous hydraulic stirred cylindrical digester, respectivelly 25°C, 35°C and 45°C shows an increasing variation up to a certain moment in the process of fermentation, respectivelly a decreasing variation in the second part of the test that lasted for approximately 170 hours.

Datele experimentale obținute la fermentarea unui amestec de dejecții de porcine cu dejecții de bovine la temperaturi diferite în instalația pilot RE-BIOMAS cu fermentator cilindric cu agitare hidraulică continuă, respectiv 25°C, 35°C şi 45°C arată o variație crescătoare până la un anumit moment al procesului de fermentare, respectiv o variație descrescătoare în a doua parte a intervalului de testare care a fost de aproximativ 170 ore.

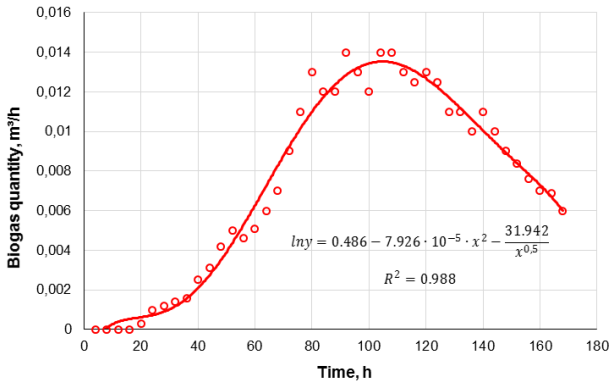

Fig. 2 – Variation of biogas production at 25°C

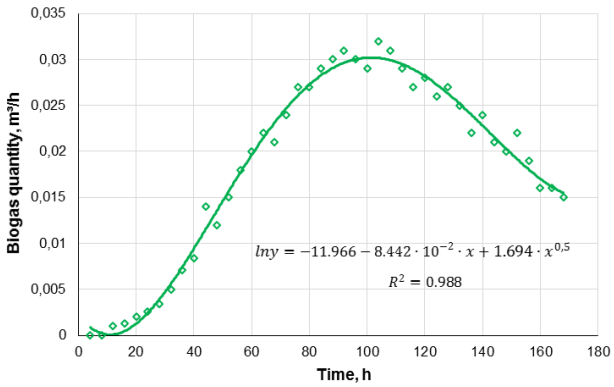

Fig. 3 - Variation of biogas production at 35°C

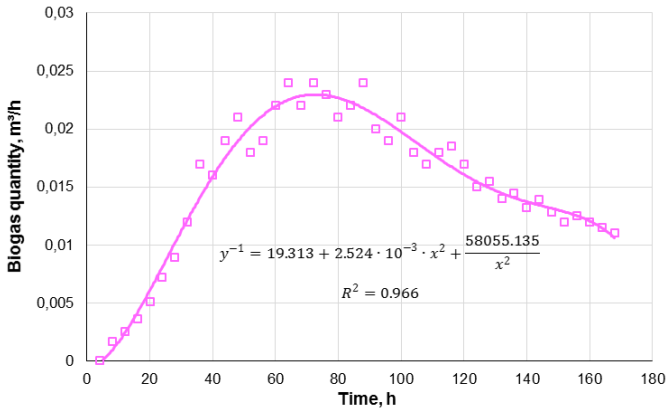

Fig. 4 - Variation of biogas production at 45°C

The maximum curve of the biogas production process are recorded after about 110 hours with a value of approximately 0.013 m^3/h for the temperature of 25°C; at the end of the test period, the production of biogas records a value of 0.0065 m^3/h.

For a temperature of 45°C, the maximum of the biogas production curve is recorded after about 75 hours of fermentation, with a value of about 0.023 m^3/h, at the end of the test range, the value is about 0.011 m^3/h, which shows that the fermentation process is not over, as in the first case.

The highest biogas production was recorded for the temperature of 35°C after about 100 hours of operation with a maximum value of 0.03 m^3/h, but at the end of the test range, the amount of biogas production is at 0.015 m^3/h and again the fermentation process is incomplete, beeing posible the continue.

The variation laws of the biogas production have been identified after the mathematical regression

Maximul curbei de variație a procesului de producție a biogazului se înregistrează după circa 110 ore având o valoare de aproximativ 0,013 m^3/h pentru temperatura de 25°C; la finalul intervalului de testare, producția de biogaz înregistrează o valoare de 0,0065 m^3/h.

Pentru temperatura de 45°C, maximul curbei de variație a producției de biogaz se înregistrează după circa 75 ore de fermentație, prezentând o valoare de circa 0,023 m^3/h, la finalul intervalului de testare, valoarea fiind de circa 0,011 m^3/h, ceea ce arată, ca şi în primul caz, că procesul de fermentare nu s-a terminat.

Cea mai mare producție de biogaz s-a înregistrat pentru temperatura de 35°C după circa 100 ore de funcționare având o valoare maximă de 0,03 m^3/h, dar la finalul intervalului de testare, valoarea producției de biogaz se situează la 0,015 m^3/h şi iarăşi procesul de fermentare este nefinalizat, el putând continua.

În urma analizei de regresie matematică asupra datelor experimentale folosind programul TableCurve 2D, s-au identificat legile de variație pentru producția de biogaz.

analysis of the data using TableCurve 2D software.

The variation laws of biogas production, for the tests done to determine the effect of temperature on the biogas production, that shows the best correlation with the experimental data, are exponential or hyperbolic having a correlation coefficient R^2 of over 0.966.

CONCLUSIONS

Anaerobic digestion is affected by many factors and the results obtained in this work have shown that the temperature is among the most important. In experiments was used the same substrate, the pH was kept constant and the analyzed temperatures were of 25°C, 35°C and 45°C.

The maximum amount of biogas was obtained at 35°C with a total value of 0.7798 m^3. Total biogas production values for the other two temperatures were 0.3249 m^3 for the temperature of 25°C, respectivelly 0.6394 m^3 for the temperature of 45°C.

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Legile de variație a producției de biogaz pentru testele efectuate în vederea determinării influenței temperaturii asupra cantității de biogaz care corelează cel mai bine datele experimentale sunt de tip exponențial sau hiperbolic, coeficientul de corelație R^2 fiind peste 0,966.

CONCLUZII

Fermentarea anaerobă este influențată de mulți factori iar rezultatele obținute în această lucrare au evidențiat că temperatura este printre cei mai importanți. În experimente s-a folosit acelaşi substrat, pH-ul a fost menținut constant iar temperaturile analizate au fost de 25°C, 35°C şi 45°C.

Cantitatea maximă de biogaz a fost obținută la temperatura de 35°C cu o valoare totală de 0,7798 m^3. Valorile producției totale de biogaz pentru celelalte două temperaturi au fost de 0,3249 m^3 la temperatura de 25°C, respectiv 0,6394 m^3 la temperatura de 45°C.

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BIOMASS (ENERGY CROPS) PRETREATMENT TO IMPROVE ANAEROBIC DIGESTION PROCESS – REVIEW
/
PRETRATAREA BIOMASEI (CULTURILOR ENERGETICE) PENTRU ÎMBUNĂTĂȚIREA PROCESULUI DE DIGESTIE ANAEROBICĂ - REVIEW

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Abstract: *For a few years now an important part of the environment is studied in order to obtain renewable energy. Thus, in this category most analyzed is biomass. Using biomass for obtaining biogas is one of the main concerns when it comes to renewable energy. Also an important part of biogas production is taken by the technology used, in this case anaerobic digestion process. In order to obtain biogas various types of substrate can be used like organic fraction of municipal solid waste, aquatic biomass, crop residues, animal manure and energy crops suitable for this process. In this paper are presented methods for the biomass pretreatment in order to improve anaerobic digestion process.*

Keywords: *biomass pretreatment, biogas, anaerobic digestion, energy crops, substrate*

Rezumat: *Un element important al mediului înconjurător este studiat de câțiva ani în vederea obținerii de energie regenerabilă. Astfel, din această categorie cel mai des analizată este biomasa. Folosind biomasa în vederea obținerii de biogaz este o preocupare constantă când se face referire la energii regenerabile. De asemenea, o parte importantă a producției de biogaz este reprezentată de tehnologia utilizată, în acest caz procesul de digestie anerobă. în vederea obținerii biogazului sunt utilizate diferite tipuri de substraturi precum farcții organice a deşeurilor solide municipale, biomasa acvatică, resturi vegetale, deşeuri animaliere dar şi culturi energetice pretabile acestui proces. În această lucrare se prezintă metode de pretratare a biomasei pentru îmbunătățirea procesului de digestie anaerobă.*

Cuvinte cheie: *pretratare biomasă, biogaz, fermentație anaerobă, culturi energetice*

INTRODUCTION

Modern society is based on energy that is mostly taken for granted. Considering that the number of people is constantly raising the demand for energy is also on an ascending curve regarding its usage. Despite all the energy and the technology available nowadays there are places in the world where people don't have access to it [18].

Anaerobic digestion process is a very common practice in term of waste management treatment strategy from two points of view, environmental and social benefits [21].

An important role played in handling and recycling of animal manure, organic waste, and biomass obtained from different types of crops, has anaerobic co-digestion process combined with pre- and post- treatment technologies used for obtaining biogas [6].

The necessary nutrients for the growth of anaerobic microorganisms can be found in animal manure, but even so, because it has a low concentration of total solids (usually <8%), these are mixed together with different crop residues or energy crops [16].

Lignocellulosic biomass is known to be rich in carbon, therefore it is very important that this material to be mixed with raw materials rich in nitrogen in order to be fermented to obtain an optimal C/N ratio, a good yield and an adequate stability in the anaerobic digester [17].

The origin of the pretreatment technologies for lignocellulosic is met in wood science for paper fabrication and pulp, but also in crop science in orders to increase the digestibility of forage by ruminants. Thus the origin of pretreatment technologies can be traced from 1819 when the French plant chemist H. Braconnot discovered that glucose is formed by treating wood with concentrated sulfuric acid [2].

Since then, various pretreatment technologies have been proposed, challenging the complexity of biomass

INTRODUCERE

Societatea modernă se bazează pe energie, considerată de drept în cele mai multe cazuri. Luând în considerare faptul că numărul oamenilor creşte constant şi cererea energetică este pe o pantă ascendentă. În ciuda energiei existente în momemntul de față, totuşi există locuri în lume unde oamenii nu au acces la aceasta [18].

Procesul de digestie anarobă este o practică des întâlnită în managementul strategiei de tratare a deşeurilor din două puncte de vedere: beneficiile sociale şi de mediu [21].

Un rol important în manipularea şi recilarea dejecțiilor animaliere, deşeurilor organice şi a biomasei obținute din diferite tipuri de culturi energetice, este dat de codigestia anaerobă proces combinat cu tehnologii de pre- şi post-tratament folosit pentru obținerea biogazului [6].

Nutrienții necesari pentru creşterea microorganismelor anerobe se întâlnesc în dejecțiile animaliere, cu toate acestea, datorită unei concentrații scăzute de materii solide (de obicei <8%) sunt amestecate cu diferite reziduuri vegetale sau reziduuiri din culturi energetice [16].

Biomasa lignocelulozică conțite cantități ridicate de carbon, fiind foarte important ca acest material să fie amestecat cu materie primă bogată în azot, astfel încât să se obțină un raport optimal C/N, un randament bun şi o stabilitate adecvată în digestorul anaerob [17].

Originea tehnologiilor de pretratare prentru lignoceluloză este din ştiința lemnului în vederea creşterii gradului de digestibilitate de furaje pentru rumegătoare. Astfel originea tehnologiilor de pretratare este încă din 1819 când chimistul francez H. Bracnnot a descoperit că glucoza este obținuta prin tratarea lemnului cu acid sulfuric concentrat [2].

Din acel moment, diferite tehnologii de pretratare au fost propuse, punând la încercare complexitatea structurii

structure and attempting to overcome the duality of obtaining high recovery of fermentable products with no or very limited amount of degradation products [14]. Researchers accomplished various experimental testing by focusing on the identification, evaluation and demonstration of promising approaches. The entire global costs and configuration in refinery system is affected by the selection on the pretreatment method applied.

Thus taking into consideration all said, biogas is considered to be a win-win solution for energy source used to reduce water contamination, global warming emissions caused by animal waste, pollution etc. [20].

In this paper there is presented a synthesis of some experimental results conducted in our country or abroad, regarding the biomass pretreatment in order to improve anaerobic digestion process.

biomasei şi încercare de a depăşi dualitatea de recuperare mare a produseor fermentabile cu sau fără cantitate limită de produse degradabile [14].

Cercetătorii au obținut rezultate experiementale concentrare asupra identificării, evaluării şi demonstrării a abordărilor promițătoare. Costul total global şi configurarea sistemului în rafinării este influențat de selecția metodei de pretrataement aplicată.

Astfel, considerând toate cele menționate, biogazul este o soluție win-win pentru obținerea unei surse de energie folosită pentru reducerea contaminației apei, emisilor privind încălzirii globale cauzate de dejecțiile animaliere, poluare etc. [20].

În această lucrare se prezintă o sinteză a câtorva teste experimentale atât din țară cât şi din străinătate, privind pretratarea biomasei în vedere îmbunătățirii procesului de digestie anaerobă.

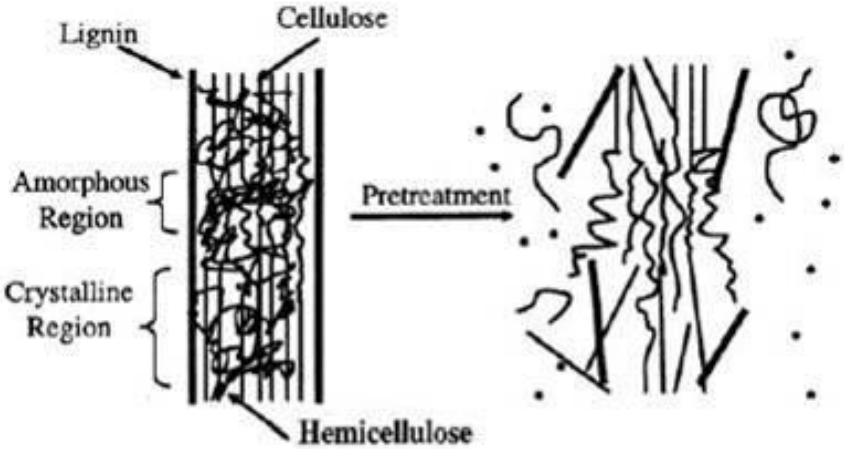

Fig. 1 – Schematic overview of pretreatment of lignocellulosic biomass [11, 22]

MATERIAL AND METHOD

Outlining the pretreatment process of biomass, mainly for energy crops, was the focus of many researchers, this current paper showing research papers and studies from speciality sites, ASABE, articles published in journals from international data base (ScienceDirect, Springerlink, etc.) or volumes of some national and international conferences which had as an interest this theme, and are presented as bibliographical sources.

RESULTS

Considering the biomass pretreatment process of energy crops, the aim of this paper, it is necessary to say that it appeared to be very important in biogas production in order to improve methane yields. These processes aim to solubilize carbohydrates in order to enhance their conversion into biogas. Different pretreatments have been investigated in literature, such as mechanical pretreatment (milling), thermal pretreatment (liquid hot water, steam explosion, CO_2 explosion), chemical pretreatment (acid, alkaline, oxidative) or biological pretreatment (fungal, enzymes, fermentation) [7, 12].

MATERIAL ŞI METODĂ

Evidențierea procesului de pretratare a biomasei, în mod special pentru culturile energetice, a fost studiată de către numeroşi cercetători în lucrarea de față fiind prezentate lucrări de cercetare şi studii preluate de pe site-uri de specialitate, ASABE, articole publicate în jurnale din baze de date internaționale (ScienceDirect, Springerlink, etc.) sau volume ale unor conferințe naționale şi internaționale care au avut ca interes această tematică şi utilizate ca surse bibliografice.

REZULTATE

Luând în cosiderare procesul de pretratare al biomasei din culturi energetice, scopul acestei lucrări, este necesar să menționăm că este foarte important în producția de biogaz în vederea îmbunătățirii randamentului metanului obținut. Aceste procese au drept scop solubilizarea carbohidraților pentru a spori transformarea lor în biogaz. În literatura de specialitate au fost investigate o serie de pretratamente precum, pretratament mecanic (mărunțirea), pretratament termic (cu apă caldă, cu abur cald, cu CO_2), pretratament chimic (acid, alcaline, oxidant) sau pretratament biologic (enzimatic, prin fermentare, fungic) [7, 12].

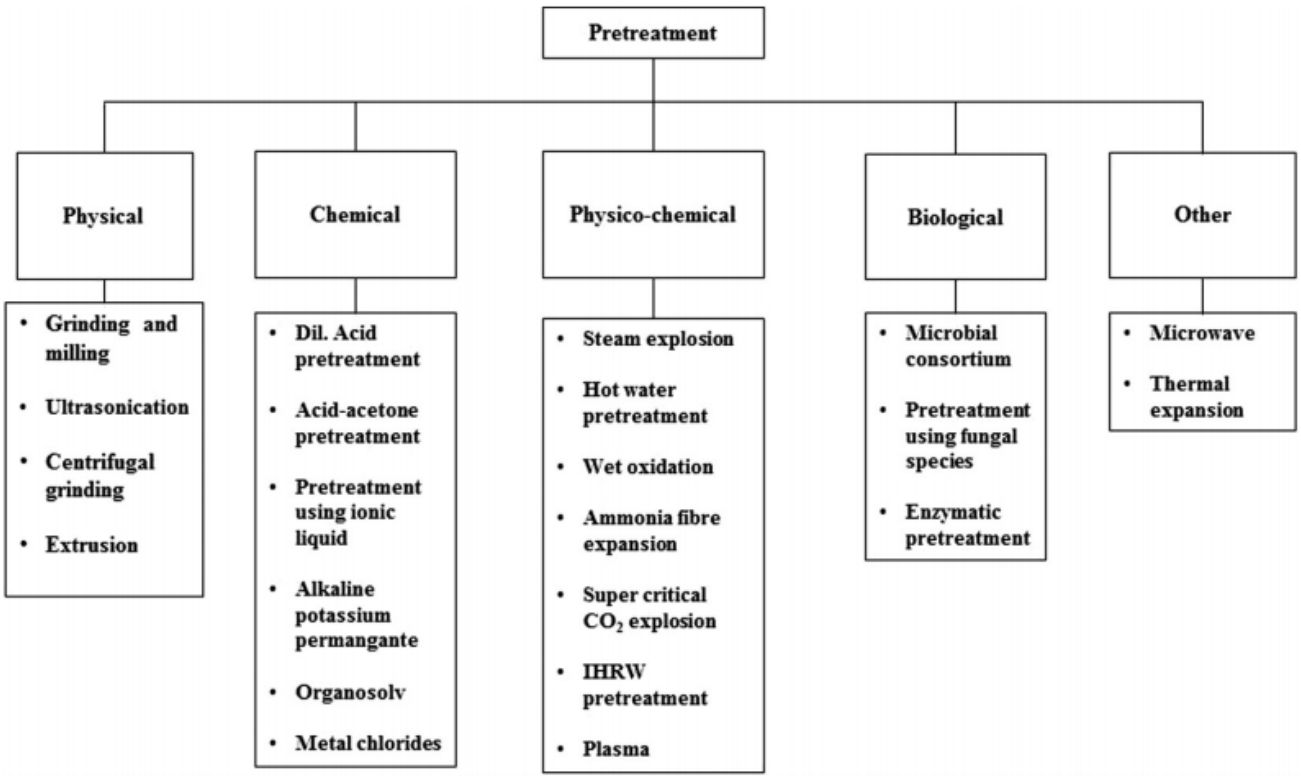

Fig. 2 – Pre-treatment methods for lignocellulosic biomass [15]

Considering the mechanical pretreatment process H.J. Kim et al. [9] used a laboratory ball mill, attrition mill and planetary mill for testing rice straws. Before testing rice straws were grinded using a home blender. As researchers said mill pretreatments were performed after adding the rice straw into enzymatic reaction buffer. Hence, it is not necessary to exchange the buffer for further processes. After the planetary mill pretreatment, the rice straw was completely dissolved into the buffer. Another aspect mention was that the attrition and planetary mills are more effective to reduce size, which ultimately increases the accessibility of enzyme to biomass. The study conclusion was that Mechanical mill techniques have several benefits prior to chemical pretreatment for biofuel production. First of all, it does not produce toxic compounds which improve saccharification and fermentation processes. It also uses same buffer with enzymatic process. Hence, it can reduce process time. Pretreatment methods currently used, such as chemical pretreatment, are not acceptable to mass biofuel production [9].

Chemical and physico-chemical pretreatments were studies by researchers in paper [14] where the authors presented different technologies with their advantages and disadvantages as well as their effects on the treated biomass. At first they presented acid pretreatment mentioning that acids are used as catalysts. Concentrated acid allows obtaining high yield of sugars such as glucose from cellulose with low temperature. Hydrolysis rate is, however, slower for crystalline cellulose than for amorphous hemicelluloses due to their difference in intrinsic properties, but a disadvantage is the corrosion of the equipment, environmental toxicity, high energy demand for acid recovery. [8, 14]. The chemical alkaline pretreatment compared to other chemical pretreatment technologies, can be conducted at lower temperature and pressure causing less sugar degradation than acid pretreatment but the reaction times take several hours or days, or even weeks for softwood.

Considerând procesul de pretratare mecanică, H.K. Kim et al [9] a folosit o moară cu ciocane de laborator, o moară cu pietre şi o moară planetară pentru testarea paielor de orez. Înainte de testare, paiele de orez au fost măcinate folosind un blender de casă. Aşa cum au raportat cercetătorii, pretratările prin moară au fost făcute după introducerea paielor de orez într-un buffer de reacție enzimatică. Deci, nu este necesar să schimbam bufferul pentru alte procese. După pretratamentul din moara planetară, paiele de orez s-au dizolvat complet în buffer. Un alt aspect de menționat a fost faptul că morile cu pietre, respectiv cele planetare sunt mai eficiente pentru reducerea dimensiunilor particulelor, lucru care favorizează accesabilitatea enzimei în biomasă. Studiul a concluzionat faptul că tehnicile care folosesc moara mecanică au mai multe beneficii înainte de pretatarea pentru producția de biocombustibil. În primul rand, nu produce compuşi toxici care îmbunătățesc procesele de fermentație şi zaharificare. De asemenea, foloseşte acelaşi buffer cu procesul enzimatic. Deci, poate reduce timpul de procesare. Metodele de pretratare folosite aici, cum ar fi pretratarea chimică, nu sunt acceptabile pentru producția în masă a biocombustibilului [9].

Pretratările chimice şi fizico-chimice, au constituit studiile făcute de cercetători în lucrarea [14] unde autorii au prezentat diferite tehnologii cu avantajele şi dezavantajele acestora, şi efectele asupra biomasei tratate. Întâi au prezentat pretratarea acidă menționând că acizii au fost folosiți ca şi catalizatori. Acidul concentrat permite obținerea de zaharuri cum ar fi glucoza din celuloză la temperatură joasă. Viteza de hidroliză, este totuşi mai mică pentru celuloza cristalină decât pentru hemiceluloza amorfă, datorită diferenței în proprietăți intrinsece, dar un dezavantaj este corodarea echipamentului, toxicitate a mediului, un consum mare de energie pentru recuperarea acidului [8, 14]. Pretratarea alcalină chimică comparată cu alte tehnologii de pretratare chimică, poate fi pusă în practică la temperaturi şi presiuni mai joase cauzând mai puțină degradare a zaharurilor decât pretratarea acidă dar timpii de reacție sunt de câteva ore până la zile, sau chiar săptămâni pe lemn de esență moale [3, 14]. Una din impedimentele hidrolizei alcaline este faptul că foloseşte

[3, 14]. One of the drawbacks of alkaline hydrolysis is that it uses high temperature which implies high energy demands removing parts of the hemicelluloses, thus causing sugar loss.

temperatura ridicată care implică un consum energetic ridicat, eliminarea părților din hemiceluloză, astfel cauzând pierderea zaharurilor.

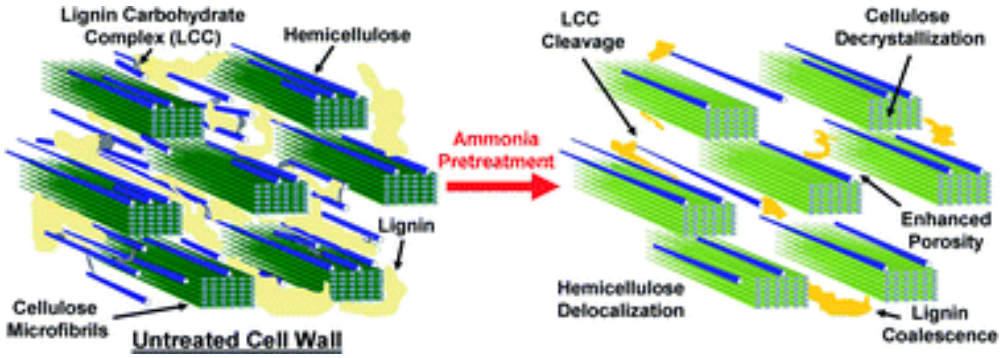

Fig. 3 – Biomass pretreatment - ammonia pretreatment, [23]

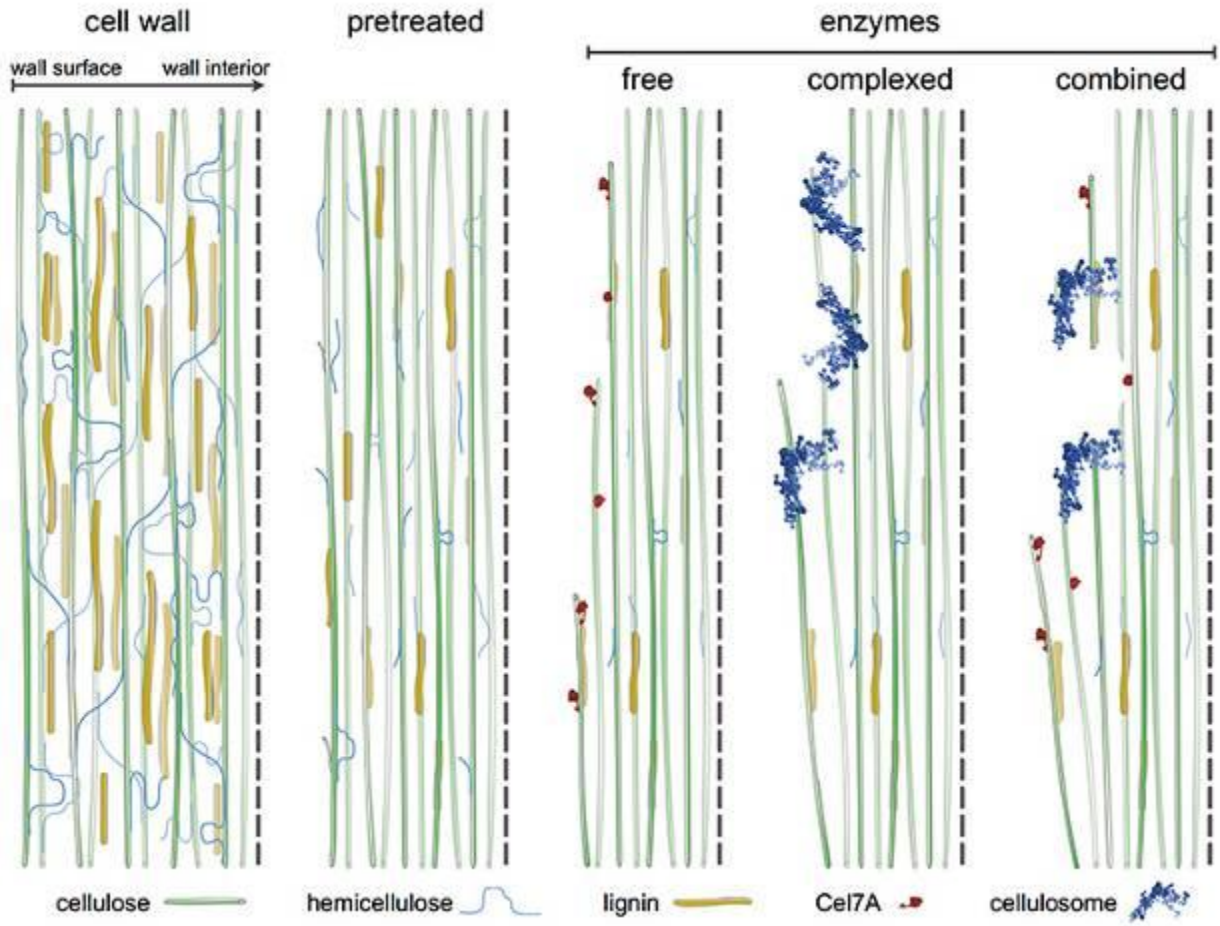

Fig. 4 – Illustration of plant cell walls before and after pretreatment and models of hydrolysis by free (red) and complexed (blue) enzyme systems (Bioenergy crops) [24]

Regarding physico-chemical alkaline pretreatment at first it needs to be mentioned that in order to enhance lignin removal and increase efficiency, physical parameters such as pressure were added to the chemical alkaline pretreatment. Most commonly used are Ammonia-fiber expansion (AFEX) and Ammonia recycle percolation (ARP).

The physico-chemical pretreatment AFEX in conducted using 1–2 kg of liquid ammonia per kg of dry biomass in relatively moderate temperature (60–120° C) and high pressure (1.72–2.06 MPa) for 5–30 min, and then the pressure is suddenly reduced [10,14]. It is

Având în vedere pretratarea alcalină fizico-chimică, mai întâi trebuie menționat faptul că pentru a îmbunătăți procesul de eliminare a ligninei şi pentru a creşte eficiența, parametrii fizici cum ar fi presiunea au fost adaugați în pretratarea alcalină chimică. Cei mai deşi paramentrii sunt expandarea fibrei de amoniac (AFEX) şi percolația reciclării amoniacului (ARP). Pretratarea fizico-chimică AFEX, folosind 1-2kg amoniac lichid per kg de biomasă uscată la temperatură moderată (60-120° C) şi presiune mare (1.72–2.06 MPa) pentru 5-30min, apoi presiunea este redusă brusc [10,14]. Este similar procesului de explozie a aburilor dar amoniacul lichid

similar to steam explosion but liquid ammonia is used instead of water. As mentioned the ammonia recycle percolation (ARP) is another form of alkaline physico-chemical treatment in which aqueous ammonia (2.5–15%) passes through a reactor packed with biomass, with a temperature set between 140–210 ^{0}C. 90 minutes is the reaction time and the percolation rate around 5 ml/min. Although this method is efficient for delignification of hardwoods and herbaceous plants, it is less effective for softwoods [4, 14].

este folosit în locul apei. Aşa cum am menționat percolația reciclării amoniacului (ARP) este o altă formă de tratare fizico-chimica în care amoniacul lichid (2.5–15%) trece printr-un reactor plin cu biomasă, cu o temperatură între 140-210^{0}C. 90 minute a fost timpul de reacție şi rata de percolație de circa 5ml/min. Deşi această metodă este eficientă pentru eliminarea ligninei din lemnul de esență tare şi plante erbacee, nu este la fel de eficientă pentru lemnul de estență moale [4, 14].

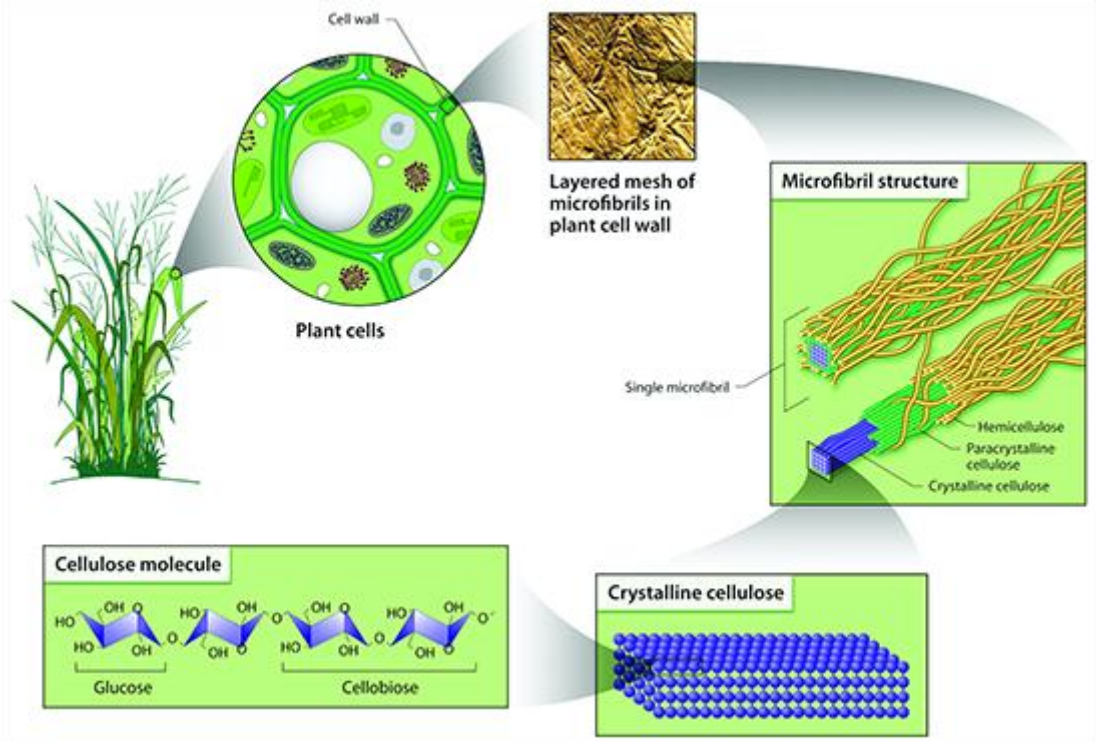

Fig. 5. – Switchgrass, to plant cells, to mesh of microfibrils, to microbril structure, to crystalline cellulose to a cellulose molecule [25]

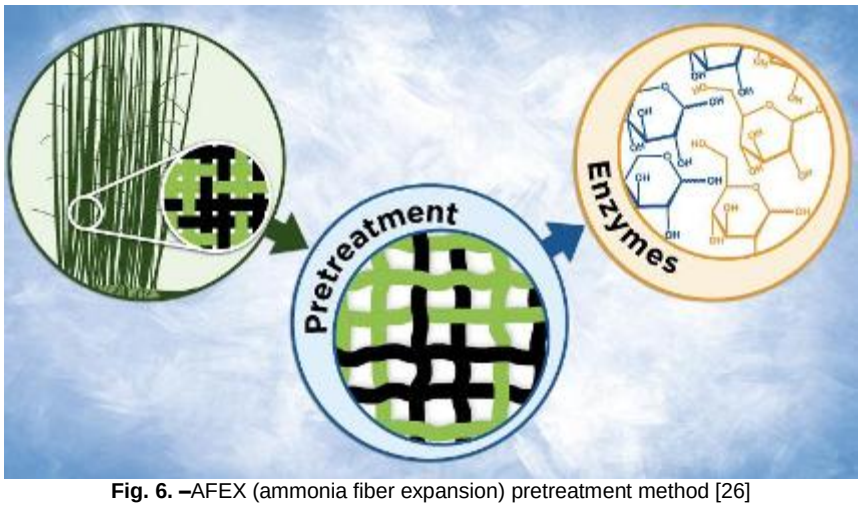

Fig. 6. –AFEX (ammonia fiber expansion) pretreatment method [26]

Biological pretreatments involve biological sacharification (microbial saccharification, enzymatic saccharofication), biological delignification (microbial delignification, enzymatic delignification), consolidated bioprocessing.

The main important parameters for microbial saccharification are temperature, pH, particle size, substrate accessibility and hydrogen partial pressure [5, 14]. The pretreatment technology involving delignification of lignocellulosics with microorganisms is called solid-state fermentation. A drawback of enzymatic

Pretratamentele biologice implică zaharificarea biologică (zaharificarea microbială, zaharificarea enzimatică), delignificarea biologică (delignificarea microbială, delignificarea enzimatică), consolidând bioprocesarea.

Cei mai importanți paramentri pentru zaharificarea microbială sunt temperatura, pH-ul, mărimea particulei, accesibilitatea substratului şi presiunea parțială a hidrogenului [5,14]. Tehnologia pretratării implică delignificarea lignocelulozicelor cu microorganisme şi este denumită fermentația în stare solidă. Un impediment al pretratării enzimatice este reprezentat de faptul că dependența de pH a activității, care este optimă la pH scăzut, în timp ce

pretreatment is represented by the pH-dependence of the activity, which is optimal at low pH, while alkaline pH is preferred for industrial applications [13, 14]. A promising solution mentioned by researchers [1, 14] is formed out of Gene modification or use of multiple enzymes.

pH-ul alcalin este preferat pentru aplicațiile indstriale [13,14]. O soluție promițătoare menționată de cercetători [1,14] este forrmată din modificarea genelor sau folosirea enzimelor multiple.

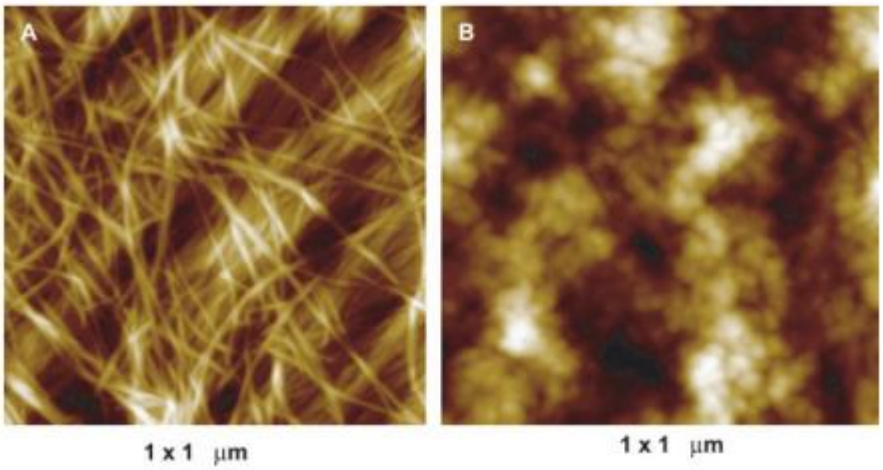

Fig. 7. – Corn stover before treatment (A) and after treatment (B) by AFM [19]

Zhang et al. analyzed avicel, α-cellulose, corn stover, switchgrass, hybrid poplar and Douglas before and after pretreatments. After testing authors mentioned that lignocellulose fractionation has something in common with OS, which is well known as an environmentally friendly technology and has been fully tested in pilot plants. The changes in the supramolecular structures of corn stover before and after pre-treatment are shown by atomic force microscopy (AFM) images (Fig. 7). As it can be seen in fig. 7A before pretreatment, the plant cell wall structures of corn stover and elementary cellulose fibers can be clearly identified. After pretreatment, no fibril structures were observed (Fig. 7B), indicating that concentrated phosphoric acid not only disrupted all linkages among cellulose, hemicellulose, and lignin, but also broke up the orderly hydrogen bonds [19].

Zhang et al. au analizat avicel, α - celuloză , stiuleți de porumb, switchgrass, plop hibrid şi Douglas înainte şi după pretratament. După testare, autorii au menționat că fracționarea lignocelulozei are ceva similar cu OS, care este un procedeu cunoscut ca fiind o tehnologie invazivă asupra mediului şi a fost testată din toate punctele de vedere în centrale pilot. Schimbările la nivel supramolecular ale ştiuleților de porumb înainte şi după pretratament sunt prezentate în fig. 7 prin folosirea unui microscop atomic (AFM). După cum se poate observa în fig.7A, înainte de aplicarea pretratamentului, structura peretelui plantei şi fibrele celulozice elementare se pot distinge foarte clar. După aplicarea pretrataemntului, nu se mai pot observa structuri de fibre (fig. 7B) indicând faptul că acidul fosforic concentrat nu doar că a dislocat toate legături celulozice, hemicelulozice şi de lignină, dar totodată, a rupt legăturile de hidrogen [19].

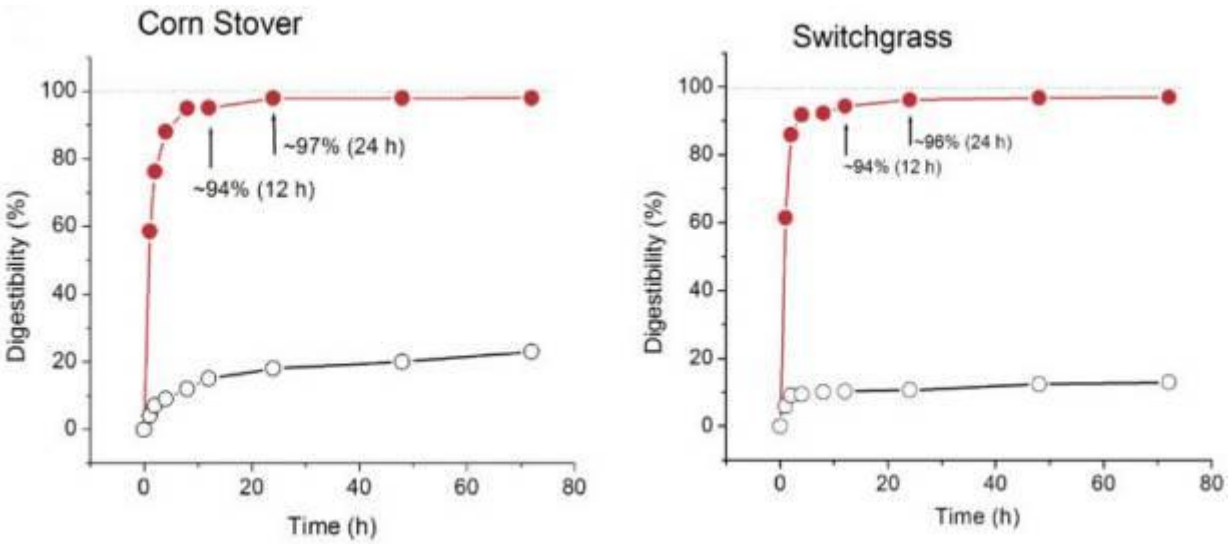

Fig. 8. – Profile of enzymatic cellulose hydrolysis for the cellulosic samples (corn stover and switchgrass were pre-treated by 84% phosphoric acid at 50°C for 45 min.) [19]

CONCLUSIONS

As it can be concluded from the processed mentioned

CONCLUZII

Aşa cum se poate observa din procesele menționate,

the pretreatment is very important in obtaining biogas; involving high costs, however, the only process step more expensive than pretreatment being no pretreatment. Without pretreatment, yields are low. According to scientists the best method used for pretreatment applied on biomass depends on the type of biomass used for obtaining biogas.

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procesul de pretratare este foarte important în obținerea biogazului, implicând costuri ridicate, dar singurul proces mai scump decât acestea este lipsa pretratării biomasei. Fără pretratare, randamentele paramentrilor sunt foarte scăzute. Conform cercetătorilor, cea mai bună metodă folosită în procesul de pretratare a biomasei depinde de tipul biomasei utilizate în vederea obținerii de biogaz.

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THE IMPACT ASSESSMENT OF A DIESEL CONTAMINATION OF SOIL - A BIOLOGICAL APPROACH
/
EVALUAREA IMPACTULUI UNUI SOL CONTAMINAT CU MOTORINĂ – O ABORDARE BIOLOGICĂ

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Abstract: *Spillage of diesel oil and other petroleum products is a commonly problem for site remediation of contaminated soils. Soil biological activity, including soil microbial biomass and enzymatic activity, is influenced by a range of physicochemical, environmental parameters and perturbations. This paper present the results obtained at laboratory scale for a diesel contaminated soil. Two types of soils were tested, one type was taken directly from nature, and one was a soil that can be found on the market. The contamination with diesel was different, of about 1%, 5%, 10%, 15% and 20% and the monitoring was done after each week of contamination.*

Keywords: *diesel, diesel contamination, biological cultures, soil treatment*

Rezumat*: Scurgerile de motorină şi de alte produse petroliere este o problemă des întâlnită pentru remedierea solurilor contaminate. Activitatea biologică a solului, inclusiv biomasa microbiană a solului şi activitatea enzimatică , este influenţată de o serie de parametrii fizico-chimici de mediu şi de perturbatii. Această lucrare prezintă rezultatele obţinute la nivel de laborator pentru un sol contaminat cu motorină. Două tipuri de soluri au fost testate, un tip a fost luat direct din natură, şi unul a fost un sol , care poate fi găsit în comerţ. Contaminarea cu motorină a fost diferită, de 1 % , 5 % , 10 % , 15 % şi 20 %, iar monitorizarea s-a realizat după fiecare săptămână de la contaminare .*

Cuvinte cheie: *motorină, contaminare cu motorină, culturi biologice, tratarea solului*

INTRODUCTION

Petroleum products are among the most widely used chemicals in the world today [4, 5]. Leakages, accidental and deliberate spills become unavoidable when we look at the massive quantity of fuel used, stored, transported etc. Soil biological activity, including soil microbial biomass and enzymatic activity, is influenced by a range of physicochemical, environmental parameters and perturbations [3]. Therefore, soil microbial activity is commonly used to assess disturbed soil. According to the "Progress in the management of Contaminated Sites in Europe" from 2014, the estimates for the extent of local soil contamination are available for about one third of the countries surveyed from European Union; an average of about 4.2 Potentially Contaminated Sites are reported per 1,000 inhabitants and about 5.7 Contaminated Sites per 10,000 inhabitants. A tentative extrapolation to the whole of Europe produces an estimate for the total number of Potentially Contaminated Sites of 2.5 million, of which about 14% (340,000 sites) are expected to be contaminated and likely to require remediation [2].

MATERIAL AND METHOD

The experimental research consisted in testing five concentrations for the pollutant. These concentrations were 1%, 5%, 10%, 15% and 20% of diesel in soil.

First step of an experimental test is the destruction or sterilization of microorganisms that is essential to prepare the material and working culture media [1].

Sterilization is the destruction or removal of all vegetative forms and resistance of pathogenic microorganisms and apatogene.

A product is considered to be sterile when is not containing forms of microorganisms that can be revitalized. There are many methods of sterilization which correspond to the different kinds of materials to be treated.

The experimental research was performed in a

INTRODUCERE

Produsele petroliere sunt printre cele mai utilizate chemicale în lume în ziua de azi [1,2]. Scurgerile, deliberate sau accidentale inevitabile atunci când ne uităm la cantitatea masivă de combustibil utilizat , depozitat, transportat etc. Activitatea biologică a solului, inclusiv biomasa microbiană a solului şi activitatea enzimatică , este influenţată de o serie de parametrii fizico-chimici de mediu şi de perturbatii [3]. De aceea, activitatea biologică a solului este adesea folosită pentru a evalua solul afectat. Conform „Progresul în managementul solurilor contaminate în Europa" din 2014, estimările pentru extinderea locală a contaminării solurilor sunt disponibile pentru o treime dintre ţările analizate din Uniunea Europeană; o medie de 4.2 situri potenţial contaminate sunt raportate la 1000 de locuitori şi aproape 5.7 situri contaminate la 10 000 de locuitori. O tentativă de extrapolare pentru întreaga Europă duce la o estimare a unui număr total de Situri Potenţial Contaminate de 2.5 milioane, dintre care aproximativ 14% (340 000) sunt presupuse a fi contaminate şi probabil necesită remediere [2].

MATERIAL ŞI METODĂ

Cercetarea experimentală constă în testarea a cinci concentraţii de poluant. Aceste concentraţii de motorină în sol au fost 1%, 5%, 10%, 15% şi 20%.

Distrugerea microorganismelor sau sterilizarea este indispensabilă pentru pregătirea materialului de lucru şi a mediilor de cultură [1].

Sterilizarea reprezintă operaţia de distrugere sau îndepărtarea tuturor formelor vegetative şi de rezistenţă a microorganismelor patogene şi apatogene.

Un produs este considerat steril când nu mai conţine forme de microorganisme ce pot fi revitalizate. Există mai multe procedee de sterilizare care corespund diferitelor tipuri de materiale ce trebuie tratate.

Cercetarea experimentală a fost realizată într-un laborator şi ideea a fost să se vadă câtă motorină poate

laboratory and the idea was to see how much the diesel influences the development of microorganisms once the pollutant has entered the soil. In order to see how the microbiota is influenced, the Koch method was used.

Koch method consists in seeding of a given volume of the cell suspension/or solidified culture medium in Petri plates and, after an incubation period, the colony count is done considering that each colony is resulting from the multiplication of a single cell. Plate cultivation method is very often used to determine the number of live microorganisms from a product and allows at the same time, a qualitative analysis by studying morphological characters of the developed colonies. Usually it is used the decimal dilutions of the analyzed product (fig. 1) [1].

The result is expressed in CFU (colony forming units), as there may be more crowded cells that are forming a colony, and for fungi fragments of multicellular hyphae can appear. In addition, there are plenty of isolated cells that do not form colonies. The plates that are containing between 30 and 300 colonies will be chosen.

The number of colony forming units is given by the following formula:

UFC / mL = no. colonies X dilution ratio

For the experiment it was decided to use two types of soils: one type of soil extracted from a natural area, a garden, identified as S1; one that can be obtained from commerce and it is used for flower planting and because of that contains a larger quantity of humus, identified as S2.

The Koch method was applied for all five concentrations (for each type of soils) and also for a blank sample from each type of soil.

This research will observe the influence of pollutant concentration on soil microbiota after an artificial contamination and will use plants and see how the microbiota is influenced also.

The analysis were performed in the Microbiology Laboratory from Faculty of Biotechnical Systems Engineering of University Politehnica of Bucharest.

Each type of soil was artificially contaminate with diesel. The contaminant was procured from local fuel station. After the contamination each sample was mixed very well and left for a week to homogenize. The initial analysis were done after the sample were in contact with the contaminant for a week.

Each time the method was applied, the main steps were the followings:

a) 1 mg of contaminated soil (or clean one for the blank sample), was weighted and combined with 10 ml of water;
b) 1 ml of the combined sample from the step 1, was extracted and combined with other 10 ml of water;
c) at the end 1 ml from the second solution was extracted and put on the Petri plate;
d) the next step was to insert the environment needed to develop the microbiota, and homogenized the sample through circularly movements and left it to solidify;
e) the Petri plates were introduced at 250^0 C and after 24 hours the colony number was determined.

influența dezvoltarea microorganismelor odată ce poluantul a pătruns în sol. Pentru a vedea cum este influențată microbiota, s-a folosit methoda Koch.

Metoda culturală Koch constă în însămânțarea unui volum cunoscut din suspensia de celule în/sau pe medii de cultură solidificate în plăci Petri şi, după o perioadă de incubare, se face număratoarea coloniilor considerând că fiecare colonie este rezultată prin multiplicarea unei singure celule. Metoda cultivării în plăci este foarte adesea folosită pentru determinarea numărului de microorganisme vii dintr-un produs şi permite, în acelaşi timp, o analiză calitativă prin studiul caracterelor morfologice ale coloniilor dezvoltate. De obicei se utilizează diluțiile decimale ale produsului de analizat (fig 1) [1].

Rezultatul se exprimă în UFC (unități formatoare de colonii), deoarece pot exista mai multe celule aglomerate care formează o colonie, iar în cazul mucegaiurilor există fragmente multicelulare de hife; în plus, există destule celule izolate care nu formează colonii. Se vor alege plăcile care conțin între 30 şi 300 colonii.

Numărul de unități formatoare de colonii este dat de formula:

UFC/mL = nr. colonii · coeficientul de diluție

Pentru experiment s-a hotărât să se folosească două tipuri de sol: un tip de sol extras dintr-o zonă naturală, o grădină, identificat ca S1; unul ce poate fi obținut din comerț şi este folosit pentru plantarea de flori şi pentru că are în compoziție o cantitate mare de humus, identificat ca S2.

Methoda Koch a fost aplicată pentru toate cele cinci concentrații (pentru fiecare tip de sol) şi de asemenea şi pentru o probă martor din fiecare tip de sol.

Cercetarea va observa influența concentrației de poluant asupra microbiotei solului după o contaminare artificială şi va folosi plante pentru a vedea cum este influențată microbiota.

Analizele au fost realizate în cadrul Laboratorului de Microbiologie de la Facultatea de Ingineria Sistemelor Biotehnice a Universității Politehnica din Bucureşti.

Fiecare tip de sol a fost contaminat artificial cu motorină. Contaminantul a fost procurat de la o stație de combustibil locală. După contaminare fiecare probă a fost amestecată foarte bine şi lăsată să se omogenizeze. Analizele inițiale au fost făcute după ce probele au fost în contact cu contaminantul o săptămână.

De fiecare dată când metoda a fost aplicată, principalii paşi au fost următorii:

a) 1 mg de sol contaminat (sau sol curat pentru proba martor) a fost cântărt şi combinat cu 10 ml de apă;
b) 1 ml din proba combinată de la pasul 1 a fost extras şi combinat cu alți 10 ml de apă;
c) La sfârşit 1 ml de soluție din pasul 2 a fost extras şi pus pe o placă Petri;
d) Următorul pas a fost să se introducă mediul de cultură necesar pentru dezvoltarea microbiotei, şi să omogenizeze proba prin mişcări circulare şi lăsată să se solidifice;
e) Plăcile Petri au fost introduse la 250^0 C şi dupa 24 de ore s-a determinat numărul de colonii

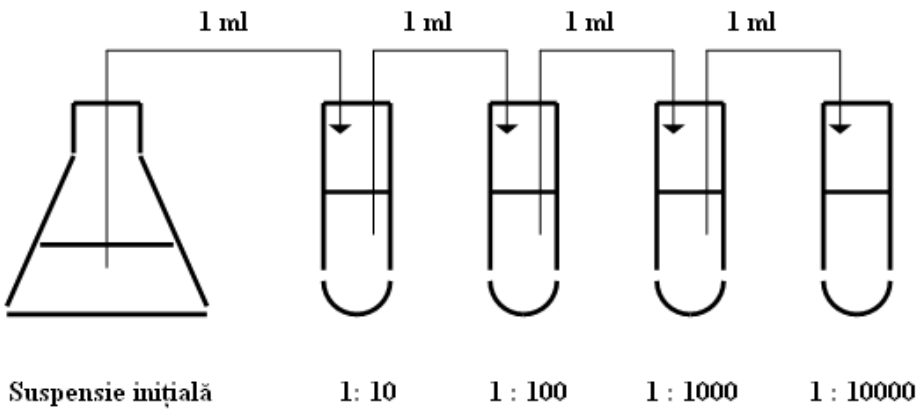


Fig. 1 – The technic for obtaining decimal dilutions [5]

RESULTS

During the experiments, two types of cultures were used. One is plate count agar and the other is chloramfhenicol yeast glucose agar. For eache type of culture the parameter that were monitored were:pH and the UFC/ml (colonies fomation units/ml).

Moreover, the experiments were done on two types of soils: a natural one (taken from a garden) and called S1, and a commercial one (taken from commerce) valled S2

The experimental research consisted in testing five concentrations for the pollutant. These concentrations were 1%, 5%, 10%, 15% and 20% of diesel in soil.

The diference between this type of research and the previous ones is that, in this case in the polluted soil were planted some plants in order to observe how the parameters are changed.

Beside the samples contaminated with five different concentration, there was for each type of soil, a witness sample.

In figure 2, the two witness samples are presented after 1 week from the contamination of the other samples for both cultures. In figure 3, 4, 5, 6 and 7 the Petri plates after one week of contaminaton for both types of soils, for both culture types are presented.

It can be noticed that for the second type of soil, S2, the number of vizible colonies are significant higher for both type of culture medium (PCA and CYG) compared with S1 type of soil.

REZULTATE

În timpul experimentelor, au fost folosite două tipuri de culturi. Una este plate count agar şi cealaltă este chloramfhenicol yeast glucose agar. Pentru fiecare tip de cultură s-au monitorizat următorii parametri: pH şi UFC/ml (unități formatoare de colonii/ml).

Mai mult decât atât, experimentele au fost realizate pe două tipuri de soluri: un tip natural (luat dintr-o grădină) şi numit S1; şi unul comercial (cumpărat din comerț) şi numit S2.

Cercetarea experimentală a constat în testarea a cinci concentrații de poluant. Aceste concentrații au fost de 1%, 5%, 10%, 15% şi 20% de motorină în sol.

Diferența dintre acest tip de cercetare şi cele dinainte constau în faptul că, în acest caz în solul poluat au fost plantate nişte plante pentru a observa cum se modifică parametrii.

În afara de probele contaminate cu cele cinci tipuri de concentrații, a existat pentru fiecare tip de sol şi o probă martor.

În figura 1, sunt prezentate cele două probe martor la o săptămână după contaminarea celorlalte probe, pentru ambele culturi.În figurile 3, 4, 5, 6 şi 7 sunt prezentate plăcile Petri după o săptămână de la contaminare pentru ambele tipuri de soluri, şi ambele tipuri de medii de cultură.

Se poate observa că pentru al doilea tip de sol, S2, numărul vizibil de colonii este semnificativ mai mare pentru ambele medii de cultură comparativ cu S1.

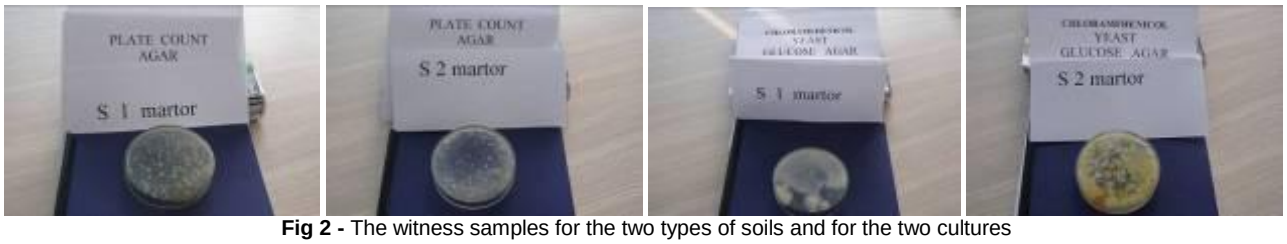
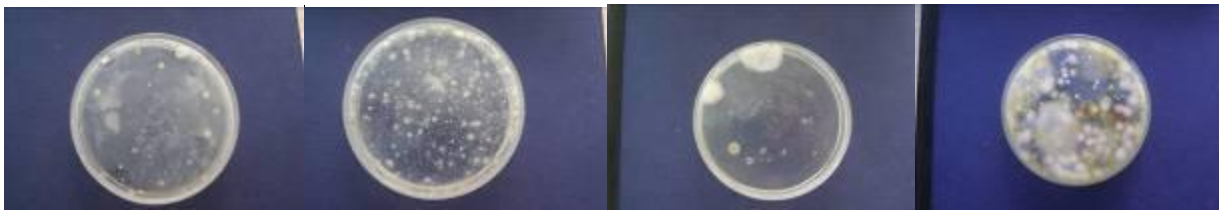
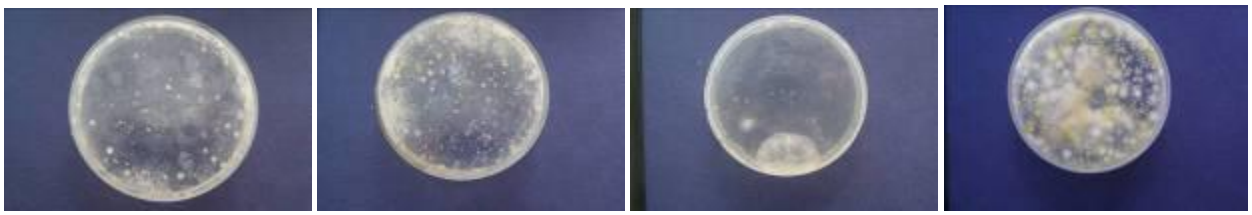


Fig 2 - The witness samples for the two types of soils and for the two cultures



a) b) c) d)

Fig 3 - Sample contaminated 1%: a) S1 – PCA; b) S2 – PCA; c) S1 – CYG; d) S2 – CYG



a) b) c) d)

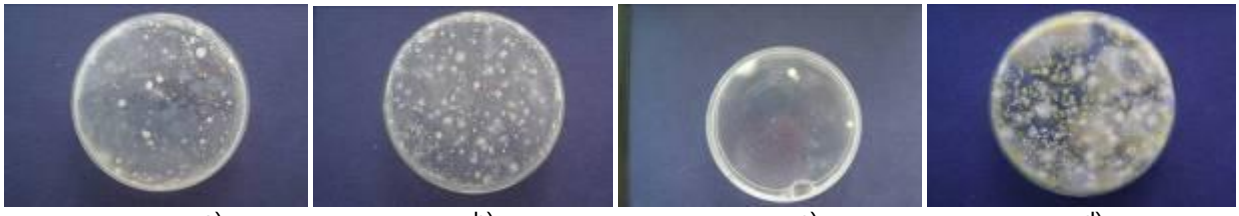
Fig 4 - Sample contaminated 5%: a) S1 – PCA; b) S2 – PCA; c) S1 – CYG; d) S2 – CYG

a) b) c) d)

Fig 5 - Sample contaminated 10%: a) S1 – PCA; b) S2 – PCA; c) S1 – CYG; d) S2 – CYG

a) b) c) d)

Fig 6 - Sample contaminated 15%: a) S1 – PCA; b) S2 – PCA; c) S1 – CYG; d) S2 – CYG



a) b) c) d)

Fig 7 - Sample contaminated 20%: a) S1 – PCA; b) S2 – PCA; c) S1 – CYG; d) S2 – CYG

The values for pH during the four weeks of experiments, did not vary to much, except for the samples 5% contaminated and 20% contaminated for S1 and 5% contaminated for S2.

Between the two types of soils, it can be noticed that for the natural one the values are a little bit higher compared with the ones for S2 soil. The pH variation is presented in figure 8 and figure 9.

Valorile pentru pH în timpul celor patru săptămâni de experiment nu au variat foarte mult, cu excepția probelor contaminate cu 5% şi 20% pentru S1 şi cu 5% pentru S2.

Între cele două tipuri de soluri, se poate observa că pentru cel natural valorile sunt un pic mai mari comparativ cu cele obținute pentru S2. Variatia pH este prezentată în figura 8 şi figura 9.

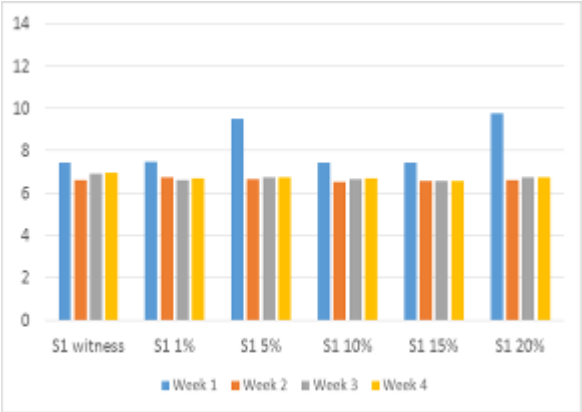


Fig. 8 - pH variation for S1 type of soils – for PCA

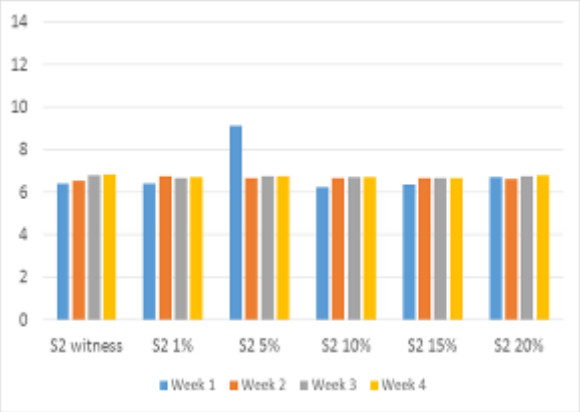


Fig. 9 - pH variation for S2 type of soils – for PCA

Regarding the colonies number for both types of

În ceea ce priveşte numărul de colonii pentru ambele

culture medium, it is observed that the polluted soil seems to be appropiate for the development of biological life.

The variations are presented in figure 10 and figure 11 for PCA medium culture and figure 12 and figure 13 for CYG medium culture.

medii de cultură se observă că solul poluat pare să fie bun pentru dezvoltarea fieții biologice.

Variațiile sunt prezentate în figura 10 şi în figura 11 pentru mediul de cultură PCA şi în figura 12 şi figura 13 pentru mediul de cultură CYG.

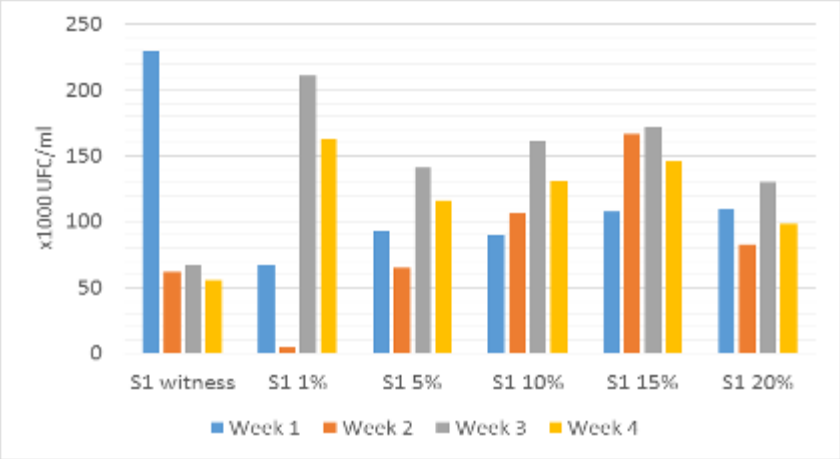


Fig.10 - UFC/ml values for S1 type of soil and for PCA medium culture

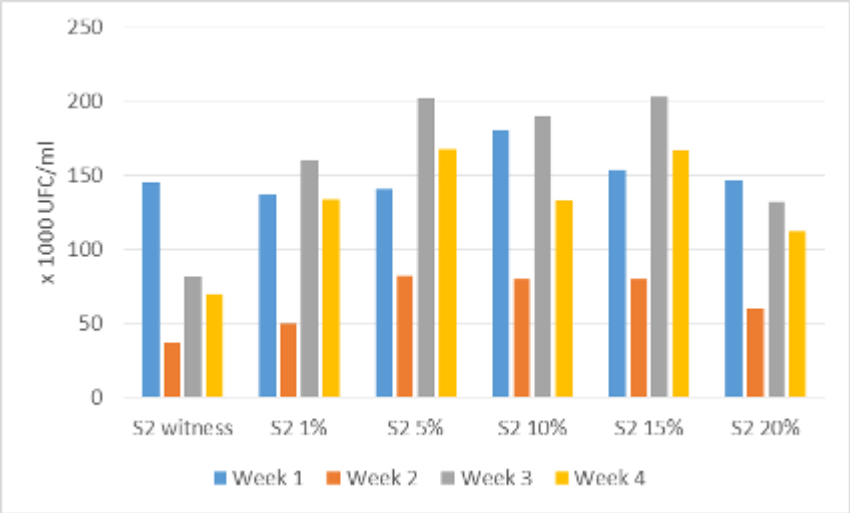


Fig. 11 - UFC/ml values for S2 type of soil and for PCA medium culture

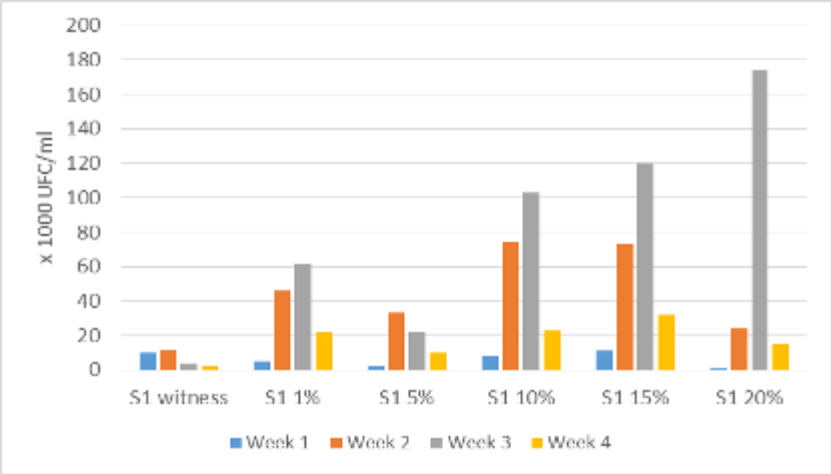


Fig.12 - UFC/ml values for S1 type of soil and for CYG medium culture

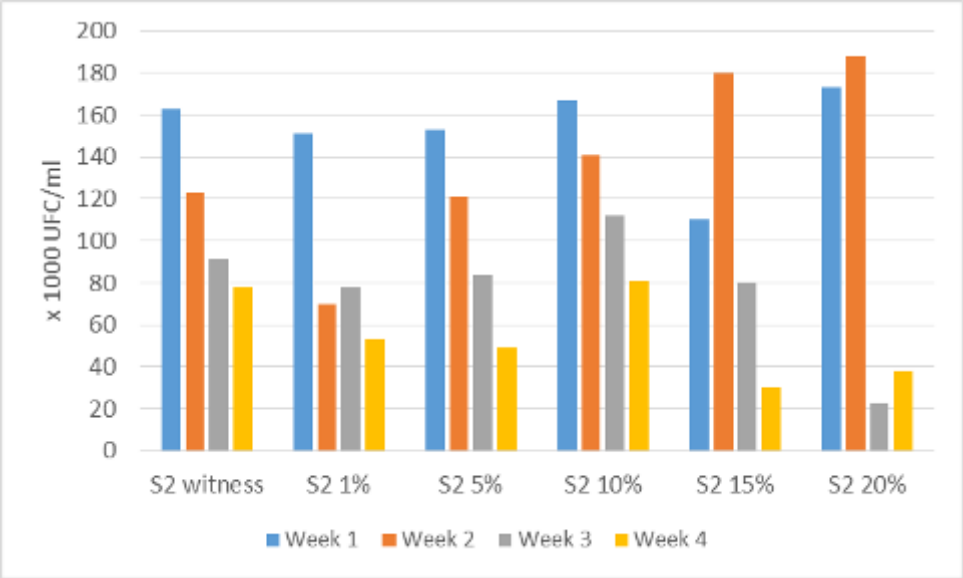


Fig. 11 - UFC/ml values for S2 type of soil and for CYG medium culture

CONCLUSIONS

When can be observe the presence of a plant in a soil, even if the soil is contaminated, it seems that the plant can help the soil to maintain the properties necessary to readapt.

The values of UFC after 4 weeks are higher for the medium culture PCA compared with CYG. The problem that appears is the high difference between the initial values of UFC and the ones after 1 month of contamination. The final values are around 100 x1000 UFC/ml for both soil S1 and S2 for PCA medium culture, and below 40 x 1000 UFC/ml for CYG medium culture.

The problem could be partially resolved if the contaminated soil will be mixed with a clean soil in order to repopulate the biological environment.

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CONCLUZII

Când se poate observa prezența unei plante într-un sol, chiar dacă este contaminat, se observă că planta poate ajuta solul să-şi mențină proprietățile necesare să se readapteze.

Valorile pentru UFC după 4 săptămâni sunt mai mari pentru mediul de cultură PCA comparativ cu CYG. Problema care apare este diferența mare dintre valorile inițiale de UFC şi cele de după o lună. Valorile finale sunt în jur de 100 x 1000 UFC/ml pentru ambele tipuri de soluri S1 şi S2 pentru mediul de cultură PCA, şi sub 40 x 1000 UFC/ml pentru mediul de cultură CYG.

Problema ar putea fi parțial rezolvată dacă solul contaminat ar fi amestecat cu sol curat pentru aputea repopula mediul biologic.

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CONSIDERATIONS ON THE IMPORTANCE OF THE PAULOWNIA TREES PLANTING

CONSIDERAȚII PRIVIND IMPORTANȚA PLANTĂRII ARBORILOR PAULOWNIA

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Abstract: *In this paper are presented as rich and updated information about the importance and the planting technology of Paulownia trees in order to capitalize the hardwood, with beautiful appearance, clean, smooth, free of knots and with a high degree of machinability, used for the manufacture of sawn wood, for the construction of yachts, light aircrafts, expensive furniture and musical instruments.*
The paper is aimed to the farmers with larger farms and to the sylviculturists which will plant this wonderful trees representing a sustainable source of biofuels, being an energetic plant which grows and is harvested like any tree, which may become firewood, briquettes, pellets and, although burns at higher temperatures, release large amounts of energy and can contribute to solving the global energy crisis.

Key words: *Paulownia, biomass, princess tree, phoenix tree.*

Rezumat: *În prezenta lucrare sunt prezentate informații cât mai bogate şi actualizate despre importanța şi tenologia de plantare a arborilor Paulownia în vederea valorificării lemnului de esență tare, cu aspect frumos, curat, neted, fără noduri şi cu un grad ridicat de prelucrabilitate, utilizat pentru fabricarea cherestelei, pentru costrucția de iahturi, avioane uşoare, instrumente muzicale şi mobilă scumpă.*
Lucrarea se adresează fermierilor în exploatații mai mari, şi silvicultorilor, care vor planta aceaşti arbori minunați, care reprezintă o sursă durabilă de bio-combustibi, fiind o plantă energetică, care creşte şi se recoltează precum orice copac, dar poate deveni lemn de foc, brichete, peleți şi, deşi arde la temperaturi mai mari, degajă multă energie, putând contribuii la rezolvarea crizei energetice mondiale.

Cuvinte cheie: *Paulownia, biomasă, copacul prințesei, copacul păsării Pheonix.*

INTRODUCTION

The deciduous tree Paulownia, Figure 1, or princess tree, also called "the aluminum of the wood" because of its resistance is a tree with broad crown, thick stems with large leaves and mauve flowers and perfumed [1]. Paulownia tree belongs to the mono generic Paulowniaceae family, related and included in the the family Scrophulariaceae [5]. It originated in China, Laos and Vietnam, but it is also grown in other parts of the Far East, especially in Japan and Korea. Paulownia is cultivated in China for at least 3000 years, in the U.S. from 1800 and in Japan since 1970, when the wood has become an export business of billions of dollars. It is very popular in China for reforestations, planting on the roadside and as an ornamental tree, being a hardwood tree, but lightweight and with very fast growth. The timber obtained has a yellowish white color, silvery or light brown, depending on variety, is highly resistant and also aesthetic (fine texture, without knots).

INTRODUCERE

Arborele foios Paulownia, fig.1, sau copacul prințesei, supranumit datorită rezistentei lui şi "aluminiul lemnului ", este un arbore cu coroană largă, lujeri groşi cu frunze mari şi flori liliachii şi parfumate [1]. Arborele Paulownia face parte din familia monogenerică Paulowniaceae, înrudită şi inclusă în familia Scrophulariaceae [5]. Este originară din China, Laos şi Vietnam, dar cultivată şi în alte părti din Extremul Orient, mai ales în Japonia şi Coreea. Paulownia este cultivată în China de cel puțin 3000 ani, în S.U.A. din anul 1800, iar în Japonia din anul 1970, când lemnul a devenit o afacere de export de miliarde de dolari. Este foarte popular în China pentru reîmpăduriri, plantarea pe marginea drumului şi ca arbore ornamental, fiind un arbore cu un lemn de esență tare, dar uşor şi care creşte foarte repede. Lemnul obținut are culoarea alb gălbuie, argintie sau brun deschis, în funcție de soi, este foarte rezistent dar şi estetic (textură fină, fără noduri).

Fig. 1 - Paulownia Plantation **/** *Plantație de Paulownia* [8]

If hundreds of years ago the Chinese planted this tree

Dacă în urmă cu sute de ani chinezii plantau acest

almost entirely for ornamental purposes, the massive deforestations that occurred in the last two decades, the woodworking industry development, the increasing demand for timber, the emergence and development of more and more plants using biomass for energy production as well as the accelerated growth of the price of wood turns every Paulownia plantation into a real gold mine for its owners [12]. The rapid growth of the Paulownia tree makes it extremely suitable for obtaining of large amounts of biomass (60-80 t/ha) in a short period of time [7].

MATERIAL AND METHOD

- **Spreading**

Ideal for the Paulownia tree is the temperate climate with minimum temperatures between -19° C and + 3.9° C (for Tomentosa species) and up to -26° C (for Elongata species) [2]), and according to [9], the maximum average temperatures may range between 31 and 42.7° C. It is found at altitudes starting about from the sea level, up to about 2400 m [1].

There are over 20... 23 species of Paulownia and are similar in terms of appearance and properties of the wood mass, but are scientifically designed and acclimatized to different environmental conditions. Shantong type trees are frost tolerant hybrids, obtained by multiplying in vitro Paulownia Tomentosa and Fortune Paulownia species [16]. Shantong hybrid that was developed in China in 1982 can withstand temperatures of minus 29° C and has a faster growth and a higher resistance to drought than the basic species, having a higher capacity for regeneration and production of valuable hardwood timber, being adapted to the weather conditions from Romania.

It arrived at this wonderful tree only now, when mankind has realized that the forests are destroyed and the carbon dioxide emissions are extremely high, all this inevitably leading to the gradual and rapid degradation of the planet. The interest for the recycling of the lands polluted by industry, the binding of enormous amount of carbon dioxide and the increasing demand for energetic plants have created the need for attention and researches to be given increasingly higher. In Europe this species has spread through the medium of France, who took over from Japan and not from China, where has its origins and which may contribute to increasing the alternative energy sources, offering a chance to supplement the reserves of the Earth. Such an opportunity is considered to be Paulownia, because, due to its fast growth, the large amount of wood obtained could be used both for heating and for the production of furniture or for the use in the construction.

- **Environmental conditions**

Paulownia tolerates a wide range of soil types, but nonetheless the deep and fertile soils are required for an optimal growth [1]. Are preferred clay soils sandy and loosened or those loamy, to which the groundwater level is less than 1.5 m...2 m and where there is no cliff up to a depth of 6 m. Hydric requirements are of 750 mm³ / year. The trees lose their leaves and may even die after the land was flooded for a short period of 3...5 days. The salty soil and the water can also affect the growth. In order to ensure the maximum growth, the irrigation may be necessary throughout the development cycle.

Generally, Paulownia does not tolerate a low level of light, growing the best in the direct sunlight, being it required a daily average temperature of about 24....29° C [1].

- **Features and benefits of the plantation**

arbore aproape în totalitate în scop ornamental, defrişările masive care au avut loc în ultimele două decenii, dezvoltarea industriilor prelucrătoare a lemnului, creşterea cererii de cherestea, apariția şi dezvoltarea a tot mai multor centrale care folosesc biomasa pentru producerea de energie precum şi creşterea accelerată a prețului lemnului, transformă fiecare plantație de Paulownia într-o adevarată mină de aur pentru proprietarii ei [12]. Creşterea rapidă a Paulowniei îl face extrem de potrivit pentru obținerea de cantități mari de biomasă (60-80 t/ha) într-o perioadă scurtă de timp [7].

MATERIAL ŞI METODĂ

- **Răspândirea**

Ideal pentru arborele Paulownia este clima temperată cu temperaturi minime cuprinse între -19 °C şi +3,9 °C (în cazul speciei Tomentosa) şi până la -26 °C (în cazul speciei Elongata [2]), iar conform [9], temperturile medii maxime pot varia între 31 °C şi 42,7 °C. Se găseşte la altitudini care încep aproape de nivelul mării, până la aproximativ 2400 m [1].

Există peste 20...23 specii de Paulownia şi sunt similare în ceea ce priveşte aspectul şi proprietățile masei lemnoase, dar sunt concepute şi aclimatizate în mod ştiințific la diferite condiții de mediu. Arborii de tipul Shan Tong sunt hibrizi rezistenți la îngheț, realizați prin înmulțirea în-vitro din speciile Paulownia Tomentosa şi Paulownia Fortunei [16]. Hibridul Shan Tong, care a fost dezvoltat în China în 1982, poate rezista la temperaturi de minus 29 °C, are o creştere mai rapidă, şi o rezistență mai mare la secetă, decât specia de bază, având o capacitate de regenerare şi o producție de lemn de esență tare valoros mai mare, adaptat la condițiile meteorologice din România.

S-a ajuns la acest copac minunat abia acum când omenirea, şi-a dat seama că pădurile sunt distruse iar emisiile de dioxid de carbon sunt extrem de ridicate, toate acestea ducând inevitabil la distrugerea treptată şi rapidă a planetei. Interesul pentru reciclarea terenurilor poluate de industrie, legarea cantității imense de dioxid de carbon, şi cererea în creştere pentru plante energetice, au făcut necesară acordarea unei atenții şi cercetări din ce în ce mai mari. În Europa a fost răspândită prin intermediul Franței, care a sosit din Japonia şi nu din China, unde îşi are originile şi care poate contribuii la creşterea surselor alternative de energie, oferind o şansă pentru suplinirea rezervelor Terrei. O astfel de oportunitate este considerată Paulownia, deoarece datorită creşterii sale rapide, cantitatea mare de lemn obținut ar putea fi utilizată atât pentru încălzire, cât şi pentru fabricarea mobilelor, respectiv pentru prelucrarea în construcții.

- **Condiții de mediu**

Paulownia tolerează o gamă largă de tipuri de sol, dar cu toate acestea solurile adânci şi fertile sunt necesare pentru o creştere optimă [1]. Sunt de preferat solurile argiloase nisipoase afânate sau cele argiloase, la care nivelul freatic este sub 1,5 m... 2 m şi unde nu există stâncă până la o adâncime de 6 m. Cerințele hidrice sunt de 750 mm³/an. Arborii se defoliază şi pot chiar muri după ce terenul a fost inundat pentru o perioada scurtă de 3 ... 5 zile. Solul sărat şi apa pot de asemenea afecta creşterea. Pentru a asigura creşterea maximă, irigarea poate fi necesară pe întreaga durată a ciclului de dezvoltare.

În general, Paulownia nu tolerează un nivel scăzut de lumină, crescând cel mai bine la lumina directă a soarelui, fiindu-i necesară o temperatură medie zilnică de aproximativ 24 °C.... 29 °C [1].

Paulownia trees are regenerating from the existing root systems, being able to harvest between minimum 3 and maximum 5 turns (cycles 3 ... 4 years) of growth of the wood without the need for replanting, deservedly earning nickname of the Phoenix bird tree;

Its deeply rooted system gives it the possibility of greening the degraded soil surfaces. It has deep pivoting root of 10...12 m whose role is to stabilize soil, saving it of landslides and maintaining the underground water systems. Paulownia trees are resistant to drought, their roots penetrate deep into the soil once fixed looking for water, more than at the surface.

Paulownia leaves are heart-shaped having a diameter of (15 ... 40)x10^{-2} m, being arranged in pairs on opposite branches and having a rapid growth and a huge capacity of absorbing the carbon dioxide (in a year can absorb 100 tons of CO^2 /ha per plantation) and producing 75 tons of oxygen. They can be used for the manufacture of medicaments (because they contain substances that positively affects the liver, kidney, gallbladder, lung diseases) also for feeding of animals, or as organic fertilizer [3]. In summer, during a hot day it is normal that Paulownia leaves to wilt, this one being a mechanism to avoid the excessive perspiration. If the trees are withered because it is warm but the ground is wet, the leaves will rise again when it cools, in the evening. The fallen leaves in autumn on the ground are rich in nutrients and helps at feeding these trees;

Paulownia leaves have also properties that can be used in the cosmetic industry, for the production of perfumes and creams. Also the flowers can be used for the same purpose, their aroma being one of vanilla or almond. It was demonstrated that this is due to the heliotropine content [13];

One of the most promising applications is the manufacture of bioethanol from cellulose by two methods, namely: using microorganisms especially cultured for this purpose, or by relying on the effect of certain enzymes;

It is the fastest growing tree in the world, in the early years may grow about 2-3 m / year [6]. In contrast with other fast-growing trees which have a short life, a healthy Paulownia tree can withstand for 80 to 100 years [3]. It is perfectly ornamental, it has gorgeous flowers flowering abundantly in the spring, before of leaf emergence, with big flowers lilac and beautiful spreading a discreet scent of violets particularly pleasant, being used in manufacture of perfumes. The flowers appear in early spring in bunches long of (10 ... 20)x10^{-2} m, with a corolla (petals) tubular in purple nuances, the flower resisting at least a month;

It is a good tree melliferous, being more prolifically than the acacia in the production of honey, the flowers are very appreciated by the bees for the production of honey, which is flavored, light coloured, of about 700 ... 1000 kg of honey / ha, (a single hive producing 10 ... 15 kg of honey of highest quality during the flowering season, compared to that of acacia) [7];

Due to the existing hairs to the underside of the leaves and of the the stem, the tree is a good sound absorber. Banish the insects, absorbs the noise and dust (a hectare of plantation cancels an annual quantity of 48 tons of dust and air pollutants) [3];

The fruit is a dry capsule containing 1200 ... 2300 of small seeds, with fins, having the mass of 1000 grains of 0.15 g and germinating power of 80 ... 90% [9]. The seeds, which contain a highly valued oil in the Far East, enters in the manufacturing of varnishes used for the impregnation of various materials [9]. Paulownia

- **Caracteristicile şi beneficiile plantaţiei**

Arborii Paulownia se regenerează de la sistemele existente de rădăcină, putându-se recolta între minim 3 şi maxim 5 rotaţii (cicluri de 3 ... 4 ani) de creştere a lemnului fără a fi nevoie de replantare, câstigând pe merit apelativul de copacul păsării Pheonix;

Sistemul sau de rădăcini profunde îi dă posibilitatea de a ecologiza suprafeţele degradate de sol. Are rădăcină pivotantă adâncă de 10 m... 12 m având rolul de a stabiliza solul, salvându-l de alunecări de teren şi menţinând sistemele subterane de apă. Arborii Paulownia sunt rezistenţi la secetă, rădăcinile lor odată fixaţe intră adânc în pământ, în căutarea apei, mai mult decât la suprafaţă;

Frunzele de Paulownia sunt în formă de inimă cu diametrul de (15 ... 40)x10^{-2} m, fiind dispuse în perechi opuse pe ramuri şi având o creştere rapidă şi o capacitate imensă de absorbţie a bioxidului de carbon (putând absorbii într-un an 100 tone de CO_2/ha de plantaţie) şi producând 75 tone de oxigen. Ele`pot fi folosite pentru fabricarea unor medicamente (deoarece conţin substanţe care influenţează pozitiv activitatea ficatului, rinichilor, vezicii biliare, al bolilor de plămâni) şi pentru furajarea unor animale, sau ca îngrăşământ ecologic [3]. Vara în timpul unei zile fierbinţi este normal ca frunzele de Paulownia să se ofilească, acesta fiind un mecanism de evitarea transpiraţiei excesive. În cazul în care copacii sunt ofiliţi, pentru că este cald dar solul este umed, frunzele se vor ridica din nou atunci când se răceşte seara. Frunzele căzute toamna pe sol sunt bogate în nutrienţi şi ajută la hrănirea acestor arbori;

Frunzele de Paulownia au şi proprietăţi care pot fi folosite în industria cosmeticii, la producerea de parfumuri sau diferite creme. Şi florile pot fi folosite în acelaşi scop, aroma acestora fiind una de vanilie sau migdale. S-a demonstrat ca acest lucru se datorează conţinutului de heliotropină [13];

Una dintre aplicaţiile cele mai promiţătoare este cea de fabricare a bioetanolului din celuloză, prin două metode şi anume: folosind microorganisme speciale cultivate în acest scop, sau bazându-se pe efectul anumitor enzime;

Este copacul cu cea mai rapidă creştere din lume, putând să crească în primii ani circa 2-3 m/an [6]. Spre deosebire de alţi arbori cu creştere rapidă, care au o durată de viaţă scurtă, un arbore Paulownia sănătos poate rezista timp de 80 până la 100 de ani [3]. Este perfect ornamental, are flori superbe, înflorind abundent primăvara, înainte de înfrunzire, cu flori mari liliachii şi frumoase care împrăştie un miros discret de violete deosebit de plăcut, fiind folosite la fabricarea parfumurilor. Florile apar primăvara devreme în buchete lungi de (10 ... 20)x10^{-2} m, cu o corolă (petale) tubulară în nuanţe violet, floarea rezistând cel puţin o lună;

Este un bun arbore melifer, fiind mai prolific decât salcâmul la producţia de miere, florile sunt foarte apreciate de albine pentru producţia de miere, care este aromată, de culoare deschisă, de circa 700 kg ... 1000 kg miere/ha, (un singur stup producând 10 kg... 15 kg de miere în timpul sezonului de inflorire de cea mai înaltă calitate, comparată cu cea de salcâm) [7];

Datorită perişorilor existenţi pe partea inferioară a frunzelor şi a peţiolului, arborele este un bun absorbant al zgomotelor. Alungă insectele, absoarbe zgomotul şi praful (un hectar de plantaţie anulează o cantitate anuală de 48 de tone de praf şi poluanţi ai aerului) [3];

Fructul este o capsulă uscată care conţine 1200 ...2300 de seminţe mici, aripate, având masa a 1000 de boabe de 0,15 g., şi o putere de germinaţie de 80...90 % [9]. Seminţele, care conţin un ulei extrem de apreciat în Extremul Orient, intră în fabricarea unor lacuri, utilizate pentru impregnarea diferitelor materii prime [9]. Paulownia produce seminţe după vârsta de 8 ani, într-un gram de

produces seeds after the age of 8 years, into a gram of Paulownia seeds existing about 6000 pieces, and a mature tree can produces 20 million seeds [15]. Autumn is the best season for harvesting the seed of Paulownia. The optimum temperature for seed germination is of 26°C. These are sown on the surface and are covered with a thin layer of soil or may to be not covered at all. Soil has to be moist, but not in excess. Paulownia seeds need light and oxygen to germinate. Can be used the natural light or the artificial light. The time of germination of the Paulownia seeds is between 7 and 21 days;

The wood is resistant to twisting (grows straight, clean and smooth), is resistant to contraction (no splits, no cracks) and to deformations, it is stable during the modifications of humidity. feels few downsizing or dilatations compared to most other types of wood, It has a fine texture, which makes from Paulownia a tree with exceptional wood for boats, pallets, household furniture, as well as plywood, houses, prefabs, semi-products and internal panels for construction [2];

Recently this tree has received a great attention for its beneficial environmental properities and was presented as a possible solution to the problem of deforestation at globally level, issue that is central to the debate on climate change, plantations representing a curtain good forestry protrction belt;

It has a very good fire resistance, having a high ignition temperature of 420...430°C compared with the average of hardwoods at which the ignition temperature is of 220 .... 225° C;

Paulownia is an exotic tree from which are used all parts of the tree [5] as the trunk, leaves, flowers and seeds (fig. 2), the whole tree with its remarkable growth being a treasure for environmentalists.

semințe de Paulownia existând aproximativ 6000 de bucăți, iar un copac matur putând produce 20 de milioane de semințe [15]. Toamna este anotimpul optim pentru recoltarea semințelor de Paulownia. Temperatura optimă pentru germinarea semințelor este de 26 °C. Acestea se seamănă la suprafață şi se acoperă cu un strat subțire de pământ sau pot să nu fie acoperite deloc. Solul trebuie să fie umed, însă nu în exces. Semințele de Paulownia au nevoie de lumină şi oxigen pentru germinare. Se poate folosi lumina naturală sau lumină artificială. Timpul de germinare al semințelor de Paulownia este cuprins între 7 şi 21 de zile;

Lemnul are rezistență la contorsionare (creşte drept, curat şi neted), are rezistență la contracție (nu se despică, nu crapă) şi la deformări, este stabil pe parcursul modificărilor de umiditate. Resimte puține micşorări sau dilatări în comparație cu majoritatea altor tipuri de lemn, are o granulație fină, fapt care face din Paulownia un copac cu lemn excepțional pentru bărci, paleți, mobilier de uz casnic, precum şi placaj, case, prefabricate, semifabricate şi panouri interne de construcție [2];

Recent acest arbore a primit o mare atenție pentru proprietățile sale benefice pentru mediu şi a fost prezentat ca o posibililă soluție la problema defrişărilor la nivel mondial, problemă care se află în centrul dezbaterii privind schimbările climatice, plantațiile reprezentând o perdea forestieră de protecție bună;

Are o rezistență la foc foarte bună, având temperatura de aprindere mare de 420 °C... 430 °C în comparatie cu media lemnului de esență tare la care temperatura de aprindere este de 220 °C.... 225 °C;

Paulownia este copac exotic, de la care sunt folosite toate componentele copacului [5], ca trunchiul, frunzele, florile şi semințele (fig. 2), întregul arbore cu remarcabila sa creştere fiind o comoară pentru ecologişti.

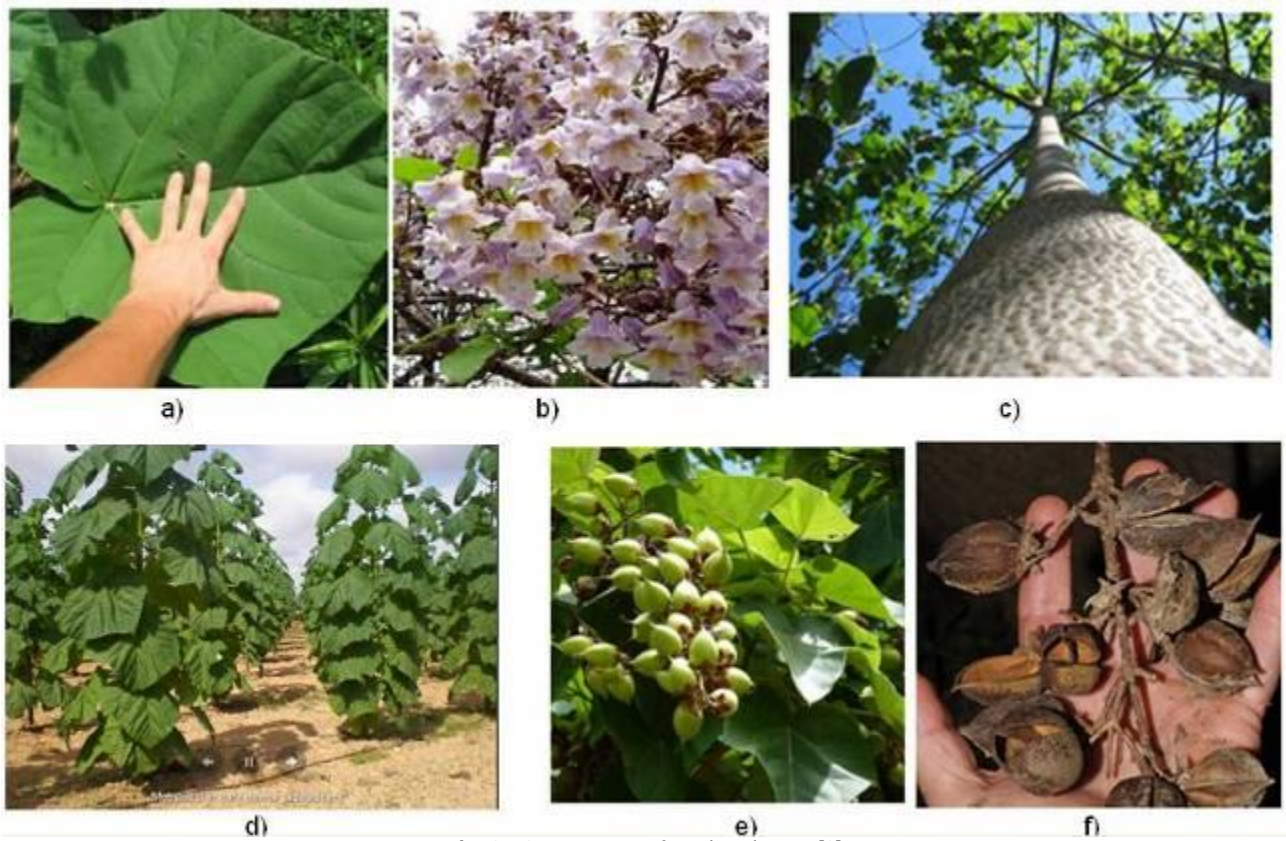

Fig. 2 - Components of Paulownia tree [8]
a - leaves; b - flowers; c, d - trunk; e - capsules with green seed ; f - capsules with dry seed

From the Paulownia Shan Tong approx. 70% can be

Din arborele Paulownia Shan Tong cca. 70% poate fi

used for the manufacturing of timber, and 30% for the production of pellets, briquettes or biomass for the factories that use gasification in order to obtain green energy [11];

As firewood performs very well, having a calorific power of 15407 kJ/kg (3680 kcal/kg) [3]. For instance, the calorific power released by 2 kg of Paulownia wood is equal to that released by 1 liter of diesel oil and is comparable with the types of coal quality [4];

It is a light wood (2 times lighter than oak, with a density of 300-330 kg/m^3) and it is 2 times more resistant to fire than usual beech wood, being a wood with a very low humidity degree (15%), itself being not affected by moisture. It is a very good insulator, it is easy to dry (the outdoor drying being performed in a time of 30-60 days without curving, deforming, bursting or cracking) and shows a high degree of processability being also known as the "aluminum timber". From tree bark are produced special paints. It has low silicon content and reduces a lot the processing tools attrition, bringing sentient savings in the production peocess.

RESULTS

Cultivation technology

- **Land preparation**

Sapling planting technologies (in greenhouses and tree nurseries) as well as the monitoring of their behavior into experimental crops, starting from the harvesting of the seeds, performing tests of germination, planting, maintenance (weeding of weeds and soil mobilization), irrigation, pricking-out, etc., are not the subject of this paper, of these technologies being engaged the experimental research resorts. This material merely offer information related from preparing the ground, Paulownia seedlings or cuttings planting and the maintenance of the culture up to its harvest.

Choice of the place to establish plantations of Paulownia involves the identification of a land with a sunny exposure (SE, S, SV), with well drained soil, with a slight slope, preferring sites sheltered from cold winds in winter.

The land is plowed deep in autumn at (35 ... 40) x 10^{-2} m) and then is worked with the rotary hoe or is applyed a disking tillage, after which can be applied herbicides for weeds, and at 3 weeks after the application of herbicides the saplinggs can be planted [10]. The application of NPK fertilizers (in ratios of 14:10:20 or 12:10:18), as basic fertilization is recommended of course [12]. If using a borer with a diameter of 60 cm and carry out holes at the depth of (60 ... 100) x 10^{-2} m, it is possible to no longer carry out the plowing in autumn [13].

- **Planting**

Planting of the 1 year saplings, having a minimum diameter at the base of the stem of 1.0 cm, must be made in holes of at least (30 x 30 x 30)x10^{-2} m in soil sloppy in the fall [9], or at a depth of one meter and a diameter of 30 x 10^{-2} m [12], after which the holes are filled with a mixture of peat, osmocote (a coated fertilizer containing nitrogen, phosphorus, potassium and

folosit pentru fabricarea cherestelei, iar 30% pentru producerea de peleți, brichete sau biomasă pentru uzinele care folosesc principiul gazeificării în vederea obținerii de energie verde [11];

Ca lemn de foc se comportă excelent are o putere calorică de 15407 kJ/kg (3680 kcal/kg) [3]. De exemplu puterea calorică eliberată 2 kg lemn Paulownia este egală cu cea eliberată 1 litru de motorină, şi este comparabilă cu tipurile de cărbune de calitate [4];

Este un lemn uşor (de 2 ori mai uşor decât stejarul, având o densitate de 300-330 kg/m^3) şi este de 2 ori mai rezistent la foc decât lemnul obişnuit de fag, fiind un lemn cu grad foarte redus de umiditate (15%), el însuşi nefiind afectat de umezeală. Este un foarte bun izolant, este uşor de uscat (uscarea în aer liber putându-se efectua întru-un timp de 30-60 de zile, fără a se curba, deforma, crăpa sau secționa) şi prezintă un grad mare de prelucrabilitate fiind cunoscut şi sub numele de “aluminiul din lemn”. Din coaja arborelui se produc vopsele speciale. Are conținut scăzut de siliciu şi reduce mult tocirea dispozitivelor de prelucrare, aducând economii simțitoare în procesul de producție.

REZULTATE

Tehnologia de cultură

- **Pregătirea terenului**

Tehnologiile de producere a puieților (în sere şi pepiniere) precum şi urmărirea comportării lor în culturi experimentale, începând de la recoltarea semințelor, efectuarea probelor de germinație, semănat, lucrări de întreținere (plivirea buruienilor şi mobilzarea solului), irigat, repicat, etc., nu fac obiectul acestei lucrări, de aceste tehnologii ocupându-se stațiunile de cercetări experimentale. Acest material oferă doar informații referitoare începând cu pregătirea terenului, plantarea puieților sau butaşilor de Paulownia, operațiile de întreținere a culturii până la recoltarea acesteia.

Alegerea locului pentru înființarea plantației de Paulownia presupune identificarea unui teren cu o expoziție însorită (SE, S, SV), cu sol bine drenat, cu o uşoară pantă, preferând şituri ferite de vânturile reci din timpul iernii.

Terenul se ară profund din toamnă la (35 ... 40) x 10^{-2} m) şi apoi se prelucrează cu freza rotativă sau se discuieşte, după care se poate erbicida pentru buruieni, iar la 3 săptămâni de la erbicidare se pot planta butaşii [10]. Aplicarea unor îngrăşăminte chimice NPK (în rapoarte de 14:10:20 sau de12:10:18), ca fertilizare de bază este desigur recomandată [12]. În cazul în care se foloseşte un burghiu de 60 cm în diametru şi se efectuează găuri la adâncimea de (60 ... 100) x 10^{-2} m, este posibil să nu se mai efectueze aratul în toamnă [13].

- **Plantarea**

Plantarea puieților de 1 an, cu diametrul minim la colet de 1,0 cm, trebuie făcută în gropi de cel puțin (30 x 30 x 30)x10^{-2} m în sol desfundat din toamnă [9], sau la o adâncime de un metru şi un diametru de 30 x 10^{-2} m [12], după care gropile se umplu cu un amestec de turbă, osmocote (un îngrăşământ peliculizat, ce conține azot, fosfor, potasiu şi microelemente, elemente care sunt puse la dispoziția plantei

micronutrients, elements that are available to the plant on a longer period of time) and other fertilizers according to the soil analysis. The hole can be completed when planting with a mixture of soil with manure, sand, peat and forest land, and on the bottom of the hole (to achieve a good drainage), will put a little gravel [14]. Half of the soil fertilized with the aforementioned mixture must be introduced into the hole until the hole reaches a depth of (30 ... 40)x10^{-2} m [13], some authors recommending to put 100 grams of artificial fertilizer and of 10 kg of cattle manure instead of this mixture [15].

If it is planted in a position with windy slightly higher, then it is necessary to put a tutor for support in the early years of growth and formation.

Paulownia tree must be ordered 10 weeks before the desired time of planting, because it requires 8 weeks for the early stage of growth, which is realized in specially designed greenhouses. The interval of two weeks is required for delivering the product depending on where planting will be done (eg hill, plain, mountain) [6].

Paulownia does not support acidic soils, the pH value must be at least 5.5, the optimum being between 6.1 and 7.8 [13].

The water requirement in the summer months is about. 50 liters / tree, but if it is placed at planting a quantity of 20 grams of hydrogel into the ground, then will put only half of this amount of water [16].

The planting of the saplings is done in straight rows, at a distance of 4 m between plants on row. The ideal period for planting is in spring, after the last frosts, so that the plant to have the time to form a lignified root as strong throughout the spring, summer and autumn [12]. Place the roots in the hole so that the top of the stem must be at the ground level or with (2 ... 3)x10^{-2} m over it [13]. After planting, for a better anchoring, are made around the sapling mounds (ridges) of soil with the height between (15 .... 20) x 19^{-2} m. It is particularly important that when planting to have a sapling with a well developed root and with a stem lignified in an as high proportion [12]. The accelerated rythm of groth of these shrubs is due their pivoting root, that reaches 10 ... 12 m in depth, but the plant will not have the capacity to develop and grow independently than from the second or the third year. The periods suitable for planting the cuttings is from November to late April, iar puietul trebuie plantat de la sfârşitul lunii aprilie până la începutul lunii august [13].

It is recommended the planting for the wood production, at the distance between trees in the row and between rows according to the following matrix (planting schemes): 4 m x 4 m - in order to ensure a density of 630 trees/ha (in which case the first exploitation is performed at 4 years); The investment is about 3,000 euro/ha, at which are added the costs for preparing the land (plowing, milling or disking, digging holes, etc), the maintenance expenses (comprising the activities of: fertilization, pruning and removing weeds, harvesting and storage), as well as those of irrigation, that can vary depending on the irrigation system (flow on ditches, drip

pe o perioadă mai îndelungată de timp) şi alţi fertilizatori în funcţie de analiza solului. Se poate completa groapa la plantare şi cu un amestec de pământ cu gunoi de grajd, nisip, turbă şi pământ de pădure, iar pe fundul gropii (pentru a se realiza un drenaj bun), se va pune puţin pietriş [14]. Jumătate din solul fertilizat cu amestecul sus amitit trebuie reintrodus în gaură până când gaura ajunge la o adâncime de (30 ... 40)x10^{-2} m [13], unii autori recomandând punerea a 100 de grame de îngrăşământ artificial, şi a 10 kg îngrăşământ natural de vită în locul acestui amestec [15].

Dacă este plantată într-o poziţie cu vânt ceva mai mare, atunci este necesară punerea unui tutore pentru sprijin în primii ani de creştere şi formare.

Arborele Paulownia trebuie comandat cu 10 săptămâni înainte de momentul în care se doreşte plantarea, deoarece este nevoie de 8 săptămâni pentru faza incipientă de creştere, care se realizează în sere special amenajate. Intervalul de 2 săptămâni este necesar pentru livrarea produsului în funcţie de zona în care se va face plantarea (ex: deal, şes, munte) [6].

Paulownia nu suportă solurile acide, valoarea pH-ului trebuie să fie peste 5,5, valoarea optimă fiind cuprinsă între 6,1 şi 7,8 [13].

Necesarul de apă în lunile de vară este de cca. 50 litri/copac, însă dacă se pune la plantare o cantitate de 20 grame de hidrogel în pământ, atunci se pune numai jumătate din această cantitate de apă [16].

Plantarea puieţilor se face în rânduri drepte, la distanţe de 4 m între plante pe rând. Perioada ideală pentru plantare este primăvara, după ultimele îngheţuri, astfel încât planta să apuce să îsi formeze o rădăcină lignifiată cât mai puternică pe întreg parcursul primăverii, verii şi al toamnei [12]. Se aşează rădăcinile în gaură asfel încât partea superioară a tulpinei trebuie să fie la nivelul solului sau cu (2 ... 3)x10^{-2} m deasupra acestuia [13]. După plantare, pentru o mai bună ancorare, se execută în jurul puietului movile (biloane) de pământ cu înălţimea cuprinsă între (15 .... 20) x 19^{-2} m. Este deosebit de important ca la momentul plantării să avem un puiet cu o rădăcină foarte bine dezvoltată şi cu o tulpină lignifiată într-o proporţie cât mai mare [12]. Ritmul accelerat de creştere al acestor arbuşti se datorează rădăcinii pivotante, care ajunge pânâ la 10 m ... 12 m adâncime, însă planta nu va avea capacitatea de a se dezvolta şi creşte independent decât din anul al doilea sau chiar al treilea. Perioadele potrivite plantării butaşilor este din noiembrie până la sfârşitul lunii aprilie, iar puietul trebuie plantat de la sfârşitul lunii aprilie până la începutul lunii august [13].

Se recomandă plantarea pentru producţia de lemn, la distanţa dintre pomi pe rând şi între rânduri conform următoarei matricii (scheme de plantare): 4 m x 4 m - pentru a asigura o densitate de 630 arbori/ha (caz în care se efectuează prima exploatarea la 4 ani); Investiţia este de aproximativ 3.000 euro/ha, la care se mai adaugă cheltuielile de pregătire a terenului (arat, frezat sau discuit, săpat gropi, etc), cheltuielile de întreţinere (cuprinzând activităţile de fertilizare, tăieri şi îndepărtarea buruienilor, recoltarea şi depozitarea), precum şi cele de irigaţii, care pot varia în funcţie de sistemul de irigare (curgere pe şanţuri,

irrigation or mobile) [12].

In case when the plantation is intended exclusively for the production of biomass, the distance between trees on row and between rows is of 2 m x 0.5 m or of 1 m x 1 m, in order to ensure a density of 1600 trees/ha, but the this variant involves an investment of around 8000 euros/ha, at which are added te the above mentioned expenses.

- **Watering**

Pour about 10 liters of water (watering is not necessary if the Paulownia is planted in the fall). If the soil is too dry, especially in depth, is recommended a watering (irrigation) of supply, with at least 200 ... 250 m^3 of water/ha (20 ... 25 l/m^2), with 24 ... 48 hours before of planting. The water reserve in the soil at the moment of planting is a critical aspect of the success of a Paulownia plantation.

- **Ridging**

Formation of ground in layers raised (ridges) is optional, but it has advantages such as: a better drainage, ensuring a greater depths of the soil layer for root and faster warming of the soil in early spring.

- **Weeding and removing the grass**

Now comes the most fragile phase of the tree, when it is still young but the grass grows and if it is not removed (generally by hand or by herbicides), the tree can be suffocated by it [13]. It is well to remove the weeds around the young trees within a radius of (30 ... 40)x 10^{-2} m. This phase represents the greatest danger of attack with *Mamestra Brassicae* or with *Trialeudores vaporariorum*, which can be treated three times in their early growth phase. In spring and at early summer, insects can appear on the Paulownia trees, particularly caterpillars, This does not mean serious problems, and if necessary, it may be treated with the known pesticides used also to fruit trees. When trees grow more than 1 m (they grow between (5 ... 10) x 10^{-2} m per day), the bugs can no longer attack. Till reaches at least 1.5 m, it should be protected from insects. Removal of weeds is necessary for the trunk grows straight, without branches to at least 8 m. The lack of branches guarantees the quality of the wood.

Even if it is planted in autumn or spring, the Paulownia cuttings begin their rise from mid-April to early May. Of course, the temperature plays a very important role. It is possible that the young trees to flourish prematurely because of the early heat. At cold there is the risk of freezing. the Paulownia defeat the cold and is budding again, this process slowing their growth, but did not kill them. After the danger of frost has passed, usually grow two offshoots. It must grow 10 x 10^{-2} m and then will be cut the weakest. This is the way that is formed the tree trunk. It is extremely important (if planting Paulownia for wood), not to let the buds to grow, because the Paulownia tree will become a bush. It is recommended that in the areas where the temperature variations between seasons are very high, the saplings to be covered with straws during the winter, and during the summer to have the bark painted white, to be protected from solar rays [15].

prin picurare sau irigare mobilă) [12]. În cazul când plantația este destinată exclusiv obținerii de biomasă, distanța dintre pomi pe rând şi între rânduri este de 2 m x 0,5 m sau de 1 m x 1 m, pentru a asigura o densitate de 1600 arbori/ha, însă această variantă presupune o investiție de aproximativ 8000 eur/ha, la care se mai adaugă cheltuielile sus-amintite.

- **Irigare**

Se toarnă aproximativ 10 de litri de apă (dacă se plantează Paulownia toamna, udarea nu este necesară). Daca solul este prea uscat, mai ales în profunzime, se recomandă o udare (irigare) de aprovizionare, cu cel puțin 200...250 m^3 apă/ha (20 ... 25 l/m^2), cu 24 ... 48 ore înainte de momentul plantării. Rezerva de apă din sol, la momentul plantării, este un aspect critic al reuşitei unei plantații de Paulownia.

- **Bilonare**

Formarea terenului în straturi înălțate (biloane) este opțională, dar prezintă avantaje, cum ar fi: un mai bun drenaj, asigurarea unei adâncimi mai mari a stratului de sol pentru rădăcină, şi încălzirea mai rapidă a solului primăvara devreme.

- **Plivirea şi înlăturarea ierbii**

Acum urmează cea mai fragilă fază a copacului, când acesta este încă tânăr, dar iarba creşte şi dacă nu este înlăturată (manual în general sau cu ierbicide), copacul poate fi sufocat de aceasta [13]. Este bine să se plivească tinerii copaci pe o rază de (30 ... 40)x 10^{-2} m. Această fază reprezintă cel mai mare pericol de atac cu Mamestra Brassicae sau cu Trialeudores vaporariorum, care poate fi tratată de trei ori în faza de început a creşterii lor. Primăvara şi la începutul verii, pot apărea pe copacii de Paulownia insecte, în special omizi, acest lucru însă nu înseamnă probleme grave, şi dacă este necesar, poate fi tratată cu pesticidele cunoscute, folosite şi la pomi. Când copacii cresc mai mult de 1 m (ei cresc între (5 ... 10) x 10^{-2} m pe zi), gândacii nu-I mai pot ataca. Până ajunge la cel puțin 1.5 m, trebuie ferit de insecte. Înlăturarea buruienilor este necesară pentru ca trunchiul să crească drept, fără ramuri până la cel puțin 8 m. Lipsa de ramuri garantează calitatea lemnului.

Chiar dacă este plantat toamna sau primăvara, butaşii de Paulownia îşi încep creşterea de la mijlocul lunii aprilie până la începutul lunii mai. Desigur, temperatura joacă un rol foarte important. Este posibil ca tinerii copaci să încolțească prematur din cauza căldurii timpurii. La frig există riscul de îngheț. Paulownia învinge frigul şi înmugureşte din nou, acest proces încetinindu-le creşterea, dar nu-i omoară. După ce pericolul de îngheț a trecut, cresc de obicei 2 vlăstari. Trebuie să crească 10 x 10^{-2} m şi apoi se vor tăia cei mai slabi. Acesta este modul prin care se formează trunchiul copacului. Este extrem de important (dacă se plantează Paulownia pentru lemn), să nu se lase mugurii să crească, asltfel copacul de Paulownia va devenii un tufiş. Se recomandă ca în zonele în care, variațiile de temperatură între anotimpuri sunt foarte mari, puietul să fie învelit în paie pe timpul iernii, iar pe timpul verii să aibă scoarța vopsită în alb, pentru a fi protejată de razele solare [15].

- **Irigarea**

După plantare, aprovizionarea constantă cu apă este de asemenea o problemă esențială. Modalitatea recomandată

- **Irrigation**

After planting, the constant supply with water is also an essential problem. The recommended watering way is the drip irrigation, carried out using the dropping lines (or pipes). The regime sustained of watering (flooding 2 times per week with a minimum of 10 l/plant in the first months after planting), in conjunction with the phasial fertilization, ensure obtaining of a sustained growth regime, especially in the early stages of vegetation. This type of watering (abundant) is preferable to short frequent watering. In the following years after developing their own root system, the amount of water may be reduced, being necessary the irrigation of the culture only during the very dry periods.

- **Fertilization**

Paulownia requires autumnal fertilization and several additional fertilization throughout the year. In autumn, if there is the possibility to place at the base of the stem several shovels of manure, during the winter it will decompose and provide a good nutrition in the next year, and in the spring will spread fertilizer with slow release near the stem [14]. In order to ensure a good growth, Paulownia needs a soil rich in nutrients, fed strong in the vegetative period, especially with nitrogen-rich fertilizer.

- **Hoeing**

As cultivation measures, the soil will be maintained free of weeds by hoeing or using herbicides. It is very important to keep the soil free of weeds, especially in the first year of vegetation (due to competition for the resources of water and nutrients). If the soil is clean, a superficial hoeing at (2 ... 5) X 10^{-2} m depth applied monthly is enough.

- **Pruning (cutting) the saplings**

In November, with the first signs of rime, the tree will enter into a dormant period, the leaves will dry and the entire stem will be cut from the base, in order to forcing the pivoting root of the plant to develop as quickly [12].

The ideal time for pruning the saplings at base of their stem, is in the period of vegetative rest (in late autumn, in winter and in early spring), because in November, instead of cutting the stem will create a surplus of sap [12]. Because this tender strain with tubular structure is hollow inside, and following the cold and the upcoming low temperatures, this sap will freeze and will turn into a stopper. The ice stopper will descend through the tubular stem remained and will arrive shortly at the root, phenomenon that can be fatal for Paulownia tree. After making this cut in autumn is recommended carrying out a bed over the remaining trunk consisting of sawdust, soil and protective foil. It marks the place and in the spring the trunk is uncovered [7].

- **Cutting the lateral branches**

The main trunk is vertical having branches growing at an angle of 45-60 degrees from the stem, and the width of rich crown can reach at over 8 m [12]. To obtain a quality wood, with a straight trunk, beautiful, the trees are cleaned every year to a height of approx. two meters, by cutting the the lateral branches as close to the stem [15]. Above the leaves, the trunk will be cut taking care not to tear the leaves, because otherwise will remain traces on

de udare este irigația prin picurare, realizată cu ajutorul benzilor (sau conductelor) de picurare. Regimul susținut de udare (inunudări de 2 ori pe săptămână cu minim 10 l/plantă în primele luni de la plantare), coroborat cu fertilizarea fazială, asigură obținerea unui regim de creştere susținut, mai ales în primele faze de vegetație. Acest tip de udare (abundent) este preferabil celui de udări scurte şi frecvente. În anii următori, după dezvoltarea sistemului radicular propriu, cantitatea de apă poate să scadă, fiind necesară irigarea culturii doar în perioadele foarte secetoase.

- **Fertilizarea**

Paulownia are nevoie de fertilizări de toamnă şi câteva fertilizâri suplimentare pe parcursul anului. Toamna dacă există posibilitatea de a pune la baza tulpinii câteva lopeți de gunoi de grajd, pe timpul iernii se acesta se va descompune şi va asigura o bună nutriție în anul următor, iar în primăvară se vor împrăştia îngrăşăminte cu eliberare lentă pe lângă tulpină [14]. Pentru a se asigura o creştere bună, Paulownia are nevoie de un sol bogat în nutrienti, planta trebuiind hrănită puternic în perioada vegetativă, şi în special cu îngrăşăminte bogate în azot.

- **Praşila**

Ca măsuri de cultivare, solul se va menține curat de buruieni, prin praşile, sau cu ajutorul erbicidelor. Este foarte importantă menținerea solului curat de buruieni, mai ales în primul an de vegetație (datorită concurenței față de resursele de apă şi nutrienți). Dacă solul este curat, o praşilă superficială la (2 ... 5) X 10^{-2} m adâncime aplicată lunar este suficientă.

- **Potarea (tăierea) puieților**

În luna noiembrie, odată cu apariția primelor semne de brumă, arborele va intra într-o perioadă de repaos vegetativ, frunzele se vor usca, iar întreaga tulpină va fi tăiată de la bază, în vederea forțării rădăcinii pivotante a plantei de a se dezvolta cât mai rapid [12].

Momentul ideal pentru potarea puieților la colet sau de tăiere la baza tulpinii, este în perioada de repaus vegetativ (toamna târziu, iarna şi începutul primăverii), deoarece în luna noiembrie, în locul tăierii tulpinei se va crea un excedent de sevă [12]. Din cauza faptului că această tulpină fragedă cu structură tubulară de Paulownia este goală în interior, în urma frigului, a temperaturilor joase care vor urma, această sevă va îngheța şi se va transforma într-un dop. Dopul de gheață va coborî prin tulpina tubulară ramasă şi va ajunge în scurt timp la rădăcină, fenomen care poate fi fatal pentru arborele de Paulownia. După ce se face această tăiere în toamnă se recomandă efectuarea unui pat peste trunchiul rămas format din rumeguş, pământ şi folie protectoare. Se înseamnă locul şi în primăvară se descoperă trunchiul [7].

- **Tăierea crengilor laterale**

Trunchiul principal este vertical având ramuri care cresc sub un unghi de 45-60 grade față de tulpină, iar lațimea coroanei bogate poate ajunge la peste 8 m [12]. Pentru obținerea unui lemn de calitate, cu un un trunchi drept, frumos, copacii se curăță în fiecare an, până la înălțimea de cca. doi metri, tăindu-se crengile laterale cât mai aproape de tulpină [15]. Deasupra frunzelor, trunchiul va fi tăiat, avându-se grijă, să nu se rupă frunzele, pentru că altfel vor rămâne

the trunk which can reduce its value.

- **Harvesting the trees**

The harvesting of the trees starts after 3-4 years depending on the purpose for which were planted and the growing conditions, but due to the high growth rate, the crops intended for biomass can be harvested regularly, at very short intervals. Fallowing the cutting of trees can be obtained a volume of timber of the highest quality of approximately 0.3 to 0.7 m^3/plant (depending if harvesting is done at 4, respectively 9 years after planting), what it provides about 200 to 500 m^3/ha of timber Paulownia, to which is added the rest of the branches used for the production of biomass 30 ... 50%.

In the case of Paulownia trees cultivated for timber, after 3 ... 5 cycles of cutting (about 15 years), the plantation must be renewed with young saplings, because both the quality of the wood material and especially the growth of the trees initially planted will decline. The growth rate and the volume of wood produced since the year 4 of life is presented in Table 1 [6].

urme pe trunchi, care pot reduce valoarea acestuia.

- **Recoltarea copacilor**

Recoltarea copacilor începe după 3-4 ani în funcție de scopul pentru care s-a plantat şi condițiile de creştere, însă datorită vitezei mari de dezvoltare, culturile destinate biomasei se pot recolta periodic, la intervale foarte mici. În urma tăierii arborilor se poate obține un volum de cherestea de cea mai bună calitate de aproximativ 0,3 până la 0,7 m^3/plantă (funcție dacă se recoltează la 4 respectiv la 9 ani de la plantare), ceea ce ne asigură aproximativ 200 m^3/ha până la 500 m^3 /ha de cherestea Paulownia, la care se adaugă restul crengilor folosite la producția de biomasă 30...50%.

În cazul arborilor Paulownia cultivați pentru cherestea, după 3 ... 5 cicluri de tăiere (aproximativ 15 ani), plantația trebuie să fie reînnoită cu puieți tineri, deoarece atât calitatea materialului lemnos dar mai ales ritmul de creştere a copacilor plantați inițial vor scădea. Viteza de creştere şi volumul de masă lemnasă obținută începând din anul 4 de viață, este prezentată în tabelul 1 [6].

Table 1 [6]

The growth rate

The growth rate /	Height [m]	Diameter [m]
approx. 6 months	2 ... 3	4 ... 6)x10^{-2}
1 year	4 ... 5	(8 ... 10)x10^{-2}
2 years	10 ... 12	(15 ... 20)x10^{-2}
3 years (approx. 0.3 m³)	15 ... 20	(24 ... 30)x10^{-2}
6 years (approx. 0.5 m³)	18 ... 22	(35 ... 40)x10^{-2}
9 years (approx. 0.7 m³)	20 ... 25	(45 ... 55)x10^{-2}

Initial investment in the trees planted at a distance of 4 x 4 m (to provide a density of 630 trees / ha), and revenues from the 3rd year of the potting (the 4th year after planting) and up to the extraction of the roots made in the 10th year after planting are shown in Table 2 [6].

Investițiile inițiale în arborii plantați la distanța de 4 x 4 m (pentru a se asigura o densitate de 630 arbori/ha), precum şi veniturile începând cu al 3-lea an de la potare (al 4-lea an de la plantare) şi până la extracția rădăcinilor efectuată în al al 10-lea an de la plantare sunt prezentate în tabelul 2 [6].

Table 2 [6]

Investments and incomes

Initial investment in trees planted at a distance of 4x4 m (density 630 pcs./ha)	Income in the 3rd year	Income in the 6th year	Income in the 9th year	Income in the 10th year
3,000 € +vat	30,000 €/ha	60,000 €/ha	90,000 €/ha	9,000 € extracting roots/ha

CONCLUZIONS

Because of the many advantages and potential benefits in agriculture, environment and industry offered by Paulownia tree planting, they represent a sustainable source of biofuel which can help solve the global energy crisis. The main product obtained is the hardwood, which is light, resistant and easily machinable, having a very good commercial value.

It is the fastest growing trees in the world, which can to grow by 2-3 m / year in the early years, gaining tremendous popularity and because it regenerates quickly, is a good melliferous tree (being more prolific than acacia at the honey production) and an excellent plant for carbon sequestration and oxygen release, contributing to the slow down effect of global warming which we are facing and being a possible solution to the

CONCLUZII

Datorită multiplelor avantaje şi beneficiilor potențiale în agricultură, mediu şi industrie pe care le oferă plantarea arborilor Paulownia, aceştia reprezintă o sursă durabilă de bio-combustibil, putând contribuii la rezolvarea crizei energetice mondiale. Produsul principal obținut este lemnul de esență tare, care este uşor, rezistent şi lesne prelucrabil, având o valoarea comercială foarte bună.

Este copacul cu cea mai rapidă creştere din lume, putând să crească în primii ani circa 2-3 m/an, căpătând o imensă popularitate şi datorită faptului că se regenerează rapid, este un bun arbore melifer (fiind mai prolific decât salcâmul la producția de miere) şi o plantă excelentă pentru sechestrarea carbonului şi eliberarea oxigenului, contribuind la încetinirea efectului încălzirii globale cu care ne confruntăm şi fiind o posibililă soluție

problem of global deforestation.

Compliance with planting and maintenance technology of the Paulownia leads to obtaining of high productions of high quality of wood mass (200 m^3/ha when the plantation is harvested in cycles of 3 years, except for the first harvest which is made at 4 years after planting), or of 500 m^3/ha when the plantation is harvested after 10 years after planting), as well as to the production of large amounts of biomass in a short period of time.

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la problema defrişărilor la nivel mondial.

Respectarea tehnologiei de plantare şi întreţinere a Paulowniei, conduce la obţinerea de producţii mari de masă lemnoasă de foarte bună calitate (200 m^3/ha când plantaţia se recoltează la cicluri de 3 ani, cu excepţia primei recoltări care se face la 4 ani de la plantare), sau de 500 m^3/ha când plantaţia se recoltează după 10 ani de la plantare), precum şi la producţia de cantităţi mari de biomasă într-o perioadă scurtă de timp.

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PHYSICO-CHEMICAL AND MICROBIOLOGICAL CHARACTERIZATION OF LAVENDER WATER OBTAINED AS BY- PRODUCT FROM LAVENDER (Lavandula angustifolia L) ESSENTIAL OIL
/
CARACTERIZAREAEA FIZICO- CHIMICA SI MICROBIOLOGICA A APEI DE LAVANDA OBTINUTA CA PRODUS SECUNDAR, DIN ULEIUL VOLATIL DE LAVANDA (Lavandula angustifolia L)

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Abstract: *Medicinal and aromatic plants contain biologically active substances with therapeutic value. As the medicinal and aromatic plant phyto-therapy is based on the relation of bioactive substance-therapeutic action, knowing the biologically active substances contained by plants is very important in order to appreciate their therapeutic value, extraction or isolation method, or other of their uses, so that the action should be as efficient as possible. In this paper, the results related to checking of microbiological parameter of quality and security-microbial contamination, as well as physical and chemical analyses of lavender water resulted as waste, after essential oil obtaining from Lavandula angustifolia plant, are presented. Through lavender water vapour distillation, the lavender essential oil was obtained, as main product and lavender water resulted, as waste. Results are important for lavender processors, in order to ensure a high capitalization of this medicinal and aromatic plant in cosmetics, perfume industry, household and industrial cleaning products, such as powerful perfumed substances, but also in pharmaceutic industry.*

Keywords: *lavender water, essential oil, water vapour distillation, microbial contamination, Lavandula angustifolia*

INTRODUCTION

Medicinal and aromatic plants are a category of vegetal species which accumulates in certain parts of plant different active substances useful in the treatment of different disorders [9]. In order to cultivate medicinal and aromatic plants for therapeutic purpose, but also to be used in industry of food, cosmetics, perfumes, establishing an ecological crop(= biologic= organic) is very important for obtaining safe and high quality vegetal raw matter[1,7], as well as ensuring their appropriate processing [5].

Lavender *(Lavandula angustifolia L)* - fig.1 is one the most valuable aromatic species. Being of Mediterranean origins, it is cultivated for its inflorescences nicely smelling with characteristic freshness notes. Essential oil obtained by fresh inflorescences distillation represents the main product of this species and has wide utilizations in industry of perfume, cosmetics, pharmaceutical product and aromatherapy industry, etc [4]. Lavender is also a very good melliferous plant.[7].

Rezumat: *Plantele medicinale si aromatice contin substante biologic active cu valoare terapeutica. Deoarece la baza eficienței fitoterapiei plantelor medicinale şi aromatice stă relația substanță bioactivă - acțiune terapeutică, este importanta cunoasterea substantelor biologic active continute in plante pentru a se aprecia valoarea terapeutica, modul de extractie sau izolare al acestora sau alte intrebuintari, astfel incat actiunea sa fie cat mai eficace, in conditii de eficienta. In lucrare se prezinta rezultatele privind verificarea parametrului microbiologic de calitate si siguranta-contaminare microbiana precum si cele ale analizelor fizco-chimice a apei de lavanda rezultata ca deseu din procesul de obtinere a uleiului volatil de lavanda din planta Lavandula angustifolia . Prin distilarea cu vapori de apa a florilor de lavanda s-a obtinut uleiul volatil de lavanda, ca produs principal si apa de lavanda, rezultata ca deseu. Rezultatele sunt importante pentru procesatorii de lavanda, in vederea valorificarii superioare a plantei medicinale si aromatice, in industria cosmetica, a ~~si~~ parfumeriei, produse de igienizare si curatenie casnica si industriala, ca puternic aromatizant, dar si in cazul unor afectiuni, in industria farmaceutica.*

Cuvinte cheie: *apa de lavanda, ulei volatil, distilare cu vapori de apa, contaminare microbiana, Lavandula angustifolia*

INTRODUCERE

Plantele medicinale si aromatice sunt ~~o~~ categorii~~e~~ de specii vegetale care acumulează în anumite părți ale plantei diverse substante active utile în tratarea diferitelor afecțiuni [9]. Pentru cultivarea plantelor medicinale si aromatice in scop terapeutic, dar si a utilizarii lor in industria alimentara, cosmetica, a parfumurilor, este importantă infiintarea de culturi ecologice(= biologice= organice) in scopul obtinerii de materii primew vegetale de calitate si sigure[1,7], precum si procesarea corepunzatoare a acestora [5].

Lavanda *(Lavandula angustifolia L)* - fig.1 este una din cele mai valoroase specii aromatice. De origine mediteraniana, se cultiva pentru inflorescentele ei cu miros placut, caracteristic, cu note de prospetime.Uleiul volatil obtinut prin distilarea inflorescentelor proaspete reprezinta produsul principal al acestei specii si are largi utilizari în industria parfumurilor, produselor cosmetice, produselor farmaceutice, aromoterapiei,etc [4]. Lavanda este si o foarte buna planta melifera [7].

Fig. 1 – Lavander *(Lavandula angustifolia L)* [7]

In our country, especially in Moldavia centre conditions, lavender variety ,,Codreanca"[4], homologated in 1992 and, on smaller surfaces, lavandine (*Lavandula hybrida*) represented by local population as ,,De Brăneşti", are cultivated. In order to enhance lavender and lavandine crops extension, they must be established in Romania's Southern and South-Eastern area. [10].

At national plan, studies on multiplication of lavender genotypes with high bio-synthetic potential [2], and studies related to superior valorisation by extracting essential oils [3], have been achieved.

Essential oils are volatile liquids with characteristic smell and different utilizations, being found in important quantities in plants, being produced in specific tissues and accumulating in all plant organs. Literature data indicate the presence of essential oils in a great variety of vegetal species, framing between 1-15%.What is known as an "essential oil" or " volatile oil" is the oil extracted from respective plant. It is"essential" because it has a distinctive smell or wears plant essence [11].

Lavender essential oil main components are linalool (51%) and lianyl acetate (35%). Other components include α-pinene, limonene, 1.8-cineole, cis-and trans-ocimene, 3-octanone, camphor, caryophyllene, terpinen-4-ol and lavandulyl acetate [3, 8, 12].

Lavender essential oil obtaining by industrial way is achieved by distillation in water, in water and with vapours, or only with vapours [7, 8].

Having in view the importance of an appropriate cultivation and processing in order to use volatile oil and lavender water in industry of manufacturing of soaps, liqueurs, perfumes, as well as, to insecticides preparation for fighting against moths, etc, this paper presents the results of important microbial and physicochemical parameters of lavender water.

MATERIAL AND METHOD

Installation of distillation aimed to obtain the essential oil of lavender has used the classical method, namely the water steam driving method of dry vegetal matter.

Water vapours method is currently used to extract volatile oils from most aromatic plants, being frequently used at industrial scale extraction, but also at wide scale, at laboratory level.

Although, it is a very efficient process, heat, water acidity or heavy metal traces from sample may provoke saponifications, isomerizations, or other undesired reactions, that may affect smell and taste of original essential oil. By this method, the water vapours penetrate

În țara noastră, în special în condițiile din centrul Moldovei se cultivă soiul de lavandă ,,Codreanca"[4], omologat în anul 1992 şi, pe suprafețe mai mici, lavandinul (*Lavandula hybrida*) reprezentat de populația locală ,,De Brăneşti". Propice pentru extinderea culturii lavandei şi lavandinului trebuie ca infiintarea culturilor să se facă în partea de sud şi sud-est a tarii noastre [10].

Pe plan national s-au realizat studii pentru multiplicarea genotipurilor de lavanda cu potential biosintetic crescut [2], dar si studii referitoare la valorificarea superioara prin extragerea uleiurilor volatile din acestea [3].

Uleiurile volatile *(esentiale),* sunt lichide volatile cu miros caracteristic si diverse utilizari, ce există într-un număr foarte mare de plante, fiind produse în țesuturi specifice, acumulându-se în toate organele plantei. Datele de literatură indică prezența uleiurilor volatile într-o mare varietate de specii vegetale, în cantități între 1-15%.Ceea ce este cunoscut ca un "ulei esențial" sau "ulei volatil" este ulei din planta din care a fost extras. Este "esențial" în sensul că poartă un miros distinctiv sau esența plantei [11].

Componentele principale ale uleiului volatil de lavandă sunt linaloolul (51%) şi acetatul de linalil (35%). Alte componente includ α-pinenul, limonenul, 1,8-cineolul, cis- şi trans-ocimenele, 3-octanonă, camfor, cariofilenă, terpinen-4-ol şi acetat de lavandulil [3, 8, 12].

Obtinerea pe cale industriala a uleiului volatil de lavanda se realizeaza prin distilarea in apa, in apa si cu aburi, sau cu aburi [7, 8].

Dată fiind importanța cultivarii si procesarii adecvate in vederea utilizarii uleiului volatil si apei de lavanda in industrie, la fabricarea sapunurilor, a lichiorurilor, a parfumurilor, precum si la prepararea insecticidelor, pentru combaterea moliilor, etc., în această lucrare se prezintă rezultatele unor parametri microbieni si fizico-chimici importanti ai apei de lavanda.

MATERIAL ŞI METODĂ

Instalația de distilare utilizata pentru obținerea uleiului volatil de lavandă a folosit procedeul clasic reprezentat de metoda antrenarii cu vapori de apa a materialului vegetal in stare uscata.

Antrenarea cu vapori de apă este o metoda folosită în mod curent la extracția uleiurilor volatile din majoritatea plantelor aromatice; este frecvent utilizată pentru extracția la scară industrială, dar are şi utilizare pe scară largă la nivel de laborator.

Deşi este un proces foarte eficient, aplicarea căldurii, aciditatea apei sau urmele de metale grele din proba sau

the vegetal matter, subject to distillation, destroy the oil glands cover, volatilize the oil and then, mix to it. The mixture of water vapours and oil vapours passes into the refrigerant vessel (condensation vessel), where it transforms into a liquid, that is, in fact the proper mixture of water and essential oil. This mixture reaches the Florence flask (separation vessel) where separation takes place, namely the essential oil being lighter, it will settle down above the water [6].

Vapour heat makes the small intercellular pockets containing essential oil, to open. Essential oil is released from intercellular pockets of vegetal material, it evaporates and driven by vapour molecules, is led to a condenser cooled with water. Essential oil and water mixture is collected into a vessel where it separates due to different density and because the two liquids are not miscible, the oil being lighter, it lifts at water surface and is evacuated. Water remained may still contain aromatic compounds and is, usually, named cologne water, hydrosol or herbal distillate, and sometimes, after making analyses of chemical and physical composition, it can be traded as such.

Analysis of microbial contamination parameter has been performed according to "Microbial contamination" monograph form European Pharmacopoeia, 8-th ed. [7].

- *Determination of microbial contamination* – plate numbering method:

It allows the quantitative a qualitative evaluation of viable living microorganisms (bacteria, levures and filamentous fungi).

Working technique: 10 g out of analysis sample are weighed. 90 ml broth is turned to slurry with sodium chloride and peptone buffer. It is obtained the dilution 1:10, from which series dilutions are prepared (1:100; 1:1000, etc), using the same diluting solution.

In two Petri plates of 9 cm diameter, 1 ml out of each dilution are transferred.

For growing the bacteria, 15-20 ml Casein soya bean digest agar, are distributed, and for growing levures and filamentous fungi 15-20 ml Sabouraud dextrose agar are distributed. The inoculated growth environment for detecting the bacteria, is incubated at 30-350C, and for levures and fungi is incubated at 20-25 0C, for 5 days interval.

UFC determination

Petri plates on which less than 250 UFC is grown for bacteria, and 50 UFC for levures and filamentous fungi, are selected. Colonies from each dilution are numbered. For finding out the number of unities generating the colonies (UFC / g) the arithmetic average of colonies number from each dilution is calculated, by dividing the number of dilutions taken into consideration.

Lavender water physical and chemical analysis was performed according to monograph *„Lavandulae aetheroleum"* from European Pharmacopeia, 8.0 issue[7].

Method used in this analysis are the following:

- *Relative density:*
  - Equipment: analytic balance, density bottle;
  - Reagent: water R;
  - Working technique:

The empty density bottle is weighed, it is filled with water R at 200C and is weighed once more. Difference between density bottle mass filled with water R and empty density bottle mass represents the mass of water R volume at 200C (m1). The density bottle is emptied, dried and filled with relevant sample brought at 200 degrees C and is weighed. Difference between mass of density bottle with liquid and empty density bottle represents the mass of analysis sample at 200C (m).

aparat pot provoca saponificări, izomerizări, sau alte reacţii nedorite care pot afecta echilibrul dintre miros şi gust al uleiului volatil original. Prin această metodă, vaporii de apă pătrund în masa vegetativa, supusă distilării, distrug învelişul glandelor oleifere, volatilizează uleiul şi apoi se amestecă cu acesta. Amestecul de vapori de apă şi vapori de ulei trece în refrigerent (vas de condensare), unde se transforma într-un lichid care nu este altceva decât amestecul de apă şi ulei volatil. Acest amestec ajunge în vasul florentin (vas de separare) unde are loc separarea şi anume, uleiul volatil fiind mai uşor se va depune în strat deasupra apei [6].

Căldura aburului provoacă deschiderea micilor buzunare intercelulare care conţin ulei volatil. Uleiul volatil este eliberat din buzunarele intracelulare ale materialului vegetal, se evaporă şi, antrenat de moleculele de abur, este dirijat spre un condensator răcit cu apă. Amestecul de ulei volatil şi apă este colectat într-un vas în care acestea se separă datorită densităţilor diferite şi a faptului că cele două lichide nu sunt miscibile, uleiul mai uşor ridicându-se deasupra apei şi fiind evacuat. Apa rămasă încă mai poate conţine compuşi aromatici şi este de obicei numită apa de colonie, hidrosol sau distilat herbal, iar în unele cazuri în urma efectuării unor analize asupra compoziţiei fizico-chimice poate fi comercializată ca atare.

Analiza parametrului contaminare microbiana s-a efectuat conform monografiei"Microbial contamination" din Farmacopeea Europeana editia a 8.0-a [7].

- *Determinarea contaminarii microbiene* - metoda de numaratoare in placa:

Aceasta permite evaluarea cantitativă si calitativa a microorganismelor aerobe viabile (bacterii, levuri si fungi filamentosi).

Tehnica de lucru: se cantaresc 10 g din proba de analizat. Se suspenda in 90 mL bulion cu clorura de sodiu si peptona tamponat. Se obtine dilutia de lucru 1:10, din care se prepara diluţii seriale (1:100; 1:1000, etc), folosind aceeaşi solutie diluanta.

In cate doua placi Petri cu diametrul de 9 cm se transfera 1 mL din fiecare dilutie.

Pentru cultivarea bacteriilor se repartizeaza 15-20 mL Agar cu hidrolizat de caseina si soia (Casein soya bean digest agar) iar pentru cultivarea levurilor si fungilor filamentosi se repartizeaza 15-20 ml Agar Sabouraud cu dextroza (Sabouraud dextrose agar) . Mediile de cultura inoculate pentru detectarea bacteriilor se incubeaza la 30-350C, iar pentru levuri si fungi se incubeaza la 20-25 0C, pentru un interval de 5 zile.

Determinare UFC

Se selecteaza placile Petri pe care se dezvolta mai putin de 250 UFC pentru bacterii si 50 UFC pentru levuri si fungi filamentosi. Se numara coloniile din fiecare dilutie. Pentru determinarea numarului de unitati formatoare de colonii (UFC / g) se efectueaza media aritmetica a numarului de colonii din fiecare dilutie, impartind la numarul de dilutii luate in considerare.

Analiza fizico-chimica a Apei de lavanda s-a efectuat conform prevederilor monografiei *„Lavandulae aetheroleum"* din Farmacopeea Europeana editia a 8.0-a [7].

Metodele folosite la analiza fizico- chimica a apei de lavanda sunt:

- *Densitate relativa:*
  - Echipament: balanta analitica, picnometru;
  - Reactivi: apa R;
  - Tehnica de lucru:

Se cantareste picnometrul gol, se umple cu apa R la 200C si se cantareste din nou. Diferenta dintre masa picnometrului cu apa R si a picnometrului gol reprezinta

Precision of determination is of four decimals.

Calculation formule:

where:

d_{2020} – relative density;

m – mass of analysis sample volume, in g;

m_1 = mass of water volume, in g.

- *Determination of pH*:
  - Equipment: pH-meter.
  - Reagents: water R; water extract for pwders, creams, lotions and gels.

In a laboratory glass,1 g (or sample quantity mentioned in ST) of analysis sample is weighed, at which 99 ml cold water R is added, it is boiled for 5 minutes and the resulted solution is filtered through filtering paper of average porosity.

- Working technique:

Determination of pH is based on water extract and is made with pH-meter device, at 20°C ÷ 25°C, at one minute after introducing the electrode into the solution.

In case of liquid state samples, pH is directly determined by introducing the electrode into the analysis sample.

- *Chromatographic profile:*
  - Equipment: chromatographic gas;
  - Reagents:
    - ✓ limonene R;
    - ✓ cineole R;
    - ✓ 3-octanone R;
    - ✓ camphor R;
    - ✓ linalol R;
    - ✓ linalyl acetate R;
    - ✓ terpinen-4-ol R;
    - ✓ lavandulyl acetate R;
    - ✓ lavandulol R;
    - ✓ α - terpineol R;
    - ✓ hexane R;

- test solution: 1 ml of sample is mixed with hexane R and is diluted at 50 ml with the same solvent. Solution is treated with a layer of anhydrous sodium sulphate R. It is filtered at 0.22µm.

- reference solution 0.1g limonene R , 0.2 g cineole R, 0.2 g 3-octanone R, 0.05 g camphor R , 0.4 g linalool R, 0.6 g linalyl acetate R, 0.2g terpinen-4-ol R, 0.1 g lavandulyl acetate R, 0.2 g lavandulol R and 0.2 g α - terpineol R are diluted into 5 ml hexane R ;

Chromatographic system:

a) Gas chromatography device equipped with:

- detector MS (mass spectrometer);
- splitting injector;
- automated system of integration of peak areas from chromatograms obtained;
- PC; printer;

b) macrogol column 20 000 R (film thickness 0. 25 µm); l= 30 m; Ø= 0.25 mm

Working conditions:

- carrying gas- helium for chromatography R;
- flow rate: 1.5 ml/minute;
- splitting ratio 1/100;
- temperature:

Program (according to table 1):

masa volumului de apa R la 200C (m1). Picnometrul se goleste, se usuca, se umple cu proba de analizat adusa la temperatura de 200C si se cantareste. Diferenta dintre masa picnometrului cu lichid si a picnometrului gol reprezinta masa probei de analizat la 200C (m). Precizia determinarii este la a patra zecimala.

Formula de calcul:

$$d_{2020} = \frac{m}{m_1} \quad (1)$$

in care:

d_{2020} - densitatea relativa;

m - masa volumului probei de analizat, in g;

m_1 = masa volumului de apa, in g.

- *Determinarea pH-ului*:
  - Echipament: pH-metru.
  - Reactivi: apa R; extract apos pentru pulberi, creme, lotiuni si geluri.

Într-un pahar de laborator, se cântăreşte 1 g (sau cantitatea de proba mentionata in ST) probă de analizat, se adaugă 99 mLapă R, se fierbetimp de 5 minute şi se filtreză soluția prin hârtie de filtru cu porozitate medie.

- Tehnica de lucru:

Determinarea pH-ului se face pe extractul apos cu pH-metrul, la 20°C ÷ 25°C, dupa un minut de la introducerea electrodului in solutie.

In cazul probelor de analizat aflate deja in stare lichida, pH-ul se determina direct prin introducerea electrodului in proba de analizat.

- *Profil cromatografic:*
  - Echipament: gaz cromatograf;
  - Reactivi:
    - ✓ limonene R;
    - ✓ cineole R;
    - ✓ 3-octanona R;
    - ✓ camphor R;
    - ✓ linalol R;
    - ✓ acetat de linalil R;
    - ✓ terpinen-4-ol R;
    - ✓ lavandulil acetate R;
    - ✓ lavandulol R;
    - ✓ α - terpineol R;
    - ✓ hexan R;

- solutia test: Se amesteca 1 ml proba de analizat cu hexan R si se dilueaza la 50 ml cu acelasi solvent. Solutia se trece pe un strat de sulfat de sodiu anhidru R. Se filtreaza la 0,22µm.

- solutia de referinta: se dizolva 0,1g limonene R , 0,2 g cineole R, 0,2 g 3-octanona R, 0,05 g camphor R , 0,4 g linalol R, 0,6 g acetat de linalil R, 0,2g terpinen-4-ol R, 0,1 g lavandulil acetate R, 0,2 g lavandulol R si 0,2 g α - terpineol R in 5 ml hexan R ;

Sistem cromatografic:

a) Cromatograf de gaze echipat cu:

- detector MS (spectrometru de masa);
- injector cu splitare;
- sistem automat de integrare a ariilor picurilor din cromatogramele obtinute;
- PC; imprimanta;

b) coloana macrogol 20 000 R (grosimea filmului 0, 25 µm); l= 30 m; Ø= 0,25 mm

Conditii de lucru:

- gaz purtator- heliu pentru cromatografie R;
- debit: 1,5 ml/minut;
- raport de splitare de 1/100;
- temperatura:

Program (conf. tabel 1):

Table 1

Program:	Time (minutes)	Temperature (°C)
Column	0 – 10	40
Port injector	10 – 70	40 → 220
Detector	-	220
	-	235

- injection: the same volume for each solution, namely 1µL;
- order of elution: order indicated in reference solution.

System suitability (confidence test):

- resolution: minimum 1.5 between peaks determined, due to lavandulyl acetate and terpinen 4-ol.

Working technique

The test solution is injected.

The reference solution is injected. Retention time is registered. Using the retention time determined from the chromatography obtained with reference solution, the reference solution components are located in chromatography obtained with test solution.

Components percentage content is determined by normalizing procedure. The hexane peaks determined and those smaller than 0.05%, are substracted.

- *Evaporation waste*
  - Equipment: water bath, analytical balance.
  - Reagents: it is not the case
  - Working technique:

One empty clock glass is weighed, is put into the water bath for one hour and is cooled in the dessicator. 5 g of analysis sample (or quantity indicated in Technical Specification), are weighed and evaporate in water bath in a clean atmosphere. It is cooled in the dessicator and is weighed.

Calculation of evaporation waste, R_{ev} [%], relation (2):

- injectia: acelasi volum pentru fiecare solutie, cate 1µL;
- ordinea de elutie: ordinea indicata in solutia de referinta.

System suitability (testul de incredere in sistem):

- rezolutia: minimum 1,5 intre picurile determinate datorate acetatului de lavandulyl si terpinen 4-ol.

Tehnica de lucru

Se injecteaza solutia test.

Se injecteaza solutia de referinta. Se inregistreaza timpii de retentie. Folosind timpii de retentie determinati din cromatograma obtinuta cu solutia de referinta se localizeaza componentele solutiei de referinta in cromatograma obtinuta cu solutia test.

Se determina continutul procentual al acestor componente prin procedura de normalizare. Se scad picurile determinate de hexan si cele mai mici de 0,05%.

- *Reziduu la evaporare*
  - Echipament: baie de apa; balanta analitica.
  - Reactivi: nu este cazul
  - Tehnica de lucru:

Se cantareste o sticla de ceas, goala, se pune pe baia de apa timp de 1 ora si se raceste in exicator. Pe aceasta sticla de ceas se cantresc 5 g proba de analizat (sau cantitatea indicata in Specificatia Tehnica), si se evapora pe baia de apa intr-o atmosfera curata. Se raceste in exicator si se cantareste.

Calculul reziduului la evaporare, R_{ev} [%], relația (2):

$$R_{ev} = \frac{m_1 - m_0}{m_p} x100 \ [\%] \qquad (2)$$

where :

m_1 =mass of clock glass with drying sample, in g ;
m_0 = mass of clock glass, empty, in g ;
m_p = mass of sample taken during work, in g.

in care :

m_1 =masa sticlei de ceascuproba dupa uscare, in g ;
m_0 = masa sticlei de ceas, goala, in g ;
m_p = masa probei luata in lucru, in g.

RESULTS

Results of test on lavender water microbial contamination are shown in table 2.

REZULTATE

Rezultatele verificarii privind contaminarea microbiana a apei de lavanda sunt prezentate în tabelul 2.

Table 2

Verification of lavender water microbial contamination

Den. no.	Parameters analyzed	Allowed limits	Results obtained
1.	Total number of aerobic microorganisms (TAMC) UFC/mL	1×10^5	< 10
2.	Total number of levures and filamentous fungi (TYMC) UFC/mL	1×10^5	< 10
3.	Escherichia coli/mL	absent	absent

Sample analyzed CORRESPONDS to requirements from European Pharmacopoeia, current

Proba analizata CORESPUNDE cerintelor din Farmacopeea Europeana , editia in vigoare.

edition.

Results of chemical and physical analyses of lavender water and the chromatographic profile are shown in tables 3 and 4:

Rezultatele analizelor fizico-chimice a apei de lavanda şi profilului cromatografic sunt prezentate in tabelele 3 şi 4:

Table 3

Results of physical and chemical analyses of lavender water

Den.No.	Characteristics	Lavender water results
1	Relative density, d_{20}^{20}	0.991
2	pH	3.5
3	Evaporation waste ,%	0.08
4.	Chromatography profile	According to Table 3 and Chromatogram / Table 4 and Graphic 1

Table 4

Chromatography profile of lavender water

Characteristics	Allowed limits F.E. 8.0/ for Lavender Essential Oil	Results	Notes
Chromatography profile :			Sample was analyzed through gas-chromatography along with mass spectrometry.
Limonene %	< 1.0	<0.01	
Cineole %	< 2.5	**6.59**	
Linalool oxide %	-	18.75	
3-Octanone %	0.1-5	**<0.01**	
Camphor %	<1.2	**2.45**	
Linalool β %	20.0-45.0	25.22	
Linalyl acetate %	25.0 - 47.0	**<0.01**	
Terpinen-4-oL %	0.1 – 8.0	6.88	
Lavandulyl acetate %	>0.2	**<0.01**	
Lavandulol %	>0.1	**<0.01**	
α – Terpineol %	<2.0	<0.01	
Octadiene dimethyl %	-	0.91	
Crypton %	-	5.63	
CAS 498-16-8 %	-	1.75	
Borneol %	-	22.35	
Epoxy linalool %	-	0.89	
Cumaric aldehyde %	-	1.46	
Thymol %	-	2.02	
Carvacrol %	-	1.12	
Cymenol %	-	3.04	
Cumarin %	-	0.94	

CONCLUSIONS

In order to ensure a high capitalization of products resulted after lavender appropriate processing, using the dried or fresh inflorescences for obtaining essential oils (by water distillation and/ or vapour method), the waste by product-lavender water has been subject to microbiological and chemicophysical analysis.

Very good results in terms of quality and microbiological security and enhancing values of active principles obtained in determining the qualitative and quantitative composition, have offered clear scientific proofs of by-product valorisation potential in industry of perfume, cosmetics, cleansers, hygiene and cleaning products, both as aromatic substance, and antimicrobial features ingredients. Large quantities of vegetal matter necessary as raw material for obtaining essential oils, can contribute to non cultivated agricultural lands

CONCLUZII

În vederea valorificarii superioare a produselor rezultate ca urmare a prelucrarii corespunzatoare a lavandei, folosindu-se inflorescentele uscate sau proaspete pentru obtinerea de uleiuri volatile (prin metoda distilarii in apa si/ sau abur), am efectuat analiza fizico- chimica si microbiologica si a subprodusului deseu- apa de lavanda.

Rezultatele foarte bune privind calitatea si siguranta microbiologica si valorile incurajatoare in principii active obtinute prin determinarea compozitiei calitative si cantitative, ofera dovezi stiintifice clare privind potentialul de valorificare al subprodusului in industria parfumurilor, cosmeticelor, al produselor detergente, de igiena si curatenie, atat ca aromatizant, dar mai ales ca ingrediente cu proprietati antimicrobiene. Cantitățile mari de material vegetal necesare ca materie prima pentru

valorisation.

Furthermore, water vapours driving method(distillation) presents the following advantages:

- parameters of vapour used for heating (flow rate, temperature) can be controlled and there is not any risk of overheating the vegetal matter at over 100 ^{o}C and, thus degradation is avoided;
- it has a high productivity while the manufacturing costs are reduced;
- foreign smells do not persist, that is why they are used for obtaining essential oils in perfume industry.

Therefore, a by-product, a waste resulted after lavender distillation can be valorised respecting the concept of efficacy by efficiency.

Results of samples analyzed have *demonstrated the conformity to requirements of monograph "Microbial Contamination from* European Pharmacopoeia, current issue, and *a very high content of terpenic active principles.*

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obținerea uleiurilor volatile, pot contribui la valorificarea unor suprafețe de teren agricol care în prezent sunt necultivate.

Mai mult, procedeul de antrenare cu vapori de apă (distilarea) prezintă următoarele avantaje:

- parametrii aburului utilizat pentru încălzire (debit, temperatură) pot fi controlați şi nu exisă riscul supraîncălzirii materialului vegetal la peste 100 ^{o}C şi al degradării;
- are o productivitate ridicată în condițiile unor costuri de fabricație reduse;
- în uleiuri nu rămân mirosuri străine, de aceea se utilizează pentru obținerea uleiurilor volatile pentru parfumerie.

Ca urmare, un subprodus, un deseu, rezultat în urma procesului de distilare al lavandei apa de lavanda, poate fi valorificata respectand conceptul eficacitate prin eficienta!

Rezultatele probelor analizate pe apa de lavanda *au demonstrat conformitatea cu cerintele monografiei Contaminare microbiana* din Farmacopeea Europeana, editia in vigoare si *un continut foarte mare in principii active de natura terpenica*.

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CONSIDERATIONS ON PRODUCING ESSENTIAL OIL OF LAVENDER (LAVANDULA ANGUSTIFOLIA MILL.) IN AN EXTRACTION PLANT, BY ENTRAINMENT WITH STEAM / *CONSIDERAȚII PRIVIND OBȚINEREA ULEIULUI VOLATIL DE LAVANDĂ (LAVANDULA ANGUSTIFOLIA MILL.), ÎNTR-O INSTALAȚIE DE EXTRACȚIE PRIN ANTRENARE CU ABURI*

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Abstract: *Within this work was carried out a study regarding obtaining the volatile oil from lavender. The oil was obtained in the distillation unit, using the classical method represented by the steam distillation method of the vegetal dried material. From the study appears that the volatile oil is the basic compound obtained by distillation, but results also a secondary compound, the Lavender hydrolate, containing small amounts of volatile oil. There were also studied the physical characteristics of the volatile oil obtained. The measurements of the physical characteristics were performed by regulated methods or of apparatus, using dedicated laboratory equipment. The results obtained from the study carried out on the lavender volatile oil reveals that the lavender processing activity and of obtaining the volatile oil with its by-product, starts to become a profitable activity also in our country (Romania).*

Keywords: *volatile oil, Lavandula angustifolia, steam distillation, pharmaceutical industry, density, refractive index*

Rezumat: *În cadrul acestei lucrări s-a efectuat un studiu privind obținerea uleiului volatil din lavandă. Uleiul s-a obținut într-o instalație de distilare, utilizand procedeul clasic reprezentat de metoda distilării cu abur a materialului vegetal uscat. În urma studiului reiese că uleiul volatil este compusul de bază obținut în urma distilării, dar mai rezultă şi un compus secundar, hidrolatul de lavandă, în care se regăsesc cantități mici de ulei volatil. S-au studiat, de asemenea, caracteristicile fizice ale uleiului volatil obținut. Măsurările caracteristicilor fizice s-au efectuat după metode reglementate sau de aparat, utilizând aparatură de laboartor dedicată. Rezultatele obținute din studiul efectuat pe uleiul volatil de lavandă relevă faptul că activitatea procesare a lavandei şi de obținere a uleiului volatil, cu subprodusul său începe să devină o activitate profitabilă şi în țara noastră (Romania).*

Cuvinte cheie: *ulei volatil, Lavandula angustifolia, distilare cu abur, industria farmaceutică, densitate, indice de refracție*

INTRODUCTION

The lavender (*Lavandula angustifolia* Mill.), supra called the "mauve gold", is a plant species of the *Lavandula* genus, family *Lamiaceae*. It is an aromatic and medicinal plant, with strains branched in bush, tall of 30 - 50 cm, small leaves, narrow and scented blue flowers. Lavender history begins in Phoenician times, of the Egyptians and Arabs who used this plant as perfume, especially. Subsequently, lavender is increasingly used for the flavoring purpose, especially in the Roman Empire, known being the Roman Baths with lavender. From here and the origin of the word "*Lavandula*" from the Latin *„lavare"* that is translated by to wash. Native being from the calcareous and mountainous Mediterranean regions, in our country grows cultivated and flourishes all the summer. For medicinal purposes are harvested only the flowers detached from the inflorescence axis, or the whole inflorescence, when the corolla it is not fully opened (*Flores Lavandulaes*). After the harvest is dry in the shade, in thin layer, without being pressed.[1]

Lavender is a plant that can be used in many fields, such as: pharmaceutical industry, food industry, cosmetics industry, production of teas and others. The volatile oil obtained by the distillation of the inflorescences, fresh or dried, represent the main product of this species, which has numerous uses in the mentioned fields. The lavender oil is the most commonly used and most known essential oil being considered by many aroma therapists as an panacea.[5]

The volatile oil content of the fresh raw material (flowers with stalk) varies depending on: the seeding material, the years of vegetation, the weather conditions from the time of the flowers formation and flowering, the time and harvest conditions. The highest content of volatile oil is obtained in the years with high temperatures during the lavender flowering.[2]

The volatile oils also called etheric oils or essential are

INTRODUCERE

Levănţica sau lavanda (*Lavandula angustifolia* Mill.), supranumită „aurul mov",este o specie de plante din genul *Lavandula*, familia *Lamiaceae*. Este o plantă aromatică şi medicinală, cu tulpini ramificate în tufă, înaltă de 30–50 cm, frunze mici, înguste şi flori albastre parfumate. Istoria lavandei incepe pe vremea fenicienilor, egiptenilor si a arabilor care foloseau aceasta planta ca parfum, în special. Ulterior, lavanda este din ce in ce mai folosita cu scop aromatizant, mai ales in Imperiul Roman, cunoscute fiind baile romane cu lavanda. De aici si originea cuvantului *„lavandula"* de la latinescul *„lavare"* care se traducea prin a spala. Originară fiind din regiunile calcaroase şi muntoase mediteraneene, la noi în ţară creşte cultivată şi înfloreşte toată vara. În scopuri medicinale se recoltează numai florile detaşate de pe axul inflorescenţei, sau toată inflorescenţa, când corola nu este complet deschisă (*Flores Lavandulaes*). După recoltare se usucă la umbră, în strat subţire fără a fi presate.[1]

Lavanda este o plantă care poate fi valorificată în multe domenii, cum ar fi: industria farmaceutică, industria alimentară, industria cosmeticelor, producția de ceaiuri ş.a. Uleiul volatil obținut prin distilarea inflorescențelor, proaspete sau uscate, reprezintă principalul produs al acestei specii, care are nenumărate utilizări în domeniile menționate. Uleiul de lavandă este cel mai des folosit şi mai cunoscut ulei esențial şi considerat de mulți aromaterapeuți un panaceu.[5]

Conținutul de ulei volatil al materiei prime proaspete (flori cu tijă cu tot) variază în funcție de: materialul săditor, anii de vegetație, condițiile meteorologice din timpul formării florilor şi înfloririi, timpul şi condițiile de recoltare. Cel mai mare conținut de ulei volatil se obține în anii cu temperaturi ridicate în timpul înfloririi lavandei.[2]

Uleiurile volatile denumite şi uleiuri eterice sau esentiale reprezintă un amestec de substanțe volatile existente într-

a mixture of volatile substances existing in a plant product. It has been demonstrated by scientific researches, that these oils have antimicrobial action, antifungal, anti-inflammatory and even stimulatory on the respiration and circulation. Also through their flavoring and odorous qualities can increase the value of certain foodstuffs, improving their organoleptic characteristics.[6]

Volatile oils although they have a different chemical composition, have many common characteristics, both as appearance and as physical properties. In general, are liquids at the ambient temperature and with few exceptions are icolore or yellow to brown being characterized by a less than unity density, refractive indexes higher, instability at preservation and a low solubility in water. Nevertheless, small amounts of volatile oils are found in the distillationresulting hydrosol, which makes it to be used in the perfume industry.[7]

From the point of view of the chemical composition, analyzing the data in the literature, follows that the main components of the volatile oils are: alcohols and monoterpenic oxides, aldehydes and monoterpenic ketones, ethers, phenols, etc.

The main components of the lavender volatile oil are the linalool (51%) and the linalyl acetate (35%). Other components include the α-pinene, the limonene, 1,8-cineol, cis and trans ocimenes, 3-octanone, camphor, caryophyllene, terpinene-4-ol and lavandulil acetate. [3]

To obtain the volatile oils there are several methods, but as a share of the production, the most widely used is the distillation, and in as regards the lavender, the largely used procedure is the steam distillation.

Obtaining the lavender volatile oil is realized through distillation by 3 different ways:

- distillation in water - the raw material is introduced into the boiler and is covered with water. Heating the water can be done at direct fire or with steam produced directly or indirectly;
- distillation in water and with steam - into the boiler, under the raw material, is put the water. The vapors pass firstly through water and then through the raw material from which take the volatile oil;
- the distillation with steam - the raw material is put into the boiler dry, without water. The vapors are produced outside the boiler in special installations and are inserted directly under the raw material.

Technical conditions for reception the product in the dry state: impurities are allowed - max. 5% (remnants of floral stems, brownish flowers, fructifications), are not admitted organic foreign bodies, mineral foreign bodies - max. 0.5%, humidity - max. 11%, volatile oil content - min. 1%. [4]

In the greatest extent the aromatic plants are processed fresh, because drying leads to evaporation of some from the volatile oil, as a result of its evaporation. However, if for objective reasons, the processing can not be done to obtain the volatile oils, the drying process must happen in the best conditions, in accordance with the methods recommended by the norms imposed. The plants must not ferment or to become moldy, because these phenomena adversely affect the quality of oil.

MATERIAL AND METHOD

The lavender essential oil which is the subject of this paper is obtained in a steam distillation plant. The dry lavender used is presented as a vegetal material evenly dried, without depreciated parts, without mineral or organic impurities, as shown in Figure 1. The humidity determined by the method of oven is of 16.46 %. The Lavender wet (fresh) is presented as a uniform vegetal material, without mineral or organic impurities, harvested as shown in Figure 2. The humidity of the plant is of 48.60%.

un produs vegetal. S-a demonstrat, prin cercetări ştiinţifice, că aceste uleiuri au acţiune antimicrobiană, antifungică, antiinflamatoare şi chiar, stimulatoare asupra respiraţiei şi circulaţiei. De asemenea prin calităţile lor aromatizante şi odorante pot mări valoarea unor produse alimentare, îmbunătăţindu-le însuşirile organoleptice.[6]

Uleiurile volatile, deşi au o compoziţie chimică diferită, au multe caracteristici comune, atât ca spect cât şi ca însuşiri fizice. In general, sunt sub formă lichidă la temperatura ambiantă, cu mici excepţii sunt icolore sau galben deschis până la brun şi se caracterizează printr-o densitate subunitară, indici de refracţie mai ridicaţi, instabilitate la păstrare şi o solubilitate mică în apă. Cu toate acestea cantităţi mici din uleiurile volatile se regăsesc în hidrosolul rezultat la distilare, ceea ce face ca acesta să fie utilizat în industria parfumurilor.[7]

Din punct de vedere al compoziţiei chimice, analizând datele din literatură rezultă că, principalele componente ale uleiurilor volatile sunt: alcoolii şi oxizii monoterpenici, aldehide şi cetone monoterpenice, eteri, fenoli ş.a.

Componentele principale ale uleiului volatil de lavandă sunt linaloolul (51%) şi acetatul de linalil (35%). Alte componente includ α-pinenul, limonenul, 1,8-cineolul, cis-şi trans-ocimenele, 3-octanonă, camfor, cariofilenă, terpinen-4-ol şi acetat de lavandulil. [3]

Pentru obţinerea uleiurilor volatile există mai multe metode, dar ca pondere a producţiei, cel mai utilizat este distilarea, iar în ceea ce priveşte lavanda, procedeul folosit pe scară largă este distilarea cu aburi.

Obţinerea uleiului volatil de lavandă se realizează prin distilare după 3 metode diferite:

- distilarea în apă - materia prima se introduce în cazan şi se acoperă cu apa. Încălzirea apei poate fi făcută la foc direct, sau aburi produşi direct sau indirect;
- distilarea în apă şi cu aburi - în cazan sub materia primă se pune apa. Aburii trec mai întâi prin apă şi apoi prin materia primă din care preiau uleiul volatil;
- distilarea cu aburi - materia primă se pune în cazan uscat, fără apă. Aburii sunt produşi în afara cazanului în instalaţii speciale şi se introduc direct sub materia primă.

Condiţii tehnice de recepţie la produsul în stare uscată: sunt admise impurităţi – max. 5% (resturi de tulpini florale, flori brunificate, fructificaţii), nu se admit corpuri străine organice, corpuri străine minerale - max. 0,5%, umiditate - max. 11%, conţinut în ulei volatil - min. 1%. [4]

In cea mai mare măsură plantele aromatice se prelucrează în stare proaspătă, deoarece uscarea duce la evaporarea unei părţi din uleiul volatil, ca urmare a evaporării acestuia. Totuşi, dacă din motive obiective, nu se poate efectua procesarea în vederea obţinerii uleiurilor volatile, procesul de uscare trebuie să se petreacă în cele mai bune condiţii, respectând metodele recomandate de normele impuse. Plantele nu trebuie să fermenteze sau să se mucegăiască, deoarece aceste fenomene influenţează cât se poate de negativ calitatea uleiului.

MATERIAL ŞI METODĂ

Uleiul esenţial din lavandă, care face obiectul acestei lucrări, este obţinut într-o instalaţie de distilare cu aburi. Lavanda uscată, utilizată se prezintă sub forma unui material vegetal uniform uscat, fără părţi depreciate, fără impurităţi organice sau minerale, după cum se vede în figura 1. Umiditatea determinată prin metoda cu etuvă este de 16,46 %. Lavanda umedă (proaspătă) se prezintă sub forma unui material vegetal uniform, fără impurităţi organice sau minerale, recoltată aşa cum se vede în figura 2. Umiditatea plantei este de 48,60 %.

Fig.1 - Lavender dried and chopped

Fig. 2 - Parcel cultivated with lavender, at harvest [8]

The steam distillation installation has as main component parts:

- the distillation vessel;
- the steam generator;
- the condenser;
- the separator type "Florentine vessel".

The lavender sizes, the filiform shape of the plant and the flexible stalk allow the uniform placement and compaction into the distillation vessel and, at the same time, obtaining of an extraction degree higher than at other plants.

The necessary steam for distillation produced in the steam boiler, exits through the orifices of the distribution pipe, and enters into the mass of plants, entraining the volatile oils. Thus, at the upper part of the vessel is formed a mixture of steam which is headed into the condenser. By the cooling water circulation is obtained the condensate which flows into the separator, where, due to the fact that the two components are immiscible and have different densities, the oil and water (the hydrosol) are separated. From here are collected subsequently in the desired recipients. When oil visibly is no longer accumulates into the separator, the process is interrupted. If it continues, it becomes economically unprofitable. We must point out that the values of the processing indexes of the installation and of the volatile oil obtained, depends on the qualities of the plant of which is extracted the oil and of the humidity in the processing time.

Following the experimentations in the steam distillation unit results a heterogeneous mixture of volatile oil and lavender water, which is shown in Figure 3.

Instalația de distilare cu abur are ca piese componente principale:

- recipientul de distilare;
- generatorul de abur;
- condensatorul;
- separatorul de tip „vas Florentin”.

Dimensiunile lavandei, forma filiformă a plantei şi tulpina flexibilă permit aşezarea şi compactarea uniformă în recipientul de distilare şi, totodată, obținerea unui grad de extracție mai ridicat decât la alte plante.

Aburul necesar distilării, produs în cazanul de abur, iese prin orificiile țevii de distribuție, pătrunde în masa de plante şi antrenează uleiurile volatile. Astfel la partea superioară a recipientului se formează un amestec de vapori care este condus în condensator. Prin circulația apei de răcire se obține condensul care curge în separator, unde, datorită faptului că cele două componente sunt nemiscibile şi au densități diferite, uleiul şi apa (hidrosolul) se separă. De aici se colectează ulterior, în recipientele dorite. Când în mod vizibil nu se mai acumulează ulei în separator procesul se întrerupe. Dacă se mai continuă, devine nerentabil din punct de vedere economic. Trebuie să precizăm că valorile indicilor de procesare ai instalației şi ai uleiului volatil obținut, depind de calitățile plantei din care se extrage uleiul şi de umiditatea din momentul procesării.

În urma experimentărilor în instalația de distilare cu abur rezultată un amestec eterogen de ulei volatil şi apă de lavandă, care este prezentat în figura 3.

Fig. 3 – Vial with volatile oil and lavender hydrosol

Can observe that into the oil lavender collection container, penetrated also water. To prevent this issue, experience is needed to adjust the liquid level into separator.

The thus obtained oil, after separation, is analyzed physically and organoleptically in laboratory.

The tests are carried at ambient temperature of 22° C.

The density is performed by the method with the areometer or densimeter, method regulated by standard (SR EN ISO 3675:2002).

The relative density of a body is the ratio between the density of that body and the density of a reference body, which is in a given state and is a physical quantity

Se observă că în recipientul de colectare a uleiului de lavandă, a pătruns şi apă. Pentru a preîntâmpina acest aspect, este nevoie de experiență pentru a regla nivelul lichidului în separator.

Uleiul astfel obținut, după separare, este analizat din punct de vedere organoleptic şi fizic în laborator.

Testele sunt efectuate la temperatura ambiantă de 22 ºC.

Densitatea este efectuată prin metoda cu areometrul sau densimetru, metodă reglementată prin standard, (SR EN ISO 3675:2002).

Densitatea relativă a unui corp este raportul dintre densitatea acelui corp şi densitatea unui corp de referință, aflat înt-ro stare dată şi este o mărime fizică

dependent on the temperature at which the measurement is done.

Densimeter is a device for measuring the density of liquids. It is also called hydrometer.

The areometer used is specific for oils and has the field of measurement 0.8800÷0.9400 g/cm^3 and the division of 0.001.

The densimeter is calibrated at 20° C in relation to the water at 4° C, and for accuracy is done a correlation with data existing in special tables.

The refractive index characterizes quantitatively the substantial environment where the light refraction occurs. It is expressed as the ratio between the speed of light in vacuum C_0 and the speed of light propagation through the medium crossed *C*. For the measurement of the refractive index are used devices called refractometers.

The refractometer used is a manual refractometer ABBE - AR3 with measuring range 1300 ÷ 1700 nD and the size of one division of 0.0005 nD. The main part of this refractometer is the assembly of two prisms between which is placed the drop of liquid that is tested.

Before performing the working sample measurement, the device is calibrated with distilled water whose refractive index at 20° C is 1.3330 nD.

Figure 4 presents the refractometer ABBE (a) and the measurement of the refractive index (b).

dependentă de temperatura la care se face măsurarea.

Densimetrul este un dispozitiv de măsurare a densităţii lichidelor. Mai e denumit şi hidrometru.

Areometrul utilizat este specific pentru uleiuri şi are domeniul da măsurare 0,8800÷0,9400 g/cm^3 şi diviziunea 0,001.

Densimetrul este etalonat la temperatura de 20 ºC în raport cu apa la 4 ºC, iar pentru corectitudine se face o corelare cu date care există în tabele speciale.

Indicele de refracţie caracterizează cantitativ mediul substanţial unde se produce refracţia luminii. Se exprimă ca raport între viteza luminii în vid C_0 şi viteza de propagare a luminii prin mediul străbătut *C*. Pentru măsurarea indicelui de refracție se folosesc aparate numite refractometre.

Refractometrul utilizat este un refractometru manual ABBE - AR3, cu domeniul de măsurare 1300÷1700 nD şi diviziunea 0,0005 nD. Partea principala a acestui refractometru este ansamblu a doua prisme, între care se aşează picătura de lichid, pe care îl testăm.

Înainte de a efectua măsurarea probei de lucru, se calibrează aparatul cu apă distilată, al cărei indice de refracție la 20 ºC este 1,3330 nD.

In figura 4 sunt prezentate refractometrul ABBE (a) şi măsurarea indicelui de refracție (b).

a) Refractometer ABBE type AR3

b) Adjusting the image and reading the index of refraction value

Fig. 4.

RESULTS

It can be considered that the results are promising for the vegetal material, the method and the apparatus used, and the volatile oil obtained keeps pregnant and specific fragrance of lavender. This oil can be successfully used in the perfume industry, dar şi în cea farmaceutică, în aromoterapie etc.

If for the organoleptic characteristics are sufficient the senses acuity and experience of an operator, for the physical characteristics determination is used laboratory equipment appropriate to the desired measurements.

The results obtained are shown in Table 1.

REZULTATE

Se poate considera că rezultatele sunt promițătoare pentru materialul vegetal, metoda şi instalația utilizate, uleiul volatil obținut păstrează parfumul pregnant şi specific de lavandă. Acest ulei se poate utiliza cu succes în industria parfumurilor, dar şi în cea farmaceutică, în aromoterapie etc.

Dacă pentru însuşirile organoleptice sunt suficiente acuitatea simțurilor şi experiența unui operator, pentru determinarea caracteristicilor fizice se foloseşte aparatură de laborator adecvată măsurărilor dorite.

Rezultatele obținute sunt prezentate în tabelul 1.

Table 1 / *Tabelul 1*

The feature / *Caracteristica*	**Results / *Rezultate***
Appearance and Color / *Aspect şi culoare*	limpid, hue dark yellow to brown / *limpede, nuanță galben închis spre brun*
Odor / *Miros*	typically of lavender / *caracteristic de lavandă*

Density at 22 °C / *Densitate la 22 °C*	0.8980 g/cm^3
Refractive index at 22 ºC / *Indice de refracție la 22 ºC*	1.4680 nD

In Table 2 are presented the weights of the three components determined for the lavender subjected to the process of extraction by steam distillation, namely: volatile oil, water, dry substance. The results presented in parallel, both for the dry plant as well as for the wet plant are given in percentage.

În tabelul 2 sunt prezentate ponderile celor trei componente determinate pentru lavanda supusă procesului de extracție prin distilare cu abur, şi anume: ulei volatil, apă, substanță uscată. Rezultatele prezentate în paralel, atât pentru planta uscată, cât şi pentru planta umedă sunt redate în procente.

Table 2/*Tabelul 2*

Caracteristica	Plantă uscată tocată	Plantă umedă
	Valoare măsurată	Valoare măsurată
Mărimea şarjei de plante	32,00 kg	32,00 kg
Umiditatea inițială a plantei, la 105ºC (inclusiv volatilele)	*16,50 %*	*48,60 %*
Cantitatea de uleiuri volatile rezultată	0,30 %	0,76 %
Cantitatea de substanță uscată din şarjă	83,5 %	51,40 %
Cantitatea de apă din plantă	16,20 %	47,84 %

Analysing the results shown in Table 2 it is noted that:
- are subjected to processing of the same quantity of vegetal material, one dry and the other fresh;
- between the initial moisture there is a big difference, (the fresh plant humidity is 3 times higher);
- the amount of volatile oil is slightly higher in the case of fresh plant, of approximately 2.5 times.

Din analiza rezultatelor prezentate în tabelul 2 se observă că:
- sunt supuse procesării aceleaşi cantități de material vegetal, unul uscat, iar celălalt în stare proaspătă;
- între umiditățile inițiale există o mare diferență, (umiditatea plantei proaspete este de 3 ori mai mare);
- cantitatea de ulei volatil este sensibil mai mare în cazul plantei proaspete, de aproximativ 2,5 ori.

CONCLUSIONS

Extraction of Lavender volatile oil by steam distillation demonstrates that it worth of investing in the culture of this aromatic plant, that the products obtained bring extra value, that it is a niche culture that can bring economic benefits to those who want to cultivate it.

Following the results obtained appears that the processing of fresh lavender is more indicated in terms of volatile oil production, but also as regards the energy saving, both for the process of distillation and for that of drying.

Steam distillation used to obtain of volatile oil from lavender, provides the following advantages:
- it has a high productivity in terms of low manufacturing costs;
- in oil not remain extraneous odors;
- the parameters of the steam used being controlled, does not exist the risk of overheating and of degradation of the vegetal material.

It is obtained a mixture of volatile oil and water which separates simple from the collecting vessel, due to the different densities.

The remaining water may contain some aromatic compounds and it is called hydrosol or colognes. Sometimes it can be marketed as such, if following some physico-chemical tests, the results recommend it.

So, by the steam distillation of the lavender is obtained as the main product the volatile oil, with multiple applications in pharmaceutical industries, of cosmetics, food, etc., and as a byproduct, an eau de cologne.

CONCLUZII

Extragerea uleiului volatil din lavandă prin distilare cu abur, demonstrează că merită să se investească în cultura acestei plante aromatice, că produsele obținute aduc plus-valoare, că este o cultură de nişă, care poate aduce beneficii economice celor care doresc s-o cultive.

În urma rezultatelor obținute reiese că procesarea lavandei proaspete este mai indicată din punct de vedere al producției de ulei obținut, dar şi în ceea ce priveşte economia de energie, atât pentru procesul de distilare, cât şi pentru uscare.

Distilarea cu abur, utilizată pentru obținerea uleiului volatil din lavandă, prezintă următoarele avantaje:
- are o productivitate ridicată în condițiile unor costuri de fabricație reduse;
- în ulei nu rămân mirosuri străine;
- parametrii aburului utilizat, fiind controlați nu exisă riscul supraîncălzirii materialului vegetal şi al degradării.

Se obține un amestec de ulei volatil şi apă, care se separă simplu, din vasul colector, datorită densităților diferite.

Apa rămasă, poate să mai conțină compuşi aromatici şi este numită hidrosol sau apa de colonie. Uneori se poate comercializa ca atare, dacă în urma unor teste fizico-chimice, rezultatele o recomandă.

Deci, prin distilarea cu abur a lavandei, se obține ca produs principal uleiul volatil, cu multiple utilizări în industriile farmaceutice, de cosmetice, alimentară ş.a., iar ca produs secundar, o apă de colonie.

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BASIC EQUIPMENT FOR THE MECHANICAL TREATMENT OF WASTEWATER
/
ECHIPAMENTE DE BAZĂ PENTRU TRATAREA MECANICĂ A APEI UZATE

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Abstract: *In a continuously developing world, where many activities are high consumers of natural resources, including water, it has become absolutely necessary to apply methods of wastewater treatment. The purpose of wastewater treatment is to improve water quality, in order to be discharged into the environment, without being harmfull for different environmental factors. In this paper are presented the equipment used in the mechanical stage of a wastewater treatment plant, and also the status of wastewater treatment plants in Romania.*

Keywords: *wastewater, mechanical water treatment, treatment plant*

INTRODUCTION

In the current state of economic and social development, is becoming more difficult to achieve the satisfaction of water needs for household, industrial, energy and agricultural use, given that each of these activities entail the pollution of groundwater and surface waters. Water pollution is mostly due to industrial development, growth of urban population and discharge into rivers and lakes of sewage, more or less treated [10].

In recent years increasing attention has been directed toward the discharge, presence and potential effects of persistent pollutants in the environment. While many of these pollutants break down relatively quickly in the environment, many others are highly resistant to degradation [6].

European Council Directive 91/271/2002 is the legal basis regarding the legislation on wastewater. This Directive, transposed by G.D. 188/2002, defines water treatment as the process of "removal from wastewater of toxic substances, microorganisms, etc., aiming to protect the environment, the envoy first, and also soil and air."

Hence, water treatment is a complex process of witholding and neutralizing harmful dissolved substances, in colloidal state or in suspension, present in industrial and municipal wastewater, that are not supported in the aquatic environment into which is discharged the treated water and that allow restoring the physicochemical properties of water before use [10].

Given the differences in location, economic resources, living standards of different countries, and also the characteristics of water and its pollutants, many nations adopt diverse techniques for wastewater treatment [1].

Wastewater treatment processes include:

a) *Mechanical treatment (primary)* - the wastewater treatment processes are of physical-mechanical type, and consists of: witholding of coarse bodies and suspension of wastewater, sedimentation (settling) of the solids in suspension, floating of impurities with lower density than that of water or which are brought by aggregating to this status, filtration and centrifugation, methods generally used in the sludge treatment and

Rezumat: *Într-o lume în continuă dezvoltare, în care numeroase activități sunt mari consumatoare de resurse naturale, printre care şi apa, a devenit absolut necesară aplicarea unor metode de epurare a apei uzate. Scopul epurării este de a îmbunătăți calitatea apei, astfel încât aceasta să poată fi deversată în emisar fără a fi dăunătoare diverşilor factori de mediu. În această lucrare sunt prezentate instalațiile folosite în treapta mecanică a unei stații de epurare a apelor uzate, precum şi situația stațiilor de epurare la nivelul României.*

Cuvinte cheie: *apă uzată, epurare mecanică a apei, statie de epurare*

INTRODUCERE

În stadiul actual al dezvoltării economico-sociale, devine tot mai greu de realizat satisfacerea nevoilor de apă pentru uz casnic, industrial, energetic şi agricol, având în vedere că fiecare dintre aceste activități atrage după sine poluarea apelor subterane şi a celor de suprafață. Poluarea apelor se datorează în cea mai mare parte dezvoltării industriale, creşterii populație urbane şi deversării în râuri şi lacuri a apelor uzate, mai mult sau mai puțin epurate [10].

În ultimii ani, s-a acordat o atenție deosebită deversării, prezenței şi efectelor potențiale ale poluanților persistenți în mediul înconjurător. Deşi o mare parte dintre aceşti poluanți se descompun relativ repede în mediu, foarte mulți sunt au rezistență crescută la degradare [6].

Directiva Consiliului Europei 91/271/2002 reprezintă baza legală referitoare la legislația privind apele uzate. Această Directivă, transpusă prin H.G. 188/2002, defineşte epurarea ca fiind procesul de "îndepărtare din apele uzate a substanțelor toxice, a microorganismelor, etc., în scopul protecției mediului înconjurător, a emisarului în primul rând, dar şi a solului şi aerului".

Prin urmare, epurarea apelor este un proces complex de reținere şi neutralizare a substanțelor nocive dizolvate, în stare coloidală sau de suspensii, prezente în apele uzate industriale şi orăşeneşti, care nu sunt acceptate în mediul acvatic în care se face deversarea apelor tratate şi care permit refacerea proprietăților fizico-chimice ale apei înainte de utilizare [10].

Datorită diferențelor în ceea ce priveşte localizarea, resursele economice, standardele de viață ale diferitelor țări, dar şi caracteristicile apei şi ale poluanților acesteia, multe națiuni adoptă tehnici diferite pentru tratarea apei uzate [1].

Procedeele de epurare a apelor uzate cuprind:

a) *Epurarea mecanică (primară)* - în care procedeele de epurare sunt de natură fizico-mecanică şi constau în: reținerea corpurilor şi suspensiilor grosiere în apele uzate, sedimentarea (decantarea) materialelor solide în suspensii, flotarea impurităților cu densitate mai mică decât cea a apei sau care sunt aduse prin agregare la această stare, filtrarea şi centrifugarea, metode folosite în

ultraviolet disinfection.

European Council Directive 91/271/2002 stipulates that, following the processes of mechanical treatment, the biochemical oxygen demand of the incoming waste water is reduced by at least 20 % before discharge and the total suspended solids of the incoming waste water are reduced by at least 50 % [15].

b) *Chemical treatment* - the wastewater treatment processes are of physico-chemical nature. Chemical processes are applicable in wastewater holding large quantities of fine matter in susspension, colloid, or even dissolved substances that are are very difficult to separate by classical mechanical methods. In this case, after the classical the chemical step, into which are placed a number of substances that favor the accumulation of large flocs colloidal substances, or which react with compounds in the water, forming compounds that are easier to separate. Also as chemical process is water disinfection at the end of the treatment process, using chemical substances.

c) *Biological treatment* - the treatment processes are both physical, and biochemical. Biological processes involved in the treatment of wastewater refers to the decomposition of organic materials by bacteria and are of two types, depending on the nature of the bacteria: *aerobic processes* of decomposition of organic substances in the presence of oxygen, a process carried out by aerobic bacteria, which feed on these substances; *anaerobic processes* of decomposition of organic oxygen scavengers that organic compounds by anaerobic bacteria, in terms of lack of oxygen.

In figure 1 is presented the technological flow in the mechanical stage of a wastewater treatment plant.

general la prelucrarea nămolului şi dezinfecția cu raze ultraviolete.

Directiva Consiliului Europei 91/271/2002 stipulează că în urma procedeelor din treapta mecanică, consumul biochimic de oxigen al apelor uzate trebuie redus cu cel puțin 20%, iar conținutul total de solide în suspensie trebuie redus cu cel puțin 50% înainte de deversarea în emisar [15].

b) *Epurarea chimică* - în care procedeele de epurare sunt de natură fizico-chimică. Procesele de natură chimică se aplică în cazul în care în apele uzate sunt cantități mari de substanțe fine în suspensie, substanțe coloidale, sau chiar dizolvate, care sunt foarte greu de separat prin procedeele mecanice clasice. În acest caz, după procedeele mecanice clasice apa uzată ajunge la etapa chimică când sunt introduse o serie de substanțe care să favorizeze acumularea substanțelor coloidale în flocoane mari, sau care reacționează cu substanțele aflate în apă formând compuşi care sunt mai uşor de separat. Tot ca proces chimic este şi etapa de dezinfectare a apei în finalul procesului de epurare, cu ajutorul substanțelor chimice.

c) *Epurarea biologică* - în care procedeele de epurare sunt atât de natură fizică, cât şi biochimică. Procesele biologice care intervin în cadrul epurării apelor uzate, se referă la descompunerea substanțelor organice de către bacterii şi sunt de două categorii, în funcție de natura bacteriilor: *procese aerobe* de descompunere a substanțelor organice în prezența oxigenului, proces realizat de către bacteriile aerobe, care se hrănesc cu aceste substanțe; *procese anaerobe* de descompunere a substanțelor organice, respectiv extragerea oxigenului din compuşii organici, de către bacteriile anaerobe, în condițiile lipsei de oxigen.

În figura 1 este prezentat fluxul tehnologic din treapta mecanică a unei stații de epurare.

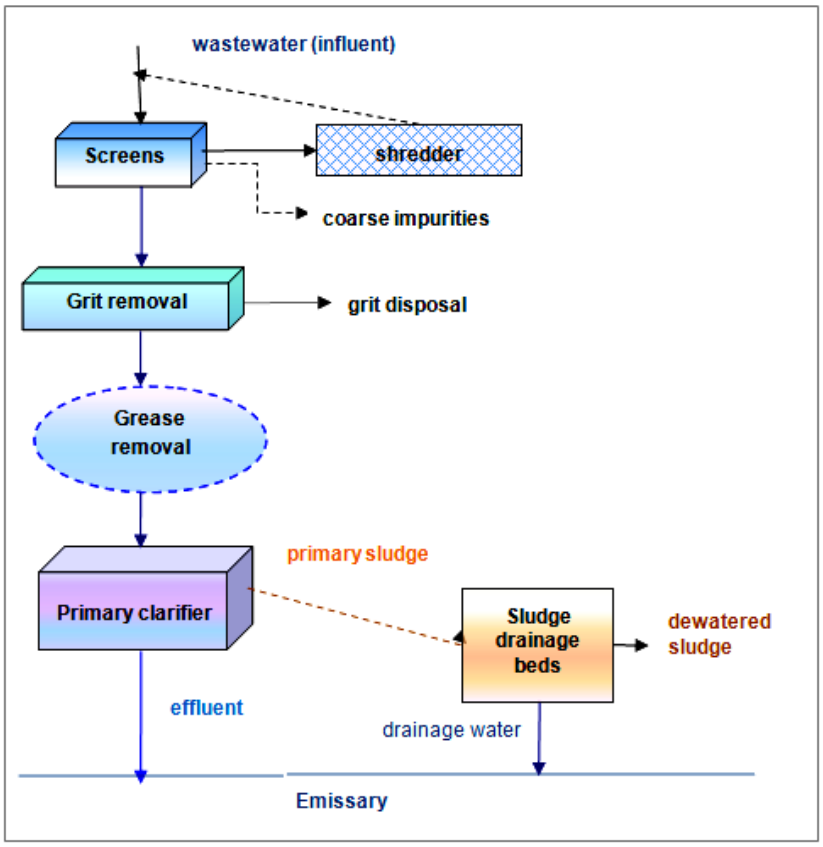

Fig. 1 – Diagram of a mechanical wastewater treatment plant

Some treatment plants are equipped with tertiary treatment step, which aims to remove excess compounds (e.g. nutrients - nitrogen and phosphorus) and to ensure water disinfection (e.g. by chlorination). This step may be biological, mechanical, chemical or combined, using conventional technologies (filtration) and special processes (adsorption on activated carbon, chemical precipitation, etc.).

By withholding or neutralization of toxic or recoverable substances from wastewater are obtained treated waters, in various degrees (which are either discharged into an emissary or are used as water for irrigation or in other purposes), and sludges that can be processed, stored, decomposed or recovered [4]. After going through these steps of treatment, the water must hane an acceptable quality, in accordance to the standards for treated wastewater.

MATERIAL AND METHOD

Bar screens are designed to withhold large bodies representing 3-5 % of the total materials transported by the wastewater. Usually, bar screens are made from profiled bars, parallel and equally spaced, rigidly fixed on ransverse bearings, leaving between interspaces named gap. After interspace size, bar screens can be classified as rare and dense, and by the plan shape, the bar screens can be: plane, radial, curved etc. [2].

Bar screens are made of stainless steal to prevent the corrosion. The retaining of coarse suspensions can be done manually or automated. Automation is preferred if the bar screens are subjected to high flow rates of wastewater or if the wastewater contains large amounts of solid debris. With the help of mechanical rakes, the screens are constantly scrapped off to remove material deposited, which is then dumped into a container [7]. In figure 2 is presented a continuous bar screen. Usually, continuous screens are often being installed in channel sewery where the screen moves through the sewage and takes with it the coarse waste; the waste can also be removed from the sewage by a slow combined movement of the screen components. These types of screens have very scant gaps (3-8 mm) [13].

Sieves have the same role as bar screens, but they have denser holes, retaining solid particles of smaller diameter. A constructive solution is the drum sieve (figure 3) presents a drum sieve that can be used for chicken slaughterhouses to remove feathers and their organs. A drum sieve consists of a slow rotating drum that is equipped with small perforations. The drum is driven through a gear box by an electric motor [13]. The wastewater enters the drum axially and leaves radially, trapping the screenings inside the drum [7].

Unele stații de epurare sunt prevăzute cu treapta terțiară de epurare, care are rolul de a înlătura compuşii în exces (de exemplu nutrienții - azot şi fosfor) şi de a asigura dezinfecția apelor (de exemplu prin clorinare). Această treaptă poate fi biologică, mecanică, chimică sau combinată, utilizând tehnologii clasice (filtrarea) sau procedee speciale (adsorbția pe cărbune activat, precipitarea chimică etc.).

Prin reținerea sau neutralizarea substanțelor nocive sau a substanțelor valorificabile din apele uzate se obțin ape epurate, în diferite grade (care fie sunt vărsate într-un emisar, fie sunt valorificate ca ape de irigații sau în alte scopuri), precum şi nămoluri, care pot fi supuse unor procedee de prelucrare, depozitate, descompuse sau valorificate [4]. În urma trecerii prin aceste trepte de epurare, apa trebuie să aibă o calitate acceptabilă, care să corespundă standardelor pentru ape uzate epurate.

MATERIAL ŞI METODĂ

Grătarele sunt destinate reținerii corpurilor mari care reprezintă între 3-5% din totalul materialelor transportate de apele uzate. În general, grătarele sunt formate din bare profilate, paralele şi echidistante, prinse rigid pe suporți transversali, astfel încât lasă între ele spații libere denumite fantă. După mărimea interspațiilor, grătarele pot fi clasificate în grătare rare şi grătare dese, iar după forma în plan, pot fi grătare: plane, radiale, curbe etc. [2].

Grătarele sunt realizate din oțel inoxidabil pentru a preveni coroziunea. Reținerea suspensiilor grosiere se poate face manual sau automat. Automatizarea este de preferat în cazul în care grătarele sunt supuse unor debite ridicate de apă uzată sau dacă apa uzată conține cantități mari de reziduuri solide. Cu ajutorul greblelor mecanice, grătarele sunt constant curățate pentru a îndepărta materialele depuse, care sunt apoi descărcate într-un container [7]. În figura 2 este prezentat un grătar continuu. De obicei, grătarele continue sunt de obicei instalate în canalizări prin care grătarul se mişcă şi rețin impuritățile grosiere; de asemenea, deşeurile pot fi eliminate din canalizare printr-o mişcare combinată lentă a componentelor grătarului. Aceste tipuri de grătare au fante foarte mici (3-8 mm) [13].

Sitele au rol identic grătarelor, dar au ochiuri dese, reținând paricule solide cu diametru mai mic. O soluție constructivă este sita cu tambur (figura 3), care poate fi folosită, de exemplu, pentru abatoare de pui pentru a elimina penele şi organele acestora. O sită cu tambur constă dintr-un tambur rotativ lent, care este echipat cu perforații mici. Tamburul este acționat printr-o cutie de viteze de un motor electric [13]. Apele uzate, care urmează a fi epurate, sunt aduse axial în tambur şi eliminate radial, prinzând impuritățile în interiorul taburului [7].

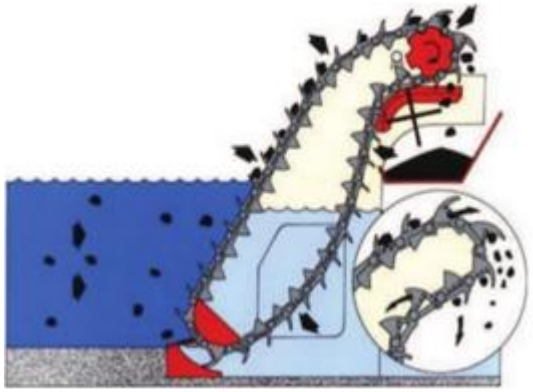

Fig. 2 – Continous bar screen [13]

The sieved particles stay in the drum and through both the revolving movement of the drum and the internal screw are placed at the end of the sieve screen and then cast out [13]. Water jets periodically clear the screenings from the drum [7].

More small particles from industrial wastewater can be removed from wastewater by sieves than by bar screens [13].

Grit chambers are devices used for retaining granular mineral suspensions, characterized by lack of putrefaction and higher sedimentation rate of solid matter organic, putrescible in suspension. The role of grit chambers is to protect moving mechanical equipment against the abrasive action of sand, to reduce the possibilities of clogging of pipes, caused by deposition of sand and to reduce the frequency of cleaning of digesting tanks and clarifiers of excessive accumulation of sand.

The vortex grit removal unit (figure 4) removes large particles of gravel and sand from the wastewater. The flow of wastewater enters into each grit unit and is directed to create a circular vortexing current. This current creates an area of low velocity in the center of the chamber. The heavier grit and sand falls down to the bottom while the water and other solids stay moving in a circular flow pattern. The grit is collected on the bottom of the unit, and is discharged and sent to the landfill for disposal [12].

Grease removal (figure 5) are equipment in which the separation of grease and oil residues under tack at the surface of domestic wastewaters and are placed between grit chambers and primary clarifiers.

Free fats, which tend to rise to the water surface are separated into rectangular tanks, and the method is based on lowering the flow rate of the water. Fats are separated from the basin surface in a specially designed space, from which are discharged manually and the water is discharged by siphoning. Fats found in colloidal state or as emulsions do not have a natural tendency to rise to the surface, and their separation is done by blowing air at low pressure in divided tanks [3].

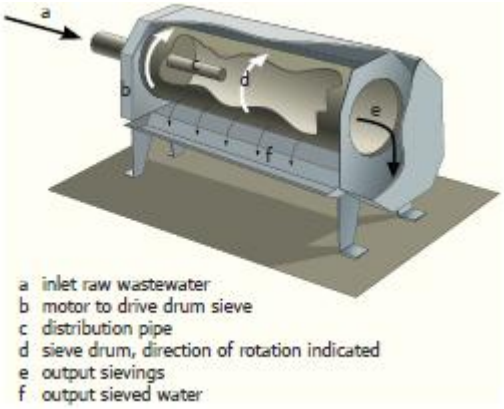

Fig. 3 – Drum sieve [13]

Particulele reţinute rămân în tambur şi prin mişcarea de rotaţie a acestuia sunt antrenate către capătul tamburului şi eliminate [13]. Jeturile de apă curăţă periodic impurităţile din tambur [7].

Cu ajutorul sitelor poate fi îndepărtată o cantitate mai mare de particule mici din apele uzate industriale decât cu ajutorul grătarelor [13].

Deznisipatoarele sunt dispozitive utilizate pentru reţinerea suspensiilor minerale granulare, caracterizate prin lipsa de putrescibilitate şi viteze de sedimentare superioare materiilor solide organice, putrescibile în suspensie. Rolul deznisipatoarelor este acela de a proteja instalaţiile mecanice în mişcare, contra acţiunii abrazive a nisipului, de a reduce posibilităţile de înfundare a conductelor, provocate de depunerea nisipului şi de a reduce frecvenţa de curăţire a bazinelor de fermentare şi a decantoarelor de acumulările excesive de nisip.

Deznisipatorul de tip vortex (figura 4) îndepărtează particulele mari de pietriş şi nisip din apele uzate. Fluxul de apă uzată intră în fiecare unitate de deznisipare şi este supus unui curent circular de agitare. Acest curent creează o zonă de viteză scăzută în centrul instalaţiei. Pietrişul mai greu şi nisipul cad spre partea inferioară, în timp ce apa şi alte solide rămân în mişcare într-un model de flux circular. Nisipul se colectează pe fundul instalaţiei, de unde este evacuat şi trimis la depozitul de deşeuri [12].

Separatoarele de grăsimi (figura 5) sunt echipamentele în care se realizează separarea grăsimilor şi a reziduurilor petroliere aflate în peliculă la suprafaţa apeor uzate menajere şi sunt plasate între deznisipatoare şi decantoarele primare.

Grăsimile libere, care tind să se ridice la suprafaţa apei se separă în bazine dreptunghiulare, iar procedeul bazându-se pe scăderea vitezei de curgere a apei. Grăsimile se separă la suprafaţa bazinului, într-un spaţiu special amenajat, din care sunt evacuate manual, iar apa iese prin sifonare. Grăsimile aflate în stare coloidală sau sub formă de emulsii nu au tendinţa naturală de a se ridica la suprafaţă, iar separarea lor se face prin insuflare de aer la joasă presiune în bazine compartimentate [3].

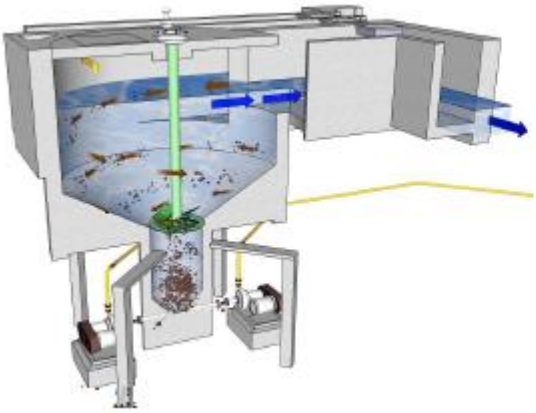

Fig. 4 – Vortex Grit chamber [12]

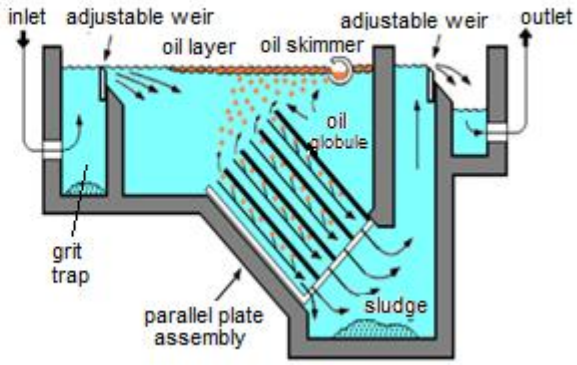

Fig. 5 – Grease removal [20]

Primary clarifier (or settling tank) has the role to withold most of the suspensions in wastewater, respectively raw water, by sedimentation – gravity deposit. They are constructions made of concrete; they generally have very large sizes, at about 30 m long and 9 m wide and can have various geometric shapes (rectangular, round).

Rectangular primary clarifier (figure 6) is a tank into which the water stays for 1.5-2 hours. Collection of deposits in the upstream hopper is done several times per day, with the help of a scraper mounted on the bridge, to prevent their fermentation [5].

Round primary clarifier (figure 7) is an installation into which the wastewater is fed into the middle and is discharged through a trough on the outer periphery. Above the tank there is a bridge that slowly rotates with sludge scrapers attached. These scrapers move the sludge on the bottom slowly towards the central sludge funnel, where it is removed. The bottom is built with a slight slope. For the effluent trough there is a scumboard or baffle for holding back the floating solids. The floating solids (fat) are pushed into a scum trough by the floating scum scrapers that are attached to the bridge [13].

Decantorul primar (sau bazinul de sedimentare) are rolul de a reține marea majoritate a suspensiilor din apele uzate, respectiv ape brute, prin sedimentare – depunere gravitațională. Sunt construcții din beton, au in general dimensiuni foarte mari, de aproximativ 30 m lungime şi 9 m lățime şi pot avea diferite forme geometrice (longitudinale, circulare).

Decantorul primar dreptunghiular (figura 6) este un bazin în care apa staționează între 1,5-2 ore. Colectarea depunerilor la pâlnia din capătul amonte se face de câteva ori pe zi, cu ajutorul unui sistem de raclare montat pe un pod, pentru a împiedica fermentarea lor [5].

Decantorul primar radial (figura 7) este o instalație în care apa uzată este introdusă prin zona centrală şi evacuată printr-un jgheab la periferia exterioară. Deasupra bazinului se află un pod care se roteşte uşor şi de care sunt ataşate racloare pentru nămol. Aceste racloare deplasează nomolul de pe fundul bazinului către pâlnia centrală evacuarea nămolului. Fundul bazinului este contruit cu o pantă uşoară. Jgheabul de evacuare a efluentului este prevăzut cu un deflector pentru spumă şi pentru reținerea solidelor plutitoare. Solidele plutitoare (grăsimile) sunt împinse într-un jgheab pentru reziduuri cu ajutorul racletelor plutitoare ataşate la podul rotativ [13].

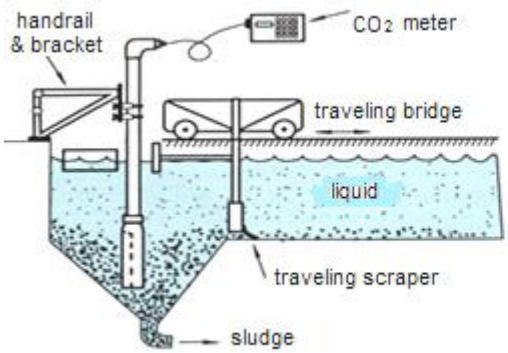

Fig. 6 – Rectangular primary clarifier [20]

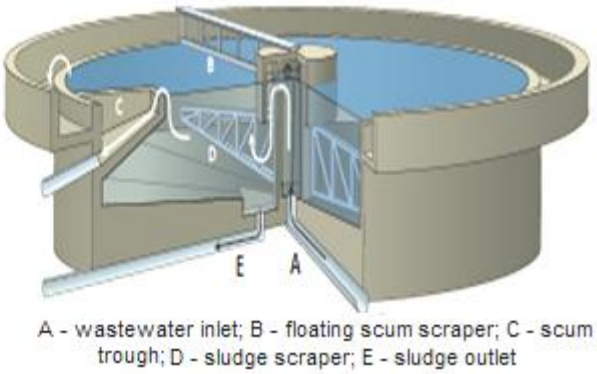

Fig. 7 – Round primary clarifier [13]

Processes in the primary treatment generate primary sludge. The sludge is removed and pumped to the solids treatment process for ultimate removal [9].

RESULTS

In Romania, a major problem is the lack of sewerage network in certain areas and the inadequate treatment system. According to the National Administration of Romanian Waters, the water used by 90% of romanians from the village and 50% from the city does not get into a sewer system, but is thrown directly near the house [11].

Also, in Romania, the degree of connection to the sewerage network and sewage treatment plants is 57% and respectively 46%. In Romania, physically, there are 983 sewers, of which only 631 are functional, the rest being still in various stages of implementation [17].

In 2011 were identified 511 sewage treatment plants, of which only 16 treatment plants comply with the requirements of Directive 91/271 / EEC, for the second stage of treatment. The poorly equipped treatment plants are those in Muntenia and Oltenia (Dolj, Gorj, Giurgiu, Călărați), central and southern Moldova (Galați and Vaslui) and best equipped treatment plants are in the center and west of the country (Braşov, Cluj Napoca, Mureş) [16]. Figure 8 shows the map of localities provided with wastewater treatment plants in our country, according to estimates made in 2011.

Bucharest is served by a mixed system of sewage, spread over about 2400 km, that takes wastewater from approximately 80% of the population of 1.92 million people from the city, but also from most of the industrial units and institutions. The wastewater collected is transported to the treatment plant in Glina, in the south-east of Bucharest [18].

In the wastewater treatment plant from Glina, technological and biological processes occur in three stages of wastewater treatment (figure 9). In the first stage, larger bodies floating in the waters of Dâmbovița river are retained by bar screens and sieves. Cleaning of water of these bodies is made in a similar manner to household waste management, being sent to landfill or to sludge incinerator. Then, the separation of sand takes place into grit chambers and the sedimentation of suspensions in the primary clarifier. After decanting, substances collected to surface (grease, hydrocarbons) are removed, and primary sludge deposited on the bottom of the primary clarifier is thickened and sent to digesters [14].

Mechanically treated water reaches the biological stage, where acts microorganisms that break down organic matter. From the secondary clarifier, secondary sludge is obtained, which is thickened (dried) and sent to the digester.

Procesele din treapta primară generează nămol primar. Nămolul este separat şi pompat în treapta de tratare a solidelor, în vederea îndepărtării totale [9].

REZULTATE

În România, o problemă majoră o reprezintă lipsa rețelei de canalizare în anumite regiuni şi ineficiența sistemului de epurare. Conform Administrației Naționale Apele Române, apa folosită de 90% dintre românii de la sat şi de 50% dintre orăşeni nu ajunge într-un sistem de canalizare, ci este aruncată direct în apropierea casei [11].

De asemenea, în România, gradul de racordare la rețele de canalizare şi statii de epurare a apelor este de 57%, respectiv de 46%. În România există fizic 983 rețele de canalizare, din care doar 631 sunt funcționale, restul aflându-se încă în diferite etape de execuție [17].

În anul 2011 au fost identificate 511 stații de epurare, dintre care numai 16 stații de epurare sunt conforme cu cerințele Directivei 91/271/EEC, pentru treapta secundară de epurare. Cel mai slab dotate stații de epurare sunt cele din Muntenia şi Oltenia (Dolj, Gorj, Giurgiu, Călăraşi), centrul şi sudul Moldovei (Galați şi Vaslui), iar cele mai dotate stații de epurare sunt în centrul şi vestul țării (Braşov, Cluj-Napoca, Mureş) [16]. În figura 8 este prezentată harta localităților prevăzute cu stații de epurare în țara noastră, conform estimărilor din anul 2011.

Municipiul Bucureşti este deservit de un sistem mixt de canalizare, întins pe aproximativ 2400 km, care preia ape uzate de la aproximativ 80% din populația de 1.92 mil. oameni a oraşului, dar şi de la majoritatea agenților industriali şi instituții. Apele uzate colectate sunt transportate către stația de epurare de la Glina, în sud-estul Bucureştiului [18].

În stația de epurare de la Glina, procesele tehnologice şi biologice se manifestă în trei etape de tratare a apelor uzate (figura 9). În prima treaptă, corpurile de dimensiuni mai mari care plutesc în apa râului Dâmbovița sunt reținute de grătare şi de site. Curățarea apei de aceste corpuri se face într-un mod asemănător cu gestionarea gunoiului menajer, luând drumul rampei de gunoi sau a incineratorului de nămol. Apoi are loc separarea nisipului in deznisipator şi sedimentarea suspensiilor în decantorul primar. După decantare, substanțele adunate la suprafață (grăsimi, hidrocarburi) se înlătură, iar nămolul primar depus pe fundul decantorului primar este îngroşat şi se trimite la fermentatoare [14].

Apa tratată mecanic ajunge în treapta biologică, unde acționează microorganismele care descompun materia organică. Din decantorul secundar se obține nămol secundar, care este îngroşat (deshidratat) şi trimis la fermentatoare.

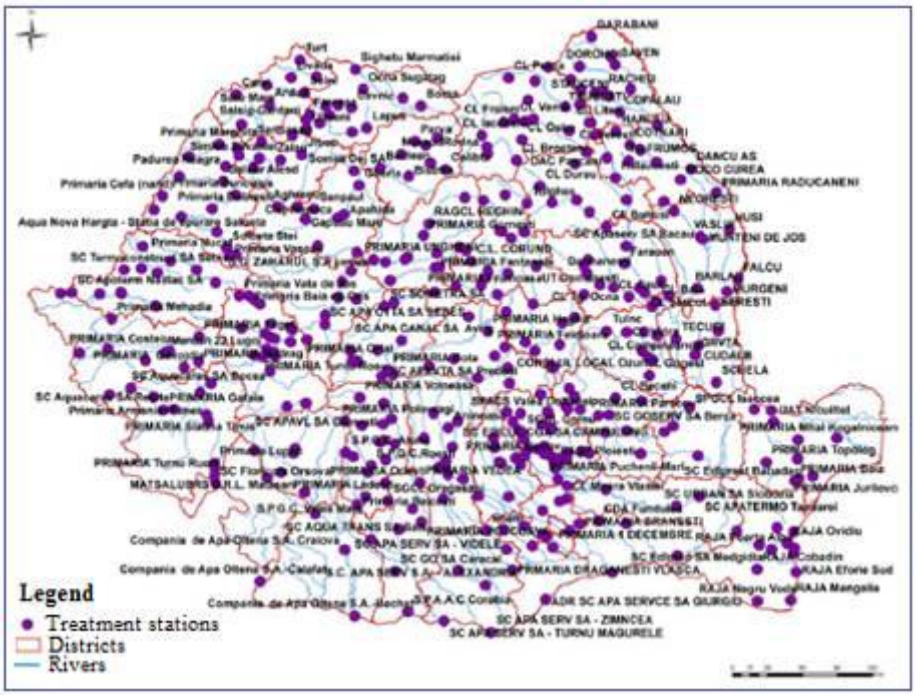

Fig. 8 – Wastewater treatment plants in Romania in 2011 [19]

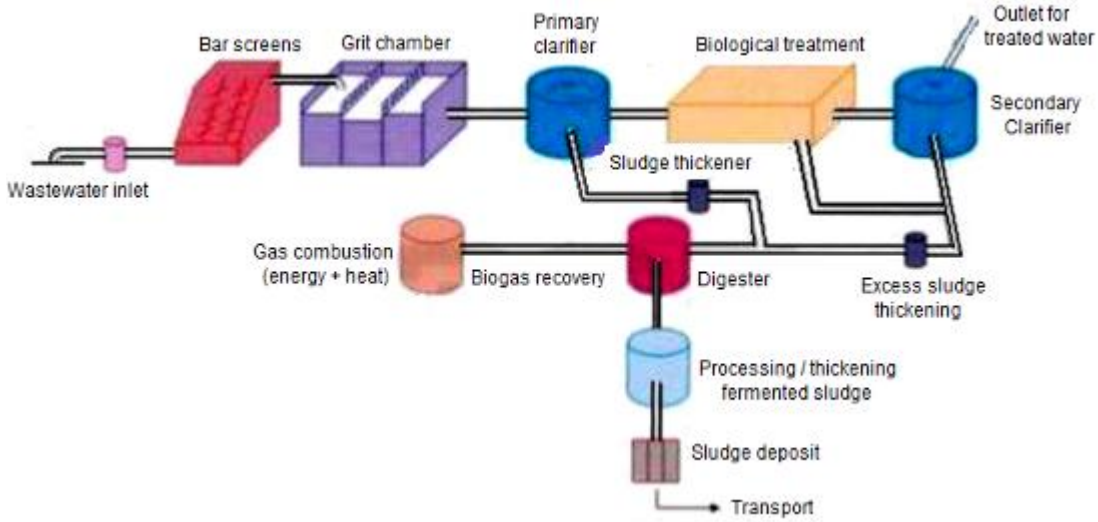

Fig. 9 – Technological flow at Glina wastewater treatment plant, near Bucharest

By anaerobic digestion of sludge is obtained the biogas, which is converted by co-generation into heat and electricity. The digestate, namely the remaining solid after fermentation, is dehydrated and can be used as fertilizer on agricultural fields.

Currently, Glina wastewater treatment plant removes mechanically only 85% of the wastewater entering the plant, with a flow of 10 m^3/s, but only half of this quantity is fully treated, according to the European environmental standards.

CONCLUSIONS

Wastewater includes water resulting from residential, industrial and commercial activities.

A wastewater treatment plant consists of various equipment and processes that have the role to remove or destroy harmful materials, chemical compounds, and microorganismsfound in the wastewater.

In order to protect the environment, especially the emissary, and also the soil and air, a proper treatment process of wastewater should provide favorable

Prin fermentarea anaerobă a nămolului se obține biogaz, care este transformat într-o centrală de cogenerare în energie termică şi energie electrică. Digestatul, adică partea solidă rămasă în urma fermentării, este deshidratat şi poate fi utilizat ca îngrăşământ pe câmpuri agricole.

În prezent, stația de epurare Glina curăță mecanic 85% din apa uzată care intră în stație, cu un debit de 10 m^3/s, însă doar jumătate din această cantitate este epurată complet, conform standardelor europene de mediu.

CONCLUZII

Apele uzate includ apele rezultate din activități rezidențiale, industriale şi comerciale.

O statie de epurare constă dintr-un ansamblu de instalații şi construcții al căror obiectiv este îndepărtarea materialelor dăunătoare, a componentelor chimice şi a microorganismelor ce se găsesc în apele uzate.

Pentru a proteja mediul înconjurător, şi mai ales emisarul, dar şi solul şi aerul, un proces corespunzător

conditions for further possible use of such water for domestic, industrial or agricultural activities.

Raw untreated wastewater, discharged into rivers, have a devastating impact.

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de tratare a apei uzate trebuie să ofere condiții favorabile pentru utilizarea ulterioară a apelor epurate în activități domestice, industriale sau agricole.

Apele uzate brute netratate, deversate în râuri, au un impact devastator.

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OPTIMIZING THE OPERATION OF MECHANICAL FILTERING EQUIPMENT THROUGHPARTIAL SEPARATION OF SOLIDS USING A RADIAL FLOW SETTLER / OPTIMIZAREA FUNCȚIONĂRII ECHIPAMENTELOR DE FILTRARE MECANICĂ PRIN SEPARAREA PARȚIALĂ A SOLIDELOR UTILIZÂND UN DECANTOR DE NĂMOL

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Abstract: *One of the main problems with a major impact on the welfare of fish in a recirculating aquaculture system (RAS) is the correct management of solid waste, which according to literature are directly proportional to the production of fish in the system. To maintain to the lowest level the concentration of TSS in a recirculating system it's needed beside the microsieve filter, also a pre-filtering equipment, able to reduce some solid settle and at the same time to ease the loading of the mechanical filter. This paper aims to present a way of optimizing the functioning of mechanical filtration equipment by using in the drainage path a radial flow settler as a pre-filtering equipment.*

Keywords: recirculating aquaculture system, *pre-filtering, radial flow settler*

INTRODUCTION

Application of innovative technical solutions for removing solids from tanks by reducing operating costs and capital is one of the directives to be followed both concerning the continuity and expansion globaly of RAS systems [16].

When designing a recirculating system an essential problem in maintaining optimal water quality is by removing solids continuously from the system [16] , solids that are coming from multiple sources, such as uneaten food, dejections and bacterial biomass [10], [6], [2].

The accumulation of solids within RAS can have serious consequences on both the fish in tanks and also on the system components [9]. The accumulation of solids will automatically lead to a further concentration of oxygen to be introduced into the system also will increase the concentration of dissolved carbon dioxide and an increase in the concentration of toxic substances [4], [16].

To get better results in the removal of solids within a RAS, one of the factors that must be considered is the type of tank to use. From this point of view the literature is unanimous agreeing that the type of tank which meets both criteria, mixing uniform the water and self-cleaning, is the circular tank [3], [5], [13].

One of the major advantages resulting from the self-cleaning process of the tanks is the fact that most of the solid particles curl around a central drain where they are

Rezumat: *Una din principalele probleme cu un impact major asupra bunastării peştilor dintr-un sistem acvacol recirculant (SAR), o reprezintă gestionarea corectă a deşeurilor solide, care potrivit literaturii de specialitate sunt direct proporționale cu producția de peşte din cadrul sistemului. Pentru menținerea la un nivel cât mai scăzut a concentrației de TSS dintr-un sistem recirculant este nevoie ca pe lângă filtrul cu microsite să mai existe şi un echipament de pre-filtrare,care să fie capabil să reducă o parte din solidele sedimentabile şi în acelaşi timp să uşureze şi încărcare pe filtrul mecanic. Lucrarea de față îşi propune să prezinte o modalitate de optimizare a funcționării echipamentelor de filtrare mecanică prin introducerea pe traseul de evacuare a apei de la bazinele de cultură a unui decantor denamol ca şi echipament de pre-filtrare.*

Cuvinte cheie: *sistem acvacol recirculant, pre-filtrare, decantor de nămol*

INTRODUCERE

Aplicarea de soluții tehnice inovative pentru îndepărtarea solidelor din bazinele de cultură printr-o reducerea a costurilor de operare şi de capital, reprezintă una din direcțile ce trebuie urmate atât în ceea ce priveşte continuitatea, cît şi extinderea sistemelor SAR la nivel mondial [16].

La proiectarea unui sistem recirculant o problemă esențială o reprezintă menținerea calității apei în parametri optimi prin îndepărtarea în mod continuu a solidelor din sistem[16], solide ce provin din mai multe surse, cum ar fi: hrana neconsumată, materiale fecale şi biomasa bacteriană [10], [6], [2].

Acumularea de solide în interiorul unui SAR poate avea consecințe grave, atât asupra peştilor din bazine dar şi asupra componentelor sistemului [9]. Acumulările de solide vor conduce în mod automat la suplimentarea concentrației necesare de oxigen ce trebuie introdusă în sistem, la o creştere a concentrației de dioxid de carbon dizolvat din system, dar şi la o creştere a concentrației de substanțe toxice [4], [16].

Pentru obținerea de rezultate cât mai bune în procesul de îndepărtare a solidelor din cadrul unui sistem recirculant, unul din factorii de care trebuie ținut cont este şi tipul de bazin utilizat. Din acest punct de vedere literatura de specialitate este unanim de acord, că tipul de bazin care îndeplineşte atât criteriile de amestec uniform al apei dar şi de autocurățare, le are bazinul de formă circulară [3], [5], [13].

Unul din avantajele majore ce rezultă din procesul de autocurățare al bazinului îl reprezintă faptul că cea mai mare parte a particulelor solide se strâng în jurul drenului central de unde mai apoi sunt evacuate [13], [21].

discharged [13], [21].

In the case of circular basins one of the methods used to remove solid particles is by introducing the double drainage system, as shown in figure 1. By systemic use of a double drainage the volume of water with the highest concentration of solids is separated from the secondary water flow and sent to the pre-filtering units [20].

According to the latest studies the flow of water which is removing settled solids through the drain center of the bottom of the pool is between 5-20% of the total flow, while the difference of flow 80-95% is discharged through a secondary drain placed sideways on the outer edge of the tank at the top of it.

În cazul bazinelor circulare una din metodele utilizate pentru îndepărtarea particulelor solide este prin introducerea sistemului de drenaj dublu, după cum se poate observa şi în figura 1. Prin utilizarea sitemului cu drenaj dublu volumul de apă cu concentrația cea mai mare de solide este separat de debitul secundar de apă şi trimis către unitatile de pre-filtrare [20].

Potrivit celor mai recente studii debitul curentului de apă ce elimină solidele sedimentabile prin intermediul drenului central de pe fundul bazinului este cuprins între 5 – 20% din debitul total, în timp ce diferența de debit de 80 – 95% este evacuată prin intermediul unui dren secundar amplasat pe latura exterioară a bazinului la partea superioară a acestuia.

Fig. 1 – Illustration of a circular tank with dual drains [3]

Balance of solids - Theoretical Approachs

The efficiency of tank whit a double drain in the concentration of solids at the level of the discharge opening of the central drain from the bottom of the tank can be described with help of a mass balance in a steady state as follows [15], [3].

Bilanțul solidelor- Abordare teoretică

Eficiența utilizării bazinelor cu drenaj dublu în concentrarea solidelor la nivelul gurii de evacuare a drenului central, poate fi descrisă cu ajutorul unui bilanț masic în regim staționar [15], [3].

$$\{Q*.TSS_{in}\}+\{P_{TSS}\}=\{Q_{e1}*TSS_{e1}\}+\{Q_{e2}.TSS_{e2}\} \quad (1)$$

where: Q * TSS_{in} is the total amount of suspended solids carried by the tank (kg) P_{TSS} - total suspended solids resulting from feeding (kg) Q_{e1} * TSS_{e1} - total amount of suspended solids in suspension discharged from the discharged effluent (kg); Q_{e1} * TSS_{e2} - total discharged suspended solids by the central drain effluent (Kg); Q - flow rate of the tank influent (m3 / s); TSS_{in} - the total concentration of solids in the suspension of the influent (kg / m3); Q_{e1}- discharged effluent flow of the tank (m3 / s); TSS_{e1} - the total concentration suspended solids in the effluent flow (m3 / s); Q_{e2} - central drain effluent flow from the bottom of the tank (m3 / s); TSS_{e2} - the concentration of total suspended solids in the central drain effluent from the bottom of the tank (m3 / s).

Regarding the total production of solids in suspension resulting from feeding, R_{TSS}, the literature indicates the following relationship for its evaluation:

unde: Q*TSS_{in} reprezintă cantitatea totală de solide în suspensie transportată de influentul bazinului (kg), P_{TSS} - cantitatea totală de solide în suspensie rezultate în urma hrănirii (kg);Q_{e1}*TSS_{e1} **–** cantitatea totală de solide în suspensie evacuate de efluentul deversant (kg); Q_{e2}*TSS_{e2} – cantitatea totală de solide în suspensie evacuate de efluentul drenului central (Kg); Q – debitul curentului influent al bazinului (m^3/s); TSS_{in} – concentrația totală a solidelor în suspensie din influent (kg/m^3); Q_{e1}- debitul efluentului deversant al bazinului (m^3/s); TSS_{e1} – concentrația totală a solidelor în suspensie din efluentul deversant (m^3/s); Q_{e2} – debitul efluentului drenului central de pe fundul bazinului (m^3/s); TSS_{e2} – concentrația totală a solidelor în suspensie din efluentul drenului central de pe fundul bazinului (m^3/s).

În ceea ce priveşte producția de solide totale în suspensie rezultate în urma hrănirii , P_{TSS}, literatura de specialitate sugerează urmatoarea relatie (nr 2) pentru evaluarea acesteia:

$$P_{TSS}=a_{TSS}*r*\rho*.V \quad (2)$$

Where: - a_{TSS} – total suspended solids production,

unde: a_{TSS} – reprezintă producția de solide totale în

expressed as a fraction of administered food (kg TSS/kg feed); r – feeding intensity (kg feed/kg over x day); p – population density of the tank (kg fish/m^3);V – volume of water growing (m^3).

Thus the fraction of removed (f) solids through a central drain of the tank can be determined from equation 3, and by combining equation 3 with equation 1 it can be obtained the relationship of calculation 4 by which the level of suspended solids from the effluent central drain from the bottom of the tank can be determinated.

suspensie, exprimate ca fracție din hrana administrată (kg TSS/kg hrana); r - intensitatea hrănirii (kg hrana/kg peste *zi); ρ – densitatea de populare a bazinului (kg peste/m^3); V – volumul apei de cultură (m^3).

Astfel dar fracția solidelor îndepărtate (f) prin drenul central al bazinului poate fi determinată din ecuația 3, iar prin combinarea ecuației 3 cu ecuația 1 se poate obține relația de calcul 4 cu ajutorul căreia se poate determina concentrația totală a solidelor în suspensie din efluentul drenului central de de fundul bazinului.

$$f = \frac{Q_{e2} * TSS_{e2}}{(Q_{e1} * TSS_{e1}) + (Q_{e2} * TSS_{e2})} \quad (3)$$

$$TSS_{e2} = [(Q * TSS_{e1}) + P_{TSS}] * \frac{f}{Q_{e2}} \quad (4)$$

According to literature the concentration of solids in the flue main central drain can be up to 10 times higher than the concentration of solids in the effluent secondary drain [3].

Pre-filtration equipment - Overview

Waste management studies from RAS showed that there are multiple benefits if before the main waste water treatment plants there are introduced other equipments for pre-filtering solids [1].

The literature states that the main technological solution for reducing the load of mechanical filters and also the operating costs can be achieved by placing pre-filtering equipment in recirculating systems [8].

Two of the most popular pre-filtering equipments that are increasingly common found in applications of RAS are radial flow settlers and hydrocyclones [4].

According to his statement (Piggott, 2007) he concluded that both the operating mode as well as the efficiency of radial flow settler as well as the hydrocyclones are superior to the traditional tanks [17].

Radial flow settlers are mentioned as part of the pre-filtering equipment category, their use has a clear purpose, namely to achieve a partial filtering of water tanks. The main advantages that are recommanding the use of radial flow settlers in RAS are:

- significantly reduces loading with solids in a system;
- equipment is passive and does not require additional energy to work;
- require donly routine cleaning;
- no additional maintenance or repairs.
- it can be produced in avariety of sizes for different flows [20].

One of the advantages of using radial flow settlers is that it does not occupy a lot of space compared to traditional settlers and their installation and dismantling on the water escape route can be done quickly [18].

One way of placing the radial flow settler is either in front of the tank, as it can be seen in figure 2, in this way the transport time of loaded water with solids is greatly reduced to the pre-filtering unit, so therefore it helps to slow down the decomposition of solids [4], or behind a group of tanks, depending on size and flow rate of circulated water in the system [10], [1].

Potrivit literaturii de specialitate concentrația de solide din efluentul drenului central principal poate fi de până la de 10 ori mai mare decât concentrația solidelor din efluentul drenului secundar [3].

Echipamente de pre-filtrare- Prezentare generală

Studiile efectuate în domeniul gestionării deşeurilor provenite din SAR au arătat că există avantaje multiple dacă înainte de principalele instalații de tratare a apei uzate, sunt introduse în sistemele recirculante alte echipamente de pre-filtrare a particulelor solide [1].

Literatura de specialitate afirmă că principala soluție tehnologică pentru reducerea sarcini de încărcare a filtrelor mecanice, dar şi a costurilor de operare se poate obține prin introducerea în cadrul sistemelor recirculante a echipamentelor de pre-filtrare [8].

Două din cele mai utilizate echipamente de pre-filtrare care sunt tot mai des întâlnite în aplicațiile din SAR sunt decantoarele de nămol şi hidrocicloanele [4].

Potrivit afirmațiilor lui (Piggott, 2007) acesta a concluzionat că atât modul de operare cât şi eficiența decantoarelor de nămol ca de altfel şi a hidrocicloanelor este mult superioară bazinelor de decantare tradiționale [17].

Decantoarele de nămol aşa cum s-a mai amintit fac parte din categoria echipamentelor de pre-filtrare, utilizarea acestora are un scop precis şi anume realizarea unei filtrări parțiale a apei din bazinele de cultură. Principalele avantaje ce recomandă utilizarea decantoarelor de nămol în cadrul unui SAR, sunt:

- reduce semnificativ încărcarea cu solide într-un sistem;
- este echipament pasiv şi nu necesită energie suplimentară pentru a lucra;
- necesită numai curățare de rutină;
- nu necesită întreținere sau reparații suplimentare;
- poate fi realizat într-o gama variata de dimensiuni pentru diferite debite [20].

Unul din avantajele utilizării decantoarelor de nămol îl reprezintă şi faptul că nu ocupă foarte mult spațiu în comparație cu bazinele de decantare tradiționale, iar montarea şi demontarea lor pe traseul de evacuare al apei poate fi realizat cu rapiditate [19].

Una din modalitățile de amplasare a decantorului de nămol este fie în dreptul fiecărui bazin, după cum se poate observa şi în figura 2, în acest mod se reduce foarte mult timpul de transport a apei încărcate cu solide către unitatea de pre-filtrare, deci în consecință ajută la încetinirea procesului de descompunere a solidelor [4], fie după un grup de bazine, în funcție de mărimea

acestora şi de debitul de recirculare a apei din sistem [11], [1].

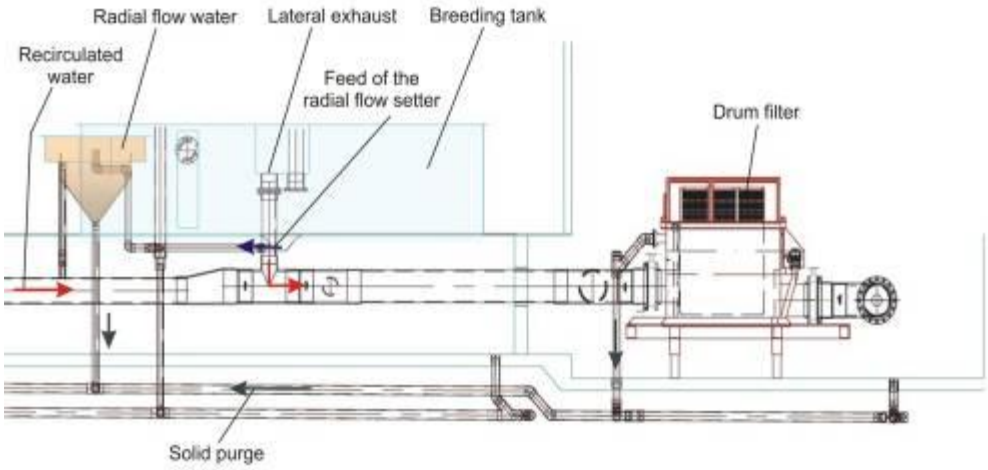

Fig. 2 - Integrating a radial flow settlers in the evacuation path of water from the tank to the mechanical filter [18]

Radial flow settler - description and technical characteristics

Because of the importance of radial flow settlers as a component of water treatment plants in the RAS, it must have a working behavior of 24 hours / day.

A technical solution to achieve a radial flow settler is shown in Figure 3. The technical solution presented is relatively simple, but it must be performed carefully to be able to successfully fulfill the role of pre-filtering equipment.

The main components that make up the radial flow settler are listed below, each having a specific purpose in the process of settling and evacuating solids from the system.

- A vertical cylindrical body 1, provided at the bottom with a flange for resting on the floor, while the top wall has a knurled circumference fragmentation for discharging the water film. Inside the body 1 there is a conical bottom 2 for collecting the mud and discharge it through an exhaust pipe 3 and a drain valve 4;
- Through the pipeline 5 for providing with wastewater and the valve 6, the water reaches the top of a central tube 7 which is open at both ends and according to the literature it should be designed with a minimum diameter of 25% of the vertical cylinder diameter 1, according to this

the water it gets down according to the the principle of communicating vessels in the body of the settler, where it discharge is over the riffled wall;

- The body 1 is provided externally at its upper part, with an overflow 8 in which the water is discharged over the riffled wall, without solid impurities whitch have been washed. From the overflow water is discharged through a pipe 9 towards its unit of mechanical filtration.

Decantorul de nămol – descriere şi caracteristici tehnice

Datorită importanței pe care o are decantorul de nămol ca şi componentă a instalațiilor de tratare a apei în SAR, acesta trebuie să aibe un regim de exploatare de 24 ore/zi.

O soluție tehnică de realizare a unui decantor de namol este prezentată în figura 3. Din punct de vedere tehnic soluția prezentată este una relativ simplă, dar care trebuie executată cu atenție pentru a putea îndeplini cu succes rolul de echipament de pre-filtrare.

Principalele compomente ce alcătuiesc decantorul de nămol sunt enumerate mai jos, iar fiecare din ele are un scop precis în procesul de sedimentare şi evacuare a solidelor din sistem.

- Un corp cilindric vertical 1, prevăzut la partea inferioară cu o flanşă pentru aşezarea pe pardoseală, iar la partea superioară circumferința peretelui este zimțată pentru fragmentarea peliculei de apă deversate. În interior corpul 1 are un fund conic,2 pentru colectarea nămolului şi evacuarea lui printr-o conductă de evacuare, 3 şi vana de golire 4;
- printr-o conductă 5 de alimentare cu apă uzată şi robinetul 6, apa ajunge în partea superioară a unui tub central 7 deschis la ambele capete şi care potrivit literaturii de specialitate ar trebuie să fie proiectat cu un diametrul minim de 25 % din diametrul cilindrului vertical 1, din acest punct apa coboară pe principiul vaselor comunicante în corpul decantorului, de unde deversează peste peretele zimțat;
- Corpul cilindric 1 are prevăzut în exterior, la partea superioară, un deversor 8 în care apa este deversată peste peretele zimțat, fără impuritățile solide ce s-au decantat. Din deversor apa este evacuată printr-o conductă 9 înspre unitatea de filtrare mecanica.

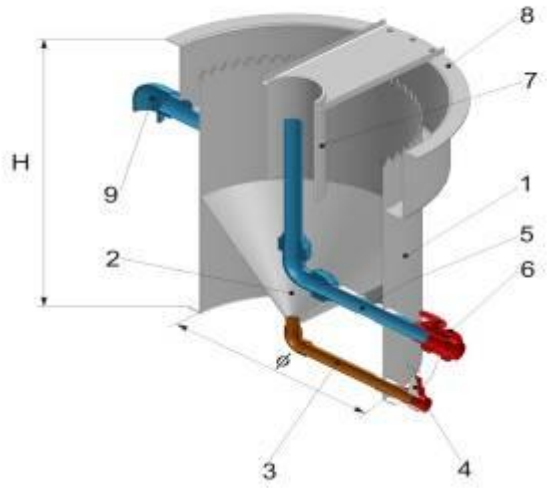

Fig. 3 – Sketch of the radial flow settler for RAS [12]

Radial flow settler – running

Radial flow settle for water from RAS are designed to be used for fish breeding tanks equipped with a double discharging system. Thus, 90% of the water is eliminated by flowing out of the tank through the upper part where it flows directly in to the mechanical filter, and the remaining 10% which flows through its lower part, reaches the radial floe settler and after the separation of solid impurities it is directed also towards the mechanical filter.

The operating principle of the radial flow settler for RAS is shown in the flow chart of figure 4.

Decantorul de nămol - Funcționare

Decantoarele de nămol a apei din SAR sunt concepute pentru a fi utilizate după bazinele de creşterea peştilor prevăzute cu dublă evacuare a apei. Astfel 90% din apa ce este evacuată din bazine prin partea superioară a acestora curge direct la filtrul mecanic, iar restul de 10% ce se scurge prin partea lor inferioară, ajunge în decantorul de nămol şi, după separarea impurităților solide, este dirijată tot spre filtrul mecanic.

Principiul de funcționare al decantorului de nămol pentru SAR este prezentat în schema tehnologică din figura 4.

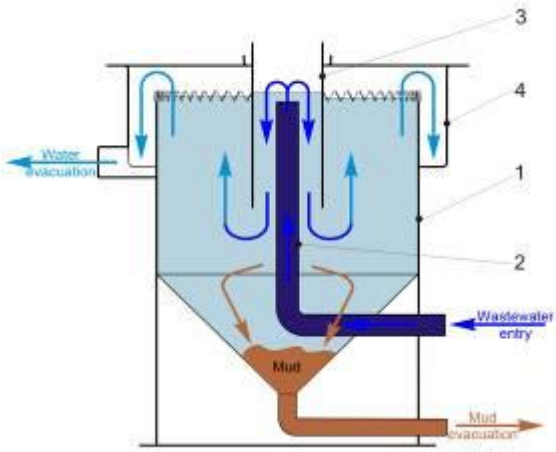

Fig. 4 – Technological operating scheme of radial flow settler [12]

From the technological scheme of operation it can be seen that loaded water with solids is discharged through the central drain from the bottom of the tank for growing fish in RAS is conducted through a central pipe 2 and discharged in a central tube 3, opened at both ends and which is designed to reduce turbulent flow of the water, so that the settled solids at the bottom of the cone are returning again into the state of suspension. According to the principle of communicating vessels, water flowing down the central pipe 3 enters the radial flow settler and is spilling over the wall of the settler 4 witch surrounds the perimeter of the area of sedimentation, where it is discharged into the RAS for the mechanical filter circuit. Because of the large difference between the central pipe section 2 and the settler body section 1, the speed of the water decreases more, which allows settling of solid particles into the cone of the settler. The solid particles, eliminated in form of mud are periodically eliminated through a discharge pipe by opening a valve.

Another factor that interest in the operation of the radial flow settler is also related to particle sedimentation velocity because of the large difference between the central pipe section 2 and the settler body section 1, the speed of the water decreases more, which allows settling of solid particles into the cone of the settler. The solid particles, eliminated in form of mud are periodically eliminated through a discharge pipe by opening a valve.

In a radial flow settler solids particles can only be removed if sedimentation rate is higher than the speed of water flow upward, Figure 5.

In this case the minimum speed particle sedimentation clarifier sludge solids is obtained by applying the relationship 5.

Din schema tehnologică de funcționare se poate observa faptul apa încărcată cu solide ce este evacuată prin drenul central de pe fundul bazinelor de creştere a peştilor dintr-un SAR este condusă printr-o conductă centrală 2, şi deversează într-un tub pozitionat central 3, deschis la ambele capete şi care are rolul de a atenua curgerea turbulentă a apei, pentru ca solidele depuse pe fundul conului să nu reintre din nou în starea de suspensie. Conform principiului vaselor comunicante, apa coboară în tubul central 3, intră în decantorul de nămol 1 şi deversează pe o directie radiala peste peretele zimțat al decantorului în deversorul 4 ce înconjoara perimetrul zonei de sedimentare, de unde este evacuată în circuitul SAR spre filtrul mecanic.

Un alt factor care intereseaza în funcționarea unui decantor de namol este legat si de viteza de sedimentare a particulelor datorită diferenței mari dintre secțiunea conductei centrale 2 şi cel al secțiunii corpului decantorului 1, viteza de transfer a apei scade mult, ceea ce permite decantarea particulelor solide în pâlnia conică a decantorului. Particulele solide, decantate sub formă de nămol, sunt evacuate periodic printr-o conductă de evacuare prin deschiderea unei vane.

Într-un decantor de nămol în mod clar particulele solide vor putea fi îndepărtate doar dacă viteza de sedimentare este mai mare decât viteza debitului ascendant al apei, figura 5.

În acest caz viteza minimă de sedimentare a particulelor solide în decantorul de namol se obține aplicând relația 5.

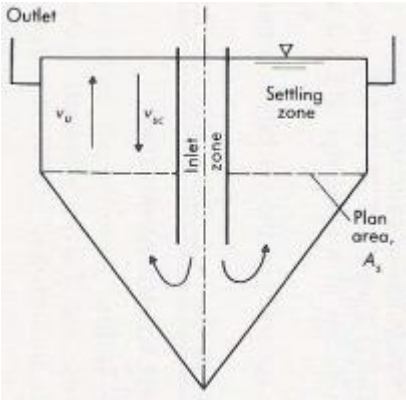

Fig.5 - Scheme of radial flow settler with representation of sedimentation rates and water drain from the unit [7]

$$V_s = \frac{Q}{A} \tag{5}$$

According to research by the Aquacare if sedimentation rate is 8 cm / min, then the remove of particulates can be done with a yield of 90% [19].

CONCLUSIONS

Essential in RAS functionality is the use of competitive operation of equipment, which are able to maximize production with costs as low as possible

Using radial flow settler inside a RAS is also advantageous in terms of operating costs, that because

Potrivit cercetărilor realizate de cei de la Aquacare, dacă viteza de sedimentare este de 8cm/min, atunci îndepărtarea particulelor se poate face cu un randament de 90% [19].

CONCLUZII

Utilizarea decantoarelor de nămol în interiorul unui SAR este avantajoasa şi din punct de vedere al costurilor de operare, asta datorita faptului ca în funcționare nu necesită utilizarea unei pompe, curgerea fiind una

the operation does not require the use of a pump, flow is one gravitational.

By introducing a radial flow settler as pre-filtering equipment on the evacuation of water from tanks, studies have shown that the efficiency of removing solids from the system with microsieves filters will increase by up to 97%.

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gravitațional.

Prin introducerea unui decantor de namol ca şi echipament de pre-filtrare pe cursul de evacuare al apei de la bazine, studiile au arătat că eficiența cu care are loc îndepărtarea particulelor solide din sistem de către filtrele cu microsite va creşte cu până la 97%

MULȚUMIRI

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STUDY ON FIELD WATER-SALT BALANCE SIMULATION USING SWAP MODEL: A CASE STUDY OF FARMLAND IN THE CENTRAL SHAANXI PLAIN
/
基于SWAP 的田间水盐平衡模拟研究——以关中农田为例

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Abstract: *To study the variation law of key components for water-salt balance of typical farmland in the central Shaanxi Plain, this paper calibrated and verified the SWAP model based on a field trial of summer maize growing season from 2013 to 2014. Variations of different components during different summer maize growth stages were analyzed and discussed according to the calculated results of water-salt balance by the verified SWAP model. Results showed that the calibrated and verified SWAP model could well simulate dynamic variation laws of water-salt content of different soil layers in the study area. Within the study period, transpiration of maize in 2013 and 2014 was restricted by water content in the surface layer. The accumulative actual transpiration accounted for 57.6% and 64.9% of potential transpiration, respectively. Soil water supply from underground water was mainly in the vigorous growth of maize. The accumulative underground water supplies in 2013 and 2014 were 10.3cm and 7.4cm, respectively. Water flux at bottom soil was highly sensitive to rainfall and irrigation, presenting the obvious deep leakage. The soil salinity changes at 0~120cm layer in 2013 and 2014 were -72.87 mg/cm^2 and -81.32mg/cm^2, respectively. Great desalination was observed in the rainy season of maize growth.*

Keywords: *Soil moisture; Salinity; SWAP model; Water balance; Salt balance*

摘要: *为了研究关中平原典型农田水盐平衡关键组分的变化规律，本文基于 2013～2014 年夏玉米生长季的田间试验，对 SWAP 模型进行了率定和验证，并根据验证后模型的水盐平衡计算结果，对其各分量在夏玉米不同生长阶段的变化过程进行了分析与讨论。研究结果表明：经过率定和验证后的 SWAP 模型较好地模拟了研究区田间土壤各层水盐含量的动态变化规律。模拟期内，2013 与 2014 年季玉米的蒸腾量受到了表层含水量的制约，累积实际蒸腾量占潜在蒸腾量的比值分别为 57.6%和 64.9%；地下水对于土壤水的上升补给主要出现在玉米生长的旺盛阶段，累积地下水上升补给量分别为 10.3cm 和 7.4cm；土壤底部水分通量变化对降雨和灌溉的响应强烈，并表现为明显的深层渗漏。2013 与 2014 年季田间 0～120cm 土壤盐分变化量分别为-72.87 mg/cm^2 和-81.32mg/cm^2，主要在玉米生长的雨季脱盐明显。*

关键词: *土壤水分; 盐分; SWAP 模型; 水量平衡; 盐分平衡*

INTRODUCTION

Salinization is a universal soil character in arid and semi-arid regions in China [8]. Soil salinization and soil secondary salinization caused by irrigation are main constraints against local agricultural development and the main influencing factors of local ecological environmental stability [2]. The Lubotan at the junction of Pucheng County and Fuping County lies in the central Shaanxi Plain where it has the richest agriculture in arid and semi-arid regions. The local groove terrain of low-in-middle but high-in-surroundings, diversion irrigation in the Luoxi irrigation area and common flood irrigation implemented in Lubotan have caused drainage silting, groundwater level rise and intensifying salinization of soil, thus influencing local food production and sustainable agricultural development significantly[5,11]. Through a series of farmland ameliorative measures like perfecting the irrigation and drainage system, no large-scale salinization of soil has occurred and crop output recovers to the normal level. However, local crop growth is still influenced by different degrees of salt stress.

The SWAP (Soil-Water-Atmosphere-Plant) model developed by Wageningen University (Netherlands) calculates water movement and solute transport in soils by using the one-dimensional Richards equation and the

引言

盐渍化是我国干旱、半干旱地区土壤的一个普遍特征[8]。土壤的盐渍化和灌溉引起的土壤次生盐渍化问题是制约该地区农业发展的主要障碍，也是影响该区生态环境稳定的重要因素[2]。陕西省富平县与蒲城县交界的卤泊滩地区位于干旱、半干旱区农业最富庶的“关中平原”地带，滩区四周高中间低的槽形地势特点，加之洛西灌区引水灌溉及当地常年实施的漫灌方式，造成滩区内排水沟道淤积，地下水位上升，土壤盐碱化逐渐加剧，严重影响了当地的粮食生产及农业的可持续发展[5,11]。通过一系列健全灌排系统等土地改良措施，滩区内整治后的地块没有再发生大面积的盐渍化，且作物产量接近正常，但当地农作物的生长，仍会受到不同程度上的盐分胁迫影响。

由荷兰 Wageningen 大学研制的 SWAP（Soil-Water-Atmosphere-Plant）模型，利用一维 Richards 方程和对流-弥散方程分别计算土壤的水分运动以及溶质运移过

convection-dispersion equation. With consideration to effect of adversity stresses like water and salt on crop growth [7,10], the SWAP model is more applicable to simulation study on water-salt movement and balance in salinization farmland soils. The SWAP model has been widely used in both China and foreign countries for its perfect physical mechanism. However, few researches on its applicability in the central Shaanxi Plain have been reported yet. Based on field trial data of summer maize in 2013 and 2014, the SWAP model was calibrated. It was confirmed feasible to describe component variation law of water-salt balance in the study area. Dynamic changes of different components of water-salt balance at different summer maize growth stages were analyzed and discussed, aiming to provide theoretical basis for soil secondary salinization control in the agricultural irrigation area in the central Shaanxi Plain.

MATERIAL AND METHOD

Field test

One improved typical salinization farmland in the midwest of Lubotan was chosen as the study area. It belongs to semi-arid continental climate, with extremely uneven precipitation distribution in one year. Most precipitations are received from July to September, accounting for 49% precipitation of the whole year. It is dry in rest time of the year. The groundwater depth is about 2m throughout the year. There're distinct dry and wet seasons. The dry season is longer than the wet season. Particularly, it is windy but has less rainfall in spring, accompanied with great evaporation. The annual sunshine duration is 2349.5~2472.0h. The 0 ℃ accumulated temperature is 4906.5～5022℃ and the ≥10℃ accumulated temperature is 4276.3～4477.3℃, basically satisfying growth demands of wheat, maize and cotton [11]. Physical and chemical parameters of soil in the study area are listed in Table 1 [11].

The State Key Laboratory of Ecohydraulic Engineering for Northwest Arid Regions, Xi'an University of Technology established a field observation station in the study area in 2013 in order to observe the water cycle elements and water-salt dynamics of typical farmlands in the Lubotan. Instruments in this station are mainly for conventional meteorological observation, soil water-salt observation and groundwater level observation. The observation items of conventional meteorological elements could be used to calculate evapotranspiration of reference crops. Soil water-salt observation is mainly accomplished by multiparameter sensors (Campbell-CS655) which are buried 2m deep in test pits. There are four small shafts surrounding the test pit, where water level sensors (Campbell-CS450) are buried in to observe groundwater level. Crop rotation of wheat in winter and maize in summer is adopted for farmlands surrounding the soil water-salt observation profile. The summer maize uses "Zhengdan 958" which is generally sowed in early June and harvested in middle October. According to farming habit of local peasants, since there are plentiful precipitation after the elongation stage of summer maize (July~September), two flood irrigation with subsiding water from the Yellow River will be implemented at trefoil stage and elongation stage of maize. To observe dynamic growth of maize in the observation stage, the 101m×105m study area was divided into 25 20m (L)×20m (W) blocks. Plant height,

程，同时考虑了水盐等逆境胁迫对于作物生长的影响[7,10]，使得该模型更可能适用于盐渍化农田土壤水盐运动及其平衡过程的模拟研究。SWAP 模型以其较为完善的物理机制在国内外各地区得到了广泛应用。但在关中平原地区的相关适用性研究还相对较少。本文利用 2013～2014 年两季夏玉米的田间试验观测资料，率定并验证了 SWAP 模型对于描述研究区田间水盐平衡分量变化规律的适用性，并对模型计算的两季夏玉米各生长阶段的水盐平衡各组分动态进行了分析与讨论，旨在为关中农灌区土壤次生盐渍化的防治提供理论基础。

材料与方法

田间观测实验

选取卤泊滩中西部(109°22′E、34°48′N)一处改良过后的典型盐渍化农田作为研究区域。研究区属半干旱大陆性气候，降雨年内分布极不均匀，多集中在 7 到 9 月份，占全年降雨量的 49%，其他季节较为干旱，常年地下水埋深约 2m 左右。干湿季节分明，干季长于湿季。尤其是春季多风少雨，蒸发量大。年日照时数 2349.5~2472.0h，0 ℃积温 4906.5～5022℃，≥10℃积温 4276.3～4477.3℃，基本上满足小麦、玉米、棉花等作物的生长需求[11]。研究区土壤理化特性指标如表 1 所示[11]。

西安理工大学西北旱区生态水利工程国家重点实验室于 2013 年在研究区建立了田间观测站，目的是为了对卤泊滩地区典型田间的水循环要素及水盐动态进行观测。站内布设的仪器主要用于常规气象观测、土壤水盐观测以及地下水位观测等。常规气象要素的观测项目可以满足参考作物腾发量的计算需要；土壤水盐观测主要由埋深 2m 的测坑当中所布设的多参数传感器（Campbell-CS655）完成；测坑附近打有 4 口小型竖井并分别埋设了水位传感器（Campbell-CS450）用于地下水位的观测。环绕土壤水盐观测剖面的农田，种植模式为冬小麦-夏玉米轮作。其中，夏玉米品种为"郑单 958"，大致在每年 6 月初播种至同年 10 月中旬收获。按照当地农民的耕作习惯，由于每年夏玉米拔节期后（7 月～9 月）的降水充沛，故基本在玉米的三叶期和拔节期前后进行两次淡水灌溉，方式为大水漫灌，所用灌溉淡水为黄河退水。为了对观测期内的玉米生长动态进行观测，将 101m×105m 的研究区域均匀划分为长宽约 20m×20m 的样方，共计 25 个。通过定期

root depth, leaf area index and aboveground biomass were observed manually through regular uniform sampling of each block. The field test design and instrument layout in the observation station are displayed in Fig.1.

在每个样方当中进行的均匀采样来完成作物株高、根深、叶面积指数以及地上部生物量的人工观测。田间观测试验设计和站内仪器的布设概况如图 1 所示。

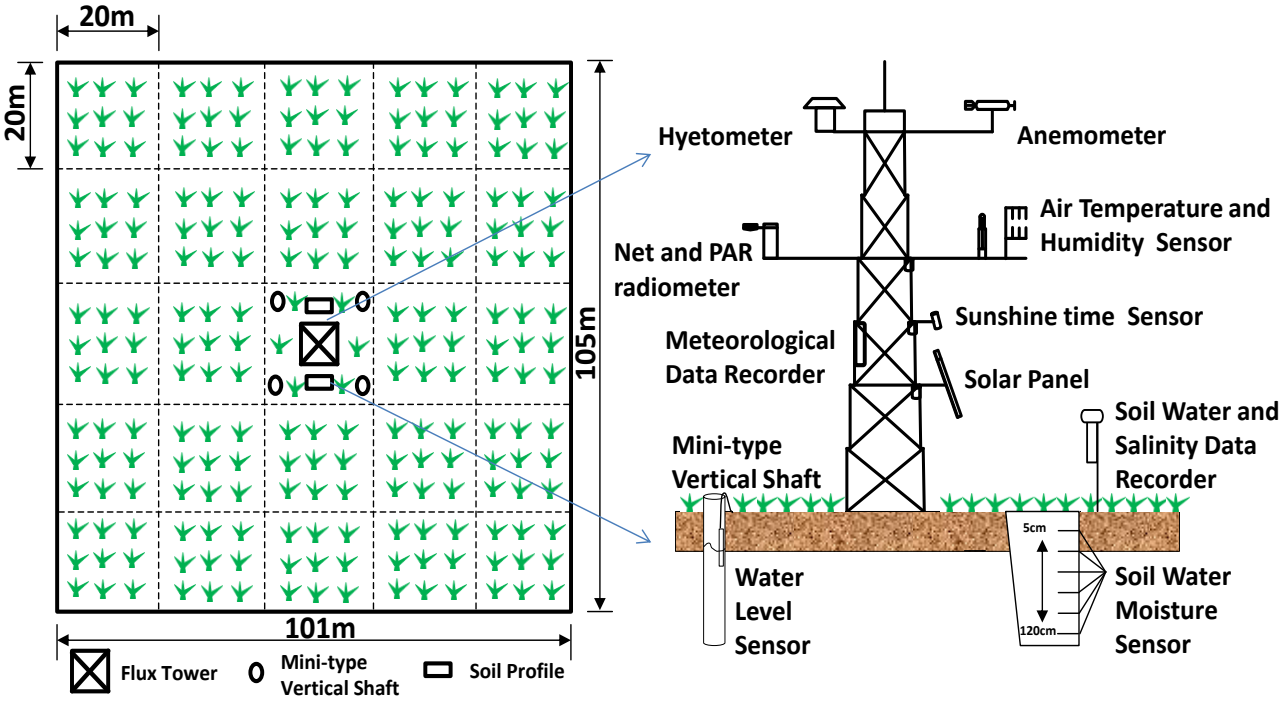

Fig. 1- Schematic representation of the experimental design and instruments layout.

Table 1

Physical and chemical properties in the soil profile of 0–100 cm

Depth (cm)	Soil particle size distribution (%)			Bulk density (g/cm^3)	pH (H_2O)	Organic C (%)
	Sand (>0.05mm)	Silt (0.002-0.05mm)	Clay (<0.002mm)			
0-20	44.1	52.7	3.2	1.48	8.3	1.15
20-40	43.2	54.0	2.8	1.46	8.4	1.03
40-70	44.1	53.4	2.5	1.45	8.6	0.82
70-100	42.5	53.8	3.7	1.45	8.6	0.76

SWAP model

SWAP model is an open-source simulation model applicable for field macro quantitative analysis. It is developed by Wageningen University (Netherlands) on the basis of new research fruits concerning water dynamics and soil water movement of the current SPAC (Soil-Plant-Atmosphere Continuum) system. It is mainly used for simulation analysis on field soil water movement, solute transport and crop growth under different irrigation levels, and also could solve research and practice problems involving agriculture, water resources management and environmental protection [10]. The SWAP model could be divided into three main parts: meteorology part, crop part and soil part. Each part could be further divided into several sub-modules (which are realized by different functions). It simplifies soil heat and water movement as well as solute transport into vertical one-dimensional movement and solves the partial differential equation by finite different method. Soil water movement is described by Richards equation and soil solute transport is described by traditional

模型介绍

SWAP 模型是荷兰 Wageningen 大学在充分吸取了当前 SPAC（Soil-Plant-Atmosphere Continuum）系统水分动态以及非饱和土壤水分运动最新研究成果的基础上，研制开发的适用于田间宏观量化分析的开源模拟模型，主要用于田间尺度不同灌溉水平下的土壤水分运动、溶质运移及作物生长等过程的模拟分析，并能够解决农业、水资源管理和环境保护等几个领域的研究与实践问题 [10] 。模型分为 3 个主要部分，即气象部分、作物部分、土壤部分，每个部分又分为若干个子模块（由各个函数实现）。模型将土壤水热运动和溶质运移简化为垂向一维运动，并采用有限差分法求解偏微分方程。土壤水分运动利用 Richards 方程描述，土壤溶质运移过程采用传统的对流-弥散方程描述。模型通过分析作物根系吸水速率在不同水

convection-dispersion equation. It reflects effect of water and salt stress on crop growth through water absorption rate of crop roots under different water potentials.

Considering practical soil texture in the study area and active layer depth of summer maize roots, the simulated soil depth in this paper was 0～120cm, which were divided into three layers: 0～30cm, 30～60cm and 60～120cm. When simulating water and salt contents in different layers of the soil profile, each soil layer shall be further divided into several units. In this simulation, the soil depth 0～120cm was divided into 32 units. To simulate water dynamics in the upper soil layers precisely, units close to the earth surface were set 0.5~1cm thick and those of the lower layer were set 5~10cm thick. The upper boundary inputs of the model were parameters that determine water flux in surface soil layer, such as irrigation, rainfall and surface evaporation. Due to the shallow water table in the study area, variation of groundwater level with time was taken as the lower boundary condition of the model. Initial condition setting includes initial salinity of soil layer and pressure head which could be gained from observation data of instruments in the station.

势下的削减情况来体现水盐胁迫对于作物生长的影响。

根据研究区土壤质地的实际情况以及夏玉米根系活动层深度，本文选择模拟的土层深度为 0～120cm，并将土柱划分为 0～30cm、30～60cm、60～120cm 三个层次。模拟土壤剖面各层次的水盐含量时，要求将每个土层再细分为若干单元。本次模拟将 0～120cm 土柱共划分为 32 个单元。为了能精确模拟土柱上层的水分动态，将接近土表的单元格设定为 0.5～1 cm 厚度，下层设为 5～10 cm 厚度。模型上边界条件输入为灌溉、降雨以及土面蒸发等决定土壤表层水分通量状况的有关参数。考虑到研究区地下水位常年为浅埋深状态，故以地下水位随时间的变化过程作为模型的下边界条件。初始条件设定包括各土层初始时刻的含盐量及压力水头等，均可从站内仪器的观测资料当中获得。

RESULTS AND DISCUSSIONS

Model calibration and verification

Measured data of meteorology and soil water and salt content from 2013 to 2014 in the observation station were collected for model parameter calibration and verification. Field observation data in 2013 were used to calibrate model parameters and those in 2014 were used to verify the model. In this paper, international universal root-mean-square error (RMSE) and mean relative error (MRE) were used as the evaluation indexes of model simulation effect.

结果与分析

模型率定与验证

收集并整理观测站 2013～2014 年的气象和土壤水盐含量等实测数据作为模型参数率定与验证的数据资料。其中，2013 年的田间观测数据用来率定模型参数，2014 年的数据用于模型验证。本文采用国际上较为通用的均方根误差（RMSE）和平均相对误差（MRE）作为模型模拟效果的评价指标。

$$\mathrm{RMSE} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(P_i - O_i\right)^2} \tag{1}$$

$$\mathrm{MRE} = \frac{1}{N}\sum_{i=1}^{N}\left|\frac{P_i - O_i}{O_i}\right| \times 100\% \tag{2}$$

Where N is number of measured data, O_i is the ith measured data and P_i is the corresponding simulated value.

To simulate soil water content, hydraulic characteristic parameters of soil layers have to be determined. Soil samples of different layers were collected from the test pit profile in the study area, which were then carried back to the laboratory to get the soil water characteristic curve through “tensiometer weighing method”. Later, related test data were fitted using the RETC (retention curve program for unsaturated soils) software developed by USSL (US Salinity Laboratory) [4], thus getting the initial values of hydraulic characteristic parameters of soils. With reference to measured soil water of summer maize during the calibration period (2013), meteorological and irrigation system of the study area as well as initial values of soil hydraulic characteristic parameters gained from laboratory test were input into the SWAP model together until getting the optimum fitting result between the simulated results and measured results. In this way,

上式中的 N 为实测值的个数，O_i表示第 i 个实测值，P_i表示对应的模拟值。

对于土壤含水量的模拟，需要确定土柱各层次的土壤水力特性参数。具体是通过在研究区测坑剖面各层采集土样并带回室内进行“张力计称重法”得到其对应的土壤水分特征曲线后，利用 USSL（美国盐改中心）开发的 RETC（retention curve program for unsaturated soils）软件对相关试验数据进行拟合[4]，从而得到土壤水力特性参数的初值。参考 2013 年率定期夏玉米整季的土壤含水量实测资料，并将研究区气象、灌溉制度以及室内试验得到的土壤水力特性参数初值一并输入 SWAP，以模拟值与实测值拟合度达到最优为止，从而得到了研究区土壤各层

calibration results of VG (Van Genuchten) model parameters of soil layers in the study area were gained (Table 2).

Limited by test conditions, this paper didn't setting parameters of solute adsorption and decomposition rate in the soil solute transport module of the model when simulating soil salinity. Dispersity and molecular diffusion coefficient are the main calibrating parameters in soil salinity simulation. The multiparameter sensor CS655 in the station couldn't output soil salinity directly. Laboratory "conductometry" is needed to further determine the transformational relation between soil bulk electrical conductivity (EC_b, dS/m) measured by the multiparameter sensor in the station and the salinity (S, g/kg). The goal is to get the optimum fitting between measured salinity and simulated result. The calibration results of dispersity and molecular diffusion coefficient are 13cm and 0.4cm^2/d, respectively.

Maize growth dynamics in the study area within the observation period were simulated by the simple crop module in the SWAP model. Based on regular manual observation of maize growth in the study area, plant height, leaf area index and root depth of different stages that have to be input in the module could be determined. Additionally, initial values of parameters difficult to be measured, such as extinction coefficient of canopy, critical pressure head that causes water stress and critical soil conductivity that causes salt stress, are all determined through literature review [1,9]. Calibration results of main input parameters of this module are shown in Table 3.

VG（Van Genuchten）模型参数的率定结果，如表 2 所示。

针对土壤含盐量的模拟，鉴于试验条件的限制，本文省略了模型土壤溶质运移模块里的溶质吸附及其分解速率等细节问题的参数设定。因此，进行含盐量模拟时率定的参数主要是弥散度和分子扩散系数。站内的多参数传感器 CS655 并不能直接输出土壤的含盐量结果，需要借助室内"电导法"试验来进一步确定站内多参数传感器测量的土壤电导率值 EC_b（bulk electrical conductivity，dS/m）与全盐量 S（salinity，g/kg）之间的转换关系。以含盐量实测值与模型模拟值的吻合度达到最优为目的，弥散度和分子扩散系数的率定结果分别为 13cm 和 0.4cm^2/d。

对于观测期内研究区玉米生长动态的模拟，本文采用了 SWAP 模型当中的简单作物模块。基于对研究区玉米生长定期的人工观测，能够确定该模块所需要输入的各阶段株高、叶面积指数以及根系深度三方面的生长动态。另外，冠层消光系数、引起水分胁迫的临界压力水头值和引起盐分胁迫的土壤临界电导率值等不易测量的参数，均是通过查阅相关文献来确定其初始值[1,9]。经过反复调参，该模块的主要输入参数率定值如表 3 所示。

Table 2

VG model parameters calibrated values of soil moisture characteristic curve

Soil Depth (cm)	Saturated water content θ_s (cm^3/cm^3)	Residual water content θ_r (cm^3/cm^3)	Saturated hydraulic conductivity Ks (cm/d)	Shape factor		
				α	n	λ
0～30	0.37	0.0885	11.4	0.017	1.26	0.5
30～60	0.41	0.0936	10.7	0.011	1.48	0.5
60～120	0.40	0.1031	10.2	0.010	1.66	0.5

Table 3

Calibrated values of primary crop biological parameters in simple crop growth module

Parameters	Selected values (summer maize)
Extinction coefficient for diffuse visible light (-)	0.53
Extinction coefficient for direct visible light (-)	0.75
Press head (cm) below which roots: h1, h2, $h3_{high}$, $h3_{low}$, h4 #	-15, -30, -325, -600, -15000
ECsat level below which no salt stress (dS/m)	1.5
Decline root water uptake above this level (%/dS/m)	8.5
Minimum canopy resistance (s/m)	70.0
Precipitation interception coefficient (-)	0.25

Note: #. Parameters of water stress response function adjusted as per value suggested by Veenhof and McBride (1994).

Analysis on simulation results of soil water and salt contents

Calibrated parameters for simulating soil water

土壤水盐含量模拟结果分析

将用于土壤含水量模拟的相关参数率定值输入到模型当

content (SWC) were input into the SWAP model to simulate SWC of summer maize in 2013 and 2014. Results are shown in Fig.2. Meanwhile, a statistical test on the fitting degree between measured and simulated SWC was made (Table 3). Overall, RMSE of soil layers during the calibration period and verification period was smaller than 0.03cm^3/cm^3, and MRE was lower than 10%, indicating that calibrated and verified SWAP model could well simulate SWC dynamics in the study area. However, water content in the surface layer (0～30cm) fluctuates more violently than that in deeper layers (>30cm). Moreover, the simulation precision of surface soil volumetric moisture content is lower than that of deep soil layer. This is mainly because organic content, macro pores and other soil properties often have high spatial temporal variability in upper layer, thus making surface SWC dynamics more complicated than deeper layers [10]. When simulating SWC dynamics under crop influence by uploading crop files, some parameters, especially those related with water absorption of roots, were set as theoretical values provided by associated references. This will bring great error in describing transpiration of crop root zone in the study area.

Soil salt content (SSC) of summer maize in 2013 and 2014 were simulated based on calibrated relative parameters. Results are shown in Fig.2. A statistical test on measured and simulated SSC was made (Table 3). RMSE during the calibration period and verification period was smaller than 1.5mg/cm^3, and MRE was lower than 15%, indicating that the calibrated and verified SWAP model could reflect general variation law of SSC in the study area within the observation period. However, the statistical test reported that the SSC simulation of the SWAP model is poorer than the SWC simulation. It has great simulation errors to surface soil layer (0~30cm). This is mainly because when adjusting parameters of the solute transport module, no targeted laboratory soil column test was conducted except for neglecting solute adsorption and decomposition rate. Therefore, the limited parameter calibration results are inadequate to describe dynamic changes of SSC in the crop root zone in the study area. Meanwhile, SSC in surface layer (0～30cm) changes more violently than that in deeper layers (>30cm) and surface SSC simulation precision is lower than the deeper layer. This is similar with SWC simulation results, indicating that SWC simulation influences SSC simulation precision significantly.

中，并分别对 2013 与 2014 年两季夏玉米田间土壤各层的含水量（SWC）状况进行了模拟，结果如图 2 所示。同时，对土壤含水量各层实测与模拟结果的吻合程度进行了统计检验，如表 3 所示。总体来看，率定期与验证期各层的 RMSE 值不超过 0.03cm^3/cm^3，且各层的 MRE 值均低于 10%，说明经过率定和验证后的 SWAP 模型能够较好地模拟研究区土壤剖面各层的水分动态。然而，表层 0～30cm 含水量的波动要明显高于埋深 30cm 以下土层，且表层土壤体积含水量的模拟精度要低于深层的模拟精度，这主要是由于有机质含量、大孔隙和其它土壤属性通常在上层具有较高的时空变异性，使得表层土壤水分的动态比深层土壤复杂得多[3]；而且通过加载作物文件来模拟作物影响下的土壤水分动态时，个别参数的设置主要来源于相关文献提供的理论值，尤其是与根系吸水有关的参数设置，这在一定程度上会对研究区作物根系层蒸腾耗水过程的描述带来较大偏差。

基于率定后的相关参数分别对 2013 与 2014 年两季夏玉米田间土壤各层含盐量（SSC）状况进行了模拟，结果如图 2 所示。对各层含盐量的实测和模拟值进行了统计校验，见表 3。率定期和验证期的 RMSE 值不超过 1.5mg/cm^3，且各层的 MRE 值均低于 15%，说明经过率定和验证后的 SWAP 模型较好地反映了观测期内研究区土壤剖面各层含盐量的大致变化趋势。但从统计校验结果来看，模型对于土壤含盐量的模拟效果并没有土壤含水量的模拟效果好，尤其是表层 0～30cm 含盐量的模拟偏差较大。这主要是因为在对溶质运移模块进行调参的过程当中，除了未考虑溶质吸附及其分解速率等细节问题以外，未开展针对性较强的室内土柱试验，使得有限的参数率定值不足以描述研究区作物根系层土壤盐分的动态变化。同时，表层 0～30cm 含盐量变化较 30cm 以下土层剧烈，且表层含盐量的模拟精度要低于深层，这与含水量的模拟结果类似，说明对于土壤含水量的模拟在很大程度上影响了土壤含盐量的模拟精度。

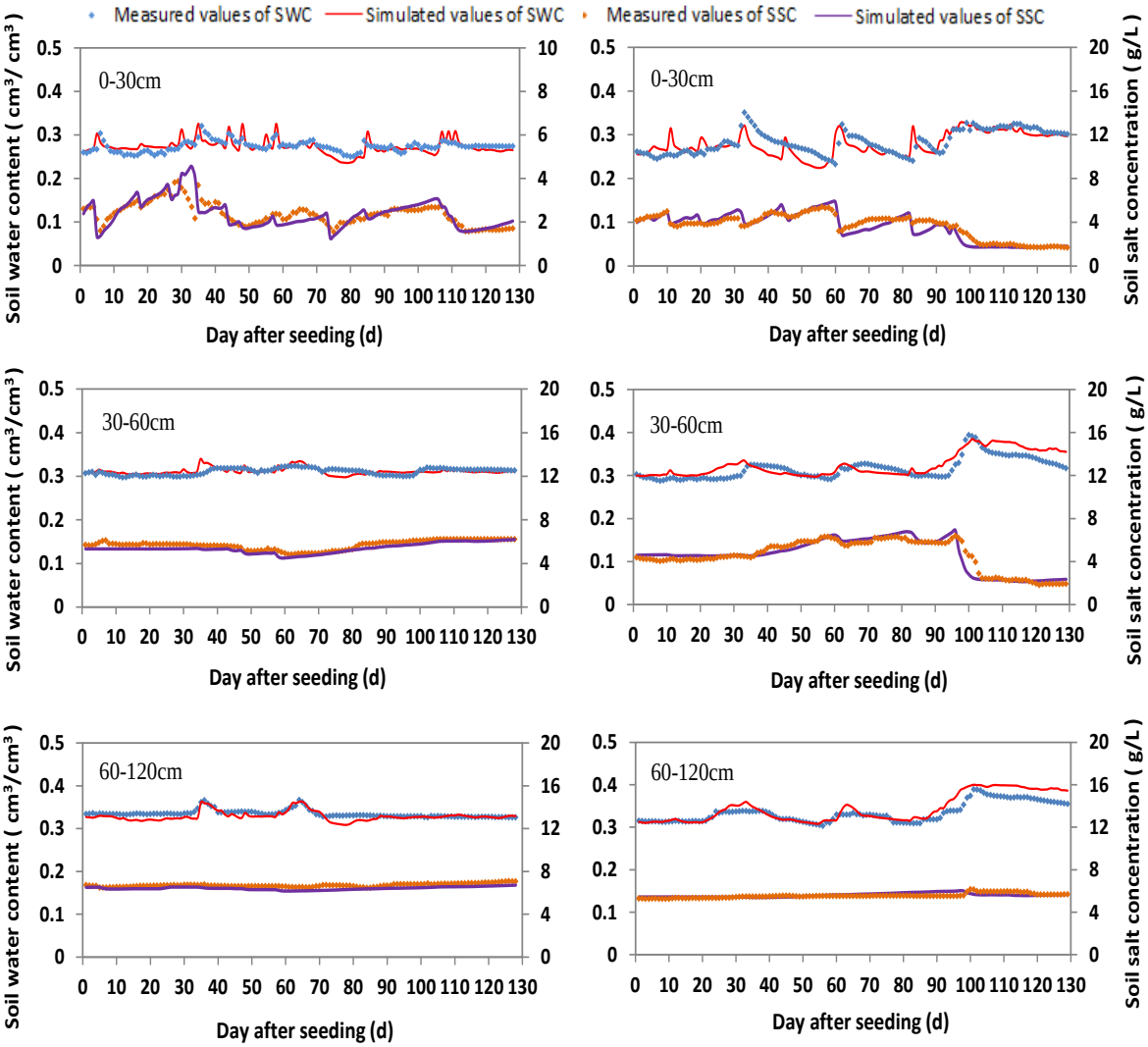

Fig.2- Simulated versus measured water and salt content of the soil solution in different soil layers during model calibration (left) and verification (right).

Table 4

Goodness-of-fit test indicators relative to SWAP model calibration and verification

Growing season	Soil depth (cm)	Soil water content (cm^3/cm^3)		Soil salt content (mg/cm^3)	
		RMSE (cm^3/cm^3)	MRE (%)	RMSE (mg/cm^3)	MRE (%)
Calibration (2013)	0-30	0.014	4.2	1.392	13.8
	30-60	0.008	2.2	0.827	8.2
	60-120	0.009	2.0	0.490	4.1
Verification (2014)	0-30	0.022	5.9	1.268	11.1
	30-60	0.018	3.8	0.922	9.3
	60-120	0.016	3.4	0.424	3.2

Analysis on calculated results of water-salt balance

The calibrated and verified SWAP model maintains high simulation precision of SWC, implying that this model could simulate soil water movement and solute transport in the study area and the simulated results of field water-salt balance components are reliable.

水盐平衡计算结果分析

经过率定和验证后的 SWAP 模型对土壤水盐含量的模拟保证了较高的精度，说明该模型能够进行研究区土壤水分运动及溶质运移的模拟，且模拟得到的田间水盐平衡分量的计算结果是可靠的。

Calculated results of water balance

Daily results of precipitation, irrigation (IRR) and groundwater level (GWL) during the summer maize growth period from 2013~2014 as well as main water balance components output by the model are exhibited in Fig.3. Main water balance components include crop transpiration, surface evaporation, bottom water flux (QBOT) and water storage changes in 0～120cm soil layers (DSTOR). No independent observation data of surface evaporation and crop transpiration were available in the station. However, it can be seen from Fig.3 that simulated results of the SWAP model basically conform to different forms of evapotranspiration change features of maize in different growth stages and under different surface coverage. In the study area, field evapotranspiration during seedling stage of summer maize (about 30d from emergence stage to seven leaves stage) is dominated by surface evaporation because of the slow growth of aboveground parts and low field coverage. The summer maize achieves the most vigorous growth of nutritive organs like leaves and stems during the heading stage (about 50d from the elongation stage to tasseling stage). During this stage, leaf area index and crop transpiration increase significantly compared to the early period, but surface evaporation reduces because of the high canopy density. Reproductive growth takes the dominant role during the anthesis maturity period (about 45d from milk-ripe stage to maturity stage), while vegetative growth stops basically. With the gradually aging of nutritive organs, crop transpiration declines. In the model output results, the accumulative actual transpiration in 2013 and 2014 accounted for 57.6% and 64.9% of potential transpiration, respectively. This symbolizes crop transpiration in the simulation period is influenced by surface soil water content to a certain extent.

Viewed from dynamic changes of water flux on the soil water-groundwater interface during maize growth period in 2013 and 2014, groundwater level in the study area was mainly influenced by precipitation and irrigation. The simulated soil water storage changes are consistent with observed groundwater level changes. The bottom flux changes was less influenced by crop factors, and made strong responses to only rainfall and irrigation. The accumulative soil water supplies from groundwater in 2013 and 2014 were 10.3cm and 7.4cm, respectively. The water storage in 0~120cm layers reduced by 5.52cm in 2013 and increased by 1.58cm in 2014. Specifically, the negative soil water supply from groundwater mainly occurred after the elongation stage when maize grows vigorously. With the growth of leaves, field evapotranspiration intensified gradually, so that soil water in saturated zone flows to the unsaturated zone through capillary action, thus resulting in the positive bottom flux and upward supply. Increase of soil water storage and deep leakage of soil water mainly occurred after irrigation and heavy rainfall. For example, twice irrigation at the 30th day and 58th day after summer maize sowing in 2013 as well as the twice irrigation at the 28th day and 59th day after summer maize sowing in 2014 accumulated 6.7cm and 7.2cm deep leakage, respectively. The highest accumulative deep leakage was in the lasting heavy rainfall at late maize growth period in 2014, reaching 4.86cm. Deep leakage of soil water is a kind of waste of farmland water resources. In particular, plentiful deep leakage after irrigation lowers

水量平衡计算结果分析

图 3 所示为 2013～2014 年两季夏玉米生长期内降雨、灌溉（IRR）、观测地下水位（GWL）以及模型输出的田间水量平衡主要分量的逐日计算结果，包括作物蒸腾量、土面蒸发量、底部水分通量（QBOT）和 0～120cm 土壤储水变化量（DSTOR）。试验站缺乏对土面蒸发和作物蒸腾的分别观测，但由图 3 可以看出，模型对于两个分量的模拟，基本符合玉米在各生育期内不同形态及地表覆被情境下的蒸散变化特征。其中，研究区夏玉米由于苗期（出苗期至七叶期，约 30 天左右）地上部茎叶生长缓慢，农田覆被率较低，因而田间蒸散发以土面蒸发为主。穗期阶段（拔节期至抽穗期，约 50 天左右），玉米叶片及茎节等营养器官的生长是整个生育期内最为旺盛的阶段，所以叶面积指数及作物蒸腾量相比初期显著增加，但此时较高的冠层郁闭度使得土面蒸发呈现低值。夏玉米到了花粒期（乳熟期至成熟期，约 45 天左右），生殖生长占据主导，而营养生长已基本停止，伴随着营养器官的逐渐老化，作物蒸腾量亦呈现衰减趋势。模型输出的计算结果当中，2013～2014 年两季玉米生育期内累积实际蒸腾量占潜在蒸腾量的比值分别为 57.6%和 64.9%，说明模拟期内的作物蒸腾量在一定程度上受到了表层土壤含水量的影响。

从两季玉米各生育期土壤水-地下水界面水分通量的动态变化来看，研究区地下水位主要受降雨和灌溉的影响，且模拟得到的土壤储水变化量与观测地下水位的波动较为一致。两季的底部通量变化受作物因素影响较小，仅在降雨和灌溉时响应强烈。2013 年与 2014 年两季玉米田间的地下水累积入渗补给量分别为 10.3cm 和 7.4cm，0～120cm 土壤储水变化量分别为-5.52cm 和 1.58cm。具体来看，地下水给予土壤水方向向上的负补给主要出现在拔节期以后，该阶段玉米生长发育旺盛，随着叶片的增大增多，田间蒸散日趋强烈，使得饱和带土壤水经由毛细作用补给至非饱和带，底部通量为正值，方向向上。土壤储水量的增大及土壤水的深层渗漏主要发生在灌溉和强降雨过后。例如，2013 年夏玉米播种后第 30 天和第 58 天的两次灌溉，2014 年夏玉米播种后第 28 天和第 58 天的两次灌溉，分别累计产生了 6.9cm、7.2cm 的深层渗漏量；2014 年夏玉米生长后期发生的长历时强降雨期间产生的累计深层渗漏量最高达 4.86cm。土壤水的深层入渗属于农田水资源的无效损耗，尤其是灌溉后的大量深层入渗降低了灌溉水的利用效率，应采取相应的措施用以缓解灌水所造成的深层入渗[6]。

utilization of irrigation water. It is strongly suggested to adopt corresponding measures to relieve deep leakage of irrigation water [6].

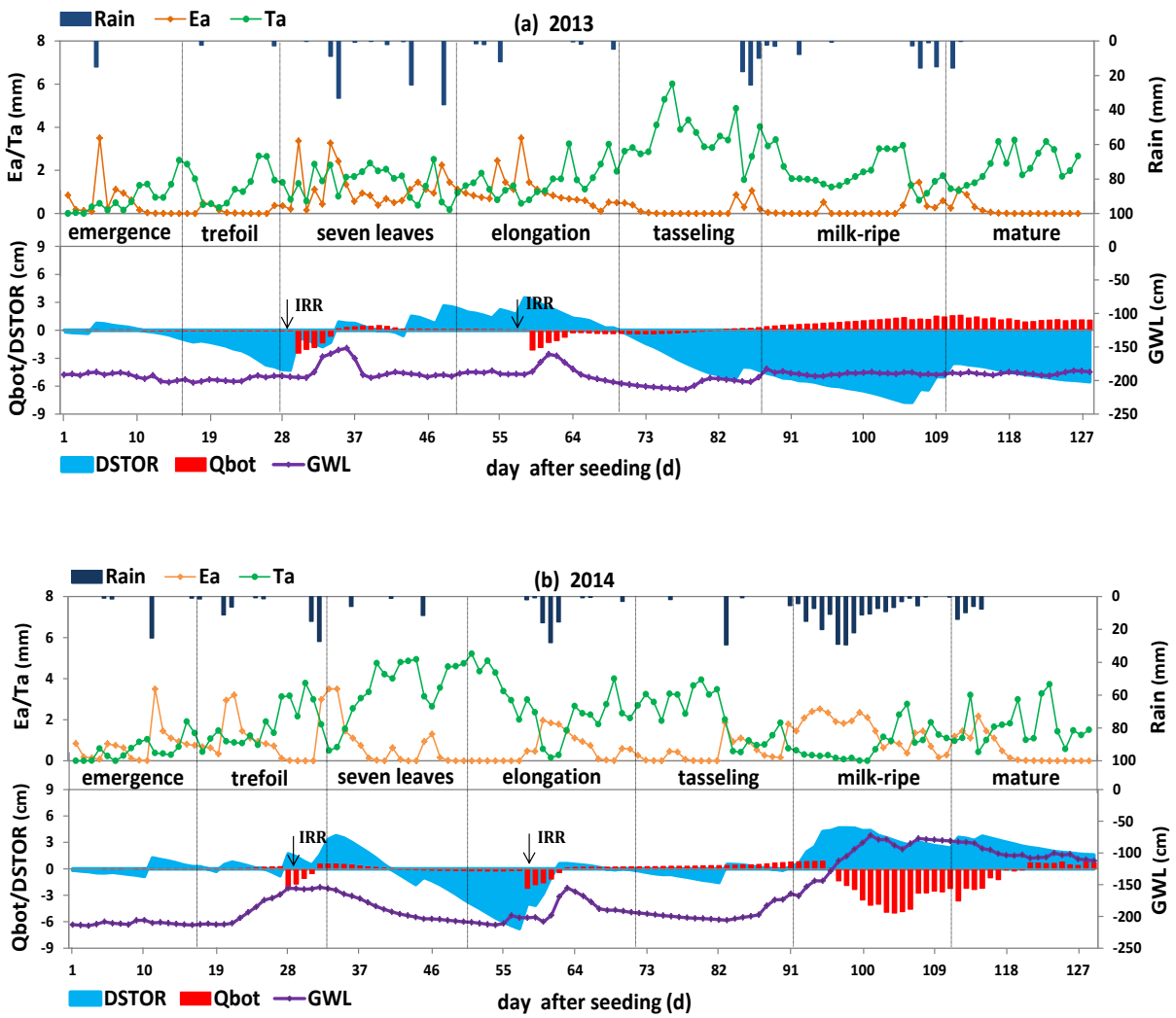

Fig.3- Actual evaporation (Ea), actual transpiration (Ta), vertical bottom flux (Qbot) and change water storage (DSTOR) at 120 cm soil profile versus rainfall (Rain), irrigation (IRR) and groundwater level (GWL) changes during summer maize's growth seasons of 2013 (a) and 2014 (b).

Calculated results of salt balance

Fig.4 shows simulated results of salt balance components at different maize growth stages from 2013~2014, including solute flux at soil surface (SQTOP), solute flux at soil bottom (SQBOT) and solute storage of 0~120cm soil layers (SAMPRO). In Fig.4, SAMPRO at maize harvest in 2013 and 2014 decreased by 72.87 mg/cm^2 and 81.32mg/ cm^2 compared to that at early period, indicating the desalinization of 0~120cm soil layers after maize plant. The most distinct desalinization was in the mid and late growth periods of summer maize. SQBOT presented evident downward leaching states at the same periods. Due to the lasting heavy rainfall during the milk-ripe stage of maize in 2014, both salt reduction and downward SQBOT reached the maximum of the simulation period. This is mainly caused by the frequent heavy rainfalls in the

盐分平衡计算结果分析

图 4 所示为 2013～2014 两季夏玉米各生长阶段田间盐分平衡组分的模拟结果，包括土壤表层盐分通量（SQTOP）、底部盐分通量（SQBOT）和 0～120cm 土壤盐分储量（SAMPRO）。由图 4 可以看出，两季玉米收获时的土壤盐分储量相比初期均有不同程度上的削减，表明每经过一季玉米种植后，0～120cm 土壤将处于脱盐状态。2013 与 2014 年季的盐分储量分别减少了 72.87 mg/cm^2 和 81.32mg/ cm^2，主要是在夏玉米生长的中后期脱盐明显，而且两季的底部盐分通量变化，亦在该时段表现为明显的向下淋洗状态，尤其是发生在 2014 年玉米乳熟期的长历时强降雨事件，使得盐分削减量与向下的底部盐分通量均达到了模拟期内的最大值。究其原因主要是该生长时段正值当地的雨季，本研究在不考虑侧向排水的情况下，该阶段频繁发生的强降雨事件是导致研究区土壤盐

study area if neglecting lateral drainage. However, this paper set few parameters for the solute transport module and neglected salt storage in macro pores and absorbed salt by root system . Therefore, the simulated salt balance result is still one-sided and needs further deep researches.

分向下淋洗的主要因素。然而，本文针对溶质运移模块所设定的参数较少，未考虑到大孔隙盐分储量和根系吸盐量等盐分平衡输出项，因此模型计算得到的盐分平衡结果仍较为片面，有待后续对此进行深入研究。

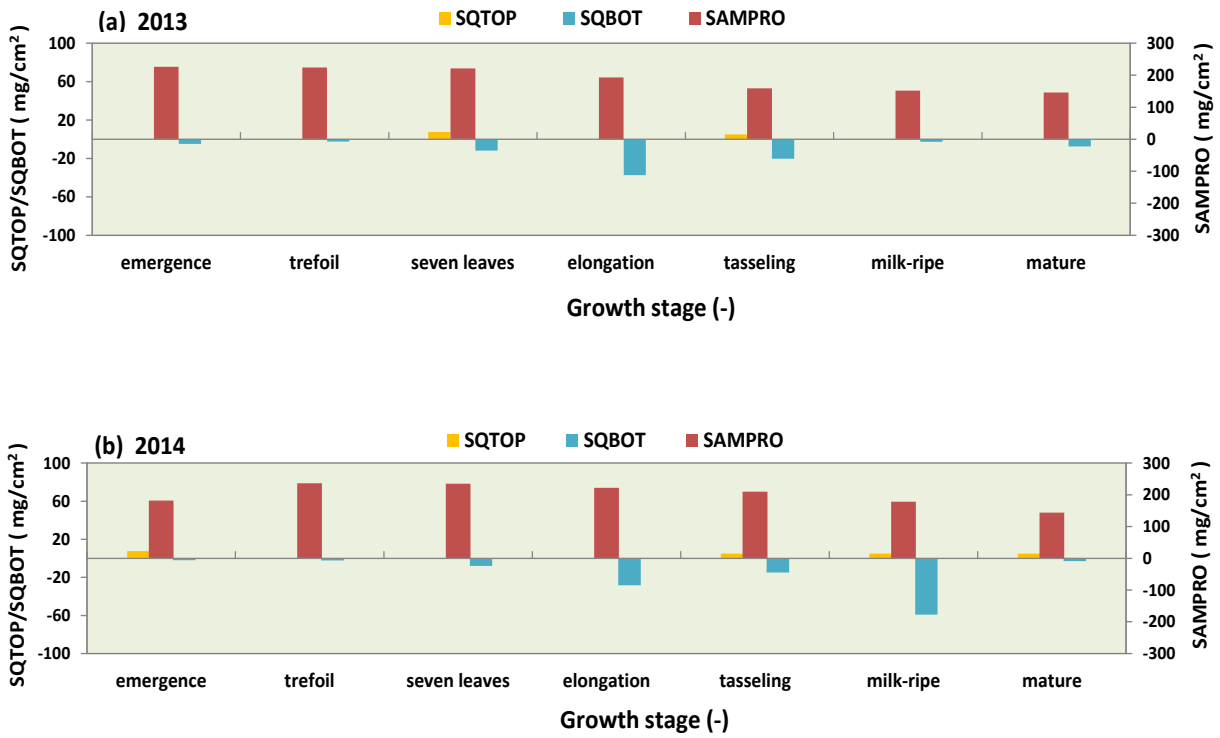

Fig.4- Solute flux at soil surface (SQTOP), solute flux at soil bottom (SQBOT) and solute amount at 120cm soil profile (SAMPRO) in different summer maize's growth stages during seasons of 2013 (up) and 2014 (down).

CONCLUSIONS

Field applicability of SWAP model is tested by the observation data during summer maize growth period from 2013~2014 in typical farmland in the irrigation area of the central Shaanxi Plain. Meanwhile, water-salt balance results simulated by the verified SWAP model are analyzed and discussed. It concludes that:

(1) During model calibration and verification, simulated soil water and salt contents reflect the general variation trend of measured values. During the calibration (2013) and verification (2014), RMSE of SWC is smaller than 0.03cm3/cm3 and MRE is lower than 10%. RMSE of SSC is smaller than 1.5mg/cm3 and MRE is lower than 15%. This means that the calibrated and verified SWAP model is applicable for simulation study on water-salt dynamic changes of the soil profile in the study area. The simulated water-salt balance components are reliable.

(2) According to SWAP results on field water balance components during summer maize growth periods in 2013 and 2014, the accumulative actual transpiration accounts for 57.6% and 64.9% of potential transpiration, indicating that crop transpiration is restricted by surface soil water content. DSTOR reduced by 5.52cm in 2013

结论

本文利用关中灌区典型农田 2013～2014 年夏玉米生长季的观测数据，对 SWAP 模型进行了田间适用性检验。同时，对验证后的模型所模拟的水盐平衡结果进行了分析与讨论。得到主要结论如下：

（1）模型率定和验证的过程中，土壤水盐含量的模拟值均较好的反映了实测值的大致变化趋势。其中，率定期与验证期各层含水量的 RMSE 值不超过 0.03cm^3/cm^3，且各层的 MRE 值均低于 10%；率定期和验证期各层含盐量的 RMSE 值不超过 1.5mg/cm^3，且各层的 MRE 值均低于 15%，说明经过率定和验证后的 SWAP 模型适用于模拟研究区土壤剖面各层的水盐动态变化，且模拟得到的水盐平衡分量结果是可靠的。

（2）根据 SWAP 对研究区两季夏玉米田间水量平衡各分量的计算结果：2013 与 2014 年季夏玉米生育期内累积实际蒸腾量占潜在蒸腾量的比值分别为 57.6%和 64.9%，说明作物蒸腾受到了表层土壤含水量的制约。2013 与

and increased by 1.58cm in 2014. Soil water supply from groundwater mainly is mainly achieved in vigorous growth of maize. The accumulative soil water supply from groundwater in 2013 and 2014 was 10.3cm and 7.4cm, respectively. In the study area, QBOT is highly sensitive to rainfall and irrigation, mainly manifested by great deep leakage. The accumulative deep leakages after irrigation in 2013 and 2014 reached 6.9cm and 7.2cm.

(3) According to SWAP results on field salt balance components during summer maize growth periods in 2013 and 2014, SAMPRO at the harvest reduced by 72.87 mg/cm2 and 81.32mg/ cm2 compared to that at early stage, indicating the desalinization of 0~120cm soil layers after maize plant. The most distinct desalinization is observed in the mid and late growth periods of summer maize. Neglecting lateral drainage, heavy rainfalls are the main cause of overall desalinization of 0～120cm soil layers in the study area.

ACKNOWLEDGEMENT

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2014 年季 0～120cm 土壤储水变化量分别为-5.52cm 和 1.58cm，地下水给予土壤水的上升补给主要出现在作物生长旺盛阶段，地下水累积上升补给量分别为 10.3cm 和 7.4cm；研究区土壤底部水分通量变化对降雨和灌溉的响应强烈，主要表现为明显的深层渗漏，2013 与 2014 年季灌水后的累计深层入渗量分别为 6.9cm 和 7.2cm。

（3）根据 SWAP 对研究区两季夏玉米田间盐分平衡各分量的计算结果：2013 与 2014 年季玉米收获时的土壤盐分储量相比初期的盐分储量分别减少了 72.87 mg/cm^2 和 81.32mg/ cm^2，表明经过一季的玉米种植后，研究区 0～120cm 土壤处于脱盐状态，并且两季玉米普遍在生长的中后期脱盐明显。在不考虑侧向排水的条件下，强降雨事件是造成研究区 0～120cm 土层整体脱盐的主要因素。

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EFFECTS OF LIQUID FILM MULCHING ON SOIL EVAPORATION AND COTTON PLANT GROWTH BY DRIP IRRIGATION

液体地膜覆盖对滴灌棉花土壤蒸发和作物生长的影响

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Abstract: *The feasibility of using liquid films as substitute to plastic films and the combination of liquid film mulching technique and drip irrigation were investigated to explore a solution to the increasingly serious white pollution induced by agricultural film residues in cotton fields in arid areas. With the adoption of bucket tests, five different mulching treatments (liquid film 1900 kg/hm^2, LFD1; liquid film 2200 kg/hm^2, LFD2; liquid film 2500 kg/hm^2, LFD3; ordinary plastic film, PFD; in bare soil, NFD) were performed on the cotton plants, and the effects of different treatments on soil moisture and temperature, as well as the growth of cotton plants and roots, were monitored and analyzed. The results indicate that liquid film spraying can promote the growth of cotton roots and affect the growth and development of cotton plant. In particular, the squaring stage was 2–5 days earlier with liquid film than that in bare land, and the yields were increased by 7.1%–14.39%. Compared with the results on the use of plastic films, soil evaporation were increased by 1.85%–6.90%; the ground temperature at 5 cm was reduced by 1°C, with a decreasing ratio of 2.5%–7.7%; the decreasing ratios of the ground temperature at 10 cm soil depth were 3.0%–6.4%; the growth stages were 1–2 days later; the yield was only reduced by 0.11%. The amount of liquid film (not less than 2500 kg/hm^2) combined with the drip irrigation and plastic mulch film of cotton with drip irrigation is a water-saving and yield-increasing effect compared with the NFD, with liquid film can be degradable; hence, the proposed technique can be used in numerous applications because of these non-pollution characteristics. With the urgent need to protect the agricultural ecological environment and to conserve agricultural water, the use of liquid film can be improved on the basis of sustainable and efficient agricultural development.*

Keywords: *Cotton by drip irrigation; Liquid film mulching; Soil moisture; Soil temperature; Growth and development*

摘要：*为了探寻解决干旱区棉田日益严重的“白色污染”问题的途径，本论文研究了液体地膜代替塑料薄膜与滴灌结合的可行性。试验采用桶栽方法，设置了 5 种处理（液体地膜 1900 kg/hm^2，LFD1；液体地膜 2200 kg/hm^2，LFD2；液体地膜 2500 kg/hm^2，LFD3；普通塑膜，PFD；裸地对照，NFD），监测和分析了不同处理对滴灌棉花土壤水分、温度及作物生长、根系的影响。结果表明，喷施液体地膜可以促进棉花根系的生长，影响棉花植株的生长和发育。特别地，喷施液体地膜后的滴灌棉花蕾期比裸地对照提前 2–5 天，产量比裸地对照增加了 7.1%–14.39%。与塑料地膜相比，土壤蒸发量增加了 1.85%–6.90%；5cm 处的地温降低了 1℃，下降 2.5% -7.7%，10cm 处的地温下降 3.0%–6.4%；生育期晚了 1–2 天；产量也只减少了 0.11%。适量液体地膜（不少于 2500 kg/hm^2）与滴灌结合可以与塑料地膜膜下滴灌棉花具有相当的节水、增产效果（与 NFD 相比），液体地膜具有的可降解、无污染特点将使该技术具有较大的应用潜力。随保护农业生态环境和农业节水的迫切需要，从农业持续高效发展的角度出发，液体地膜栽培具有广阔的应用前景。*

关键词:*滴灌棉花; 液体地膜; 土壤水分; 土壤温度; 生长发育*

INTRODUCTION

Mulching for soil moisture conservation is an effective measure for saving water resources, increasing crop yields, and improving crop quality due to its capacity to effectively regulate and control soil moisture in farmlands and to enhance crop water production efficiency. Because of its remarkable function in increasing cotton yield and quality, plastic film mulching cultivation technology has currently been widely applied in Xinjiang, the largest cotton producing area in China. However, plastic films are usually used for many years, and it cannot be recycled timely and effectively, which results in an increasing amount of plastic film residues in most cotton producing farmlands in Xinjiang. Inevitably, these residues have caused serious pollution to soils and the surrounding environments. Improving cotton yield without any pollution is generally recognized as a challenge [6,7,13].

Liquid film is a kind of composite black–brown viscous

引言

覆盖保墒可对农田土壤水进行有效调控，提高作物水分生产效率，是节约水资源、提高作物产量及改善作物品质的有效措施。由于塑料地膜覆盖栽培技术能大幅度提高棉花的产量与质量， 所以在中国最重要的棉花产区-新疆被广泛采用。但塑料地膜的长年使用及回收措施的不力，造成新疆大部分棉区土壤中的地膜残留量越来越多，土壤中的残膜给土壤及生活环境带来严重的污染，这已是公认的难题[6,7,13]。

liquid that is degradable, thus making it environmentally friendly. After being mixed with water and sprayed on soil, this liquid film can become a layer of black immobilizing film on soil surfaces, which can contribute significantly in enhancing soil temperature and inhibiting water evaporation [3,18].

The use of potato-dreg-based degradable liquid film can increase soil temperature and moisture content by 0.8–1.6 °C and 6.4%–17.9%, respectively [2].

Compared with the conditions on traditional bare land, the soil that is processed with liquid film mulching technology exhibits substantial improvements, particularly in the topsoil with depth of 0–25 cm, where daily mean temperature and average moisture content were increased by 2.38 °C and 2.50%, respectively, and the yield of potato tubers was increased by approximately 27.17% [4].

The soil temperature during liquid film mulching can be enhanced by 0.5–1.3 °C [5].

Liquid film mulching can increase soil temperature, especially for soil under medium-water and water-deficient treatments, where soil temperature can be increased by approximately 7.4% [8].

Both plastic film mulching and liquid film mulching exhibit favorable moisture-holding and water-promotion effects. Specifically, in topsoil with depth of 0–10 cm, plastic film mulching exhibits relatively remarkable effects, whereas in deep soil layer with depth of 30–40 cm, liquid film mulching is more preferred [12].

By using plastic films, the soil layers with depth of 0–5, 5–10, and 10–15 cm have increased their average soil temperatures by 4.92%, 3.45%, and 0.65% compared with the results using liquid films [15].

When the liquid film used is 225 kg/hm^2, the weed inhibition ratio of the soil is the highest, being up to 65.7%; whereas, when the liquid film used was 300 kg/hm^2, the ratio of yield increase of the soil was the greatest, being up to 19.7% [16].

By using liquid films, the seeding emergence ratio of corn plant can be increased by 17%, i.e., the liquid film contributes to corn plant growth and development; the corn yield can also be increased with liquid film by 17.4% greater than without liquid film mulching [19].

Therefore, to date, few studies were made on the effects of liquid film mulching technique on the growth and development of cotton plant by drip irrigation, especially the studies in Xinjiang, where drip irrigation under mulching is widely applied. In this study, we conducted experiments on cotton plant by drip irrigation under liquid films to analyze the effects of liquid film mulching on soil moisture and temperature, as well as, on the growth of crop and underground root system. Thus, the analysis of these effects can provide theoretical and technical guidance for the scientific applications of liquid films. With the urgent need to protect the agricultural and ecological environment and to conserve agricultural water, the sustainable and efficient development of agriculture in China becomes increasingly extensive.

MATERIALS AND METHODS

Brief introduction of the test area

The tests were conducted during the period from April to October, 2014. The test field was located in the test site of Corps Key Laboratory of Modern Water-saving Irrigation (85° 59′ E and 44° 19′ N) with an elevation of 412 m. Its annual average sunshine duration is up to 2865 hours, and the frost-free period lasts for 170 days. The accumulated temperatures above 10 °C and above

液体地膜是一种复合环保型可降解黑褐色粘稠液体，兑水喷施后，可在土壤表层形成一层黑色固化膜，能够显著提高土壤温度、抑制土壤水分蒸发等[3,18]。

马铃薯渣基液体降解地膜可提高地温 0.8–1.6℃，提高土壤含水量 6.4%–17.9%[2]。

与传统裸地相比，液体地膜覆盖处理使土壤的性质得到改善，特别是使耕层土壤（0–25cm）日平均温度和平均含水率分别提高 2.38℃和 2.50%，可使马铃薯块茎产量增加 27.17%[4]。

使用液态地膜，可提高地温 0.5–1.3℃ [5]。

液膜覆盖的土壤增温效果明显，特别是中、低水分处理，增温 7.4%左右[8]。

塑料地膜覆盖和液体地膜覆盖均有较好的保水促水效应。具体来说，塑料地膜覆盖的保水促水效应在 0–10cm 表耕层较为突出，而液体地膜在 30–40cm 土层的保水促水效果则优于塑料地膜[12]。

塑料地膜在 0–5、5–10 和 10–15 cm 土层较液体地膜处理平均温度分别提高 4.92%、3.45%和 0.65%[15]。

液态地膜用量 225kg/hm^2 的处理杂草抑制率最高，为 65.7%；用量 300kg/hm^2 的处理增产率达 19.7%[16]。

液态地膜能使玉米的出苗率提高 17%，促进玉米的生长与发育，提高玉米产量，较对照高出 17.4%[19]。

因此，到目前为止，液体地膜覆盖对滴灌棉花的影响研究相对较少，特别是在膜下滴灌广泛应用的新疆。本研究通过液体地膜覆盖滴灌棉花试验，分析液体地膜覆盖对滴灌棉花土壤水分、温度及作物生长、根系的影响，从而为液体地膜的科学应用提供理论与技术指导。随保护农业生态环境和农业节水的迫切需要，从农业持续高效发展的角度出发，液体地膜栽培在中国具有广阔的应用前景。

材料与方法

研究区概况

试验于 2014 年 4 月-10 月进行，试验地点位于现代节水灌溉兵团重点实验室试验基地（85°59′E、44°19′N、海拔 412 m），年平均日照时数 2865 h，无霜期 170

15 °C were 3463.5 and 2960.0 °C, respectively. The annual average air temperature of the areas is 7.7 ± 0.90 °C. In particular, the annual highest air temperature appears in July, which averages at 25.4 ± 0.74 °C, whereas the annual lowest air temperature appears in January, which averages at −5.5 ± 2.07 °C. The annual precipitation in the area is approximately 213 ± 56.7 mm, and the annual evaporation capacity is approximately 1342 ± 413 mm [17].

d。 >10℃积温为 3463.5℃，>15℃积温为 2960.0℃。年平均气温（7.7±0.90）℃，一年中的最高气温出现在 7 月，平均气温（25.4±0.74）℃；最低气温出现在 1 月，平均气温（−5.5±2.07） ℃。年降水量（213±56.7） mm，年蒸发量（1342±413） mm[17]。

Test materials

In the tests, liquid film (Lv'ye/Greenfield; Yangling Mingrui Chemical Science & Technology Co., Ltd., Shaanxi, China) was used. These liquid films are composed of residual oils, emulators, and water, which account for 50%, 30%, and 10% of the liquid film, respectively. The early-maturing Xinlu No. 48 cotton (Huiyuan 710) was selected. Ordinary plastic films (Tianye Co., Ltd., Xinjiang) were used for comparison. These plastic films were 0.008 ± 0.0003 mm in thickness and were mainly composed of polyethylene. The adopted single-wine labyrinth drip irrigation tapes were also provided by Tianye Co., Ltd., Xinjiang, and the spacing and flow rate of drip holes were 30 cm and 2.6 L/h, respectively.

试验材料

供试液膜为明瑞牌绿野液态地膜，由中国陕西杨凌明瑞化工科技有限公司生产，各组分重量含量为：渣油（50%）、乳化剂（30%）、水（10%）及其它；棉花品种为新陆早 48 号（惠远 710）；普通塑料地膜由新疆天业公司生产，其主要成分为聚乙烯，厚度为（0.008±0.0003）mm；单翼迷宫式滴灌带由中国新疆天业公司生产，滴孔间距 30 cm，滴孔流量 2.6 L/h。

Test design

The tests were performed in plastic buckets (Fig. 1), and bucket cultivation was adopted. Fifteen plastic buckets were used in the test, and the height and inner diameters at the top and bottom of the bucket were 0.52, 0.45, and 0.35 m, respectively.

试验设计

采用桶栽试验见图 1，试验用塑料桶规格为 0.52 m×0.45 m×0.35 m（高×顶部内径×底部内径），共 15 个试验用塑料桶。

Fig.1-Plastic bucket for testing

The plastic buckets were filled with medium loams with bulk density of 1.37 kg/m^3. In the tests, five different treatment conditions were conducted on cotton plants as follows: LFD1 (1900 kg/hm^2 liquid films), LFD2 (2200 kg/hm^2 liquid films), LFD3 (2500 kg/hm^2 liquid films), PFD (plastic films), and NFD (cotton cultivated without mulching films for comparison). Each treatment was repeated for three times. On April 21, the cotton plants were sown by dry sowing and wet germination. At the distances of 15–20 cm away from the center of buckets, equilateral triangles were drawn, and 3–4 cotton seeds were placed in each vertex. The buckets formed two columns, and two drip-irrigation tapes were used for water supply. A 450 m drip-irrigation tape was placed above the top openings of 7 buckets, while the other tape that was 510 cm long was placed above the top openings of the remaining 8 buckets. For each bucket, 2 drip holes, which are 7.5 cm away from the internal wall of top opening, were made. Pressure regulating valve, pressure gauge, and water meter were installed at the connection

桶中装填土壤类型为中壤土，平均容重 1.37 kg/m^3。试验共设 5 个处理水平：液体地膜 1900 kg/hm^2，LFD1；液体地膜 2200 kg/hm^2，LFD2；液体地膜 2500 kg/hm^2，LFD3；普通塑料地膜，PFD；裸地对照，NFD；各处理 3 次重复。4 月 21 日采用“干播湿出”方式播种。在试验桶中心的 15–20cm 范围内画等边三角形，3 个顶点上各放 3–4 个棉籽，把桶排成 2 列，用 2 条滴灌带供水，1 条长 450 cm 的滴灌带贴着试验桶放置于 7 个桶的顶口上；另一条长 510cm 的滴灌带贴着试验桶放置于 8 个桶的顶口上，每个桶内有 2 个滴孔，滴孔距顶口内边壁各 7.5cm。在每条滴灌带的接口处安装有调压阀、压力表和水表，灌水时

of each drip-irrigation tape to regulate and control pressure and irrigation. On April 22, the liquid films were sprayed, with the amounts of 1900, 2200, and 2500 kg/hm^2. The liquid films were diluted in water in the proportion of 1:2, and then evenly sprayed on the soil surfaces of the buckets by using a sprayer. For plastic films, an ordinary amount of 50 kg/hm^2 was used in the tests. The irrigations and fertilizer applications were identical under different treatment conditions. During the whole growth period, the irrigation frequency was 11, with irrigation quota and irrigation water quota of approximately 378 mm and 35 mm, respectively. The local deep fresh groundwater was adopted as the irrigation water source, with the mineralization degree of 1.3 g/L. The fertilizing amount was 832 kg/hm^2 (it should be noted that urea and potassium phosphate were applied by way of topdressing with irrigation according the ratio of 2:1). The other management measures were similar to those used in ordinary cotton fields. As stated above, drip irrigation was used in the tests. The drip holes of drip-irrigation tape were pressed closely against the soil surface, and then water was gradually permeated into the soils through capillary channels (i.e., the reserved capillary channels formed during the formation of liquid films because the evaporation of water). Therefore, drip irrigation would not cause any damage on liquid films.

利用调压阀调控压力，利用水表控制灌水量。4 月 22 日喷施液体地膜，用量分别为：1900 kg/hm^2；2200 kg/hm^2；2500 kg/hm^2，兑水稀释 2 倍，使用喷雾器械均匀喷施于桶中土壤表面。塑料地膜用量同一般棉田用量一致，即 50 kg/hm^2。各处理灌水施肥一致，全生育期灌水次数共 11 次，灌溉定额 378 mm，灌水定额在 35 mm 左右，灌溉水源为当地深层地下淡水，矿化度 1.3 g/L，施肥量 832 kg/hm^2（尿素和磷酸钾铵按照 2:1 的比例进行滴灌随水追施），其他管理措施同一般棉田。由于采用的是滴灌方式，滴灌带的滴孔紧贴桶中土壤表面，滴孔中滴出的水经过毛细孔道（液体地膜在成膜过程中，由于水分蒸发形成并保留的毛细孔道）逐渐渗入土壤之中，所以不会对液体地膜造成破坏。

Technology Roadmap

技术路线图

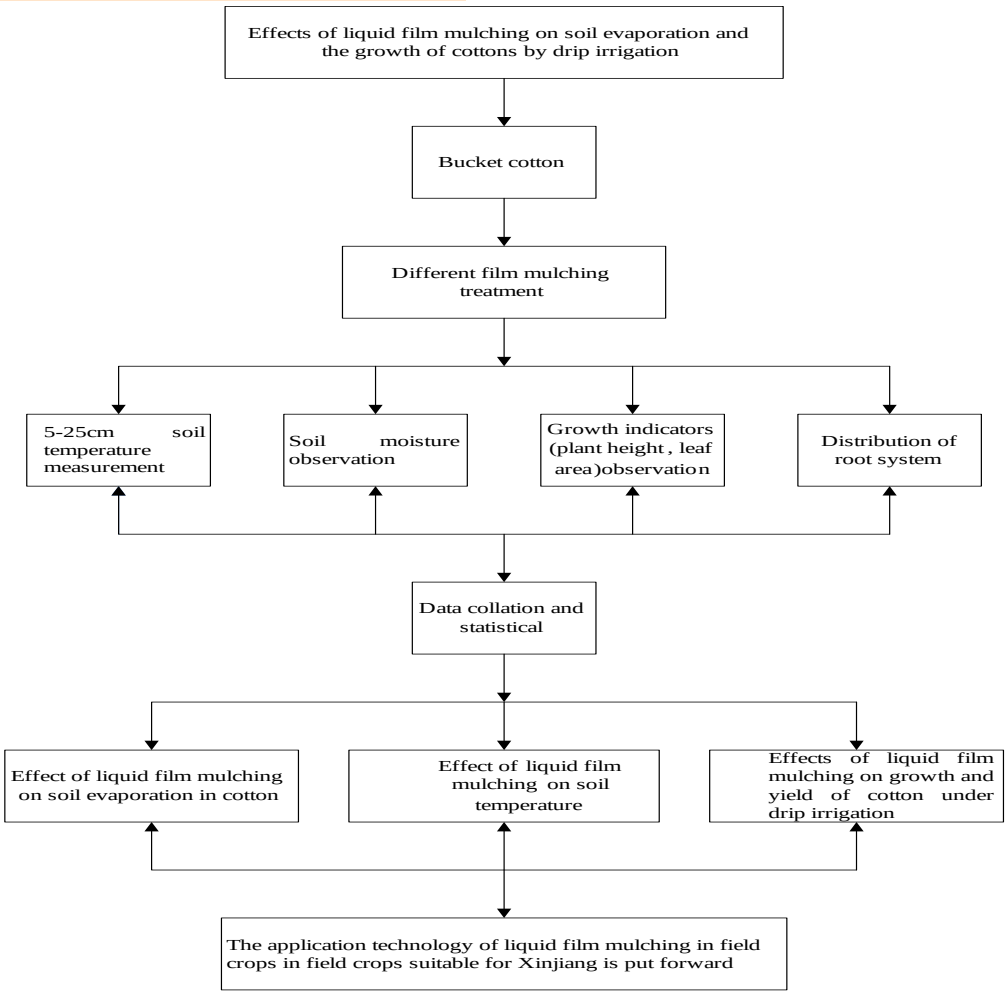


Fig.2-Technology Roadmap

Measurement and calculation method

Measurements of soil moisture and ground temperature

测定和计算方法

水分和地温观测

In measuring soil moisture, the masses of the plastic buckets before and after irrigation were measured by using the electronic scale (XK3150), and then the soil evaporation capacity can be determined.

In measuring ground temperature (Fig. 3), five angle-stem earth thermometers were placed in each plastic bucket, and then the soil temperatures at 5–25 cm depth were measured and averaged daily during 10:00, 16:00, and 20:00.

灌前和灌后使用 XK3150(W)型电子秤称量各桶的质量，进而测定土壤蒸发量。

使用曲管地温表见图 3，每个桶放置地温计 5 支（5–25 cm），每天 10:00、16:00 与 20:00 时记载测定 5–25 cm 土层温度，求平均值。

Fig.3-Bent stem earth thermometer

Observation and measurement of cotton roots

At the boll-opening stage, the root systems of cotton plant were used by transverse section method. Each 10 cm long root system was selected as a sampling unit. The soil samples were soaked for 24 h and then sifted by using a 0.5-mm sieve. Subsequently, all the root systems were obtained, and photographs of these were taken. Thereafter, the root length was quantified using computer-assisted image analysis technique. Finally, all these root systems were placed into the oven for 72 h at 65 °C and were weighed by using an electronic balance with precision at 0.1 mg.

The root length density (RLD) and root weight density (RWD) can be calculated by the following formulas:

棉花根系观测

在吐絮期内采用横向切片法取出根系，每 10cm 为一取样单元，将取出的土样浸泡 24 h 后过 0.5 mm 筛，捡出所有根系并拍照，用计算机图像分析技术量化总根长，之后放入烘箱，在 65℃下烘 72 h，采用精度为 0.1mg 的电子天平称其质量。

各项目计算公式：

$$RLD = \frac{TL}{V} \tag{1}$$

$$RWD = \frac{DM}{V} \tag{2}$$

where TL is the overall root length in soils, V is soil volume and, DM is the mass of dry matter of roots in unit soil column.

其中 *TL* 为土体内根系总长度； *V* 为土体体积；*DM* 为单元土柱土体内根系干物质质量。

RESULTS AND ANALYSIS

Effects of liquid film mulching on soil evaporation

Soil evaporation volume can be obtained by weighing the buckets successively for six days in two irrigation periods after liquid film mulching treatment. Fig. 4 displays the variation of soil evaporations using different mulching treatments, which shows that after one-time irrigation, the evaporation volume decreased gradually with prolonged irrigation time. Compared with the condition on bare land, the soil evaporations using liquid film mulching decreased on all treatments, and the average decreasing amplitude and ratio were 0.25–3.21 mm and 4.27%–29.14%, respectively. Specifically, compared with bare land condition, when using LFD1, LFD2, and LFD3 treatments, the soil evaporation volumes were reduced by 0.25–1.82, 0.63–3.21, and 0.57–2.14 mm, respectively, with the decreasing ratios of 4.27%–16.57%, 15.44%–29.14%, and 13.85%–19.43%, respectively. Compared with the condition using plastic

结果与分析

液体地膜覆盖对土壤蒸发量的影响

不同覆盖处理对土壤蒸发量的影响见图 4。由图 4 可以看出，在液体地膜处理后的两个灌水周期内分别选择连续的 6 天对桶进行称重。结果表明，在一次灌水后，随着时间的延长，蒸发量越来越小。液体地膜覆盖土壤蒸发量较裸地平均减少 0.25–3.21 mm，降低 4.27–29.14%。LFD1 土壤蒸发量较裸地减少 0.25–1.82 mm，降低 4.27–16.57%。LFD3 和 LFD2 土壤蒸发量较裸地分别减少 0.63–3.21 mm 和 0.57–2.14 mm，降低 15.44–29.14%和 13.85–19.43%。LFD1、LFD2 和 LFD3 土壤蒸发量较塑料

film mulching, the evaporation volumes of soils using LFD1, LFD2, and LFD3 increased by 0.31–1.89, 0.13–1.57, and 0.06–0.5 mm, respectively, with the increasing ratios of 9.26–25.86%, 3.70%–21.55%, and 1.85%–6.90%, respectively. The soil evaporation in the other irrigation periods exhibit similar tendency among these different treatment methods. The results indicate that, although liquid film mulching is inferior to plastic film mulching in terms of soil moisturizing effect, liquid film is superior in bare land conditions without any mulching. The evaporation in soils after liquid film mulching is the evaporation controlled by water flux profile at an extremely low level under the limitation imposed by organic thin-films; whereas, water is completely isolated when using plastic films. Apparently, the amount of liquid films also affects soil evaporation. With low application amount, the film properties are poor, whereas with high application amount, the film properties become desirable. However, these films were easily damaged when the cotton seedlings and weeds emerge from the ground. In addition, during the formation of films, the reserved capillary channels due to water evaporation became the channels for rainwater seepage after mulching. Therefore, compared with plastic films, liquid films are more beneficial to rainwater infiltration into soils.

地膜分别增多 0.31–1.89 mm、0.13–1.57 mm 和 0.06–0.5 mm，增加 9.26–25.86%、3.70–21.55%和 1.85–6.90%。另一灌水周期也有类似的规律。分析表明，液体地膜覆盖土壤保湿效应虽低于塑料地膜，但显著高于裸地。与塑料地膜相比，液体地膜覆盖地面后的蒸发，是有机薄膜限定下的极低水平水分通量剖面控制的蒸发，不同于塑料地膜完全隔绝水分。液体地膜施用量不同，对不同处理的土壤蒸发量影响程度亦有明显差异，其原因是施用量小，成膜质量较差，施用量大，成膜质量虽较高，但棉苗、杂草等出土过程中膜面受损较大。此外，液体地膜在成膜过程中，由于水分蒸发形成并保留的毛细孔道，成为覆盖后雨水渗透的通道，所以较塑料地膜更有利于雨水下渗土壤。

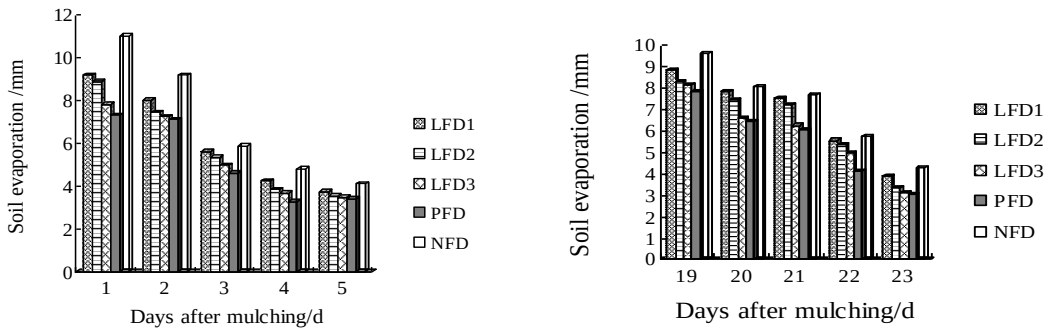


Fig.4-Soil evaporation using different mulching treatments

Effects of liquid film mulching on ground temperature

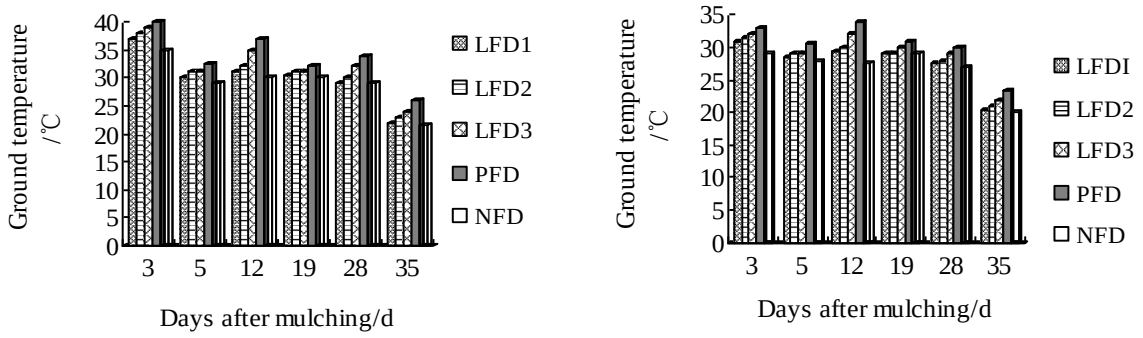
Fig. 5 displays the variation of ground temperatures with time using different mulching treatments. Fig. 6 displays the average ground temperatures 5–25 cm depth using different mulching treatments. The ground temperatures using different processing methods differ considerably. Generally, ground temperature can be enhanced to varying degrees by applying mulching treatments, and the increasing ratio eventually decreases with soil depth and prolonged irrigation time. The ground temperatures in LFD3 treatment were the highest among all treatments. Specifically, compared with bare land conditions, the ground temperature at 5 cm depth increased by 0.5–5 °C, with the increasing ratio of 2.33%–16.67%. The ground temperature at 10 cm depth increased by 0.5–4.5 °C, with the increasing ratio of 2.50%–16.36%. Compared with the conditions when using plastic film mulching, the ground temperatures at 5 cm depth were reduced by 1–5 °C. In particular, the condition using LED3 treatment in 35 days after spraying liquid film, the ground temperature was only 1 °C below that of plastic films, with the decreasing ratio of 2.5%–7.7%. The ground temperature of soil with liquid film at 10 cm depth exhibited the decreasing ratio of 3.0%–6.4% compared with plastic films. These results suggest that liquid films exhibit a moisturizing effect, which is primarily due to the layer of immobilizing films that formed on the

液体地膜覆盖对地温的影响

不同覆盖处理随时间变化对地温的影响见图 5。不同覆盖处理后 5-25cm 土层的平均地温变化见图 6。由图 5、6 可以看出，各处理不同土层间地温差异显著，各覆盖处理均不同程度提高土壤温度，且幅度随着土层的加深而减弱，随着时间的延长而变小。液体地膜处理中，LFD3 地温最高。具体地说，5cm 地温较裸地升高 0.5–5℃， 增温 2.33%–16.67%。10cm 地温较裸地升高 0.5–4.5℃，增温 2.50%–16.36%。与塑料地膜覆盖相比，在 5cm 处的地温减少 1–5℃。特别地，在 LED3 处理条件下，喷施 35 天后和塑料地膜覆盖相比，5cm 处地温只降低了 1℃，降低 2.5%–7.7%；10cm 处地温降低 3.0%–6.4%。结果表明，液体地膜具有一定的保温效应。其原因是液体地膜喷施

soil surface after spraying. The immobilizing films have terminated the water exchange between soils and the surrounding environment. Meanwhile, these black immobilizing films can absorb a great deal of solar energy, which leads to increased soil heat flux. The increase of soil temperature directly affects microbial activities and nutrient variation in soils, thus affecting the growth and development of root systems and nutrient absorption.

后，于土壤表面形成一层黑色固化膜，该膜阻隔了土壤与外界的部分水分交换，黑色固化膜也能吸收较多的吸收太阳能，最终使土壤热通量增大。土壤的增温直接影响土壤微生物的活动及养分的变化，从而影响作物根系生长发育和养分吸收。



At 5 cm soil depth

At 10 cm soil depth

Fig.5-Ground temperatures using different mulching treatments

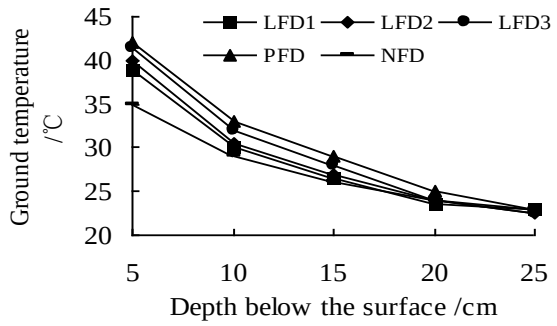


Fig.6-Ground temperatures at different soil depth using different mulching treatments

Effects of liquid film mulching on the cotton's growth and development

Table 1 illustrates the growth of cotton plants in different mulching treatments, which shows that the growth of cotton plants after mulching was faster than in bare land. For the cotton plants using LFD3 and LFD2 treatments, 10 and 11 days were required from sowing to emergence of seedlings, and the lengths were shortened by 4 and 3 days compared with that in bare land, respectively. The cotton plants in liquid films entered the squaring stage that was 2–5 days earlier than that in bare land, whereas the cotton plants in plastic films entered the initial flowering stage that was 5 days earlier than that in bare land. Apparently, the amount of liquid films affected the growth and development of cotton plants, i.e., with the increasing amount of liquid films, the early growth periods began earlier. However, with the increase of the amount of liquid film, the cotton plants were more likely to be senile at later growth periods. The primary reason is that liquid films can contribute to the preservation of soils moisture and the temperature increase. These effects are more apparent in topsoil, and thus the cotton plants have difficulty rooting, which is related to the information that the water and nutrients in

液体地膜覆盖对棉花生长发育的影响

不同覆盖处理对棉花生长发育的影响见表 1。由表 1 可以看出，各覆盖处理棉花发育进程都快于裸地对照。LFD3 从播种到出苗需要 10d，比裸地早 4d。LFD2 从播种到出苗需要 11d，比裸地早 3d。现蕾期，喷施液体地膜比裸地对照提早 2–5d。初花期，塑料地膜覆盖仅比裸地对照提早 5d。不同覆盖处理基本在同一时间到达吐絮期。滴灌条件下液体地膜用量大小影响棉花的生育期进程，即随着液体地膜用量的加大，棉花的前期生育期随之提前。但据观察：随着液体地膜用量增大，棉花在生长后期易出现早衰现象。其原因是由于液体地膜具有保墒增温性能，这种效应在土壤表层影响较明显，从而导致棉株根系不易下扎，于生育后期不能充分利用土壤深层水肥有关。

deep soils cannot be fully utilized at the later growth stages of cotton plant.

Table 1

Effects of different mulching treatments on the growth and development of cotton plant

Treatment	Sow	Seedling	Squaring stage	Initial flowering stage	Boll opening stage
	Month–day				
LFD1	4-21	5-3	6-18	7-3	8-19
LFD2	4-21	5-2	6-17	7-1	8-18
LFD3	4-21	5-1	6-15	6-30	8-18
PFD	4-21	4-30	6-13	6-29	8-17
NFD	4-21	5-5	6-20	7-4	8-19

Effects of liquid film mulching on the root length density of drip-irrigation cotton plants

Significantly positive correlations exist among the biomass of leaf area per plant, the biological yield above the ground, and the number of reproductive organs [9–11,14]. Root length density is the overall length of root systems per a unit volume of soils, which reflects the number of capillary roots and directly reflects the extension and intensity of root systems to absorb water and nutrients. Fig. 7 displays the root length densities of the drip-irrigation cottons in different mulching treatments. Compared with the data using the treatment of NFD, the root length densities of the soils at 20–30 cm depth in the LFD1 and LFD2 treatments increased by 405.063 and 851.974 m/m^3, respectively. The root length density of the soils in LFD3 was 915.803 m/m^3 higher than that in NFD, but 63.823 m/m^3 lower than that in PFD. These results indicate that the liquid film application at an appropriate amount can contribute to the root system growth of cotton plant, which lays solid foundations for growth and development, and finally, to achieve high yield. In addition, all of the root length densities in different treatments initially increased and then decreased with increasing soil depth. The root systems beneath the plough layer, although its density is fairly small, play quite important roles in absorbing and utilizing the nutrients and water in subsoil.

液体地膜覆盖对滴灌棉花根长密度的影响

棉花根系生物量与单株叶面积、地上部生物学产量及生殖器官产量之间均存在显著的正相关[9-11,14]。根长密度表示单位土体内根系总长度，反映根系毛细根数量，也间接反映了根系吸收水分、养分的范围和强度。液体地膜覆盖对滴灌棉花根长密度的影响见图 7。由图 7 可以看出，在 20–30cm 土层内，LFD1 和 LFD2 的根长密度较 NFD 分别增加 405.063 m/m^3 和 851.974 m/m^3。LFD3 的根长密度较 NFD 增加 915.803m/m^3，较 PFD 减少 63.823 m/m^3。结果表明，适量的液体地膜覆盖促进了棉花根系的生长，亦为地上部良好的生长发育及获得较高的产量奠定了良好基础。棉花根长密度在不同土层中变化趋势来看，各处理下的根长密度分布都是随土层深度的增加先增大后减小，耕层以下土层中的根系，其量虽然少，但对于吸收和利用下层土壤中的养分、水分起着重要的作用。

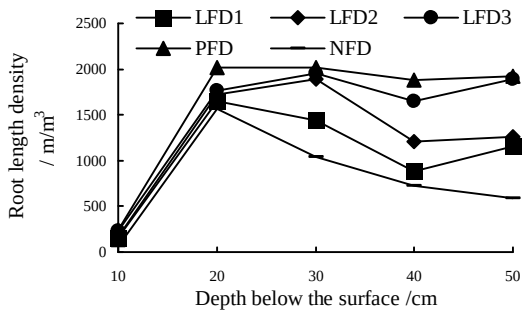


Fig.7-Root length densities in different mulching treatments

Effects of liquid film mulching on the root weight density of drip-irrigation cotton plants

Root weight density is the gross mass of the dry matters in roots, which directly reflects the mass of root systems and indirectly reflects the extension and intensity of root systems to absorb water and nutrients. Fig. 8 displays the root length densities of drip-irrigation cottons determined by using different processing methods, which shows a negative exponential function between cotton root weight density and soil depth. At 10–20 cm soil

液体地膜覆盖对滴灌棉花根重密度的影响

根重密度表示单位土体里面根系干物质总质量，反映根系质量，也间接反映根系吸收水分、养分的范围和强度大小。液体地膜覆盖对滴灌棉花根重密度的影响见图 8。由图 8 可以看出，棉花根重密度与土层深度呈负指数关系，以地表层的根重密度最大。在 10–20cm 土层内，LFD1 和

depth, the root densities in the LFD1 and LFD2 treatments increased by 0.1335 × 10^{-4}g/cm^3 and 0.4496×10^{-4}g/cm^3, respectively, compared with that in NFD. The root weight density using LFD3 was 1.3645 × 10^{-4}g/cm^3 greater than that in NFD, but 0.4429 × 10^{-4}g/cm^3 lower than that in PFD. These results indicate that liquid films, in the appropriate amount, can be comparable with plastic films in terms of root weight density. More importantly, the white pollution caused by plastic film residues can be thoroughly eliminated.

LFD2 较 NFD 分别增加 0.1335×10^{-4}g/cm^{3}和 0.4496×10^{-4}g/cm^3。LFD3 的根重密度较 NFD 增加 1.3645×10^{-4}g/cm^3，较 PFD 减少 0.4429×10^{-4}g/cm^3。结果表明，适量的液体地膜覆盖效果已接近塑料地膜，从另一方面来说，也可以彻底消除“白色污染”。

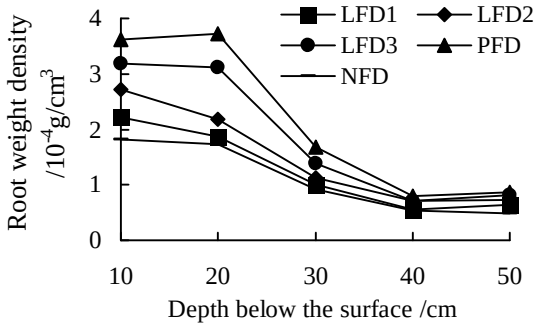


Fig.8-Root weight densities using different mulching treatments

Effects of liquid film mulching on the yield of drip-irrigation cotton plants

Table 2 presents the yield structures of cotton plants in different mulching treatments, which shows that the boll number per plant was increased by 0.31–0.67 compared with that in bare land. After liquid film spraying, the yields were approximately 4980–5317 kg/hm^2, which were increased by 7.1%–14.39% relative to the results in bare land. However, compared with the result using plastic films, the yields were reduced by 28–365 kg/hm^2, with the decreasing ratio of yield of 0.11%–7.4%. Notably, the yields of the cotton plants in LFD3 treatment were considerably close to that in plastic films. Conclusively, the cotton yields by drip irrigation in liquid films, although lower than that in plastic films, were apparently higher than the yield on bare land. From the perspective of ecological sustainability, liquid film spraying is of great application values. Practices proved that premature seedling is the key to a high cotton yield, which also requires a favorable soil environment. Therefore, liquid films can contribute to the enhancement of boll numbers and the improvement of boll quality.

液体地膜覆盖对滴灌棉花产量的影响

不同覆盖处理对棉花产量结构的影响见表 2。由表 2 可以看出，喷施液体地膜比裸地对照单株铃数增加 0.31–0.67 个。液体地膜覆盖产量为 4980–5317kg/hm^2，比裸地增产 7.1%–14.39%。液体地膜覆盖相对塑料地膜减产 28–365kg/hm^2，减产率 0.11%–7.4%，但 LFD3 产量已接近塑料地膜。由此说明，滴灌条件下液体地膜覆盖棉花产量虽次于塑料地膜，然而适量液体地膜覆盖棉花产量明显高于裸地，从生态可持续角度也具有可应用价值。实践证明，壮苗早发是棉花获取高产的关键，而棉花早发需要一个较好的土壤环境，液体地膜覆盖有利于促进棉花增结铃数、提高铃质量。

Table 2

Yield structures of cotton plants in different mulching treatments

Treatment	Boll number per plant	Single boll weight (g)	Seed cotton yield (kg/hm^2)	Growth ratio compared with the condition without mulching (%)
LFD1	4.87	5.09	4980	7.1
LFD2	5.21	5.25	5196	11.79
LFD3	5.23	5.28	5317	14.39
NFD	4.56	4.77	4648	—
PFD	5.24	5.31	5345	14.5

DISCUSSION

Currently, many similar research results the role of liquid film in preservation of soil moisture and enhancement of soil temperature were presented. However, the research regarding the combination of liquid film mulching cultivation technique and drip

讨论

液体地膜覆盖的保墒增温特点与已有众多研究结果类似，但液体地膜覆盖与滴灌结合，从而改变或影响滴灌棉

irrigation and their effects on soil moisture and temperature, as well as cotton growth and root systems, is still quite rare. In the present work, not only the effects of liquid film mulching on cotton growth and development, as well as the root systems, were analyzed, but also the effects on soil moisture and temperature were investigated. The results indicate that, after liquid film spraying on drip-irrigation cotton plants, the soil temperature can be remarkably enhanced, and simultaneously the soil evaporation capacity can be significantly reduced, i.e., the absorption and synthesis capacity of the root systems can be improved. The elevated root activity can also provide solid foundations for promoting the growth and development of overground cotton plants and achieving high yields, which are characterized by premature growth of cotton plants, greater mass of cotton bolls, and significant increase in yield. Moreover, different amounts of liquid film also exhibited different degrees of mulching effects. A favorable soil ecological environment is an important prerequisite for high yield of cottons, since it firstly affect the growth and development of underground roots and then the growth of overground cotton plants, and finally leads to a high cotton yield. Although the liquid film is inferior to plastic film in the aspects of soil moisture preservation and yield growth, it can be beneficial to the seepage of rainwater into soils, deeper rooting, the increase of the ratio of root weight beneath the soils, and the maintenance of strong absorption and synthesis capacity of the cotton root at the later growth stages. In addition, by using liquid films, the premature senility of cotton plants can be effectively prevented. After liquid film spraying, the boll numbers per cotton plant increased by 0.31–0.67 compared with the values on bare land; the average cotton seed yields were enhanced by 7.1%–14.39% compared with the values on bare land, but were reduced by 0.11%–7.4% compared with the values using plastic films. These results are slightly inconsistent with the previous research results. In further studies, we should expand the test range of liquid film mulching. In particular, we should conduct tests in farmland and probe into the effects of intensity and frequency of liquid film spraying on drip-irrigation cotton plants. Moreover, a related technical specification of liquid film mulching should be established and improved.

Liquid film, a novel cover material for cultivation in farmlands, is highly efficient, nontoxic, innocuous, and can be changed into organic fertilizers through biodegradation and light degradation [1]. Liquid films are not only applied in the cultivation of grains and cotton in fields, but also are applicable for the growth and development of fruits and vegetables in orchards. However, liquid film mulching technique should be further improved in terms of degradation characteristics and rain-wash resistance performances. As a consequence, these liquid films can be completely degraded within the mulching period, and moreover, they cannot be degraded very prematurely to lose their mulching effect. As the plastic films are commonly used for many years, the film residues causes severe contamination in cotton fields. Liquid films, owing to their low costs, strong adaptability to geographic and geomorphic conditions, favorable emergency, and ecological effects, can remarkably enhance the economic and ecologic benefits of cotton fields.

CONCLUSIONS

(1) By spraying liquid films on drip-irrigation cotton plants, the soil evaporation capacity can be reduced by

花土壤水分、温度及作物生长、根系，已有研究成果相对较少。本论文不仅分析了液体地膜覆盖对滴灌棉花生长发育和根系的影响，同时也分析了液体地膜覆盖对土壤水分、温度的影响。结果表明，液体地膜覆盖滴灌棉花可提高土壤温度并显著降低土壤蒸发量，从而促进棉株根系吸收与合成能力，而根系活力的增强，亦为地上部棉株生长发育及获得较高的产量奠定了良好基础。表现为棉株早发，铃质量大，增产效果显著。液体地膜不同用量覆盖效应存在一定差异。其原因是良好的土壤生态环境是棉花获得高产的重要基础，它首先影响到棉株地下部根系的发育，进而影响到地上部棉株的生长，最终才能实现棉花高产。这些效应表现虽然是液体地膜覆盖低于塑料地膜，但液体地膜更有利于雨水下渗土壤、棉花根系下扎，提高土壤下层根量比例，维持中后期棉株根系较强的吸收与合成能力，从而有效防止棉花早衰。喷施液体地膜比裸地对照单株铃数增加 0.31–0.67 个。液体地膜覆盖平均籽棉产量较裸地增长 7.1%–14.39%，较塑料地膜降低 0.11%–7.4%，这一点与前人研究结果不太一致。在以后的科研工作中，逐步扩大液体地膜的试验范围，尤其是大田试验，深入研究液体地膜喷施强度、喷施频率等对滴灌棉花的影响，形成并完善液体地膜配套应用技术规程。

液体地膜是一种新型的农田栽培覆盖材料， 高效、无毒无害，可以由生物和光降解转化为有机肥[1]，不仅适用于大田粮、棉等作物，也适用于果园、蔬菜及其它作物生长需要，但对其性能、防雨水冲刷等方面需要在工艺上进一步完善，使其在有效覆盖期内，既能被完全降解，又不致于过早降解而失去应有的覆盖效应。随塑料地膜的长年应用，残膜严重污染棉田。而液体地膜成本低廉、对地形地貌适应能力强，应急性好，也具有良好的生态效应，可显著提高棉田的经济效益和生态效益。

结论

4.27%–29.14%, and the soil temperatures at 5 cm depth can be enhanced by 2.33%–16.67% compared with the values on bare land. Liquid film spraying can promote the growth of cotton roots and affect the growth and development of cotton plant. In particular, the squaring stage of cotton plants in liquid films was 2–5 days earlier than that in bare land and the yields were increased by 7.1%–14.39%. The mulching effect using an appropriate amount of liquid films was comparable with the results using plastic films, that is, soil evaporation was increased by 1.85%–6.90%. The ground temperatures at 5 cm depth were 1°C lower than the values using plastic films, with the decreasing amplitude of 2.5%–7.7%. The decreasing amplitudes of the ground temperature at 10 cm depth were 3.0%–6.4%. The growth stages were 1–2 days later, and finally, the yield was only reduced by 0.11%.

(2) For the cotton cultivation by drip irrigation in arid areas, the spraying of an appropriate amount of liquid films can achieve a favorable mulching effect that is comparable with plastic films. Moreover, the liquid films can thoroughly eliminate increasing white pollution caused by film residues in farmlands, and thus contribute to the sustainable development of ecological environment in farmlands. Liquid film mulching is a feasible technique in cotton production by drip irrigation. With the urgent need to protect the agricultural ecological environment and agricultural water conservation, the sustainable and efficient development of agriculture in China is more extensive.

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（1）液体地膜喷施在滴灌棉花上，可以使土壤蒸发量减少 4.27%–29.14%，在 5cm 处的地温较裸地对照提高 2.33%–16.67%，喷施液体地膜可以促进棉花根系的生长，影响棉花植株的生长和发育。特别地，喷施液体地膜后的滴灌棉花蕾期比裸地对照提前 2–5 天，产量比裸地对照增加了 7.1%–14.39%。与塑料地膜相比，土壤蒸发量增加了 1.85%–6.90%；5cm 处的地温降低了 1℃，下降 2.5% -7.7%，10cm 处的地温下降 3.0%–6.4%；生育期晚了 1–2 天；产量也只减少了 0.11%。

（2）在干旱区滴灌棉田，喷施适量的液体地膜，可以达到和塑料地膜相当的覆盖效果。另外，使用液体地膜可以彻底消除残留在农田的“白色污染”，从而可使农田生态环境得到可持续发展。在滴灌棉花生产中采用液体地膜覆盖是一项可行技术。随保护农业生态环境和农业节水的迫切需要，从农业持续高效发展的角度出发，在中国更具有广泛的发展潜力。

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AUTOMOBILE TRACTORIZATION, AMERICAN CONCEPT APPLICABLE TO EASTERN EUROPEAN AGRICULTURE

TRACTORIZARE DE AUTOMOBILE, CONCEPT AMERICAN APLICABIL AGRICULTURII DIN ESTUL EUROPEI

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Abstract: *The paper presents several concepts of converting automobiles, and of utilizing automobile components to fabricate affordable transportation and farm mechanization means.*

Keywords: *automobile tractorization, utility vehicle, farm mechanization, student projects*

INTRODUCTION

Eastern and Southern European countries employ important part of their active population in agriculture, with Romania and Moldova nearing 30% (table 1). According to the World Bank statistics [15], in the last 20 years most of these countries experienced a decline of their total cultivated arable land (figure 1). The causes of this decline are numerous and will not be discussed here. Undoubtedly one of them however is the insufficient number of tractors and farm machinery (fig. 2). To compensate, in Romania for example there were 471,000 draught horses in use on farms in 2013 (a reduction from 667,000 in the year 2003) [12]. This is in striking contrast with the fast increasing number of newly purchased automobiles, with which they occasionally share the public roads: According to reference [23] the number of traffic accidents involving horse drawn wagons is on the rise.

The present paper suggests possible solutions to these problems drafted from the American experience.

MATERIAL AND METHOD

It is known that less than 2% of the active workforce in the USA (approximately 3 million people) is employed in agriculture [15]. This process of agricultural workforce

Rezumat: *Lucrarea prezintă câteva concepte de mecanizare a transportului şi prelucrării solului în agricultură utilizând subansambluri de automobile, sau prin conversia automobilelor în tractoare pe roți.*

Cuvinte cheie: *automobil tractorizat, vehicul utilitar, mecanizarea fermelor, proiecte studenţeşti*

INTRODUCERE

Tările din Europa Estică şi de Sud angrenează procente importante din populația activă în agricultură, cu România şi Moldova ocupând primele doua locuri (tabelul 1). Conform statisticilor Băncii Mondiale [15], în majoritatea acestor țări se remarcă un declin al suprafetelor agricole cultivate (fig. 1). Cauzele sunt multiple şi nu vor fi discutate aici. Unul dintre ele este indiscutabil insuficiența mijloacelor mecanizate pentru prelucrarea solului şi de transport (fig. 2). De exemplu în România existâ în continuare un însemnat număr de cai de muncă (471 de mii în 2013, în scădere de la 667 de mii în 2003) [12]. Aceasta contrastează cu parcul înnoit de automobile care circulă pe drumurile publice, dar crează şi o situație de conflict: Conform relatărilor presei româneşti [23], numărul accidentelor în care sunt implicate vehicule cu tracțiune animală este în creştere.

În lucrarea de față se propun câteva soluții problemelor amintite mai sus, inspirate de experiența fermierilor din Statelor Unite ale Americii.

MATERIAL SI METODA

Mai puțin de 2% din forța de muncă a SUA (circa 3 milioane de oameni) este angajată în agricultură [15]. Acest proces de reducere a forței de muncă din agricul-

Table 1

Percentage of active population employed in agriculture, and number of tractors per 1000 hectares in several European countries

Country	2000-2009	Tractors / 1000 ha		
		1995	2000	2005
Bosnia-Herzegovina	19.9%	34.1	*	*
Bulgaria	6.7%	9.6	9.8	11.4
Croatia	14.7%	31.5	27.3	*
Hungary	4.8%	19.2	24.6	26.2
Moldova	27.1%	28.2	22.9	21.4
Poland	12.7%	92.8	93.4	118.4
Romania	29.2%	17.5	17.1	19.3
Serbia	21.5%	*	*	20.6
Turkey	23.8%	31.5	39.5	*
Ukraine	17.0%	14.1	9.8	10.9
European Union	5.2%	76.3	77.3	70.8

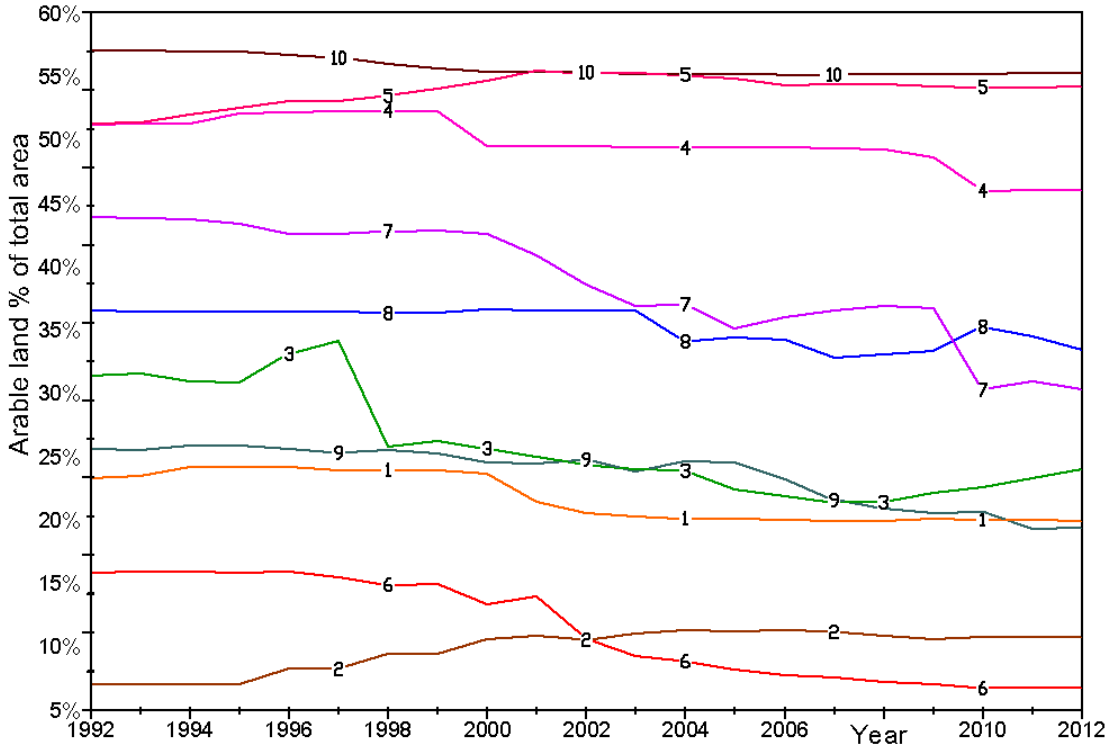

Fig. 1 – Annual fluctuations of the arable land in: (1) Belarus, (2) Bosnia-Herzegovina, (3) Bulgaria, (4) Hungary, (5) Moldova, (6) Macedonia, (7) Poland, (8) Romania, (9) Turkey and (10) Ukraine.

Fig. 2 – Tractorized Ford A and Ford T automobiles (a-c), rear axle supplementary gear reducer (d) and conversion kit.

reduction started over 100 years ago, and was facilitated by the availability of powered farm machinery and tractors. Remarkably, for several decades this trend was facilitated by the practice or converting old automobiles to tractors, known as *tractorization* (fig. 2 a-c).

A number of publications dating from 1917 to 1950 i.e. [2], [10], [11], [14] describe how a rear-wheel-drive

tură, început acum mai bine de 100 de ani, a fost facilitat de disponibilitatea maşinilor agricole cu acționare mecanică şi a tractoarelor. Remarcabil este că pentru o perioadă, la această tendință a contribuit şi aşa numita *tractorizare de automobile*, adică convertirea în maşini agricole a unor automobile dezafectate (fig. 2 a-c).

Din perioada anilor 1917 - 1950 dateaza publicațiile [2],

automobile with longitudinal front engine can be converted into a tractor. There were even industrial companies like *Pullford Co.*, *Sears Roebuck* and *Shaw Manufacturing* that were selling automobile conversion kits (fig. 2 d, e). For less than 10% of the cost of a new automobile, a farmer could obtain a tractor capable of pulling a moldboard or disk plow, a sickle mower etc. It was also possible to adapt a power-take-off for powering a thresher or a disk saw. An automobile from that era was relatively easy to convert into a tractor because of its rigid front axle and of increased ground clearance, compatible with off-road use. Additionally, the engine hood had a narrow shape, similar to a standard tractor, which allowed a clear view to the front of the vehicle [20] [21].

There were also cased of converting Jeep Willis off-road vehicles into walk-behind tractors, also known as two-wheel tractors (fig. 3 a) [2]. In fact, Jeep Willis automobiles, available in large number as military surplus after World War II, were widely used on farms (fig. 3 b). According to reference [18], there were over 70,000 Jeep automobiles in use on American farms, known under the name *Farm Jeep*.

[10], [11], [14] în care se descrie cum poate fi transformat într-un tractor agricol un automobil cu tracțiune spate şi motor longitudinal dispus în față. Companii industriale ca *Pullford Co.*, *Sears Roebuck* şi *Shaw Manufacturing* vindeau kituri de tractorzare (fig. 2 d, e), cu care, pentru nici 10% din costul unui automobil nou, se putea obține un tractor capabil să tracteze un plug cu unul sau două brăzdare sau cu discuri, o cositoare etc. Se putea de asemenea prevedea o priză de putere pentru antrenarea unei maşina de treierat sau a unui ferăstrau. Un automobil din acea perioadă se putea uşor tractoriza deoarece puntea față era rigidă, cu garda la sol crescuta ce permitea deplasarea vehiculului pe câmp. În plus, capota îngustă a motorului asigura o vedere bună spre în față, similar unui tractor standard [20], [21].

Se citează şi cazuri de conversie a unor automobile de teren Jeep în tractoare cu o punte, cunoscute şi sub numele motocultoare (fig. 3 a) [2]. De fapt, Jeepurile, disponibile în numar mare ca surplus militar după cel de-al doilea razboi mondial, au fost folosite pe larg în agricultură (fig. 3 b). Conform [18], în 1951 existau peste 70 de mii de Jeepuri în fermele americane.

(a) **(b)** **(c)**

Fig. 3 – Walk-behind tractor fabricated using automobile components (a), and Jeep Willis automobiles equipped hydraulic three-point-hitches utilized as agricultural tractors (b) and (c).

Fig. 4 – Contemporary automobiles and motorcycle converted in agricultural tractors and transport vehicles.

Occasionally, one can see nowadays automobiles and motorcycles converted by amateur mechanics into tractors and farm transport vehicles – see fig. 4 and references[4], [6], [7], [22]. The main requirements for a successful conversion are (a) an increased ground clearance, (b) using larger size wheels to reduce soil compaction, and (c) an increased transmission to the driving ground wheels ratio for added traction. Also beneficial are (d) the possibility of operating as four-wheel drive and (e) the availability of a PTO.

The tricycle in fig. 5 a and b has been fabricated by an amateur mechanic from Vălenii de Munte, Prahova [1]. No detailed information on how it was built became available. Apparently the engine and transmission of a DACIA pickup truck, and a more robust rear axle of an

Ocazional se pot întâlni automobile sau motociclete convertite artizanal în tractoare sau mijloace de transport agricol – vezi fig. 4 şi referințele [4], [6], [7], [22]. Cerințele pentru o astfel conversie sunt: (a) garda la sol crescută, (b) instalarea de roți cu diametrul mărit pentru a reduce compactarea solului şi (c) un raport de transmitere la roți crescut pentru o mai bună tracțiune. Avantaje suplimentare sunt (d) posibilitatea de a funcționa în varianta 4×4, şi (e) instalarea unei prize de putere.

Triciclul din fig. 5 a şi b a fost fabricat de către un mecanic amator din zona Vălenii de Munte, Prahova [1]. Nu se cunosc date exacte despre construcția acestui vehicul, însă este apparent că motorul şi transmisia provin de la o autofurgonetă DACIA cu tracțiune spate.

ARO SUV, connected in series via a supplementary chain or gear reducer have been used. This supplementary reducer increases the torque delivered to the wheel and limits the maximum speed of the vehicle. A resembling homemade tricycle can be viewed in the YouTube video [19].

In Eastern European countries there still available large numbers of old Dacia, Lada (VAZ), Trabant and Moskvitch cars that could be converted into tractors or slow moving utility vehicles for agriculture. Advantageous in the opinion of the authors would be to utilize the components originating from one vehicle only, and not from multiple vehicle types. The rest of the components for ground clearance and wheel torque increase could be produced in series and sold as conversion kit.

Puntea motoare, mai robustă, se pare că a aparţinut unui automobil de teren ARO, şi este înseriată cu un reductor cu roți dințate care amplifică cuplul transmis la roți şi reduce viteza maximă a vehiculului. Un model similar de tractor triciclu artizanal (fig. 5 c şi d) este documentat într-un film YouTube [19].

În țările east europene exista încă un număr însemnat de modele vechi de automobile care ar putea fi convertite în tractoare sau vehicule utilitare pentru agricultura. Avantajos în opinia autorilor prezentei lucrări ar fi ca subansamblele utilizate să provină de la un singur automobil, şi nu de la câteva automobile diferite. Restul componentelor necesare pentru creşterea cuplului la roți, şi a îmbunătățirii gărzii la sol, s-ar putea produce în serie şi comercializa sub forma de kit de conversie.

Fig. 5 – Homemade three-wheel tractors fabricated using salvaged DACIA and ARO components

BASIC UTILTY VEHICLES

Basic Utility Vehicle or BUV is a concept promoted by the Institute for Affordable Transportation (IAT) in Indianapolis, Indiana USA [9]. IAT was founded by Will Austin in 2000. Austin noticed during his visits to Latin America that the life of thousands of people living in rural areas of the Developing World could improve if affordable, simple and reliable transport vehicle would be made available to them.

One of the IAT activities consists of organizing the annual BUV competition (see fig. 6 and reference [13]), where engineering students from American and Canadian universities compete with vehicles designed and built by them. The BUV vehicles that satisfy the functional and safety requirements, and which performed well during the competition are donated through the IAT partners in countries from Africa and Latin America.

After several competitions (the first took place in 2001), the most promising design emerged as the rear-wheel drive tricycle with drive axle originating from a small pickup truck or SUV. They are typically equipped with a single cylinder, air cooled, four-stroke diesel or

VEHICULE UTILITARE DE BAZA

Vehicul Utilitar de Bază (Basic Utility Vehicle sau BUV) este un concept promovat de către Institute for Affordable Transportation (IAT) din Indianapolis, statul Indiana, SUA [9]. IAT a fost inființat la inițiativa lui Will Austin în anul 2000. Austin a constatat în periplurile sale prin America Latina, că dacă s-ar putea asigura mijloace de transport ieftine, simple şi fiabile, condițiile de viața a mii de locuitori din zonele rurale ale tarilor in curs de dezvoltare s-ar îmbunătății considerabil.

Una din activitățile IAT constă în organizarea concursului anual BUV (vezi fig. 6 şi [13]), unde studenți de la secțiile de inginerie din universități americane şi canadiene participă cu vehicule proiectate şi construite de ei. Vehiculele BUV care întrunesc cerințele funcționale şi siguranță specificate, şi care s-au comportat bine în concurs, sunt donate prin intermediul IAT unor parteneri locali din Africa şi America Latină.

După un număr de etape anuale ale concurslui BUV (primul a avut loc in anul 2001), cel mai promițător concept s-a stabilit a fi triciclul cu punte spate motoare, provenind dintr-o furgonetă sau autoturism de teren.

spark ignition engine of approximately 10 horse power. The employ a centrifugally governed continually-variable transmission (fig. 7). In this configuration the BUVs are assembled in micro factories in Indianapolis, USA and South Africa. So far over 200 BUVs have been assembled and donated to 23 developing countries from Africa and Latin America. A number of these vehicles has been built by the student participants in the BUV competition.

Motorul este monocilindru, în patru timpi, răcit cu aer, de aproximativ 10 cai putere, Diesel sau cu benzină. Transmisia este de tipul variabilă continuu cu reglare centrifugală (fig. 7). În această configurație, vehiculele BUV sunt asamblate în microfabrici din Indianapolis USA şi Africa de Sud. Pană în present mai mult de 200 de vehicule BUV au fost fabricate şi donate în 23 de țări în curs de dezvoltare. Parte dintre aceste vehicule au fost realizate de către studenții participanți la competiția BUV.

Figura 6: Instanță din timpul competiției BUV, şi unul din vehiculele BUV de serie.

Fig. 6 – Detals of a BUV equiped with continuously variable transmission (CVT). The manufacturibng cost of such a vehicle is approximately 3000 US dollars.

Under the leadership of professor Lumkes, mechanical and agricultural engineering students from Purdue University in West Lafayette, Indiana USA, proposed a resembling concept of utility vehicle named Purdue Utility Platform (PUP) [18]. They use to a large extent components from used cars, and managed to manufacture an PUP utility vehicle for less than 2000 dollars US [3] [19].

It is relevant to mention that in the senior year of all accredited engineering programs in American universities, students work on a team project that requires designing and building of a prototype [17]. Such projects named *Senior-Design Projects*, resemble the diploma projects in Romania. Same as in Romanian universities, students must submit written reports and give oral presentations. In addition to satisfying the design requirements, these projects emphasize team work as well as aspects like safety, social and ecological impact etc. The BUV and PUP projects are examples of such student projects [5].

With reference to the situation mentioned earlier, the authors of the present paper are of the opinion that the initiatives of the Institute for Affordable Transportation and of the Department of Agricultural & Biological Engineering at Purdue University can be adapted to the situation in the Eastern and South Europe. Students from technical universities in Romania, Moldova, Bulgaria, former Yugoslavia, Ukraine, Hungary etc. could convert old Dacia, Lada-VAZ, Moskvich or Trabant automobiles, as well as motorcycles, into tractors and utility vehicles for agriculture. Vehicles participating in competitions lie the IAT-BUV considered satisfactory could be auctioned to

Sub coordinarea profesorului Lumkes, studenții de la inginerie agricolă şi mecanică ai Universității Purdue din statul Indiana, SUA, au elaborat un concept asemănător de vehicul utilitar pentru agricultură numit Purdue Utility Platform (PUP) [8]. Ei folosesc în procent însemnat componente de automobile dezafectate, reuşind să fabrice un autovehicul utilitar de tip PUP pentru mai puțin de 2000 de dolari americani [3], [19].

Este semnificativ de menționat că în toate secțiile acreditate de inginerie ale universităților americane, în anul terminal (senior year), studenții lucrează în echipe la proiecte care solicită realizarea unui prototip [17]. Aceste proiecte, numite *Senior Design Projects*, sunt echivalente proiectelor de licenta din România. Ca şi în România, studenții trebuie să întocmească rapoarte scrise şi să facă prezentări orale. Sunt accentuate, pe lângă lucrul în echipă şi satisfacerea cerințelor tehnico-economice stabilite prin tema de proiect, aspecte precum siguranța în exploatare, impactul social şi ecologic etc. Proiectarea şi realizarea de vehicule BUV şi PUP sunt exemple de astfel de proiecte studenţeşti [5].

Referitor la situația din tările Europei de Est mentionată la începutul lucrării, autorii sunt de opinie că inițiativa IAT şi practica studenților de la Universitatea Purdue poate fi adaptate condițiilor din Estul şi Sudul Europei. Studenții de la universități tehnice din România, Moldova, Bulgaria, țările fostei Iugoslavii, Ucraina, Ungaria etc. ar putea converti motociclete şi automobile vechi Dacia, Lada-VAZ, Moskvich sau Trabant în tractoare şi vehicule de transport pentru agricultură. Vehiculele participante la competiții de tipul IAT-BUV considerate corespunătoare are putea fi

farmers and the funds thus raised could be used to fund future BUV competitions. Evidently, organizers of these competitions must find private and governmental sponsors to support such activities.

CONCLUSIONS

The American experience of converting old automobiles in agricultural tractors and transport vehicles, also known as automobile tractorization is applicable to Eastern and Southern Europe. Same as in the USA, the solution would be only a temporary one, until the financial situation of small farm holder is improved, and the agriculture is reorganized on larger, more productive farms. BUV-type vehicles could be manufactured as student projects. Tractorization kits could be designed by engineering students as well. The most successful of these projects could be popularized in print and over the Internet similar to [6] and [7], and local entrepreneurs can start old automobile tractorization businesses.

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apoi licitate fermierilor interesați, iar banii obtinuți ar putea fi folosiți pentru finanțarea în contunuare a competițiilor. Evident vor trebui găsiți sponsori, guvernametali şi privați, care să susțină aceste activități.

CONCLUZII

Experiența americană de convertire de automobile dezafectate în vehicule utilitare şi tractoare agricole, cunoscută şi sub numele de tractorizare, se poate foarte bine aplica condițiilor din Estul si Sudul Europei. Ca şi în cazul SUA, soluția ar fi una temporara, pană la consolidarea situației financiare a proprietăților agricole mici, şi la reorganizarea agriculturii în ferme pe suprafețe întinse, mai productive. Vehicule gen BUV ar putea fi fabricate ca proiecte studențeşti. Kituri de tractorizare al unor automobile ar putea fi proiectate tot de către studenți. Proiectele cele mai reuşite s-ar putea populariza în formă tipărită sau prin Internet similar cu [6] şi [7], iar întreprinzători locali s-ar putea specializa în tractorizare de automobile dezafectate.

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FLOW FIELD SIMULATION AND ANALYSIS OF BAG FILTER FOR AGRICULTURE SEWAGE / 农业污水袋式过滤器内流场特性仿真分析

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Abstract: *According to the agriculture sewage in the process of filtering impurity, medium pressure drop is not allowed to exceed 0.02MPa requirements. Using computational fluid dynamics(CFD) technology to study the porosity of bag filter, the inlet velocity of filter and the agriculture sewage viscosity changes that influence the pressure drop. The calculation results show that the higher the porosity, the higher outlet back-pressure and the agriculture sewage viscosity is more higher，so when it flows through the filter, its pressure drop is more higher. CFD technology can replace a part experimental study and it can provide guidance for the filter bag selection and replacement.*

Keywords: *Agriculture Sewage, Bag Filter, Flow Field, Pressure Drop, Porosity, Numerical Simulation*

摘要：*针对农业污水在过滤杂质流程中，介质压降不许超过 0.02MPa 的要求，利用 CFD 技术研究过滤袋孔隙率、过滤器出口被压、过滤器进口流速和农业污水粘度的变化对压降的影响，计算结果表明：孔隙率越大，出口被压越大，进口流速越大，农业污水粘度越大，农业污水流经过滤器后的压降越大。CFD 技术可以替代部分的试验研究，并对过滤袋的选择和替换提供指导。*

关键词：*农业污水，过滤袋，流场，压降，数值仿真*

1. INTRODUCTION

At present, in view of global water shortages, urban sewage and rainwater recycling problem has aroused people's wide concern. Urban sewage and rainwater recycling are reused for non-potable water, such as agricultural irrigation, watering road, supplement waterscape, building water [2,3,7]. But the wastewater usually need to filter. To meet the requirements of water quality, some pollutants must be removed, such as suspended solids, pathogenic bacteria/viruses, turbidity, organic matter, including nitrogen, phosphorus and other plant nutrients [6].

Qi et al[8] analyzed the reason which made the air current distribution uneven and proposed the improvement of which modify the structure of inlet and add guide plate in the lower-case. They obtained the flow field, the streamline and granule path which were around improvement with the software of CFD. The conclusion may provide the reference to performance, improve and design of fabric filters. Rocha [5] used CFD techniques to review the distribution of volumetric outflows in the bags and pressure drop for a more efficient and economic filtering operation, and provided an inferior operational pressure drop and a better distribution of fluids between the bags. A numerical simulation of CFD for bag filter was conducted to replace the experimental study by Fu et al[1], the numerical results shown that the main reasons of flow field non-uniformity are the higher inlet velocity and unreasonable bag chamber structure and the computer results are basically consistent with experimental ones, which indicated that CFD technology can replaces some test studies. Li et al[4] used CFD method to compute the velocity field between the bag filter, they analyzed the influence of different distances between the air nozzle and the filtering bag and different injecting times on the dust-cleaning effect, and supplied theoretical basis to design the optimal pulse bag filter.

According to several papers from the specialty literature [1, 7], sifting of intermediate products is affected by

1. 前言

目前，针对全球性水资源短缺问题，城市污水与雨水的再利用问题已引起人们的广泛关注。城市污水与雨水的再利用目标为非饮用水，诸如农业灌溉、浇洒道路、补充水景、建筑用水等场合[2,3,7]。但污水和雨水一般需要过滤。为满足水质要求而被去除的污染物通常为悬浮物、浊度、有机物、病原菌/ 病毒，甚至还包括氮、磷等植物性营养元素[6]。

齐银等人[8]分析了过滤袋内气流分布不均匀的原因，并提出在了改进入口结构和增加导流板的方法。并通过 CFD 软件的计算获得了流场、极限流线和颗粒的运动轨迹，获得成果为提高过滤袋的性能提供了参考。Rocha, S.M.S[5]等人运用 CFD 技术回顾了过滤袋经济操作时的内流流场的分布和压力降，并给出不利操作和合理操作时的过滤袋内压力分布。付海明[1]等人使用数值计算 CFD 软件取代实验，进行过滤袋的仿真计算，计算结果表明；流场分布不均匀的主要原因是较高的进口速度和不合理的过滤袋角部结构，并且计算结果与实验结果吻合较好，说明 CFD 技术可以取代一些实验研究。李志华等人[4]使用 CFD 方法计算了袋式过滤器的内流场，并分析了不同距离在气嘴和滤袋及不同射流时间内对灰尘清理效果的影响，并提供了用于优化设计过滤袋的理论基础。

根据专业论文文献[1]和[7]的论述，中间产品的筛选是受几个因素的影响，最重要的是；谷物颗粒的大小和形状，粒子在筛面的相对运动特性，筛布的特性，平面筛的旋转，筛上材料的数量等。

several factors, the most important being: size and shape of the grist particles, character of the relative motion of the particles on the sieve surface, characteristics of sifting sieve fabric, revolution of plansifter, and the amount of material that reaches on the sieve.

Before agriculture sewage irrigating into farmland, it need to be filtered impurity by using bag filter(as shown in Fig.1). The permeability of bag filter will change, so this paper uses CFD technology to do numerical simulation about filter internal flow field, which according to the filter bag porosity, outlet pressure, inlet velocity, agriculture sewage viscosity, so as to provided references for replacement cycle of the filter bag and for prediction of pressure drop loss.

农业用污水在灌溉农田前需要用过滤袋（如图 1）滤掉杂质，使用过程中，过滤袋的渗透性会发生变化，因此本文使用 CFD 技术对过滤袋空隙度、出口压力、进口流速、农业污水粘度对过滤器内流场进行了数值仿真，从而为过滤袋的更换周期和压降损失的预估提供了参考。

Fig. 1 –Bag Filter

2. MATERIAL AND METHOD

Table 1 is the basic characteristic parameters of flowing medium(agriculture sewage). Fig.2 is a three-dimensional geometric model of the filter, inlet diameter and outlet diameter are 160mm, the diameter of the container is 610mm, the height of the container is 1260mm. The length of the filter bag is 820mm and its diameter is 160mm, thickness is 2.8mm.

As shown in Fig. 2, geometry model of the filter is a single container and a single filter bag. The cylindrical structure which in the middle of figure is filter bag, when we do the numerical simulation, we assume it as porous materials.

The following statistics is part of the grid information of inlet liquid: inlet liquid grid of filter is 223600, outlet liquid grid of filter is 139500, and the total number of bag filter grid is 139700. The grids are divided by using ANSYS-ICEM software, self-adaption tetrahedral mesh as a main part and making grid of filter bag's part flow region becomes dense. All the wall surface of filter are divided in boundary layer. The quality of grid as shown in Fig.3-d, the minimum quality coefficient is 0.4, which fully meets the computational fluid dynamics software CFX to mesh quality requirements.

The boundary conditions are as follows；Reference pressure is 0.1 MPa. Fluid temperature is 40℃. Heat transfer option is isothermal. Turbulence model is k-epsilon. Wall function is scalable. Area porosity is isotropic. Loss model is isotropic loss. Loss velocity type is superficial. Inlet normal speed is 0.421 m/s. Inlet turbulence intensity is 5%. Outlet average static pressure is 3.5 MPa.

2. 材料与方法

表 1 为流动介质（农业污水）的基本特性参数。图 1 为过滤的三维几何模型，进口直径和出口直径为 160mm，容器直径 610mm，容器高度 1260mm，过滤袋长 820mm，直径 160mm，厚度 2.8mm。

如图 2 所示，本过滤器的几何建模为单容器、单过滤袋。图中中间的圆筒结构为过滤袋，数值仿真是假设为多空介质材料。

过滤器的进液结构部分网格信息统计如下：过滤器进液网格 22.36 万，过滤器出液网格 13.95 万，过滤袋部分网格总数 13.97 万。网格采用 ANSYS-ICEM 软件进行网格划分，自适应四面体网格为主体，过滤袋部分流域进行网格加密，过滤器所有壁面进行了边界层划分。网格质量如图 3-d 所示，最小质量系数为 0.4，完全满足流体计算动力学软件 CFX 对网格质量的要求。

边界条件如下；参考压力为 0.1 MPa. 流体温度为 40℃. 热传导方式为等温过程。 湍流模型为 k-epsilon. 壁面函数为可扩展。多孔介质为各向同性 。损失模型为各向同向损失模型。 损失速度形式为表面型。进口法向速度为 0.421 m/s. 进口湍流强度为 5%. 出口平均静压力为 3.5 MPa.

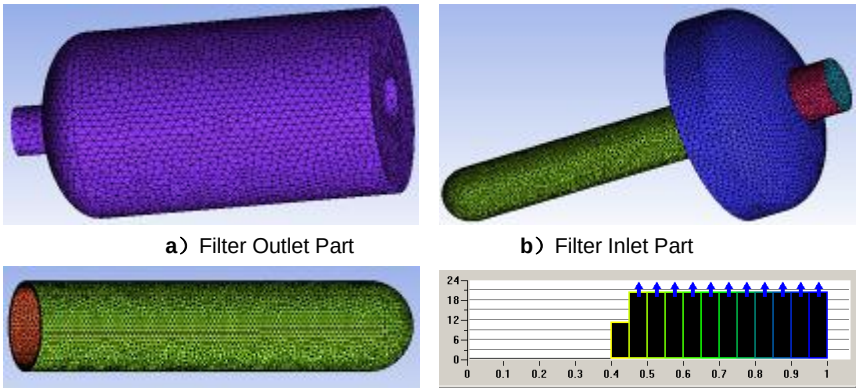
Table 1

Basic Characteristic Parameters of Flow Medium

Category	Data	Category	Data
Medium	Agriculture Sewage	Medium density	1010 kg/m^3
concentration	15000PPM	Dynamic viscosity	494 mPa.s
viscosity	494mPa.s	Specific pressure heat capacity	4178 J/kg.k
Operation temperature	40℃	Coefficient of thermal expansion	5.405×10-4k^{-1}
inlet pressure	3.5MPa	Heat conductivity coefficient	66.35×10-2W/mk

Maximum flow	150m3/h	Porosity of filter bag	0.45

Fig. 2 3D Perspective of Filter



a）Filter Outlet Part **b**）Filter Inlet Part

c）Bag Filter Part **d**）Quality Of Grid Information

Fig. 3 Three-Dimensional Mesh of Filter

3. Theoretical Basis

3. 1 Navier-Stokes Equations

The general Navier-Stokes equations written in a Cartesian frame can be expressed as:

3.基本理论

3.1 纳维-斯托克斯方程

一般纳维斯托克斯方程用笛卡尔坐标进行书写如下；

$$\frac{\partial}{\partial t}\int_{\Omega} U d\Omega + \int_{S} \vec{F}_I \cdot d\vec{S} + \int_{S} \vec{F}_V \cdot d\vec{S} = \int_{\Omega} S_T d\Omega \tag{1}$$

Where Ω is the volume and S is the surface, U is the vector of the conservative variables. $\vec{F}_I$ and $\vec{F}_V$ are respectively the inviscid and viscous flux vectors. E and q_i the total energy and the heat flux components. κ and S_T are respectively the laminar thermal conductivity and the source terms.

其中 Ω 代表体积，S 代表面积，U 代表保守变量的矢量。$\vec{F}_I$ 和 $\vec{F}_V$ 分别代表非粘性和粘性流动矢量。E 和 q_i 分别代表总能和热流量元素。 κ 和 S_T 分别代表层流带热系数和源项。

3.2 Standard $k-\omega$ Model

The turbulence kinetic energy k , and its rate of dissipation, ω , are obtained from the following transport equations:

3. 2 标准 $k-\omega$ 模型

湍流动能为 k，它的耗散率为 ω，两个变量可以通过下面输运方程获得：

$$\frac{\partial}{\partial t}(\rho k) + \frac{\partial}{\partial x_i}(\rho k u_i) = \frac{\partial}{\partial x_j}\left[\left(\mu + \frac{\mu_t}{\sigma_k}\right)\frac{\partial k}{\partial x_j}\right] + G_k + G_b - \rho\varepsilon - Y_M + S_k \tag{2}$$

$$\frac{\partial}{\partial t}(\rho \varepsilon) + \frac{\partial}{\partial x_i}(\rho \varepsilon u_i) = \frac{\partial}{\partial x_j}\left[\left(\mu + \frac{\mu_t}{\sigma_\varepsilon}\right)\frac{\partial \varepsilon}{\partial x_j}\right] + G_{1\varepsilon}\frac{\varepsilon}{k}(G_k + C_{3\varepsilon}G_b) - C_{2\varepsilon}\rho\frac{\varepsilon^2}{k} + S_\varepsilon \tag{3}$$

In these equations, G_K represents the generation of turbulence kinetic energy due to the mean velocity gradients, G_b is the generation of turbulence kinetic energy due to buoyancy. Y_M indicates the contribution of the fluctuating dilatation in compressible turbulence to the overall dissipation rate. $C_{1\varepsilon'}$ $C_{2\varepsilon'}$ and $C_{3\varepsilon}$ are constants. σ_k and σ_ε are the turbulent Prandtl numbers for k and ε , respectively. S_k and S_ε are user-defined source terms.

The turbulent (or eddy) viscosity, $\mu_{t'}$ is computed by

式中，G_K 是指由层流速度梯度而产生的湍流动能，G_b 表示由于浮力引起的湍动能的产生项，对于不可压缩流体，Y_M 可压湍流中脉动扩张值，对于不可压流体，$C_{1\varepsilon'}$ $C_{2\varepsilon'}$ 和 $C_{3\varepsilon}$ 为经验常数项。σ_k 和 σ_ε 分别为与耗散率 ε 和湍动能 k 对应的 Prandtl 数。S_k 和 S_ε 是用户自定义源项。

湍流粘性（涡粘性）$\mu_{t'}$ 是通过 k 和 ε 的合并计算得出，

combining k and ε as follows: $\mu_t = \rho C_\mu \frac{k^2}{\varepsilon}$

Where C_μ is a constant. The model constants $C_{1\varepsilon}, C_{2\varepsilon}, C_\mu, \sigma_k$ and σ_ε have the following default values: $C_{1\varepsilon} = 1.44, C_{2\varepsilon} = 1.92,$ $C_\mu = 0.09,$ $\sigma_k = 1.0,$. $\sigma_\varepsilon = 1.3$.

4. Numerical Simulation Results and Discussion

The simulation calculation cases including change of porosity, outlet pressure, inlet velocity and viscosity of fluid. Porosities are respectively 0.2、0.3、0.45、0.6、0.8, outlet pressures are respectively 0.5MPa、1.5 MPa、2.5 MPa、3.5 MPa, inlet velocities are respectively 0.168m/s、0.421 m/s、0.841 m/s、1.682 m/s、2.522 m/s, viscosities are respectively 0.001 mPa.s、0.05 mPa.s、0.1 mPa.s、0.25 mPa.s、1.5mPa.s.

4.1 Influence of Porosity to Pressure Drop

4.1.1 Porosity VS Velocity Vector Distribution

Porosity directly affect the flow velocity distribution of the filter, as is shown in figure 4, Imports around have whirlpool, have obvious local pressure loss. Inlet velocity is larger, after entering the filter, the space increases suddenly, the liquid will be slow down. After the liquid medium into the filter bag, due to narrow the space of flows, speed suddenly increases, now the liquid medium enter into the tapering bore channel and flow, there are no small loss. The speed at the outlet increased with the increase of porosity, in this case the loss is smaller than the import losses.

如式：$\mu_t = \rho C_\mu \frac{k^2}{\varepsilon}$

其中C_μ 是常数。. 模型常量$C_{1\varepsilon}, C_{2\varepsilon}, C_\mu, \sigma_k$ 和σ_ε 的默认缺省值分别为：$C_{1\varepsilon} = 1.44, C_{2\varepsilon} = 1.92,$ $C_\mu = 0.09,$ $\sigma_k = 1.0,$. $\sigma_\varepsilon = 1.3$。

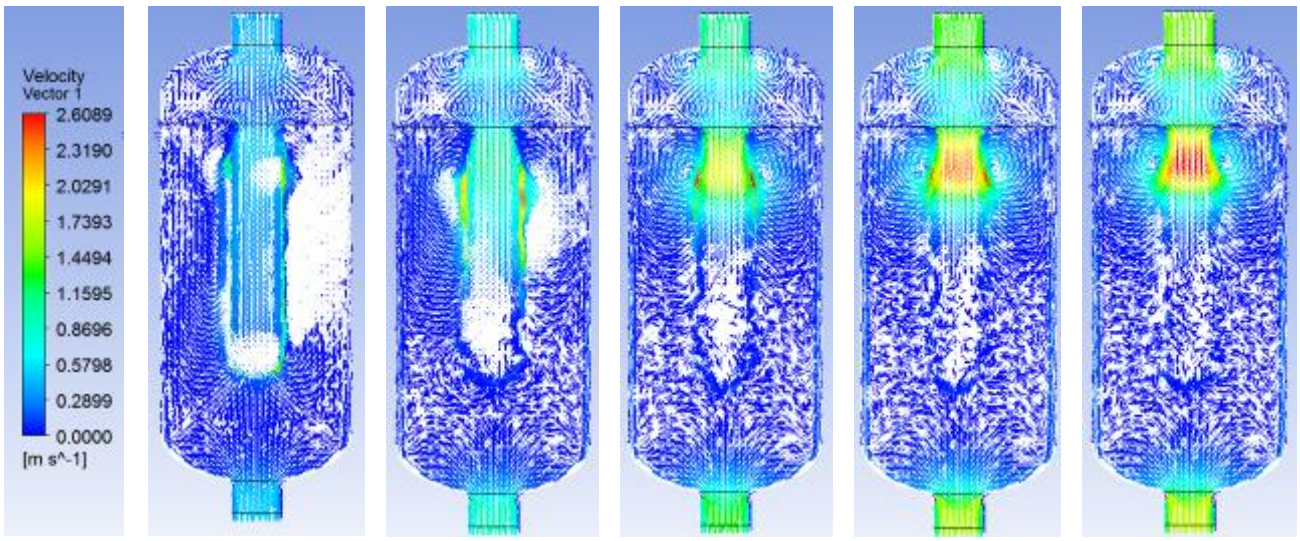
4. 数值模拟结果和讨论

仿真计算案例包括改变孔隙度、出口压力、进口流速和流体粘性。孔隙度分别为 0.2、0.3、0.45、0.6、0.8 取值，出口压力分别为 0.5MPa、1.5 MPa、2.5 MPa、3.5 MPa，进口流速分别为 0.168m/s、0.421 m/s、0.841 m/s、1.682 m/s、2.522 m/s，粘性分别为 0.001 mPa.s、0.05 mPa.s、0.1 mPa.s、0.25 mPa.s、1.5mPa.s。

4. 1 孔隙度对压降的影响

4. 1. 1 孔隙度——速度矢量分布图

孔隙度直接影响过滤器流动速度分布，由图 4 可知，进口四周有漩涡产生，有明显的局部压力损失。进口速度较大，进入过滤器后，空间突然增大，液体减速。液体介质进入过滤袋后，由于流动空间的缩小，速度由突然加速，此时输入渐缩孔道流动，也有不小的损失。出口处速度随着孔隙度的增加而增加，此时损失相对进口为小。



Porosity =0.2 Porosity =0.3 Porosity =0.45 Porosity =0.6 Porosity =0.8

Fig.4 Effect of filter bag porosity on flow field velocity vector distribution

4.1.2 Porosity vs total pressure distribution diagram

The total pressure of filter inlet has obvious gradient change, after the liquid through the inlet into the cylinder, who's space increases suddenly, so liquid become expansion and deceleration, pressure increases and velocity decreases. The orifice around have whirlpool,

4. 1. 2 孔隙度——总压分布图

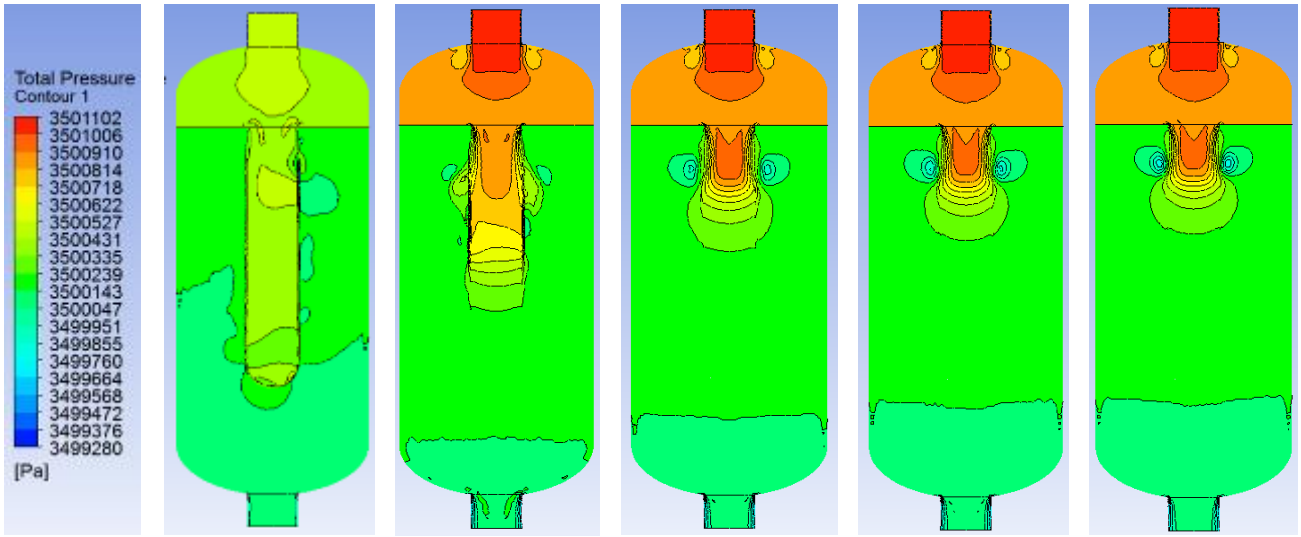
过滤器进口有明显的总压力梯度变化，液体由进口进入筒体后，空间突然增大，液体膨胀减速，压力增加，速度减小。在孔口四周有漩涡产生，此处压力损失较大。另

there is the greater pressure loss. Another place of the greater pressure loss is the inlet part of the filter bag, because of the whirlpool around inlet. As the porosity increases, the variation of the inlet pressure is not obvious (expect the porosity is 0.2). But the total pressure loss at the inlet of the filter bag gradually retreat to the outlet of filter bag.

Along with the porosity increasing, the pressure loss are increased slightly. But overall, the total pressure loss don't change much, which remains at around 360Pa. The total pressure loss is calculated using the CFD technology can reflect the change of pressure drop in the filter bag.

一处损失较大的地方为过滤袋进口部分，近袋口处有漩涡产生。随着孔隙率的增加，进口压力变化并不明显（孔隙度为 0.2 除外）。但是过滤袋进口处的总压损失渐渐退至滤袋口部。

随着空隙度的增加压力损失略有增加，但是总体来说，总压损失变化并不大，保持在 360Pa 左右。说明利用 CFD 技术计算的总压力损失能够反映压降在过滤袋内的变化规律。



Porosity =0.2 Porosity =0.3 Porosity =0.45 Porosity =0.6 Porosity =0.8

Fig.5 Effect of filter bag porosity on flow field total pressure distribution

4.2 Influence of Outlet Pressure to Pressure Drop

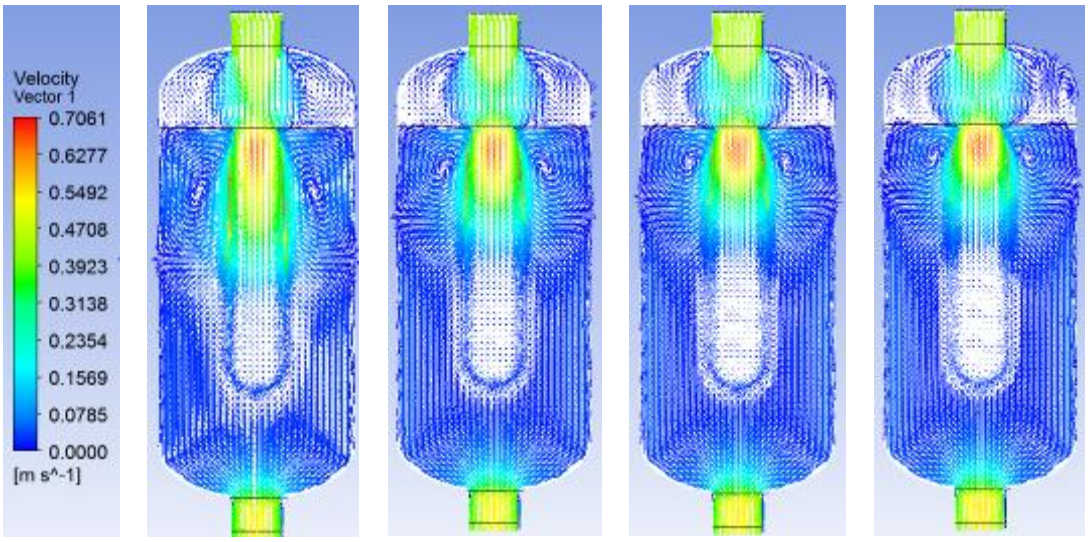
4.2.1 Outlet Pressure VS Velocity Vector Distribution

The outlet pressure is refers to setting back pressure in the liquid orifice of filter, which is respectively calculated according to 0.5MPa, 1.5MPa, 2.5MPa, 3.5MPa. As is shown in Fig.6, with the increasing of the back pressure, the whirlpool scale at the bag mouth around becomes smaller. This is caused by the downstream pressure is relatively large. The velocity vector distribution in inlet and outlet of the filter are similarity.

4.2 出口压力对压降的影响

4.2.1 出口压力——速度矢量分布图

出口压力是指在过滤器出液孔口处，设置的背压，分别按 0.5MPa、1.5MPa、2.5MPa、3.5MPa 进行分别计算。由图 6 可知，随着背压的增加，滤袋口部四周的漩涡尺度变小，这是因为下游压力较大所致。过滤器进口与出口处的速度矢量分布规律比较相似。



Pressure=0.5mpa Pressure =1.5mpa Pressure =2.5mpa Pressure =3.5mpa

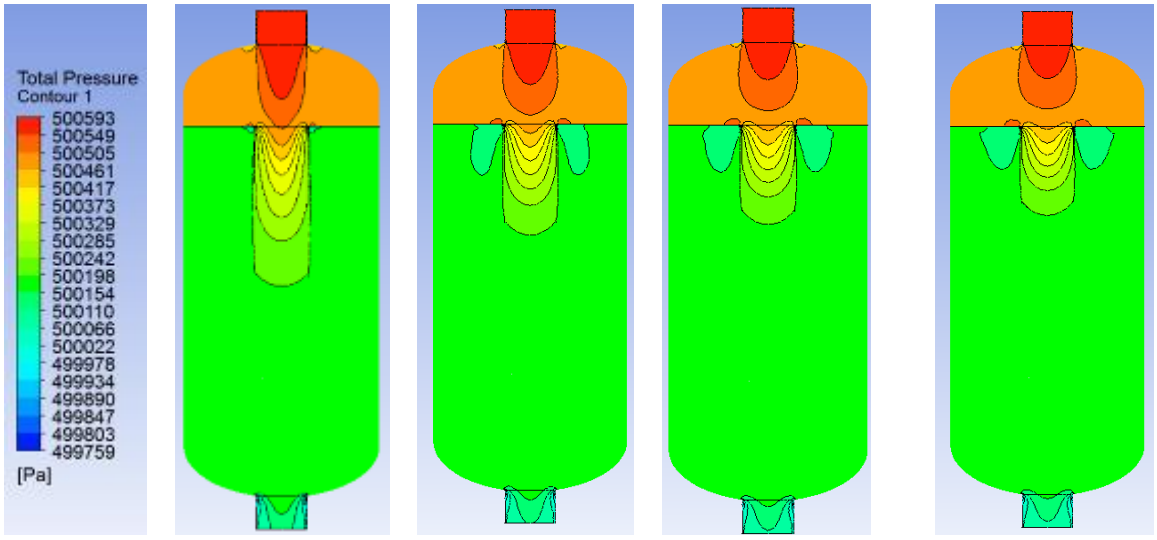
Fig.6 Effect of outlet pressure on the velocity vector distribution

4.2.2 Outlet Pressure Vs Total Pressure Distribution

Fig.7 is the contour map of total pressure on the cross section of the filter in different back pressure. With the outlet pressure increasing, the total pressure drop increases. Especially the filter bag near the inlet has apparent change and the higher back pressure is, the earlier pressure is reduced. The outlet pressure is from 0.5MPa to 1.5MPa, the pressure loss increases rapidly, pressure loss increases in processes which are from 100Pa to 550Pa and from 1.5MPa to 3.5MPa, the pressure tends to be stable, which is basically maintained at around 580Pa.

4.2.2 出口压力——总压分布图

图 7 为不同被压下，过滤器中截面上的总压力等值线图。随着出口被压得增加，总压力下降幅度增加，特别是滤袋进口附近有明显的变化，背压越大，压力降低的越早。出口压力在 0.5MPa 到 1.5MPa 时，压力损失增加较快，压力损失从 100Pa 增加到 550Pa，从 1.5MPa 到 3.5MPa 的过程中，压力趋于稳定，基本保持在 580Pa 左右。



Pressure =0.5mpa Pressure =1.5mpa Pressure =2.5mpa Pressure =3.5mpa

Fig.7 Effect of outlet pressure on flow field total pressure distribution

4.3 Effect of outlet Velocity on the Pressure Drop

4.3.1 Outlet Velocity Vs Velocity Vector Distribution

This paper carry out simulation calculation on different inlet velocity 0.168m/s, 0.421 m/s, 0.841 m/s, 1.682 m/s and 2.522 m/s by using CFD. It can be seen from figure 8 that velocity vector changes along with the increase of speed. The greater inlet velocity is, the greater high speed

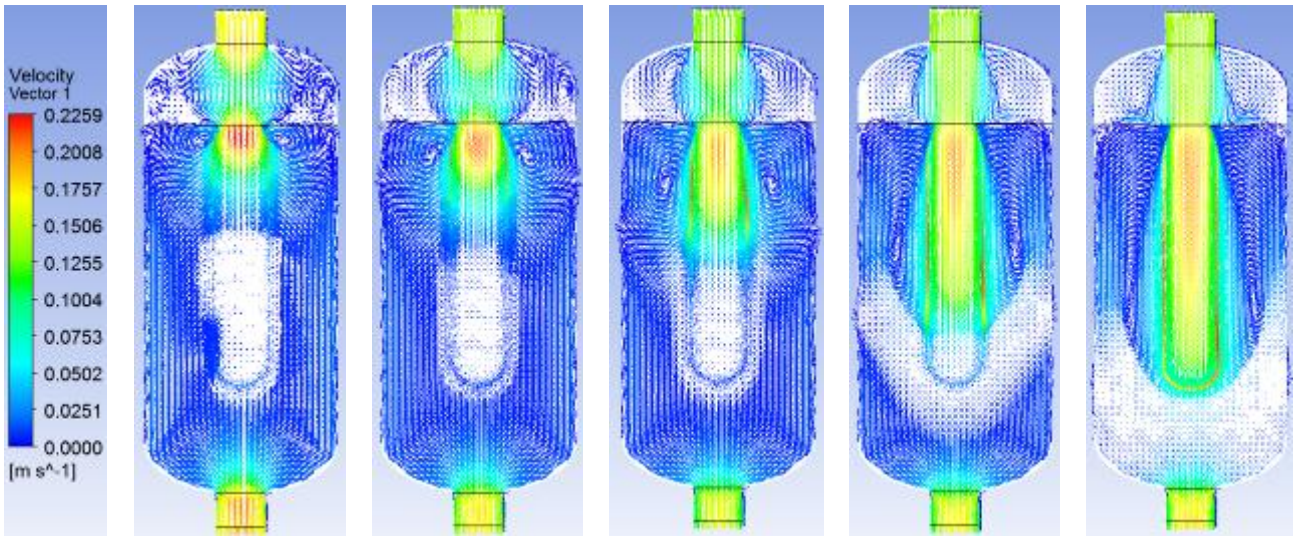
4.3 出口流速对压降的影响

4.3.1 出口流速——速度矢量分布图

分别进行了 0.168m/s、0.421 m/s、0.841 m/s、1.682 m/s 和 2.522 m/s 进口流速的 CFD 仿真计算。由图 8 可以看出速度矢量随速度增加后的变化规律。进口流速

area which in filter bag is. When the speed reaches 2.522m/s, there is great velocity in the filter bag. The greater inlet velocity is, the greater whirlpool which in the vicinity of Bag of entrance is. When the velocity is maximum, most of the cylinder space have full of turbulence.

越大，滤袋内的高速区越大，当速度达到 2.522m/s 时，整个滤袋内都保持较高的速度。进口速度越大，袋口附件的漩涡越大，最大速度时，漩涡充满大部分的筒体空间。



0.168m/s 0.421m/s 0.841m/s 1.682m/s 2.522m/s

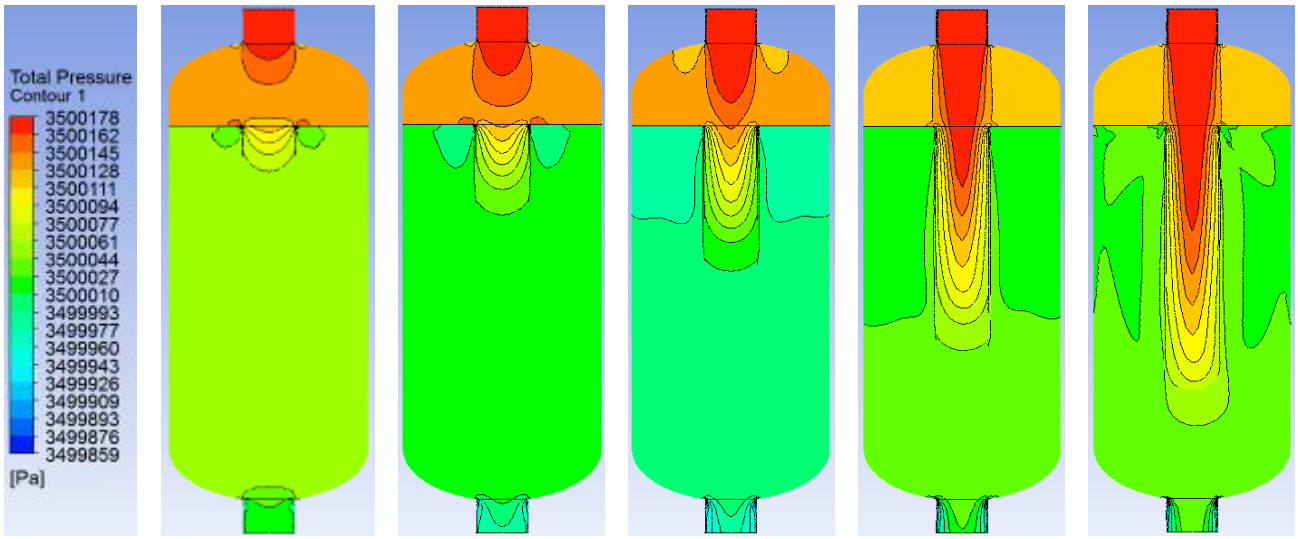
Fig.8 Effect of outlet velocity on flow field velocity vector distribution

4.3.2 Inlet Velocity Vs the Total Pressure Distribution

Fig.9 is the total pressure contour map under different inlet velocities. With the increase of the inlet velocity, total pressure areas are also larger. The total pressure gradient is larger, so that the total pressure loss is larger. With the increase of inlet velocity, which increase from 0.1m/s to 2.6m/s, the pressure drop is increased rapidly and they are nonlinear positive correlation. Changes in growth amplitude are large, which range from 170Pa to near 10000Pa and across 2 orders of magnitude.

3.3.2 进口流速——总压分布图

图 9 是不同进口流速下的总压力等值线图，随着进口速度的增加，总压值较大的区域也大，总压力梯度较大，说明总的压力损失较大。随着进口流速的增加，从 0.1m/s 增加到 2.6m/s，压降也急剧增加，二者相关性为非线性正相关。而且增长幅值变化很大，从 170Pa 到近 10000Pa，跨越了 2 个数量级。



0.168m/s 0.421m/s 0.841m/s 1.682m/s 2.522m/s

Fig.9 Effect of inlet velocity on flow field total pressure distribution

4.4 Effect of Viscosity on Pressure Drop

3.4 粘性对压降的影响

4.4.1 Viscosity Vs the Velocity Vector Distribution

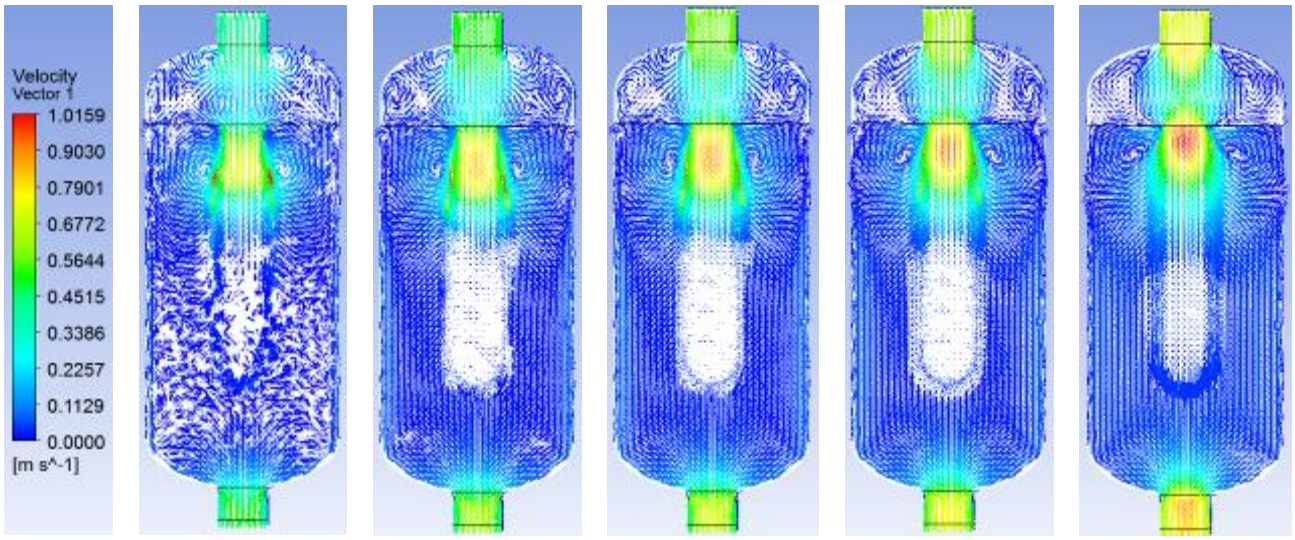
Viscosity is macroscopic properties of fluid which is linked by a stress which is applied to the fluid and the resulting deformation rate in a certain relationships; it shows the internal friction of fluid. In the aspect of numerical viscosity, it is equal to the fluid shear stress which under the unit of velocity gradient. The velocity gradient also said fluid motion angle deformation rate, so it also shows the relationship between shear ratio and angular distortion rate.

Fig.10 is the two-dimensional vector flow chart of filter cross section under different viscosity. When the viscosity is small, the whole flow field has strong turbulence and at this moment the flow loss is smaller. As the viscosity increases, there are more and more rules of flow pattern. Most of the region is the laminar region, but the inlet of cylinder and filter bag have obvious vortex.

3.4.1 粘性——速度矢量分布图

粘性是施加于流体的应力和由此产生的变形速率以一定的关系联系起来的流体的一种宏观属性，表现为流体的内摩擦。黏度数值上等于单位速度梯度下流体所受的剪应力。速度梯度也表示流体运动中的角变形率，故黏度也表示剪应力与角变形率之间比值关系。

图 10 为不同粘度下的过滤器中截面二维矢量流动图，小粘度时整个流场紊流较强，此时损失较小。随着粘性的增加，流谱越来越规则，大部分区域为层流区，但是在筒体进口和滤袋进口处均有较明显的漩涡。



Viscosity=0.001 Viscosity =0.05 Viscosity =0.1 Viscosity =0.25 Viscosity =1.5

Fig.10 Effect of viscosity on flow field velocity vector distribution

4.4.2 Viscosity Vs the Total Pressure Distribution

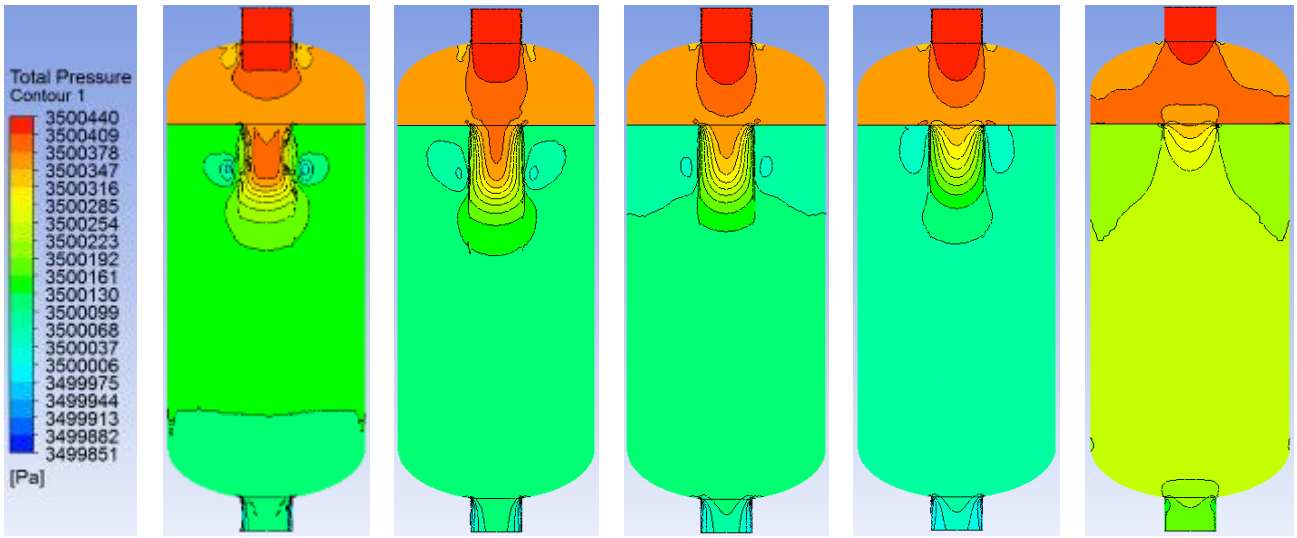
Fig.11 shows the total pressure contour map of different viscosity. In the vicinity of the inlet filter bag, the viscosity is smaller so that the pressure gradient is greater, and the flow pattern has a greater mess. With the increase of fluid viscosity, flow spectrum was shifted to the laminar flow pattern, but if the viscosity is greater, so the pressure loss is also greater.

As the viscosity increases, and the pressure drop is also increased, and the whole curve is approximatively direct proportion linear increasing. Filter viscosity is respectively 50cP, 495cP, 1500cP, pressure loss are respectively 370Pa, 600Pa, 920Pa.

4.4.2 粘性——总压分布图

图 11 表示不同粘度下的总压等值线图，在滤袋进口附近，粘度越小，压力梯度越大，流谱越紊乱，随着粘度的增加，流谱渐渐转向层流流谱，但是粘度越大压力损失越大。

随着粘性的增加，压力降增加，整体曲线近似线性地正比例增加。过滤器粘度为 50cP，495cP，1500cP 时，压力损失分别为 370Pa，600Pa，920Pa。



Viscosity =0.001 Viscosity =0.05 Viscosity =0.1 Viscosity =0.25 Viscosity =1.5

Fig.11 Effect of viscosity on flow field total pressure distribution

CONCLUSION

In this paper, the filter bag is simplified as a porous medium material. Filter bag is established into CFD numerical simulation model, and numerical calculations are performed about the effects of porosity, outlet back-pressure, inlet velocity and viscosity on the pressure. The calculation results show that;

The total pressure loss which is calculated by using the CFD technology can reflect the change regulation of pressure drop in the filter bag. With the increase of porosity, pressure loss increased slightly, but overall, the change of total pressure loss is not large, remain at around 360pa. The outlet pressure is from 0.5MPa to 1.5 MPa, and the pressure loss increases rapidly, it increases from 100Pa to 550Pa. In the process from 1.5MPa to 3.5MPa, the pressure tends to be stable, it basically maintained at around 580Pa. With the increase of inlet velocity, which increase from 0.1m/s to 2.6m/s, the pressure drop is increased rapidly and they are nonlinear positive correlation. Changes in growth amplitude are large, which range from 170Pa to near 10000Pa and across 2 orders of magnitude. As the viscosity increases, and the pressure drop is also increased, and the whole curve is approximatively direct proportion linear increasing.

结论

通过将过滤袋简化为多空介质材料，建立对应袋式过滤器的 CFD 数值仿真模型，进行孔隙率、出口被压、进口流速和粘性对压降影响的数值计算，计算结果表明；

利用 CFD 技术计算的总压力损失能够反映压降在过滤袋内的变化规律。随着空隙度的增加压力损失略有增加，但是总体来说，总压损失变化并不大，保持在 360Pa 左右。出口压力在 0.5MPa 到 1.5MPa 时，压力损失增加较快，从 100Pa 增加到 550Pa，从 1.5MPa 到 3.5MPa 的过程中，压力趋于稳定，基本保持在 580Pa 左右。随着进口流速的增加，从 0.1m/s 增加到 2.6m/s，压降也急剧增加，二者相关性为非线性。而且增长幅值变化很大，从 170Pa 到近 10000Pa，跨越了 2 个数量级。随着粘性的增加，压力降增加，整体曲线近似线性地正比例增加。

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USING AGRICULTURAL PLANTS IN ORDER TO ACCESS TOXICITY OF CHEMICAL POLLUTANTS TO CONTROL POLLUTION OF THE ENVIRONMENT: INFORMATIONAL BIOTECHNOLOGY
/
ИСПОЛЬЗОВАНИЕ СЕЛЬСКОХОЗЯЙСТВЕННЫХ РАСТЕНИЙ ДЛЯ ПОЛУЧЕНИЯ ДОСТУПА ТОКСИЧНОСТИ ХИМИЧЕСКИХ ЗАГРЯЗНЯЮЩИХ ВЕЩЕСТВ В КОНТРОЛИРОВАТЬ ЗАГРЯЗНЕНИЕ ОКРУЖАЮЩЕЙ СРЕДЫ: ИНФОРМАЦИОННАЯ БИОТЕХНОЛОГИЯ

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Abstract: *This is a short review paper. In order to control chemical pollution, it is necessary to know the main potential environmental hazards of chemicals that pollute the environment. There are traditional methods for assessing the toxicity of chemicals that are based on using rats and mice as biological test-objects. These methods are useful , however there is a need for developing alternative non-animal methods. An important class of alternative non-animal methods is the bioassay methods based on phytotest with plant seedlings. A series of the publications of the authors of this abstract was using a number of plant species to conduct this type of phytotest. Some of the plant species that were used belong to agricultural plants. Some of the agricultural plant species that were used in the phytotest in our previous publications: Fagopyrum esculentum, Sinapis alba, Oryza sativa, Triticum aestivum, Cucumis sativus, and some others. Some necessary modifications of the methods for phytotest were made by the authors in the publications mentioned below. Some of the examples of the chemicals that were bioassayed are mentioned in this review paper.*

Keywords: *environmental hazards, pollutants, bioassay, phytotoxicity, plant seedlings, toxicity assessment*

INTRODUCTION

To control chemical pollution, it is necessary to have knowledge of potential environmental hazards of chemicals that pollute the environment [1]. There are traditional methods for assessing the toxicity of chemicals that are based on using rats and mice as biological test-objects. These methods are useful , however there is a need for developing alternative non-animal methods. An important class of alternative non-animal methods is the bioassay methods based on phytotest with plant seedlings [2-14].

A series of the publications of the authors of this abstract was using a number of plant species to conduct this type of phytotest. Some of the plant species that were used belong to agricultural plants.

This is a list of some of the agricultural plant species that were used in the phytotest in our publications: Fagopyrum esculentum, Sinapis alba, Oryza sativa, Triticum aestivum, Cucumis sativus, and some others [2-4].

Some examples of the plant species, with both English and Latin names, are given in the Table 1.

Аннотация: *Это короткое бумаги отзыв. Для того, чтобы контролировать химического загрязнения, необходимо знать основные потенциальные экологические опасности химических веществ, которые загрязняют окружающую среду. Есть традиционные методы оценки токсичности химических веществ, которые основаны на использовании крыс и мышей в качестве биологических тест-объектов. Эти методы полезны, однако существует потребность в разработке альтернативных методов без животных. Важный класс альтернативных методов без животных является методы биопроб на основе phytotest с рассады растений. Серия публикаций авторов этого реферата использовал ряд видов растений провести этот тип phytotest. Некоторые из видов растений, которые были использованы принадлежат сельскохозяйственных растений. Некоторые из сельскохозяйственных видов растений, которые были использованы в phytotest в наших предыдущих публикациях: Fagopyrum Esculentum, Sinapis Альба, выдержка отрубей Oryza Sativa, Triticum AESTIVUM, Cucumis Sativus, и некоторые другие. Некоторые необходимые модификации методов phytotest были сделаны авторами в публикациях, указанных ниже. Некоторые из примеров химических веществ, которые были биоанализу упоминаются в этом обзоре.*

Ключевые слова*: экологические риски, загрязняющих веществ, биопроб, фитотоксичность, саженцы растений, оценка токсичности*

ВВЕДЕНИЕ

Для борьбы с химическим загрязнением необходимо располагать знаниями о потенциальной экологической опасности химических веществ, которые загрязняют окружающую среду [1]. Есть традиционные методы оценки токсичности химических веществ, которые основаны на использовании крыс и мышей в качестве биологических тест-объектов. Эти методы полезны, однако существует потребность в разработке альтернативных методов без использования животных. Важным классом альтернативных методов без использования животных являются методы биотестирования на основе фитотеста с проростками растений [2-14].

В серии публикаций авторов этой публикации для проведения фитотеста этого типа использован ряд видов высших растений. Некоторые из видов растений, которые были использованы в этих опытах, относятся к сельскохозяйственным растениям.

В число сельскохозяйственных видов растений, которые были использованы при проведении фитотестов, описанных в наших публикациях, входят следующие: *Fagopyrum esculentum, Sinapis alba, Oryza sativa, Triticum aestivum, Cucumis sativus*, и некоторые другие [2-4].Некоторые примеры использованных видов растений, с английскими и латинскими названиями, приведены в таблице 1.

Table 1

Some plant species that were used in the author's bioassay experiments (examples, selected)

Latin name	Russian name	English name	References (examples, selected)
Sinapis alba	Горчица белая	White mustard	[11]
Fagopyrum esculentum	гречиха	buckwheat	[2, 12]
Oryza sativa	рис		[2, 12]
Vigna radiata и	маш	mung beans	[13, 14]
Lens culinaris	чечевица	lentils	[13, 14]

MATERIAL AND METHOD

Some necessary modifications of the methods for phytotest were made by the authors in the publications mentioned below.

The examples of the chemicals that were bioassayed are some pesticides, heavy metals, and detergents [2].

Some examples of specific studies of toxicity and environmental hazards of chemicals using agricultural plants as text-organisms for bioassay are presented in the Table 2 below.

МАТЕРИАЛЫ И МЕТОДЫ

В публикациях, указанных ниже, авторами были сделаны Некоторые необходимые модификации методов фитотестирования.

Примерами химических веществ, которые были подвергнуты биотестированию, входят некоторые пестициды, тяжелые металлы, а также моющие средства (детергенты, поверхностно-активные вещества) [2].

Некоторые примеры конкретных исследований токсичности и экологической опасности химических веществ с использованием сельскохозяйственных растений как тест-организмов для биотестирования представлены в таблице 2

Table 2

Some examples of studies of chemical pollutants using agricultural plants.

Title of the publications	Content of the publications	Full references
Problems of assessment of biological activity of xenobiotics.	An analysis of problems of bio-assay of xenobiotics and pollutants is presented. A review of author's and co-workers' previous publications on bio-testing of surfactants and pesticides is given. Several new methods and modifications of methods with use of plant seedlings are discussed. A new approach to the problem of comparison of data on assessment of biological activities of xenobiotics and pollutants is suggested. Key words and Subject Terms: bioassays, comparison, methodology, toxicity testing, xenobiotics.	Ostroumov, S.A. Problems of assessment of biological activity of xenobiotics. Moscow University Biological Sciences Bulletin, 1990, v. 45 (2): p. 26-32; [New York, N.Y. : Allerton Press]. Translated from: Vestnik Moskovskogo Universiteta, Biologiia, v. 45 (2), 1990, p. 27-34. (QH301.M58). [NAL Call. No.: QH301.M6] On the list of Bibliographies in the Quick Bibliography series of the National Agricultural Library (NAL, U.S.A.); http://www.nal.usda.gov/wqic/Bibliographies/qb9405.html The original Russian version of the paper: Ostroumov, S.A. Studies of problems of assessment of biological activities of xenobiotics. Vestnik Moskovskogo Universiteta, Seriya 16 (Biologiya) [VESTN. MOSK. UNIV., SER. 16 (BIOL.).]. Vol. 16, no. 2, pp. 27-34. 1990.
Assessment of biotechnological destruction of anionic surface-active substances using biotests	[Water was treated / purified in a laboratory bioreactor with bacteria Pseudomonas mendocina. Tests: Seedlings of plants Fagopyrum esculentum, Lepidium sativum, Sinapis alba]. In order to purity polluted water containing synthetic surfactant sulphonol (0.1 g/l), Pseudomonas mendocina cells immobilized in a bioreactor were used. The efficiency of the processes of water purification was monitored using both bioassay and chemical method. The following three biotests were used: seedlings of plants Fagopyrum esculentum, Lepidium sativum and Sinapis alba. Growth of the seedlings of all the three species was strongly inhibited by the polluted water before its purification. The quality of polluted water was shown to be considerably improved after its treatment in the bioreactor according to the responses of the seedlings tested. Key words and Subject Terms: bioassays, biodegradation, biotesting, immobilized bacterial cells, microorganisms, purification, waste treatment, water purification, water quality control, water treatment, bacteria, Pseudomonas mendocina, seedlings, Fagopyrum esculentum, Lepidium sativum, Sinapis alba	S.A.Ostroumov, Samoilenko L.S. Assessment of biotechnological destruction of anionic surface-active substances using biotests // Moscow University Biological Sciences Bulletin. Vol.45. No.3. P.72-76. (Publisher: Allerton Press, Inc.; ISSN 0096-3925).
Response of seedlings of macrophytes to water pollution by macromolecular surfactant	Innovative use of rice seedlings (Oryza sativa). Toxic concentrations of a high molecular weight surfactant were found. At a concentration of 0.88 mg/L, the average length of the seedlings (92-hours after germination) was 60.6% of the average length of the seedlings of the same age in control.	Ostroumov S.A., Semykina N.A. Response of seedlings of macrophytes to water pollution by macromolecular surfactant [translit of the Russian title: Reagirovaniye prorostkov makrofitov na zagryazneniye vodnoy sredy vysokomolekulyarnymi PAV]. Ecology (Ekologiya, published in Ekaterinburg, Russia). 1991. No. 4. P. 83-85. In Russian. Another variant of the English translation of the title:

	При концентрации ПАВ 0,88 мг/мл условная средняя длина проростков через 92 ч. составляла 60.6% от их длины в контроле.	Responses of macrophytes to water pollution by a high molecular weight surfactant. https://www.researchgate.net/publication/265058550
Response of test-organisms to water pollution with quaternary ammonia compounds.	Discovery of toxicity of a cationic surfactant to plant seedlings of Fagopyrum esculentum.	Ostroumov S. A. Response of test-organisms to water pollution with quaternary ammonia compounds. - Water Resources (USA; ISSN 0097-8078) 1992, v. 18(2) p. 171-175.
Reaction of Fagopyrum esculentum Moench to Pollution of Aqueous Medium with Polymeric Surfactants	Toxicity of a polymeric synthetic surfactant to plant seedlings of Fagopurum esculentum	Ostroumov S. A., Semykina N. A. Reaction of Fagopyrum esculentum Moench to Pollution of Aqueous Medium with Polymeric Surfactants. – Russian Journal of Ecology. 1993, vol. 24; No.6, p.386 – 390.
Use of rice sprouts for bioassay of the toxicity of the surfactant sulfonol	Sulfonol is one of key components of powder laundry detergents. It is the first publication that reported that sulfonol inhibited the elongation of the seedlings of *Oryza sativa* (rice).	Ostroumov S.A., Golovko A.E. Use of rice sprouts for bioassay of the toxicity of the surfactant sulfonol // Hydrobiological Journal. 1992. 28(6): 84-88.Publisher: Begell House (United States);

RESULTS

The results demonstrated usefulness of these phytotests to discover and quantify toxicity (phytotoxicity) of the chemical pollutants. It is important that this group of test-systems are alternative non-animal methods, which is of a special value when ethical and bio-ethical considerations are taken into equation. One of advantages of these methods is the fact that no animals are killed or tortured in the experiments and bioassays with plant seedlings.

Recently the authors developed new methods of bioassay using some other species of plants.

The results of the publications [2-10] provide a substantial addition to the results reported by other authors (e.g., [15-18]

РЕЗУЛЬТАТЫ

Результаты наших опытов показали полезность этих опытов по фитотестированию для того, чтобы обнаружить и количественно оценить токсичность (фитотоксичность) химических веществ-загрязнителей окружающей среды. Важно, что эта мет оды биотестирования и использованные тест-системы представляют собой альтернативные методы оценки токсичности без использования животных. Это представляет собой особую ценность, если принять во внимание важные этические и био-этические соображения. К достоинствам и преимуществам этих методов относится то, животные не погибают и не испытывают мучений в экспериментах, поскольку биотестирование проводится на проростках растений.

Недавно авторы разработали новые методы биотестирования с использованием некоторых других видов растений, ранее не применявшихся в фитотестах.

Результаты публикаций [2-10] предоставляют существенное добавление к результатам работ в данной области, включая исследования других авторов (например, [15-18]).

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METHODS OF MEASUREMENT THE CONCENTRATIONS OF GASEOUS USED IN ENVIRONMENTAL QUALITY ASSESSMENT
/
METODE DE MĂSURARE A CONCENTRAȚIILOR DE GAZE UTILIZATE ÎN EVALUAREA CALITĂȚII MEDIULUI

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Abstract: *The issue of environmental pollution is regulated at European level by Directive 2008/50 / EC on ambient air quality and cleaner air for Europe and nationally by Law 104/2011 on ambient air quality.These regulations are designed to protect human health and the environment as a whole, by bringing under regulation measures intended for improving air quality or maintaining it where it is commensurate with air quality objectives. Assessment of industrial activities impact is important to protect human health and the environment and continuous improvement of working methods can make this complex process more accessible, more effective and more efficient.The paper studies air pollution in the environment in terms of gas concentrations (particularly NO_x), analyzing the most effective methods and techniques for measuring them.Nitrogen dioxide is known as a highly toxic gas for both humans and animals (the degree of toxicity of the nitrogen dioxide is four times higher than that of nitric oxide). Exposure to high concentrations can be fatal, and at low levels it affects the lung tissue. Population exposed to these pollutants can have difficulty breathing, respiratory tract irritation, lung dysfunction.*

Keywords: *environment, pollution, nitrogen dioxide, measuring methods, air quality, impact*

INTRODUCTION

Environmental protection legislation aims to protect human health and the environment as a whole, by bringing under regulation measures intended for maintaining air quality where it is commensurate with air quality objectives established by current legislation and its improvement in other cases [5].

Law 104/2011 on ambient air quality creates the legal framework for regulating measures for maintaining and improving air quality, based on air quality objectives, ensuring alignment of national legislation with European standards and answers Romania's obligations as a member state of the European Union.

This law transposes Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and a cleaner air for Europe [2,5].

Law on ambient air quality provides national measures on defining and establishing objectives for air quality designed to avoid and prevent the occurrence of harmfull events and reduce their effects on human health and the environment, but also on assessing air quality throughout the country based on common methods and criteria established at European level [6, 7].

In the field of air protection the following concepts are frequently used [6]:

- Emissions (evacuation of impurities in the free

Rezumat: *Problematica privind poluarea mediului este reglementată atât la nivel european prin Directiva 2008/50/CE privind calitatea aerului înconjurător şi un aer mai curat pentru Europa, cât şi la nivel național prin Legea 104/2011 privind calitatea aerului înconjurător. Aceste reglementări au ca scop protejarea sănătății umane şi a mediului ca întreg, prin reglementarea măsurilor destinate îmbunătățirii calității aerului sau menținerii acesteia, acolo unde este corespunzătoare obiectivelor pentru calitatea aerului.Evaluarea impactului activităților industriale este importantă pentru protejarea sănătății umane şi a mediului, iar perfecționarea continuă a metodelor de lucru poate face acest proces complex mai accesibil, mai eficace şi mai eficient.În lucrare se tratează poluarea aerului în mediul înconjurător din punct de vedere a concentrațiilor de gaze (în special NO_x) , analizând metodele şi tehnicile cele mai eficiente pentru măsurarea acestora. Dioxidul de azot este cunoscut ca fiind un gaz foarte toxic atât pentru oameni cât si pentru animale (gradul de toxicitate al dioxidului de azot este de patru ori mai mare decât cel al monoxidului de azot). Expunerea la concentrații ridicate poate fi fatală, iar la concentrații reduse afectează țesutul pulmonar. Populația expusă la acest tip de poluanți poate avea dificultăți respiratorii, iritații ale căilor respiratorii, disfuncții ale plămânilor.*

Cuvinte cheie: *mediu, poluare, dioxid de azot, metode de măsurare, calitatea aerului, impact*

INTRODUCERE

Prevederile legislative în domeniul protectiei mediului au ca scop protejarea sănătății umane şi a mediului ca întreg, prin reglementarea măsurilor destinate menținerii calității aerului înconjurător acolo unde aceasta corespunde obiectivelor pentru calitatea aerului înconjurător stabilite prin legislatia în vigoare şi îmbunătățirea acesteia în celelalte cazuri [5].

Legea 104/2011, privind calitatea aerului înconjurător, crează cadrul legal pentru reglementarea măsurilor destinate menținerii şi îmbunătățirii calității aerului, pe baza obiectivelor pentru calitatea aerului, asigurând alinierea legislației naționale la standardele europene în domeniu şi îndeplinirea obligațiilor României ca stat membru al Uniunii Europene.

Această lege transpune Directiva 2008/50/CE a Parlamentului European şi a Consiliului din 21 mai 2008 privind calitatea aerului înconjurător şi un aer mai curat pentru Europa [2,5].

Legea privind calitatea aerului înconjurător prevede măsuri la nivel național privind definirea şi stabilirea obiectivelor pentru calitatea aerului destinate să evite şi să prevină producerea unor evenimente dăunătoare şi să reducă efectele acestora asupra sănătății umane şi a mediului, dar şi evaluarea calității aerului pe întreg teritoriul țării pe baza unor metode şi criterii comune, stabilite la nivel european [6,7].

atmosphere by a emitter)

- Transmission (spatial distribution of impurities in the free atmosphere)

- *Imision*, transfer of the atmosphere pollutants to a receiver (man and its ecological system factors, property etc.) represents values of maximum permissible concentrations of pollutants in the atmosphere (Ord. 462/1993).

These values are regulated by STAS 12574/1987 and represent the average concentrations in various measuring ranges (averaging periods): 30 min, 24 hours, monthly, yearly. In current practice, short-term averages are used (30 min.); fixed measuring stations of Environmental Agencies perform long-term average measurements (24 hours).

În domeniul protectiei aerului se folosesc curent noțiunile [6]:

- Emisie (fenomenul evacuarii unor impuritati in atmosfera libera de catre un *emitor*)

- Transmisie (distribuția spațială a impurităților în atmosfera liberă)

- Imisie, transferul poluanților în atmosferă către un receptor (omul şi factorii sistemului său ecologic, bunuri materiale etc.) şi reprezintă valorile concentrațiilor maxime admisibile ale unor substanțe poluante în atmosferă (Ord. 462/1993).

Aceste valori sunt reglementate prin STAS 12574/1987 şi reprezintă concentrații medii pe diverse intervale de măsurare (perioade de mediere): 30 min., 24 ore, lunar, anual. In practica curentă, se folosesc mediile de scurtă durată (30 min.); stațiile fixe de măsurare ale Agențiilor de Mediu fac măsurători medii de lungă durată (24 ore).

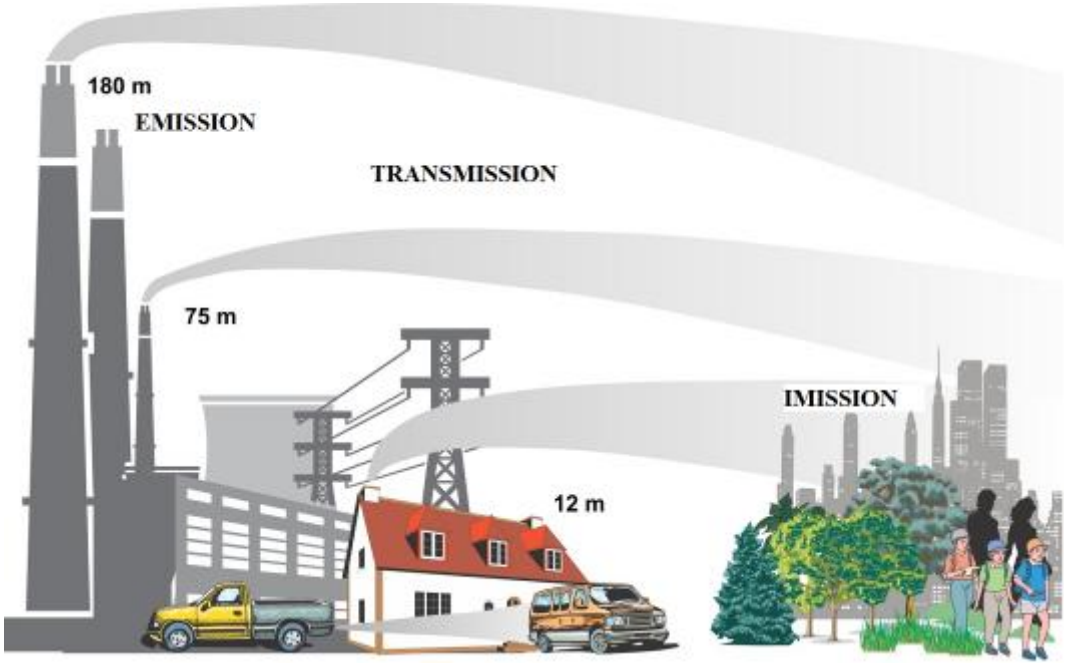

Fig. 1 - Representation emission - transmission - immission

All these phenomena (emission - transmission - immission) refer to all the processes that lead to a change or dilution of the pollutant agent in ambient air. They have a direct effect on immission and basically consist of measurements of pollutants concentrations, local weather conditions, secondary emissions, etc.

The sources of environmental degradation can be classified as [1,3]:

- industrial processes from which result toxic substances (metallurgy, chemical, petrochemical, power producing, paper, building materials, etc.),

- transport (terrestrial, maritime, air),

- incineration and treatment of waste (domestic, industrial and agricultural).

Ansamblul acestor fenomene (emisie – transmisie - imisie) se referă la toate procesele care conduc la o modificare sau o diluție a agentului poluant din aerul înconjurător. Acestea au un efect direct asupra imisiei şi constau practic în măsurători ale concentrațiilor de poluanți, a condițiilor meteorologice locale, emisii secundare, etc.

Sursele de degradare a mediului pot fi clasificate astfel [1,3]:

- procesele industriale din care rezultă substanțe toxice (metalurgie, chimie, petrochimie, producerea de energie, hârtie, materiale de construcții, etc.),

- mijloacele de transport (tereste, maritime, aeriene),

- incinerarea şi tratarea deşeurilor (menajere, industriale, agricole).

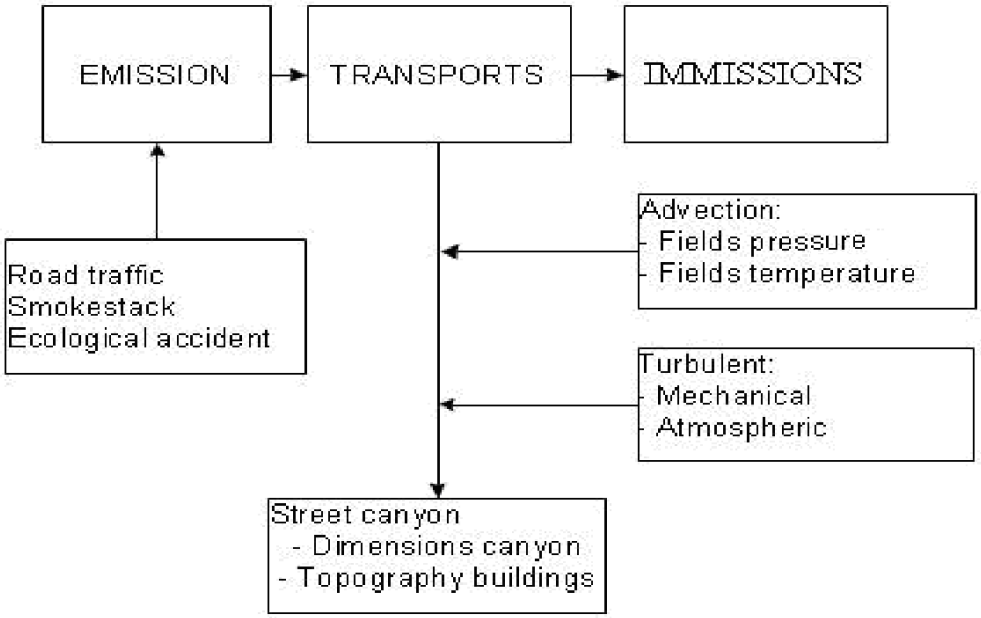

Fig.2.- The origin and formation of pollutants [6]

ATMOSPHERIC POLLUTANTS

Air pollutants considered when assessing ambient air quality are (according to Annex - no. 1 of Law. no. 104/2011 Ambient air quality): sulfur dioxide (SO_2), nitrogen dioxide (NO_2), nitrogen oxides (NO_x), particulate matter (PM_{10} and $PM_{2.5}$), lead (Pb), benzene (C_6H_6), carbon monoxide (CO), ozone (O_3), arsenic (As), cadmium (Cd), nickel (Ni), mercury (Hg) [7].

Nitrogen oxides NO_x (NO / NO_2)

Nitrogen oxides are a group of highly reactive gases which contain nitrogen and oxygen in varying amounts. Most nitrogen oxides are colorless or odorless gases. [6]

Main nitrogen oxides are:

- nitric oxide (NO) is a colorless and odorless gas;
- Nitrogen dioxide (NO_2) is a choking reddish-brown gas with a strong odor.

In the presence of sunlight, nitrogen oxides and hydrocarbons can react forming photochemical oxidants.

Anthropic sources: nitrogen oxides are formed during combustion when fuels are burned at high temperatures, but more often they are the result of road traffic, industrial activities, and electricity making proceses. Nitrogen oxides are responsible for smog, acid rain, deterioration of water quality, greenhouse effect, reducing visibility in urban areas [6].

Effects on human health

Nitrogen dioxide is known as a highly toxic gas for both humans and animals (the degree of toxicity of nitrogen dioxide is 4 times higher than that of nitric oxide). Exposure to high concentrations can be fatal, and at low levels affects the lung tissue [1].

The population exposed to such pollutants can have

POLUANȚI ATMOSFERICI

Poluanții atmosferici luați în considerare în evaluarea calității aerului înconjurător (după Anexa - nr. 1, din Legea. nr. 104/2011- Calitatea aerului înconjurător) sunt: dioxid de sulf (SO_2), dioxid de azot (NO_2), oxizi de azot (NO_x), particule în suspensie (PM_{10} si $PM_{2,5}$), plumb (Pb), benzen (C_6H_6), monoxid de carbon (CO), ozon (O_3), arsen (As), cadmiu (Cd), nichel (Ni), mercur (Hg) [7].

Oxizi de azot NO_x (NO / NO_2)

Oxizii de azot sunt un grup de gaze foarte reactive, care conțin azot şi oxigen în cantități variabile. Majoritatea oxizilor de azot sunt gaze fără culoare sau miros [6].

Principalii oxizi de azot sunt:

- monoxidul de azot (NO) care este un gaz incolor şi inodor;
- dioxidul de azot (NO_2) care este un gaz de culoare brun-roscat cu un miros puternic, înecacios.

În prezența luminii solare, oxizii de azot pot reacționa şi cu hidrocarburile formând oxidanți fotochimici.

Surse antropice: oxizii de azot se formează în procesul de combustie atunci când combustibilii sunt arşi la temperaturi înalte, dar cel mai adesea ei sunt rezultatul traficului rutier, activităților industriale, producerii energiei electrice. Oxizii de azot sunt responsabili pentru formarea smogului, a ploilor acide, deteriorarea calitătii apei, efectului de seră, reducerea vizibilității în zonele urbane [6].

Efecte asupra sănătății populatiei

Dioxidul de azot este cunoscut ca fiind un gaz foarte toxic atât pentru oameni cât şi pentru animale (gradul de toxicitate al dioxidului de azot este de 4 ori mai mare decât cel al monoxidului de azot). Expunerea la concentrații ridicate poate fi fatală, iar la concentrații

difficulty breathing, respiratory tract irritation, lung dysfunction. Long-term exposure to low concentrations can damage lung tissues leading to emphysema.

Effects on plants and animals

Exposure to this pollutant produces serious injuries to vegetation, in the form of plant whitening or tissue death, slowdown in growth.

Exposure to nitrogen oxides can cause pulmonary diseases and exposure to nitrogen dioxide may reduce the immunity of animals causing diseases such as pneumonia and influenza [6].

Other effects

Nitrogen oxides contribute to acid rain and favor the accumulation of nitrates at ground level that can alter ecological environmental balance. They can also cause damage to fabrics and paint discoloration, degradation of metals.

Measuring methods

Reference method for the measurement of nitrogen dioxide and nitrogen oxides is that provided by SR EN 14211: 2012 - Ambient air. Standard method for the measurement of nitrogen dioxide and nitrogen monoxide concentration by chemiluminescence.

Sulphur dioxide SO_2

Sulphur dioxide is a colorless, bitter, non-flammable, with a pungent odor that irritates the eyes and respiratory system.

Natural resources: volcanic eruptions, marine phytoplankton, bacterial fermentation in wetlands, oxidation of sulfur-containing gas resulting from the decomposition of biomass.

Anthropogenic sources: (human activity) population heating systems that do not use methane gas power plants, industrial processes (siderurgy, refinery, sulfuric acid), pulp and paper and, to a lesser extent, emissions from diesel engines.

Effects on human health

Depending on the concentration and exposure time, sulfur dioxide has different effects on human health. Exposure to a high concentration of sulfur dioxide in a short period of time, can cause serious breathing difficulties. Are particularly affected people with asthma, children, the elderly and people with chronic respiratory diseases. Exposure to a reduced concentration of sulfur dioxide in the long term, can result in respiratory tract infections. Also, sulfur dioxide may potentiate hazardous effects of ozone.

Effects on plants

Sulphur dioxide affects many plants visible negative effects on tissue structure and their being perceptible to the naked eye. Some of the most sensitive plants are: pin, vegetables, acorns red and black, white ash, alfalfa, blueberries.

reduse afectează țesutul pulmonar [1].

Populația expusă la acest tip de poluanți poate avea dificultăți respiratorii, iritatii ale căilor respiratorii, disfuncții ale plămânilor. Expunerea pe termen lung la o concentrație redusă poate distruge țesuturile pulmonare ducând la emfizem pulmonar.

Efecte asupra plantelor şi animalelor

Expunerea la acest poluant produce vătămarea serioasă a vegetației prin albirea sau moartea țesuturilor plantelor, reducerea ritmului de creştere a acestora.

Expunerea la oxizi de azot poate provoca boli pulmonare animalelor, iar expunerea la dioxidul de azot poate reduce imunitatea animalelor provocând boli precum pneumonia şi gripa [6].

Alte efecte

Oxizii de azot contribuie la formarea ploilor acide si favorizează acumularea nitraților la nivelul solului care pot provocă alterarea echilibrului ecologic ambiental. De asemenea, poate provoca deteriorarea țesăturilor şi decolorarea vopselurilor, degradarea metalelor.

Metode de măsurare

Metoda de referință pentru măsurarea dioxidului de azot şi a oxizilor de azot este cea prevazută în standardul SR EN 14211:2012 - Aer înconjurator. Metoda standardizată pentru măsurarea concentrației de dioxid de azot şi monoxid de azot prin chemiluminescență.

Dioxid de sulf SO_2

Dioxidul de sulf este un gaz incolor, amărui, neinflamabil, cu un miros pătrunzător care irită ochii şi căile respiratorii.

Surse naturale: erupțiile vulcanice, fitoplanctonul marin, fermentația bacteriană în zonele mlăştinoase, oxidarea gazului cu conținut de sulf rezultat din descompunerea biomasei.

Surse antropice (datorate activitatilor umane): sistemele de încalzire a populației care nu utilizeaza gaz metan, centralele termoelectrice, procesele industriale (siderurgie, rafinărie, producerea acidului sulfuric), industria celulozei si hârtiei şi, în măsura mai mică, emisiile provenite de la motoarele diesel.

Efecte asupra sănătății populatiei

În funcție de concentrație şi perioada de expunere, dioxidul de sulf are diferite efecte asupra sănătății umane. Expunerea la o concentrație mare de dioxid de sulf, pe o perioadă scurtă de timp, poate provoca dificultăți respiratorii severe. Sunt afectate în special persoanele cu astm, copiii, varstnicii şi persoanele cu boli cronice ale căilor respiratorii. Expunerea la o concentrație redusă de dioxid de sulf, pe termen lung, poate avea ca efect infecții ale tractului respirator. De asemenea, dioxidul de sulf poate potența efectele periculoase ale ozonului.

Efecte asupra plantelor

Dioxidul de sulf afecteaza vizibil multe specii de plante, efectul negativ asupra structurii şi tesuturilor

Environmental effects

In the atmosphere, SO_2 is contributing to the acidification of rainfall, with toxic effects on vegetation and soil. Increasing the concentration of sulfur dioxide accelerates the corrosion of metals due to acid formation. Sulphur oxides can erode stone, masonry, paint, fibers, paper, leather and electrical components.

Method of measurement

The reference method for the measurement of sulfur dioxide is that given in SR EN 14212: 2012 / AC: 2014 - Ambient air. Standard method for measuring the concentration of sulfur dioxide by ultraviolet fluorescence.

acestora fiind sesizabil cu ochiul liber. Unele dintre cele mai sensibile plante sunt: pinul, legumele, ghindele roşii şi negre, frasinul alb, lucerna, murele.

Efecte asupra mediului

În atmosferă, contribuie la acidifierea precipitatiilor, cu efecte toxice asupra vegetației şi solului.

Creşterea concentrației de dioxid de sulf accelerează coroziunea metalelor, din cauza formării acizilor.

Oxizii de sulf pot eroda: piatra, zidaria, vopselurile, fibrele, hârtia, pielea şi componentele electrice.

Metode de masurare

Metoda de referință pentru măsurarea dioxidului de sulf este cea prevazută în standardul SR EN 14212:2012/AC:2014 - Aer înconjurator. Metodă standardizată pentru măsurarea concentrației de dioxid de sulf prin fluorescență în ultraviolet.

Norms

Law no. 104 of June 15, 2011 **Nitrogen oxides - NO_x**	
Alert threshold	**400 µg/m^3** - measured for 3 consecutive hours at locations representative of air quality over at least 100 km^2 or an entire zone or agglomeration, whichever is lower alert.
Limit values	**200 µg/m^3 NO_2** - hourly limit value for human health protection **40 µg/m^3 NO_2** - the annual limit value for human health protection
Critical Level	**30 µg/m^3 NO_x** - Annual critical level for vegetation protection
Dioxidul de sulf - SO_2	
Alert threshold	**500 µg/m^3** - measured for 3 consecutive hours at locations representative of air quality over at least 100 km^2 or an entire zone or agglomeration, whichever is lower alert.
Limit values	**350 µg/m^3** - hourly limit value for human health protection **125 µg/m^3** - the annual limit value for human health protection
Critical Level	**20 µg/m^3** - Annual critical level for vegetation protection

METHODS OF MEASUREMENT THE GAS CONCENTRATIONS USED IN THE ASSESSMENT OF ENVIRONMENTAL QUALITY

Measuring methods

Air sampling aims either the analysis of gaseous compounds or pollutants compounds present in the atmosphere in form of solid particles. Therefore, sampling methods vary according to type of compound to be analyzed in the collected air sample. For sampling gases several methods can be used: intermittent and continuous.

Intermittent methods (instant or short period)

These methods are suitable for cases where pollutant concentration of the compound being examined is high and consist of sampling air in closed containers of known volume and various shapes, sizes and volumes such as glass vials, pipettes gas (tonometers), plastic and rubber bags, glass or plastic syringes.

Continous methods (suction sampling)

These are used in case of low concentrations of compounds to be analyzed in the air, they being able to be concentrated from a large volume of air through long-

METODE DE MĂSURARE A CONCENTRAȚIILOR DE GAZE UTILIZATE ÎN EVALUAREA CALITĂȚII MEDIULUI

Metode de măsurare

Recoltarea probelor de aer urmăreşte fie analiza compusilor gazoşi, fie a compuşilor poluanți prezenți în atmosferă sub formă de particule solide. De aceea, metodele de prelevare probe diferă funcție de tipul de compus analizat în proba de aer recoltată. Pentru prelevarea probelor gazoase se pot folosi diferite metode: discontinue şi continue.

Metode discontinue (instantanee sau de scurtă durată)

Aceste metode sunt indicate pentru cazurile în care concentrația compusului poluant analizat este mare si constau în recoltarea probelor de aer în recipiente închise, de volum cunoscut, de diferite forme, capacități şi dimensiuni cum ar fi: flacoane de sticlă, pipete de gaz (tonometre), saci de plastic, camere şi baloane de cauciuc sau de material plastic, seringi de sticlă sau de material plastic.

Metode continue (recoltarea prin aspirație)

Acestea sunt folosite în cazul unor concentrații reduse

term sampling. Air samples suction sampling systems generally consist of three parts [6]:

i) suction device (various hydrostatic devices - hydraulic vacuum, vacuum pumps or electric vacuum);

ii)the air volume measuring device (gas meters - gas meters and flow meters - rheometers and / or rotameters);

iii) the restraint device of the atmospheric constituent (pollutants); for gaseous compounds

- absorber vessel or bubbler with absorbent solution specific for each gaseous compound analyzed; for particle compounds and aerosols - a filter with filtering material according to the size of analyzed solid particles / aerosols.

Instrumental methods used for gas analyzers

Gas analyzers used in modern techniques are devices that allow sampling, detection or dosage of air pollutants compounds, gaseous or vapourous flammable and explosive compounds, individually and combined, directly from the polluated atmosphere. Gas analyzers are based on the principles used in the construction of various types of physico-chemical analysis devices, adapted to the gaseous environment in which measurements are performed. Although there are a great variety of gas analyzers, they can simply be classified based on their working principle: optical, electrochemical and thermochemical.

Optical gas analyzers

These measure the absorption of light by the pollutant compound or by the product of the reaction between the pollutant compound and the liquid or solid absorber environment.

Absorption measurement can be performed in the visible (Vis), ultraviolet (UV) or infrared (IR) range, using photoelectric cells (CF) and recording devices (R), possibly remote data transmission (Tr).

In order to avoid interference selective filters (FS) or additional chemical reagents are used, for decomposition or masking of the interfering substances (R).

Electrochemical gas analyzers

These keep trace of variation of of the absorbent solution's electrochemical properties, following pollutant prehension. The most common types of electrochemical analyzers are based on tracking the electrical conductivity variation.

Thermochemical gas analyzers

These are based on the measurement of heat resulting from chemical reactions of pollutants compounds, mostly combustion reactions.

PRINCIPLES FOR MEASURING GASEOUS POLLUTANTS

There are several principles for measuring gaseous pollutants (Table no.1), according to the applicable standards in force. Thus, to determine nitrogen oxides (NO_x) in the atmosphere are used gas analyzers that run by the chemiluminescence principle, in line with European principles and practices in the field of

ale compuşilor de analizat din aer, aceştia putând fi concentraţi dintr-un volum mare de aer prin recoltări de lungă durată. Sistemele de recoltare prin aspiraţie a probelor de aer constau în general din trei părţi componente [6]:

i) dispozitivul de aspirare (diferite dispozitive hidrostatice - aspiratoare hidraulice, pompe de vid sau aspiratoare electrice);

ii) dispozitivul de măsurare a volumului de aer (gazometrelor - contoare de gaz şi debitmetrelor - reometre şi/sau rotametre);

iii) dispozitivul de reţinere a constituentului atmosferic (poluantul atmosferic); pentru compusi gazoşi

- vas barbotor sau absorbitor cu soluţie absorbantă specifică fiecarui compus gazos analizat şi pentru compuşi particulaţi şi aerosoli - un filtru cu material filtrant corespunzator dimensiunilor particulelor solide/aerosoli analizaţi.

Metode instrumentale folosind analizoare de gaze

Analizoarele de gaze folosite în tehnicile moderne sunt aparate care permit recoltarea, depistarea sau dozarea compuşilor poluanţi atmosferici, a compuşilor inflamabili şi explozivi în stare de gaze sau vapori, individual şi în amestec, direct din atmosfera poluantă. Deşi există o foarte mare varietate de analizoare de gaze ele pot fi clasificate simplu, după principiul pe care se bazează, în: optice, electrochimice şi termochimice.

Analizoare optice de gaze

Acestea măsoară absorbţia luminii de către compusul poluant sau de către produsul de reacţie dintre compusul poluant şi mediul absorbant, lichid sau solid.

Măsurarea absorbţiei se poate face în domeniul vizibil (Vis), ultraviolet (UV) sau infraroşu (IR), folosind celule fotoelectrice (CF) şi dispozitive de înregistrare (R), eventual de teletransmisie (Tr), a datelor.

În scopul evitării interferenţelor se utilizează filtre selective (FS) sau reactivi chimici suplimentari pentru descompunerea sau mascarea substanţelor interferente (R).

Analizoare electrochimice de gaze

Acestea urmăresc variaţia unei proprietăţi electrochimice a soluţiei absorbante în urma reţinerii poluantului. Cele mai frecvente tipuri de analizoare electrochimice sunt cele bazate pe urmărirea variaţiei conductibilităţii electrice.

Analizoare termochimice de gaze

Acestea se bazează pe măsurarea energiei calorice care rezultă din reacţiile chimice ale compuşilor poluanti, în general reacţii de ardere.

PRINCIPII DE MĂSURARE A NOXELOR GAZOASE

Există mai multe principii de măsurare (tabel nr.1) a noxelor gazoase, în funcţie de standardele aplicabile în vigoare. Astfel, pentru determinarea oxizilor de azot (NOx) din atmosferă se utilizează analizoare de gaze care au ca principiu de funcţionare chemiluminiscenţa, în concordanţă cu principiile si practicile europene în domeniul protecţiei mediului, respectiv SR EN 14211:2012 şi Legea 104/2011.

environmental protection, respectively SR EN 14211: 2012 and Law 104/2011.

Table1 [9]

Crt.no.	Principle	Emission	Imission	Conti-nuous	Disconti-nuous	Examples
1	IR photometry	X	X	X		CO, CO_2, SO_2, NO, NH_3, H_2O, CH_4, C_2H_4,etc
2	UV photometry	X	X	X		O_3, NO, NO_2, SO_2, Cl_2,, H_2S, HCNO
3	Photometry in the visible	X		X		NO_2, Cl_2
4	UV Fluorescence	X	X	X		SO_2
5	*Chemiluminscence*		*X*	*X*	*X*	*NO, NO_2, (NO_X), O_3*
6	Flame photometry		X	X		The total amount of S, that SO_2
7	Flame Ionization	X	X	X		The total amount of hydrocarbons CmHn
8	Conductimetry	X	X	X		SO_2, H_2S, CO_2, Cl_2, HCl
9	Amperometric	X	(X)	X		NO_2, H_2S, O_2, CO, SO_2
10	Coulombmeter	X	X	X		SO_2, Cl_2
11	Potentiometers	X	X	X		HF, HCl, O_2
12	Chromatography	X	X		X	Wide range of individual components
13	Colorimetry	(X)	X	(X)	X	SO_2, NO_2, F, O_3, HCl, Cl_2, H_2S, NH_3, HCNO
14	PH-metric titration	X			X	SO_2, SO_3, NO_X, CO, Cl_2, H_2S, O_2, NH_3
15	Paramagnetism	X		X		O_2
16	Thermal conductivity	X		X		CO_2, H_2

Analyzers that run based on the chemiluminescence and fluorescence measurement principle, can perform continuous analysis of nitric oxide (NO_x) and SO_2 in a protected neighbouring area, situated in the vicinity of an economic agent that is a source of pollution or measurement of NO_x and SO_2 concentration in urban intersection (road traffic).

The chemiluminescence principle consist of activating to the point of generating a light phenomenon as a result of special chemical reactions of nitric oxide molecules. It is a process of physical-chemical investigation. Measurement of nitrogen oxides concentration by chemiluminescence detection is one of the most accurate direct analisys techniques.

Portable equipments can be also used to monitor objectives whose actions may lead to air pollution (road infrastructure works, construction, demolition, etc.). This type of monitoring is performed for clearly defined time periods and requires monitoring of surrounding areas, which will be determined for each situation. Also, mobile devices can be used to perform other measurements, occasioned for example by exceptional circumstances such as periods of prolonged lack of rain, while the atmosphere is loaded above average with particulates, forest fires, fires at hydrocarbons deposits etc., but also for conducting measurements in the vicinity of sanitary protection areas, particularly near hospitals serving cities, towns, villages.

CASE STUDY ON AIR POLLUTION IN THE JIU VALLEY

Description of sampling area

Jiu Valley is a mountain depression situated on the Jiu River, a mining area where at present there are seven

Analizoarele care au ca principiu de măsurare chemiluminiscența şi fluorescența, pot realiza analiza continuă a imisiilor de oxizi de azot (NO_x) şi SO_2 dintr-o zonă adiacentă protejată situată în imediata vecinătate a unui agent economic care se constituie ca sursă de poluare sau poate determina concentrația de NO_x şi SO_2 dintr-o intersecție urbană (traficul auto).

Principiul chemiluminiscenței constă în activarea până la generarea unui fenomen luminos în urma unor reacții chimice speciale a moleculelor de oxid de azot. Este un procedeu fizico-chimic de investigare. Determinarea concentrației oxizilor de azot prin detecția chemiluminiscenței este una din cele mai precise tehnici de analiză directă.

Echipamentele portabile pot fi utilizate şi pentru monitorizarea anumitor obiective ale căror acțiuni pot conduce la poluarea aerului (lucrări la infrastructura rutieră, construcții, demolări etc). Acest tip de monitorizare se face pentru perioade de timp bine delimitate şi presupune o monitorizare a zonei limitrofe, care va fi stabilită în funcție de fiecare situație în parte. De asemenea, aparatura mobilă poate fi utilizată şi pentru efectuarea altor măsurători, prilejuite spre exemplu de situații excepționale cum ar fi perioade cu lipsă prelungită de precipitații, când atmosfera este încărcată cu particule în suspensie peste mediile obişnuite, incendii de pădure, incendii ale depozitelor de hidrocarburi etc., dar şi pentru efectuarea unor măsurători în vecinătatea zonelor de protecție sanitară, cu precădere în apropierea spitalelor care deservesc municipiile, oraşele, satele.

STUDIU DE CAZ PRIVIND POLUAREA ATMOSFEREI DIN VALEA JIULUI

Descrierea zonei de prelevare a probelor

Valea Jiului este o depresiune intramontană situată pe

mining units (4 functioning as active mines and 3 are closing).

Industrial activity and traffic generates gases (SO2, NO2, CO and CO2) and particulate matter (Proorocu et al., 2014). Most of the mentioned sources generate unguided (uncontrolled) emissions, with the possibility of polluting both the working environment and the neighboring inhabited areas.

Considering that Jiu Valley is an urbanized area, locations of air quality monitoring points aimed to create a network that can provide data characteristic to the overall picture of air quality in Jiu Valley. To achieve such a goal sampling equipment was located in points of interest within cities of Jiu Valley.

There were established 7 location points of sampling equipments used to monitor air quality across the whole Jiu Valley, given the inhabited areas, activities in those areas and road traffic. It is noted that at the time of the measurements atmospheric conditions were unstable (with 70-80% humidity, 709 mmHg atmospheric pressure and wind speed of 0,3-1,3 m/s), and during summer months heating is not used.

Results and Discussion

In order to capture the imissions values, measurements were performed both in the western area of Jiu Valley and in the East, in addition to mining trying to also capture other economic activities, including road traffic. All this took into account wind direction, humidity and atmospheric pressure and the distance to populated or inhabited areas.

The length of gas sampling was one hour, the final result being the arithmetic mean of the measurements, normalized based on temperature and pressure.

The results of gas and dust imissions measurements were compared with the permissible limit of Law 104/2011 of the Ministry of Environment and Forests and Waters are presented in Table. 2.

râul Jiu,o zonă minieră în care, la ora actuală, există 7 unități miniere (4 funcționează ca mine active, iar trei sunt în perioada de închidere).

Activitatea industrială şi traficul rutier generează gaze (SO_2, NO_2, CO şi CO_2) pulberi în suspensie. Majoritatea surselor menționate generează emisii nedirijate (necontrolate), cu posibilitatea poluării atât a mediului de muncă cât a zonelor învecinate, locuite.

Ținând cont de faptul că Valea Jiului este o zonă urbanizată, amplasarea punctelor de monitorizare a calității aerului a urmărit în special crearea unei rețele care să poată oferi date caracteristice imaginii de ansamblu a calității aerului din Valea Jiului. Pentru a realiza un astfel de deziderat echipamentele de prelevare au fost amplasate în puncte de interes din interiorul localităților componente.

Au fost stabilite un număr de 7 puncte de amplasare a echipamentelor de prelevare destinate monitorizării calității aerului pe cuprinsul întregii zone a Văii Jiului, având în vedere zonele locuite, activitățile desfăşurate în acele zone şi traficul rutier. Se menționează faptul că la data efectuării măsurătorilor condițiile atmosferice au fost instabile (cu o umiditate de 70-80%, o presiune atmosferică de 709 mmHg şi o viteză a vântului de 0,3-1,3m/s), iar in lunile de vara nu se utilizează agentul termic.

Rezultate şi discuții

Pentru a surprinde valorile imisiilor, măsurătorile s-au efectuat, atât în zona de vest a Văii Jiului cât şi în zona de Est, încercând a surprinde pe lângă activitățile miniere şi celelalte activități economice, inclusiv traficul rutier. Toate acestea au ținut seama de direcția vântului, umiditatea şi presiunea atmosferică, precum şi de distanța până la zonele populate sau locuite.

Durata de prelevare a probelor de gaze a fost de o oră, rezultatul final fiind media aritmetică a măsurătorilor, normalizate în funcție de temperatură şi presiunea atmosferică.

Rezultatele măsurătorilor de imisii de gaze au fost comparate cu limita admisă din Legea 104/2011 al Ministerului Mediului Apelor şi Pădurilor şi se prezintă în tabelul nr.2.

Table 2

Location/ Sampling point	Determined pollutant	Recorded maximum average hourly value [µg/m^3]	CMA according to Law104/2011 [µg/m^3]	CMA exceeding [times]
Uricani	NO_2	13,984476	200	-
	SO_2	12,513318	350	-
	CO_2	530,96	-	-
Lupeni (Comexim SRL area)	NO_2	13,904756	200	-
	SO_2	22,689257	350	-
	CO_2	552,28	-	-
Paroşeni	NO_2	15,518381	200	-
	SO_2	13,900046	350	-
	CO_2	596,85	-	-
Vulcan	NO_2	24,150561	200	-
	SO_2	26,240579	350	-
	CO_2	571,6	-	-
Petroşani near Livezeni mine	NO_2	4,430596	200	-
	SO_2	15,678634	350	-

Location/ Sampling point	Determined pollutant	Recorded maximum average hourly value [µg/m^3]	CMA according to Law104/2011 [µg/m^3]	CMA exceeding [times]
	CO_2	525,15	-	-
Petroşani within INCD INSEMEX	NO_2	13,75	200	-
	SO_2	12,063	350	-
	CO_2	529,83	-	-
Petrila	NO_2	12,637548	200	-
	SO_2	24,619049	350	-
	CO_2	534,84	-	-

CONCLUSION

The issue of environmental pollution is regulated at European level by Directive 2008/50/EC on ambient air quality and cleaner air for Europe and nationally by Law 104/2011 on ambient air quality. These regulations are designed to protect human health and the environment as a whole, by bringing under regulation measures intended for improving air quality or maintaining it where it is commensurate with air quality objectives [2];

By analyzing methods of measurement of gas concentrations, it was found that instrumental methods (gas analyzers) are the most practical and currently used, them being adapted to the gaseous environment in which measurements are performed, using different operating principles;

Choosing portable analyzers with chemiluminescence and fluorescence in the ultraviolet operating principle, acording to legislative requirements concerning, the reference methods were used for determination portable gas analyzers as well as the accuracy of portable equipment using these methods.

Case studies that have used these analyzes showed that regardless of the degree of atmospheric pollution (large, medium, small) they have a measuring range covering, being able to estimate real-time environmental impact in the examined areas.

Given the analysis results shows that the West Jiu Valley is predominantly more polluted than the East.

Currently it can be said that the level of pollution in the Jiu Valley localities decreased compared to previous years (according to research compiled by INCD INSEMEX Petrosani), not only by the closure of mining units but also because they have taken steps to Termocentrala Paroşeni refurbishment, and economic units increasingly falling values of pollutants in the atmosphere as required by law.

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CONCLUZII

Problematica privind poluarea mediului este reglementată atât la nivel european prin Directiva 2008/50/CE *privind calitatea aerului înconjurător şi un aer mai curat pentru Europa,* cât şi la nivel național prin Legea 104/2011 *privind calitatea aerului înconjurător.* Aceste reglementări au ca scop protejarea sănătății umane şi a mediului ca întreg, prin reglementarea măsurilor destinate îmbunătățirii calității aerului sau menținerii acesteia, acolo unde este corespunzătoare obiectivelor pentru calitatea aerului [2];

Prin analiza metodelor de măsurare a concentrațiilor de gaze, s-a constatat faptul că metodele instrumentale (analizoare de gaze) sunt cele mai practice şi mai utilizate în prezent, acestea fiind adaptate la particularitățile mediului gazos în care se efectuează determinările, utilizând principii de funcționare diferite;

Alegerea analizoarelor portabile care au ca principiu de funcționare chemiluminiscența şi fluorescență în ultraviolet, s-a făcut având în vedere cerințele legislative privind metodele de referință utilizate pentru determinarea gazelor precum şi acuratețea analizoarelor portabile ce utilizează aceste metode.

Studiul de caz în care s-au utilizat aceste analizoare au arătat faptul că indifferent de gradul de poluare a atmosferei (mare, medie, mică) acestea au un domeniu de măsură acoperitor, putîndu-se estima în timp real impactul asupra mediului în zonele analizate.

Având în vedere analiza rezultatelor se constată faptul că partea de Vest a Văii Jiului este predominant mai poluantă decât partea de Est .

În prezent, se poate spune că nivelul de poluare a localităților din Valea Jiului a scăzut față de anii precedenți (conform studiilor elaborate de INCD INSEMEX Petroşani), nu numai prin închiderea unor unități miniere, ci şi datorită faptului că s-au întreprins măsuri de retehnologizare la Termocentrala Paroşeni, iar agenții economici din zonă se încadrează tot mai mult în valorile de emisii de poluanți în atmosferă conform legislației în vigoare.

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DEVELOPMENT ON DRIED YIELD RATE TESTER FOR RICE
/
稻穀成品率測定儀之研發

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Abstract: *The paddy is harvested with high moisture content (25-35% w.b.) in Taiwan. The dealers trade with farmers based on dried rice. The weight conversion ratio between dried rice and newly harvested wet paddy is defined as dried yield rate. In order to know the dried weight at trading time, various conversion tables were provided by rice dealers, in which the conversion relationship depends merely on moisture content. These conversion tables reveal the average phenomenon and cannot reflect the rice quality of individual field. Therefore, conflicts were frequently seen between rice farmers and dealers.*

This study aims at surveying the physical properties of wet grain, fundamental test of rice drying, and the dried yield rate. An algorithm, calculating the dried yield rate based on kernel husk ratio, was developed in this study. The experiment results show that the dried yield rate was affect significantly by moisture content. The bulk density has little effect on dried yield rate; however, the mature degree of paddy is the key.

Based on the newly developed algorithm of kernel husk ratio, a dried yield rate tester was produced. The fundamental tests were integrated in tester and processed in sequence control. The tester equipped with HMI is operated only by one touch, and the predicted dried yield rate is displayed in three minutes. The estimated error is near 1%. Based on the results, the dried yield rate tester actually provides a quick, fair, and objective trading platform, which may then reduce the trade conflicts.

Keywords: *dried yield rate, kernel husk ratio, brown rice, drying,wet paddy, quality*

INTRODUCTION

Rice, with annual yield of 1.732 million tons (2014), is the most important cereal crop in Taiwan [1].Because of subtropical marine climate,the harvested paddy in Taiwanisalways with a high moisture content,M.C. (22 ~ 33%, w.b.). After harvest, rice must be immediately dried to 13-15 %, in order to be stored or processed.[3, 4] The weight ratio of newly harvested wet paddy before drying and the clean dried grain after drying(M.C.=13%) is defined as dried yield rate(DYR hereafter).

The capita arable land area of each farmer in Taiwan is small [2], 78.3% of the farmers' arable land is less than 1ha. Most of the newly harvested wet paddy will be delivered directly to the drying center of the farmers' association and integrated to be dried. For effective use of dryers, grain buyer dried farmer's wet paddy in large dryers which are operated by professional technicians to control quality

Operating of single dryer for 20-24 hours is required to obtain the exact dried rice weight of individual farmer. Thus, it is not uneconomical and Infeasible in the current

摘要:國際稻穀交易價格皆以乾穀為計價對象，台灣亦然，但現行交易對象為處於高含水率之濕穀。為期於交易當時，農民能立即得知未來乾燥後所能獲得之乾穀重量，須有一濕穀換算乾燥後乾穀重量的方式，換算的比率即為成品率。台灣各農會或糧商交易時濕穀換算為乾穀成品的公式不一，大多僅為含水率之對應*值，甚或為單一換算比例，但此為平均現象，無法反應個別田區之濕穀優劣，並非一恰當、客觀之方式。*

本研究針對省*產稻穀進行濕穀物理性質、乾燥物性之基礎試驗及乾穀成品率測定，並分析其影響關係。結果顯示，除含水率呈顯著影響外，濕穀容積重量與成品率間並無顯著關係。因濕穀的未稔穀比例高低，與栽種管理的良劣有直接關係，完善的田間管理可使穀物成熟一致，完熟程度的高低影響夾雜物的總重量，稻米完熟度高，未稔米比例會大幅降低，對於容積密度、乾穀成品率的影響很大。*

本研究根據筆者新創濕穀品質觀念所提"核殼比預測成品率"之推估演算，規劃濕穀性質基礎試驗，並將各標準測定單元封裝為順序控制之測定儀，採觸控螢幕之人機介面，以單一按鍵於 *3* 分鐘*內完成測定程序。測定結果顯示成品率測定儀之估算誤差約 1%*。本儀器可應用於現行濕穀交易制度下，做為一快速、公平、客觀之交易平台，降低交易雙方紛爭，共創提升米質之合諧榮景。.

關鍵詞: 成品率、核殼比、糙米、乾燥、濕穀、品質

前言

台灣主要糧食為稻米，年產量 173.2 萬噸(2014) [1]，因地處亞熱帶，受海洋型氣候影響，於收穫季節時，田間的稻穀含水率仍處於高含水率(22~33 %, w.b.)，收穫後的濕穀必須即時進行乾燥至含水率為 13 -15 %，以利較長時間的貯藏或進行脫殼、精米等加工作業[3、4]。乾燥至13%含水率後乾穀重量與乾燥前濕穀重量的比值稱為成品率(DriedYield Rate, *DYR*)。

台灣農民每人耕地面積小，78.3%的農民耕地面積小於1ha.(2012) [2]，於稻穀收穫後，多將濕穀直接運交農會乾燥中心統一乾燥，為了有效利用稻米乾燥機，農會乾燥中心或糧商多使用大型乾燥機，由專業技術人員控制乾燥過程，以獲得較佳乾穀的品質。

欲得知正確的個別農戶甫收割之濕穀乾燥後的乾穀重量，需使用單獨乾燥機乾燥，不但不經濟且須費時 20-24 小時。收穫之稻穀無法於交易時立即獲知單一農民乾燥後的重量，交易現場僅依照其稻穀含水率折算乾穀率以計價，然此為平均現象，無法反應個別田區之濕穀品質優劣，並非一恰當、客觀之方式。

transaction site. In trading site the real dried yield of individual farmer cannot be immediately informed. The dealers will convert the weight of newly harvested wet paddy in accordance with M.C. to the weight of dried yield, and the price of transaction is based on dried rice weight. This conversion is set based on an average relationship and unable to reflect the quality of wet paddy from individual field.

The bulk density, foreign material rate and M.C. are the most common items in testing the dried rice quality. The studies related to DYR reveal that M.C. is the most significant effect. [5, 6, 7] Relationship between DYR and bulk density of newly harvested wet rice is insignificant. Separating immature rice and foreign materials from wet paddy is difficult. To improve the precision of predicting DYR for wet paddy, a new concept about wet paddy quality was developed. [8] Kernel husk ratio was applied on algorithm for deriving DYR. Newly harvested wet paddy was tested and analyzed for the proportion of mature plump grain, immature rice and foreign materials. Most moisture, immature grain and foreign materials will be winnowed away during drying process.

The algorithm [9] of deriving DYR with kernel husk ratio is described as (1). The predicted weight of clean dried rice with wet clean rice is derived by (2).

現行檢測乾穀品質的穀物性質包含含水率、容積重量、夾雜率，而有關濕穀品質的物性研究卻不多。乾穀成品率研究指出[5、6、7]，濕穀的性質與成品率關係以含水率最為顯著，而濕穀容積重量與成品率之關係則不顯著，濕穀夾雜物不易以篩選或風選完全分離出。為提升交易現場預測乾穀成品率之準確性，新研究提出濕穀品質的觀念[8]，應用"核殼比理論"在預估乾穀成品率，分析甫收割濕穀中包含飽滿完熟穀粒、夾雜物(稻草、未完熟穀粒)，飽滿完熟穀粒內必定含有糙米，乾燥後的乾穀，必能碾製出白米。乾燥過程除了水份減少，未稔穀、夾雜物也於循環乾燥過程中逐漸排出。

核殼比理論推算成品率的研究指出 [9]，測定甫收割濕穀重量 m_i (飽滿完熟濕穀乾物重 m_d、飽滿完熟濕穀水分重 $m_{w,i}$、夾雜物重 m_f)，乾燥前含水率為 MC_i，乾燥後水分為 $m_{w,o}$(13 % w.b.)，則成品率為公式(1)。

飽滿濕穀乾燥過程僅為水分變化，為可預期之關係式(2)，基於此，已知飽滿乾淨濕穀重量，即可推導乾燥後乾穀總重 m_o，乾燥前飽滿濕穀含水率為 MC_i，飽滿濕穀重量包含穀粒乾物重及濕穀內之水分重，總重為 $m_d+m_{w,i}$，乾燥至含水率 MC_o 時，飽滿乾穀重量包含不會變化的穀粒乾物重及乾燥後穀粒內之水分重，總重將成為 $m_d+m_{w,o}$。

$$\mathrm{DYR}_{13\%,\mathrm{w.b.}}(\%) = \frac{m_\mathrm{d} + m_{\mathrm{w,o}}}{m_\mathrm{d} + m_{\mathrm{w,i}} + m_\mathrm{f}} = \frac{m_\mathrm{o}}{m_\mathrm{i}} \tag{1}$$

$$m_d + m_{w,o\,(13\%,w.b.)} = \frac{m_d + m_{w,i}}{MC_\mathrm{i}} \times \frac{100 - MC_i}{100 - MC_o} \times 100 \tag{2}$$

m_o is weight of dried clean rice (MC_o)
m_d - weight of dry material in clean plumprice(MC=0%)
m_{wi} - weight of moisture in wet clean rice (MC_i)
m_{wo} - weight of moisture in dried clean rice (MC_o)
m_f - weight of foreignmaterials in wetrawpaddy(MC_i)
MC_i - Moisture content of newlyharvestedpaddy (%)
MC_o - Moisture content of dried clean rice (13 %)

Kernel husk ratio (Ω_s) defined as the ratio of brown rice weight $m_{k,i}$ and husk weight $m_{h,I}$ in mature rice as (3) is a function of M.C. It is regressed with the experimental data of fundamental test for kernel husk ratio. Mature plump rice grains were selected and weighed. Brown rice and hull were separated and weighed. M.C. of brown rice and husk were measured separately. The functions (4) and (5) were derived.

m_o ：乾淨乾穀重量(MC_o)
m_d ：飽滿乾淨穀粒中乾物質重量(MC=0%)
m_{wi} : 乾淨飽滿濕穀水分重量(MC_i)
m_{wo} : 乾淨飽滿乾穀水分重量(MC_o)
m_f ：甫收割濕穀中夾雜物重量(MC_i)
MC_i : 甫收割濕穀含水率 (%)
MC_o : 乾淨飽滿乾穀含水率 (13 %)

核殼比(Ω_s)為濕穀粒完熟飽滿狀態時之糙米重 $m_{k,i}$ 與稻殼重量 $m_{h,i}$ 的比值，定義如(3)式，核殼比為含水率的關係函數，可經由"核殼比基礎測定"求得，其方法是挑選成熟飽滿的濕穀粒，剝離糙米及稻殼並分別秤重、再分別測定其含水率，實驗結果數據迴歸分析可得關係式(4)與(5)。

$$\Omega_{\mathrm{s,i}} = \frac{m_{\mathrm{k,i}}}{m_{\mathrm{h,i}}} \tag{3}$$

$$f_m(\mathrm{MC_i}) = \frac{m_{\mathrm{k,i}}}{m_{\mathrm{h,i}} + m_{\mathrm{k,i}}} = \frac{m_{\mathrm{k,i}}/m_{\mathrm{h,i}}}{1 + m_{\mathrm{k,i}}/m_{\mathrm{h,i}}} = \frac{\Omega_{\mathrm{s,i}}}{1 + \Omega_{\mathrm{s,i}}} \tag{4}$$

$$\Omega_{\mathrm{s,i}} = \frac{f_m(\mathrm{MC_i})}{1 - f_m(\mathrm{MC_i})} \tag{5}$$

$f_m(MC_i)$: function for weight ratio of brown rice in matured rice grain

m_d+m_{wi} : weight of plump wet rice, that is $m_{h,i}+m_{k,i}$

The weight of newly harvested rice sample was measured as m_i. After husking, matured clean brown rice was separated by winnowing. The weight and M.C. of brown rice was measured as $m_{k,i}$ and MC_i. The weight of plump wet rice will be derived by (4). The DYR will be derived after the predicted weight of clean dried rice which is calculated by (2).

MATERIAL AND METHOD

Rice samples were hulled by impeller sample husker (Long Good FC2K). M.C. was measured with oven (Young Chenn CON544SD) (103℃, 72hrs) and precision scale (A&D GF600) as shown in Fig. 1. Fundamental test for kernel husk ratio is preceded as described previously. Based on the regression from experimental data, the kernel husk ratio function will be derived.

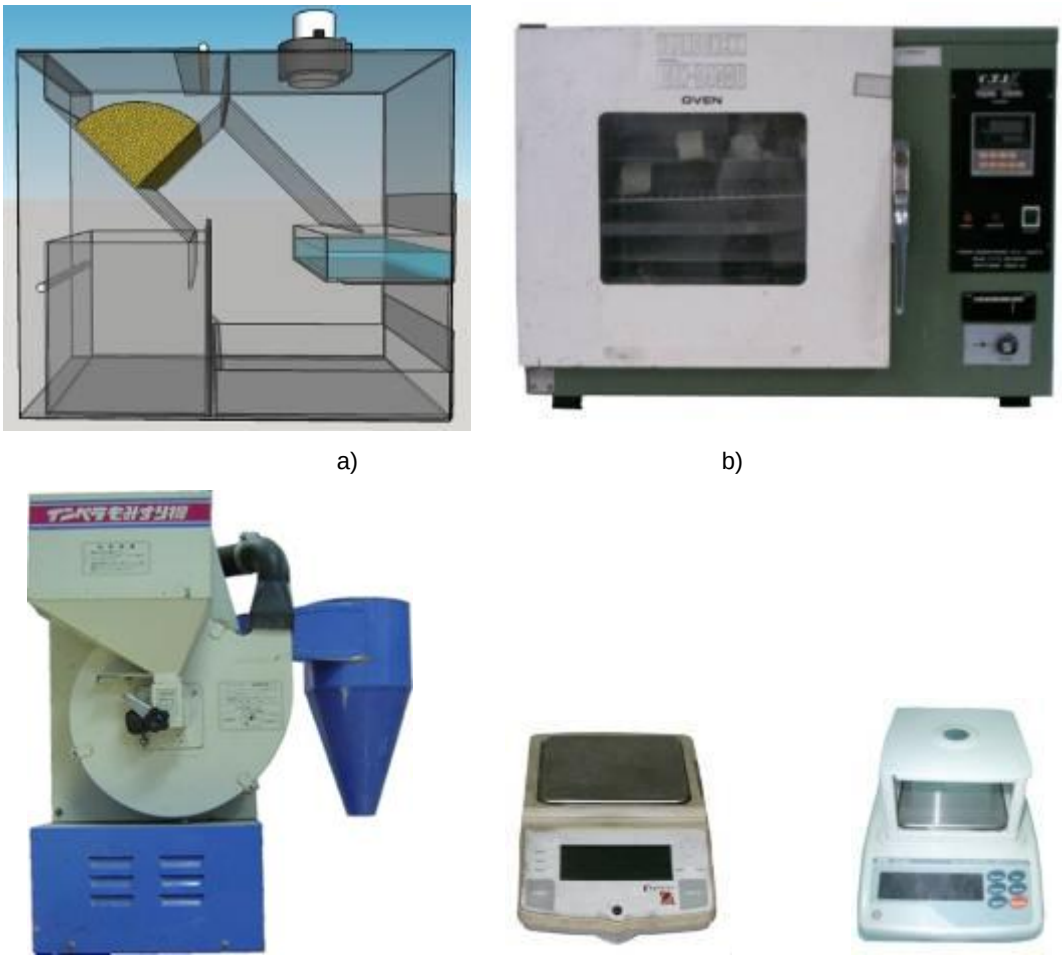
$f_m(MC_i)$ 不同含水率下，飽滿完熟穀粒中糙米重量百分比函數

m_d+m_{wi} ：飽滿乾淨濕穀重量,即 $m_{h,i}+m_{k,i}$

甫收割濕穀取樣後，秤取樣本重量 m_i，經由礱穀機脫殼風選，可獲得飽滿完熟的糙米，重量為 $m_{k,i}$，同時濕糙米含水率 MC_i 可水分測定儀測得，經由 $f_m(MC_i)$ 可推算飽滿完熟濕穀重量 m_d+m_{wi}，經由(2)式可推算，乾燥至含水率 MC_o 時，飽滿乾穀的重量 m_o，如此，甫收割田間濕穀的成品率 DYR 即可於短時間測定。

材料與研究方法

測定設備如圖 1，稻穀脫殼使用衝擊式樣本礱穀機(農富牌 FC2K)，含水率測定採用恆溫烤箱(Young Chenn CON544SD)，103℃熱風乾燥 72 小時，以精密電子秤(A&D GF600)測定水份變化計算求得含水率。”核殼比基礎測定”的過程，先挑選飽滿完熟濕穀，秤取千粒米重，及脫殼後之糙米重，統計不同含水率之實驗數據，分析獲得核殼比函數 $f_m(MC_i)$。



a) b) c) d) e)

Fig. 1 – The experiment devices for fundamental test for kernel husk ratio and DYR

a) Winnower (vertical flow), b)Oven (CON544SD) c)Husker (FC2K), d)Scale (OHAUS), e) Scale (A&D GF600)

Fig. 2 –Parallel type samples drying system

To test DYR for newly harvested samples, M.C. was measured at first. 2 kg sample was scaled by scale (Explorer OHAUS E1RW60) and placed in tubes of parallel type samples drying system. (Fig.2) Samples were drying with 50℃ hot air, and the automatic control system changed the direction of drying air flow each hour with 50 minutes of tempering. Within tempering, weight of samples was measured until M.C. decrease to about 13%. Dried sample will be stirred and then winnowed by vertical flow winnower to separate clean plump dried grain from foreign material, such as immature rice, awn, straw, branches. M.C. of dried rice was tested and exact weight of 13% M.C. will be calculated. The tested value of DYR for the sample will be derived with (1).

200g sample of same rice batch was hulled by sample husker. Wet brown rice was separated with winnowing separator. Weight and M.C. of wet brown rice was measured to derive the predicted value of DYR with Eqn. (4) and (2). The tested value and predicted value of DYR was compared and analyzed.

DYR tester was developed according to fundamental test for kernel husk ratio. Husking mechanism, winnowing separator, high Frequency Capacitive Moisture tester and load cell were compacted in tester. The kernel husk ratio function was built-in microcontrollers (MCU, H8/3002 2J1). The sequential steps of testing were controlled by human machine interface (PWS 6710-CTN) and PLC (Vigor VBO-14MR). In testing DYR, wet paddy was sampled with 300ml cup and poured into the DYR tester. By one-touch on ”Start” button in touch screen, the 1st load cell measures the sample weight. Husking disk and winnower start operating. Sample was dropped from upper measuring unit and fed gradually to husking unit by feeding screw. Matured brown rice was separated by winnowing separator and dropped into lower measuring unit. Husk and foreign materials were winnowed to waste tank. The weight of brown rice was measured dynamically by the 2nd load cell. While the weight stops increasing, it means that the entire sample was hulled and husking disk and winnower stopped operating. The weight and M.C. of brown rice were measured; the built-in function derives the weight of plump clean wet rice. By using (2), the weight of dried clean rice is calculated. The

成品率的樣本測定值實驗步驟如后：甫收割濕穀樣本先測定含水率，再以電子秤(Explorer OHAUS E1RW60)取 2 公斤樣本，置入多桶並聯式樣本乾燥桶(如圖 2)進行 50℃熱風乾燥，多桶並聯式樣本乾燥系統設有自動控制系統，乾燥過程中，乾燥空氣由控制系統定時自動變換流向經過乾燥穀層，過程每小時秤取樣本重量變化，乾燥至含水率約 13%後，取出乾穀，經過攪拌分離穀粒與枝梗，使用垂向式風選機風選去除未稔穀、殼雜等夾雜物後，測定飽滿乾穀重量，並測定乾燥後乾穀含水率，換算至含水率為 13%之乾穀重量，以獲得樣本的成品率測定值。

同批稻穀另取 200g 樣本，經由礱穀機脫殼、垂向式風選機選除殼雜，測定風選後濕糙米重量，並測定濕糙米含水率，藉由核殼比函數及乾燥水份變化函數推估乾穀成品率，比較成品率測定值與預測模式的推估值差異。

根據於”核殼比基礎測定”過程所使用之測定設備，參考設備作業原理，設計一連續作業之成品率測定儀。將衝擊式樣本礱穀機之脫殼機構、垂向式風選機風力選除機構、高週波電容式水分測定計感測元件、秤重之荷重元整合於成品率測定儀機台內，並將實驗所得之核殼比函數內建於微控制器(MCU, H8/3002 2J1)，以可程式控制器(Vigor VBO-14MR)配合人機介面(PWS 6710-CTN)控制測定之順序步驟。測定樣本時，以 300ml 取樣杯取樣，倒入成品率測定儀內之上計量單元之承斗，當重量達到設定值後，測定方可進行，以確保碾製後之糙米量足以完全覆蓋下計量單元之水分測定板高度。按控制視窗之”測定”按鈕，第一荷重元秤取樣本重量，脫殼機構與風選風機隨即啟動，濕穀樣本受進料螺桿控制，緩慢定量地進入脫殼機構，濕穀脫殼後進入風選單元選除稻殼、夾雜物，隨後乾淨濕糙米落入高週波電容式水分測定計，下計量單元(包含水分測定計)由第二荷重元固持著，當第二荷重元重量不再增加，表示樣本已全部脫殼，脫殼機構與風選風機自動停止，第二荷重元秤取糙米重量，並測定糙米含水率。內建的核殼比推估乾穀成品率程式，藉由測得之濕穀樣本重量、糙米含水率、糙米重量，推算得樣本的乾穀成品率預測

predicted DYR of sample is displayed on screen.

RESULTS

There were 126 batches of samples which included 85 batch of Japonica, 16 batch of India and 25 batch of glutinous short.

值。

結果與討論

共計 126 批(85 批粳稻、16 批秈稻、25 批圓糯)進行核殼比基礎試驗

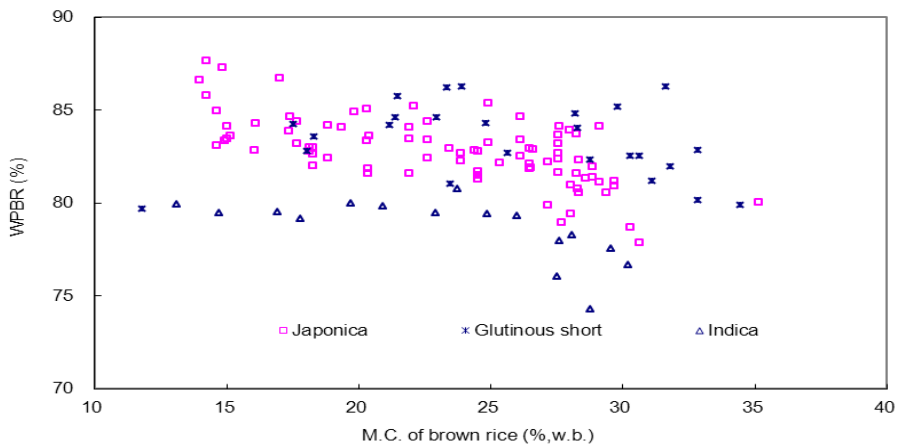


Fig.3 - Experimental results of fundamental test for kernel husk ratio

As the results of fundamental test for kernel husk ratio, relationship between M.C. of brown rice (not rough rice) and WPBR, weight percentage of brown rice accounted for paddy, was shown in Fig.3. The WPBR for Indica rice is less than Japonica rice and Glutinous short rice. The WPBR is decreasing while the M.C. is increasing. But the WPBR will decrease suddenly while the M.C. above is 27% for Indica and Japonica rice. The linear relationship function, the kernel husk ratio function $f_m(MC_i)$ were regressed for three popular varieties as shown in Table 1

核殼比基礎測定試驗結果分析，糙米含水率(而非稻穀含水率)對於糙米重百分比(即糙米重量佔稻穀總重之百分比)的影響如圖 3。糙米含水率與糙米重百分比的關係，在高含水率(27%以上)時，除了圓糯稻種的誤差較小，其餘如粳稻及秈稻等均會高估糙米重百分比，且隨著水分越高，差異越大。因稻穀含水率越高，稻殼含水百分比越高，所佔稻穀重量百分比亦隨之增加。分析中，特別針對粳稻分析三個品種的核殼比基礎測定實驗結果，統計回歸分析可得其核殼比函數$f_m(MC_i)$如表 1。

Table 1

The kernel husk ratio function of various varieties

Variety	Kernel husk ratio function $f_m(MC_i)$	R^2	Samples
TK8	WPBR = -0.3589 MC_k + 92.02	0.9063	8
Koshihikari	WPBR = -0.3979 MC_k + 92.456	0.8983	8
TK16	WPBR = -0.3912 MC_k + 90.669	0.7017	8

MCk： Moisture content of brown rice (kernel), %,w.b

WPBR： Weight percentage of brown rice in rough rice, %

The experimental results of predicting DYR with kernel husk ratio was shown in Fig. 4. There were 106 batches of effective sample. The mean error of predicted value was 1.6% and the standard deviation of estimated error was 1.11%. The estimated error increased while the M.C. is increasing. In addition to the kernel husk ratio difference among rice varieties, the higher the M.C. is in

以核殼比理論預估成品率試驗結果如圖 4，有效樣本數為 106 批，平均預估誤差為 1.60%，預估誤差標準差為 1.11%。誤差隨著含水率增加而加大，且變動幅度亦隨之增加。檢視誤差發生原因，除了個別品種糙米重百分比存在若干差異(1~2%)所造成之外，主要發生於含水率越高之濕穀，舊穀機構脫粒越不完全、風選越不乾淨。

paddy, the poorer the husking and winnowing performs.

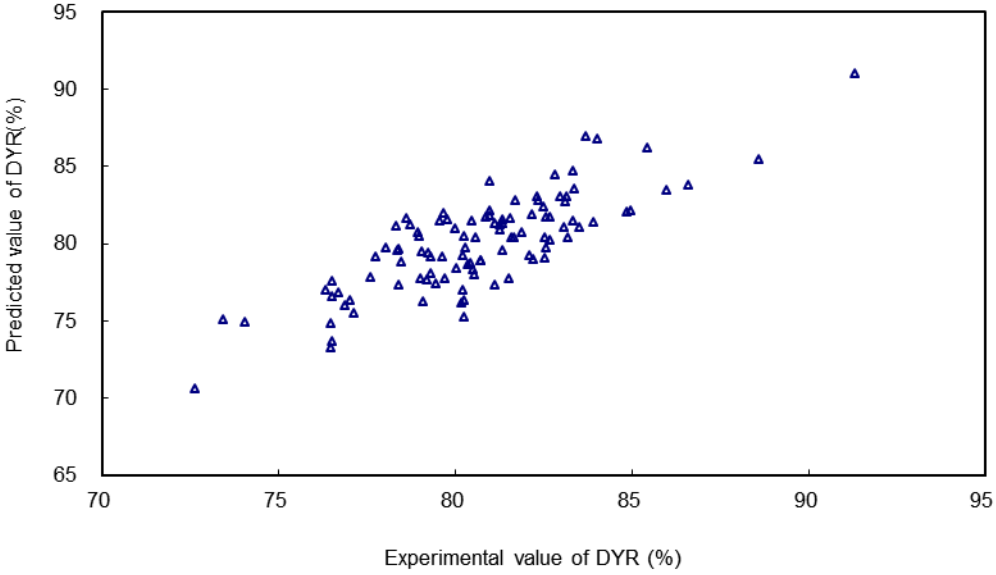


Fig. 4- Experimental results of predicting DYR with kernel husk ratio

The appearance of DYR tester is shown in Fig. 5. There is a hopper on the tester for input sample. Touch screen is installed in front side of DYR tester for operating and displaying the test result. A printer is installed for print out the test result.

本測定儀構造外型圖如圖 5，機體上方設有一投料斗，供操作者投入樣本，機台前方有一觸控螢幕，供操作及顯示測試結果。有一印表機可列印測試結果。

Fig. 5 - Front view / back view of the DYR tester

The illustration of DYR tester is shown in Fig. 6. The touch screen of tester provides a „re-zero" button to re-zero the digits of weight before testing. In trading site, newly harvested wet paddy is sampled with 300ml cup and placed into upper measuring unit through the hopper installed on the Tester. Weight of sample is weighed by 1st load cell. While the weight excesses 150g, a massage of „START TEST" lights up in operating window to ensure that the amount of brown rice is enough to cover the sensor plate of M.C. tester in testing process.
.

測定儀運作流程如圖 6，觸控螢幕的視窗中設有重量"歸零"按鈕供測定前將全部重量讀數歸零，以測得正確樣本重量值。甫收割濕穀於交易現場均勻取樣後，以定容量的量杯(300ml)取樣，以供測定成品率，投入測定儀上方樣本投入口，進入上測量單元由第一荷重元連續讀取重量，當重量達到一定重量(150g)以上，視窗將顯示"開始測定"，以確保樣本的糙米量足以覆蓋水分計感測板，自動控制系統限制重量不足時，測定程序無法進行，以確保糙米含水率可以正確測定。

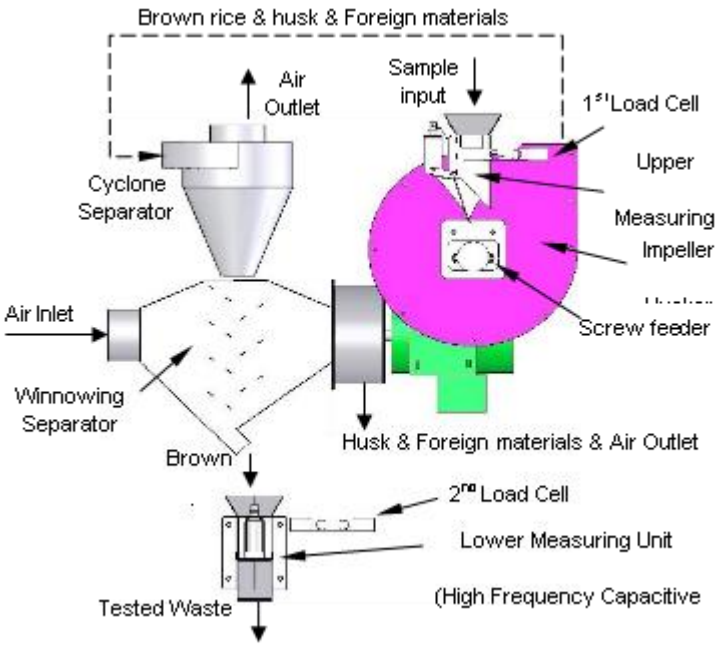


Fig. 5 - Front view / back view and schematic diagram of the DYR tester

After the „TEST" button is pressed, the exact weight of sample is weighed and husking unit starts to run. Gate of upper measuring unit was opened by electromagnetic valve. Sample was fed gradually into husking unit to be hulled by feeding screw. After cyclone separating, mixture of husk, brown rice and foreign materials dropping into winnowing unit to separate brown rice from others. While the others is collected in waste tank, brown rice drops into lower measuring unit and is weighed by 2nd load cell. While the reading of brown rice weight stops increasing, it indicates that the entire sample is hulled and husking unit and winnowing unit will stop running. The exact weight of brown rice is weighed by 2nd load cell and M.C. is measured by sensing plate of high frequency capacitive M.C. tester that is a part of lower measuring unit. The DYR of sample will be calculated by built-in function and shown in the screen. The built-in function will be modified in engineer window according to the various grain varieties.

As the results of test, husking rate of wet grain (M.C. =27%, w.b.) for DYR tester is up to 95%. The determinant of linear calibration for M.C. of brown rice and frequency is up to 0.991 as shown in Fig. 6. The mean estimated error for DYR tester is 1.08% (standard deviation is 0.91%) as shown in Fig. 7. This tester operates stably and precisely and ready to serve a reliable analyzer.

按下觸控螢幕中的"開始測定"鈕，第一荷重元讀取樣本重量後，礱穀單元開始運轉，達穩定高轉速後，電磁閥打開上計量單元閘門，樣本落入螺旋進料桿，緩慢送入礱穀單元進行濕穀脫殼。脫殼後經由旋風分離筒排出空氣，糙米與殼雜落入風選單元，由風機抽風將殼雜與糙米分離，殼雜落入收集箱，而糙米落入下計量單元，由第二荷重元連續讀取糙米重量。當第二荷重元讀取之糙米重量不再持續增加後，表示樣本皆已脫殼，礱穀單元及風選單元馬達自動停止運轉，當馬達完全靜止後，第二荷重元讀取糙米重量，下計量單元側板為高週波水分感測板，同時讀取濕糙米含水率，經由內建關係函數運算得到樣本成品率，同時將樣本含水率、成品率顯示在觸控螢幕上，螢幕上有列印按鈕可按選列印測定結果。本成品率測定儀設有工程設定畫面，提供技術人員修改內建關係函數之參數，以適合檢測不同的穀種。

測定結果顯示，濕穀(27%,w.b.)脫殼率可達 95%以上，濕糙米含水率檢量線線性判定係數可達 0.991，顯示本測定儀(高周波電容式水分計)高線性關係(如圖 6)。24 批樣本以成品率測定儀及樣本乾燥測試結果如圖 7 所示，預測乾穀成品率平均誤差為 1.08%(誤差標準差 0.91%)，相同樣本重複測定測定結果呈穩定再現性，顯示本設備已達穩定精確之上市水準。

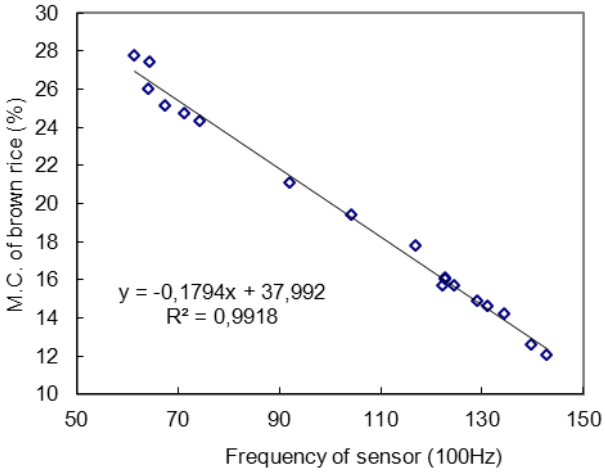


Fig. 6 - High linear relationship of M.C. tester

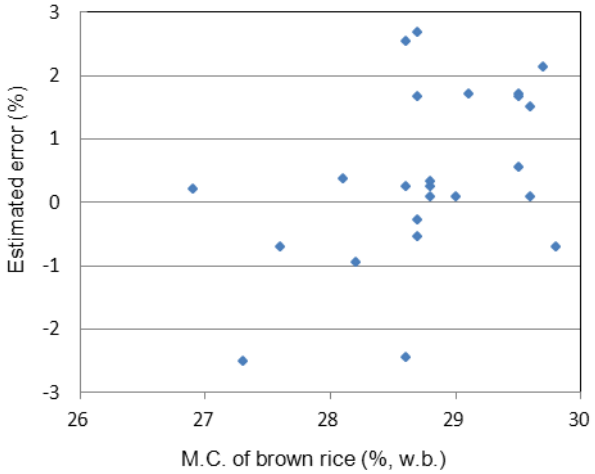


Fig. 7 - The experimental results of DYR tester

CONCLUSIONS

To prevent the error due to surface moisture of rice husk, measuring the moisture content for newly harvested rice should be measured with brown rice. Thus will reflect the real value and quality of paddy rice. By sigle onetouch, DYR will be rapidly detected in 3 minutes with this tester. Predicting DYR with kernel husk ratio will reflect real quality of wet paddy with same M.C.(especially for high M.C.) This DYR tester provide a real time and objective fair trading plateform for farmers and dealers / drying center.

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結論

甫收割稻米之含水率測量應以糙米為測定對象，較不受稻殼表層水影響造成誤差，且能反應正確稻米價值。以本測定儀可由單一按鍵操作下，於 3 分鐘內迅速且較準確測得成品率。以糙米核殼比預測濕穀乾燥後之乾穀成品率，可正確反應相同含水率（尤其於高含水率下）之稻米間的品質。本測定儀提供濕穀交易現場一套即時、客觀之公平交易平台，使農民與乾燥中心或糧商能建立公平的合作關係，並激勵稻農積極從事田間經營，提升稻穀品質。

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MATHEMATICAL MODELING OF THE KNEADING PROCESS FOR A HORIZONTAL MIXER / *MODELAREA MATEMATICĂ A PROCESULUI DE FRĂMÂNTARE LA UN MALAXOR ORIZONTAL.*

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Abstract: *In the present paper it has been studied a horizontal mixer with a revolutionary kneading arm which is not treated in its domain. The purpose of this paper is to determine a mathematical model for the energetic kneading process of the studied mixer and the specific medium kneading resistance Km, for multiple types of flour mixed with different quantities of water.*

Keywords: *torque, specific medium resistance for kneading, kneading arm, dough consistency, surface of the kneading arm*

INTRODUCTION

In bread making industry, kneading is one of the key steps that determine the mechanical properties of dough, which have a direct consequence on the quality of the end product. The rheological properties of wheat flour doughs are largely governed by the contribution of starch, proteins and water.

Therefore, there isn't an established measuring unit for consistency, but every device used for this purpose adopts conventional measuring units.

A definition for dough consistency sounds like this: consistency is a complex rheological propriety, obtained by combining viscosity, plasticity and elasticity and which varies with humidity, temperature and time, with the proportions between dough phases (solid, liquid, gas), with flour's biochemical composition, with added materials (Mx – auxiliary materials) and the quantity of energy used for kneading, [1,2].

A part of the results obtained in this project, are completely new to this area because in the analysis of the kneading arm, it was used a mathematical method of deducing the charge surface of the kneading arm, an approach which has not been tried until now.

MATERIAL AND METHOD

For a better and explicit designing of some components, a part of the calculations were adapted after those already demonstrated in specialty books and others were obtained by measuring and analyzing experimental data extracted during functioning, straight from the working machine. The kneading arm is presented in figure 1.

Due to rotary motion of the kneading arm, the material is trained in an intermittent rotary movement and one of constant run true along the vat. The rotary movement is intermittent because, after the rotation of the material with an angle Ψ (angle at which the product falls) versus a vertical plane, it starts sliding down on the helicoidally helix under the action of its own weight and the rotary motion stops [3,4].

In the first stage of the paper it is calculated the attack surface of the kneading arm.

The formula which makes it possible to establish the opposing torque at the kneading arm, is:

Rezumat: *În prezenta lucrare s-a studiat un mixer orizontal cu un braţ de frământare revoluţionar care nu se regăseşte în literatura acestui domeniu. Scopul lucrării este acela de a determina un model matematic pentru procesul energetic de frământare al acestuia şi rezistenţa specifică medie la malaxare Km, pentru mai multe tipuri de făină, la care au fost adăugate cantităţi de apă diferite.*

Cuvinte cheie: *moment de torsiune, rezistenţă specifică medie la malaxare, braţ de frământare, consistenţă aluat,·suprafaţa bratului de framantare*

INTRODUCERE

În industria de panificaţie, frământarea este unul dintre punctele cheie care determină proprietăţile mecanice ale aluatului, şi care are consecinţe directe asupra calităţii produsului finit. Proprietăţile reologice ale aluaturilor din făină de grâu sunt determinate de contribuţia amidonului, a proteinelor şi a apei.

Din aceste considerente, nu există o unitate de măsură unică pentru consistenţă, ci fiecare aparat care măsoară consistenţa foloseşte unităţi de măsură convenţionale. O definiţie pentru consistenţa aluatului sună în felul următor: consistenţa este o proprietate de natură reologică, complexă, rezultată prin combinarea vâscozităţii, plasticităţii, elasticităţii, care variază cu umiditatea, temperatura şi timpul, cu proporţia dintre fazele aluatului (solid, lichid, gaz), cu compoziţia biochimică a făinii, cu materialele adăugate (Mx – materiale auxiliare) şi cu cantitatea de energie utilizată la frământare, [1,2].

O parte din rezultatele obţinute în acest proiect sunt o noutate în domeniu, deoarece în analiza braţului de frământare, a fost folosită o metodă matematică de deducere a suprafeţei de atac a acestuia, abordare care nu a mai fost întâlnită până acum.

MATERIAL ŞI METODĂ

Pentru o mai bună şi explicită proiectare a unor părţi componente, o parte din calcule au fost adaptate după calcule existente în cărţi de specialitate şi o altă parte, au fost obţinute prin măsurarea şi analizarea datelor experimentale obţinute în timpul funcţionării, direct de la utilaje. Braţul malaxor este prezentat în figura 1.

Datorită mişcării de rotaţie a braţului de frământare, materialul este antrenat într-o mişcare de rotaţie intermitentă şi o mişcare de înaintare uniformă în lungul cuvei. Mişcarea de rotaţie este intermitentă pentru că, după ce materialul s-a rotit cu unghiul Ψ (unghiul la care are loc surparea produsului) faţă de planul vertical, alunecă pe spira elicoidală în jos sub acţiunea propriei greutăţi şi mişcarea de rotaţie încetează, [3,4].

În prima etapă a lucrării este calculată suprafaţa de atac a braţului de frământare.

Formula de calcul care face posibilă stabilirea momentului de torsiune care se opune la braţul de frământare este:

$$M_t = K_m \cdot (S_i \cdot cos\alpha \cdot cos\beta + A_{Si}) \quad (1)$$

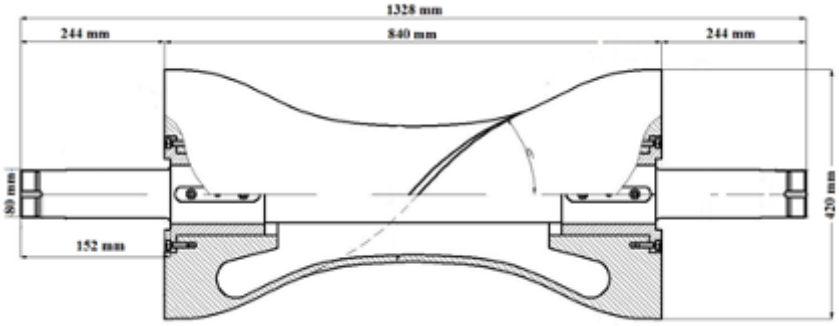


Fig. 1 – Horizontal kneading arm

It is taken into consideration that the surface of the kneading arm is inclined with an angle α in radial – horizontal plane and β angle in vertical plane. In this situation, the attack surface will be:

Se ia în considerare faptul că suprafața brațului de frământare este înclinată cu unghiul α în planul orizontal – radial şi cu unghiul β în planul vertical. În această situație, suprafața de atac va fi:

$$S_{a=}S_i \cdot cos\alpha i \cdot cos\beta i + A_{Si} \quad (2)$$

where:
- Sa is the attack surface of the kneading arm;
- S_i is the surface of one stripe, expressed in cm²;
- α is angle made by every stripe in horizontal plane, expressed in degrees;
- β is angle in vertical plane expressed in degrees;
- A_{si} is the surface for the portion between the base of the contact surface and its end, expressed in cm².

For a more accurate calculation, the surface of the arm has been divided between stripes 60 mm thick and variable height, based on the form of the kneading arm.

In order to calculate the sum of radiuses starting at the center of the surfaces determined at the rotation axis (rmi), it was drawn a scheme for calculus (figure 2) which ultimately helps to determine the resistant moment for a kneader with horizontal spindle.

unde:
- Sa este suprafața de atac a brațului de frământare;
- S_i este suprafața unei fâşii din braț, exprimată în cm²;
- α este unghi format de fiecare fâşie în plan orizontal, exprimat în grade;
- β este unghi în plan vertical exprimat în grade;
- A_{si} este suprafața porțiunii dintre baza suprafeței de contact şi terminația acesteia, exprimată în cm².

Pentru un calcul mai exact, suprafața brațului a fost împărțită în fâşii cu grosimea de 60 mm şi înălțime variabilă funcție de forma brațului de frământare.

Pentru a calcula suma razelor de la centrul suprafețelor determinate la axa de rotație (rmi), a fost desenată o schemă de calcul (figura 2), ce foloseşte ulterior pentru determinarea momentului rezistent în malaxorul cu ax orizontal.

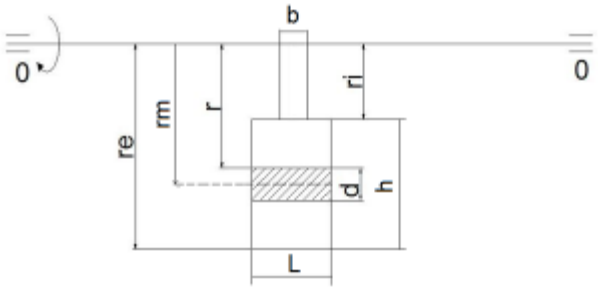


Fig. 2 - Calculus scheme for determining the attack surface for a kneader with horizontal kneading arm [11]

The surface of an arm portion it is calculated with the formula, [11]:

Suprafața unei porțiuni din braț se calculează cu formula, [11]:

$$S1 = h1 \cdot L1 \quad (3)$$

where:

unde:

- h1 is the height of a palette;
- L1 is the length of a palette.

The distance from the center of the contact surface (d) to the rotation axis, can be expressed with the following formula:

- h1 este înălțimea unei palete;
- L1 este lungimea unei palete.

Distanța de la centrul suprafeței de contact (d) la axa de rotație se poate exprima cu următoarea formulă:

$$rm1 = \frac{(re+ri)}{2} \quad (4)$$

where:
- re is the distance between the rotation axis and the end of a palette;
- ri is the distance between the rotation axis and the beginning of the palette.

The length of the contact surface is:

unde:
- re este distanța de la axa de rotație la capătul paletei;
- ri este distanța de la axa de rotație la începutul paletei.

Lungimea suprafeței de contact este:

$$L1 = re - ri \quad (5)$$

The contact surface is supported by another surface, which fills into the material and is calculated with the formula:

Suprafața porțiunii suportului suprafeței de contact, care pătrunde în material se calculează astfel:

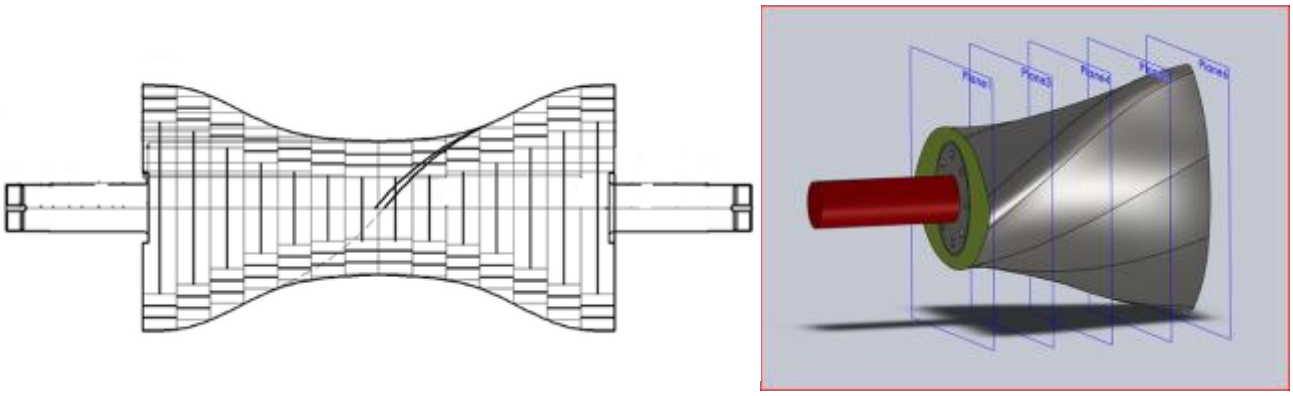
$$Asi = b \cdot (re - ri) \quad (6)$$

where:
- b is the width of a palette.

The spindle was divided in 14 surfaces, the equivalent for 28 blades, as shown in the figures 3, a and b, [6].

unde:
- b este lățimea unei palete.

Arborele a fost împărțit în 14 suprafețe, echivalent cu 28 de palete, după cum este prezentat în figura 3, a şi b, [6].



a) **b)**

Fig. 3 - The spindle, divided into 28 blades: a) 2D drawing; b) 3D drawing

For calculating the total sum of rays at the center of the surfaces determined at the rotation axis ($\sum Ri$), table 1 is constituted.

Pentru calcularea sumei totale a razelor de la centrul suprafețelor determinate la axa de rotație ($\sum Ri$), se alcătuieşte tabelul 1.

$$\sum Ri = rmi \cdot (Si \cdot cos\alpha i \cdot cos\beta i + Asi) \quad (7)$$

Because the attack surface remains constant, it is calculated just once. The variable Km and implicitly Mt, varies with increase and decrease of dough consistency.

The mathematical model proposes to demonstrate the correlation between torque and specific resistance at kneading, applied to the attack surface.

In the second stage of the paper, it is determined the medium value for specific resistance at kneading, Km.

Considering that the specific resistance, Ki has a different value from one section to another, depending on

Întrucât suprafața de atac va rămâne constantă, ea se calculează o singură dată. Variabila Km (*rezistența specifică medie la malaxare)* şi implicit momentul de torsiune, Mt variază cu creşterea sau descreşterea consistenței aluatului.

Modelul matematic îşi propune să demonstreze corelația între momentul de torsiune şi rezistența specifică la malaxare, aplicată la suprafața de atac.

În a doua etapă a lucrării, se determină valoarea rezistenței specifice medii la malaxare, Km.

tangential speed at the section's surface, it is possible to introduce in calculation, the medium value for specific resistance, Km, which is valid for the entire kneader.

The values for medium specific resistance Km, were experimentally determined by comparing the results obtained with different sets of dough made with different types of flour and different quantities of added water, as shown in table 3. In figure 4 it can be analyzed the graph that explains the variation of specific resistance for kneading depending on dough humidity.

Având în vedere că rezistența specifică, Ki în acelaşi malaxor diferă de la o secțiune la alta, depinzând direct de viteza tangențială la suprafața secțiunii, se introduce în calcule valoarea rezistenței specifice medii la malaxare Km, valabilă pentru întregul malaxor.

Valorile rezistențelor specifice medii la malaxare Km au fost determinate experimental de către autor prin compararea rezultatelor obținute cu diferite şarje de aluat din făinuri diferite care au necesitat hidratări diferite, aşa cum se poate observa în tabelul 3. În figura 4 se poate analiza graficul care explicitează variația rezistenței specifice la malaxare funcție de umiditatea aluatului.

Table 1

Calculation for the attack surfaces of the kneading arm

Section number	Si [cm²]	Cosαi	Cosβi	Asi [cm²]	rmi [cm]	Σ Ri [cm³]
I	36	0,156	0,972	88,2	17,7	1657
II	36	0.382	0.972	78,9	16,1	1486
III	36	0,587	0.972	62,22	13,3	1100
IIII	36	0,76	0.972	46,5	10,7	783
V	36	0,891	0.972	37,5	9,2	632
VI	36	0.972	0.972	33,9	8,6	584
VII	36	1	0.972	31,5	8,2	354
VIII	36	1	0.972	31,5	8,2	354
IX	36	0.972	0.972	33,9	8,6	584
X	36	0,891	0.972	37,5	9,2	632
XI	36	0,76	0.972	46,5	10,7	783
XII	36	0,587	0.972	62,22	13,3	1100
XIII	36	0.382	0.972	78,9	16,1	1486
XIV	36	0,156	0,972	88,2	17,7	1657
XV	36	0,156	0,972	88,2	17,7	1657
XVI	36	0.382	0.972	78,9	16,1	1486
XVII	36	0,587	0.972	62,22	13,3	1100
XVIII	36	0,76	0.972	46,5	10,7	783
XIX	36	0,891	0.972	37,5	9,2	632
XX	36	0.972	0.972	33,9	8,6	584
XXI	36	1	0.972	31,5	8,2	354
XXII	36	1	0.972	31,5	8,2	354
XXIII	36	0.972	0.972	33,9	8,6	584
XXIV	36	0,891	0.972	37,5	9,2	632
XXV	36	0,76	0.972	46,5	10,7	783
XXVI	36	0,587	0.972	62,22	13,3	1100
XXVII	36	0.382	0.972	78,9	16,1	1486
XXVIII	36	0,156	0,972	88,2	17,7	1657

$$\sum Ri = rmi \cdot (Si \cdot cos\alpha i \cdot cos\beta i + Asi) = 26384\ cm^3$$

The physio –chemical characteristics of the flours used for the experiments are presented in table 2.

Caracteristicile fizico -chimice ale făinurilor utilizate în realizarea experimentelor sunt prezentate în tabelul 2.

Table 2

Physio – chemical characteristics of the flours used in the experiments

Flour type	Humidity, [%]	Wet gluten, [%]	Ash, [%] d.s.	Protein content, [%] d.s	Gluten deformation [mm]	Acidity, [degrees]	Falling number, [sec]	Gluten index
FA - 650(F1)	13,5	28	0,65	26,8	3,5	2	318	84
FN - 1350(F2)	13,5	32,4	1,35	27,5	4	3,4	318	88

It is possible to conclude that Km values are linear functions dependent on flour quality and its capacity to absorb water and also directly dependent on medium tangential speeds inside the mixing bin, [3]. For all the tests, the tangential speed at the section surface had the same value: 2.8 m/s.

Se poate constata că valorile Km sunt funcții liniare de conținutul şi calitatea făinii dar şi de capacitatea acesteia de hidratare şi depind direct de vitezele tangențiale medii în interiorul cuvei de amestecare, [3]. Toate probele au avut aceeaşi viteză tangențială la suprafața secțiunii: 2.8 m/s.

Analyzing the information presented above, it is possible to formulate the following observations: once with the rise of dough humidity, the effective viscosity of dough decreases, indifferent to the flour's quality, fermentation time and superficial tension, [8,9,10].

An example of resistant moment Mt, determined for a 650 flour type which had 50% added water can be verified with the expression:

Din analiza datelor prezentate mai sus se pot formula următoarele observații: odată cu creşterea umidității aluatului, vâscozitatea efectivă a aluatului scade, indiferent de calitatea făinii, de timpul de fermentare şi de tensiunea superficială, [8,9,10].

Un exemplu de moment rezistent Mt, determinat pentru o făină tip 650 la care s-a adăugat apă în proporție de 50%, se verifică cu expresia:

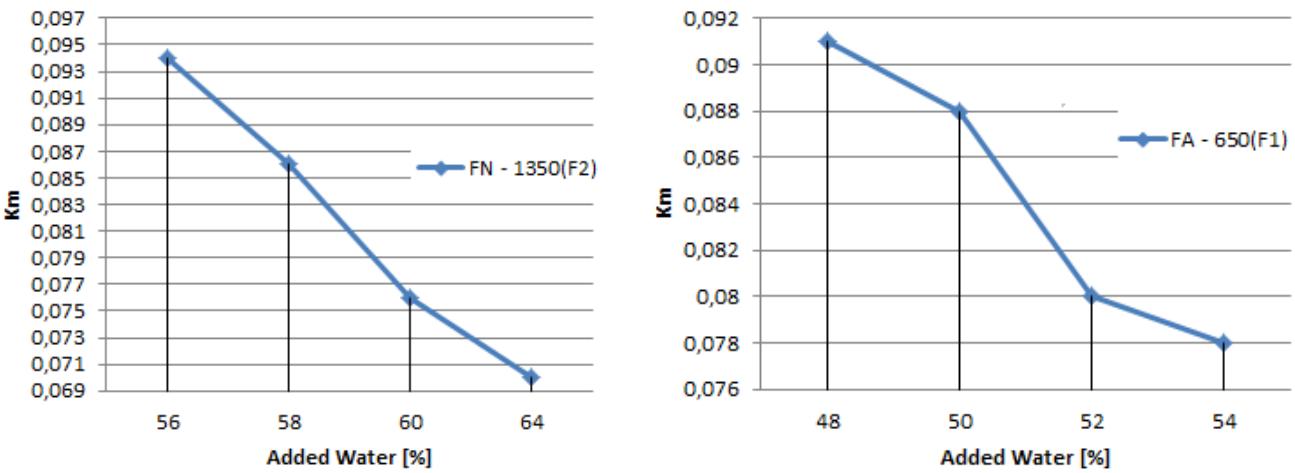
$$Mt = Km * \sum rmi(Si * cos\alpha i * cos\beta i + Asi)$$

$$Mt = 0.088 * 26384 = 2321\ [Nm] \quad (8)$$

Table 3

Experimental determinations for medium specific resistance at kneading

Flour type	Humidity [%]	Angular speed, ω [rpm]	Efficiency of transmission	Pump flow [m³/s]	Read pressures [bar]	Km	Torque [Nm]	Difference of pressure between suction and delivery of hydraulic pump [bar]	Power [Kw]
FA - 650(F1)	48	12,56	0,95	154	135	0,091	2400	125	30,48
FA - 650(F1)	50	12,56	0,95	154	128	0,088	2321	118	28,77
FA - 650(F1)	52	12,56	0,95	154	120	0,080	2110	110	26,82
FA - 650(F1)	54	12,56	0,95	154	116	0,078	2058	106	25,85
FN - 1350(F2)	56	12,56	0,95	154	123	0,094	2480	113	27,55
FN - 1350(F2)	58	12,56	0,95	154	120	0,086	2269	110	26,82
FN - 1350(F2)	60	12,56	0,95	154	130	0,076	2005	120	29,26
FN - 1350(F2)	64	12,56	0,95	154	120	0,07	1846	110	26,82



a) Km variation for 1350 flour type b) Km variation for 650 flour type

Fig.4 - Graph which explains the variation for Km, depending on dough humidity and type of flour

Knowing the oil pressure which is introduced into the hydraulic engine, it was possible to calculate the resistant moment for the spindle of the mixing arm.

The maximum resistant moment was calculated after drawing a similar graph with the one made by a farinograph, by monitoring the pressure from 5 to 5 seconds, for 230 seconds, and which could be observed directly on the monitor screen. The dough had in its composition, 650 flour type. The obtained graph can be observed in figure 5.

The necessary power for the hydraulic engine can be calculated by knowing the difference between aspiration

Cunoscând presiunea de ulei introdusă în motorul hidraulic a fost posibilă calcularea momentului rezistent la arborele brațului de mixare.

Momentul rezistent maxim a fost calculat după realizarea unui grafic asemănător cu cel trasat de un farinograf prin monitorizarea presiunii din 5 în 5 secunde, timp de 230 s, care se poate citi direct de pe ecranul monitorului. Aluatul avea în componență făină tip 650. Graficul poate fi observat în figura 5.

Puterea necesară motorului hidraulic (P_{ab}) se calculează cunoscând diferența de presiune între aspirație şi refulare (pΔp), debitul introdus în motorul

pressure and plenum pressure (pΔp), the introduced flow into the hydraulic engine (Qm) and the transmission's efficiency, (ηtm = 0.95), [4].

hidraulic (Qm) şi randamentul transmisiei (η_{tm} = 0.95), [4].

$$P_{ab} = \frac{p\Delta_{p} \cdot Q_m \cdot \eta_{tm}}{600} \quad (9)$$

The necessary torque for driving the kneading arm, after overcoming the resistant moment if the power and angular speed ωm are known, can be calculated with the following formula, [5]:

Momentul învârtitor necesar antrenării braţului de frământare după învingerea momentului rezistent dacă se cunoaşte puterea şi viteza unghiulară ωm a braţului de frământare se calculează cu formula, [5]:

$$M = \frac{P_m}{\omega_m} \quad (10)$$

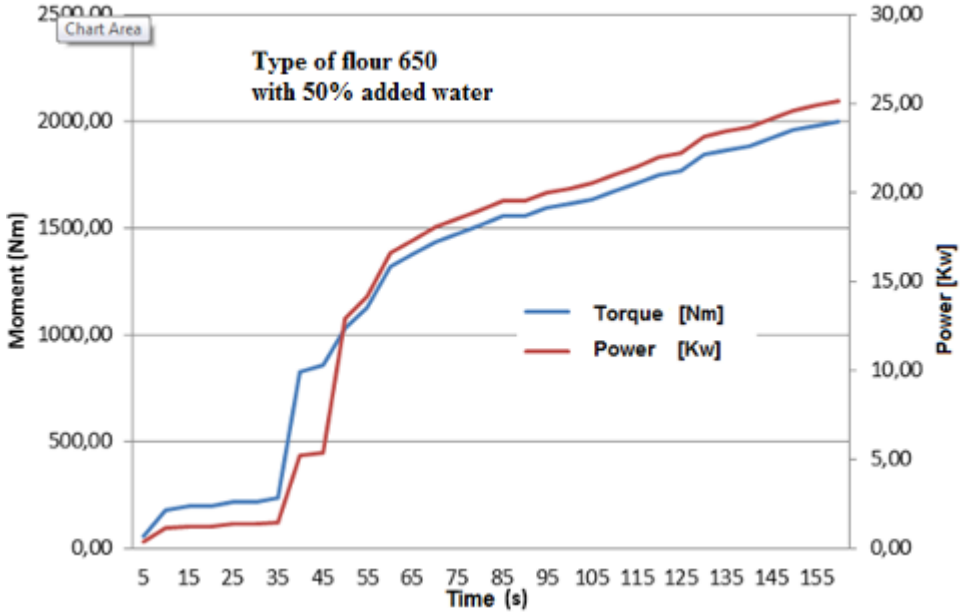


Fig. 5 - Graph which explains the variation for the resistant moment depending on time of kneading

The maximum value registered on the diagram for the torque, is:

Valoarea maximă înregistrată pe diagrama pentru momentul de torsiune este:

$$M_t = 2252\ [Nm] \quad (11)$$

CONCLUSIONS

The correlation between the mathematical model and the conducted experiment is quite accurately in order to determine the resistant moment for a kneading arm, depending on dough consistency and the type of flour used.

Intensive and fast kneading, known also as mechanical development for dough, represents much more active dough kneading, which is achieved at higher speeds for kneading arms and in smaller time compared to classical mixers.

The kneading process at high speeds for kneading arms determine a more pronounced loosening of globular proteins, along with surface exposure for a bigger number of reactive groupings, capable of reacting with those of neighbor molecules in order to form a bigger number of intermolecular connections.

Besides flour quality, the optimal quantity of energy which must be introduced in the kneading process depends also of its humidity and temperature, the quality

CONCLUZII

Corelaţia între modelul matematic şi experimentul efectuat este una destul de exactă pentru a putea determina momentul rezistent la braţul de frământare funcţie de consistenţa aluatului şi tipul de făină utilizat.

Frământarea intensivă şi rapidă, cunoscută şi ca dezvoltarea mecanică a aluatului, constă într-o frământare mult mai energică a aluatului, care se realizează la turaţii mai mari ale braţelor de frământare şi într-un timp mai scurt faţă de frământătoarele clasice.

Frământarea la turaţii mari ale braţelor de frământare determină desfacerea mai pronunţată a proteinelor globulare, însoţită de expunerea la suprafaţă a unui număr mai mare de grupări reactive, capabile să reacţioneze cu cele ale moleculelor vecine şi să formeze un numar mai mare de legături intermoleculare.

În afară de calitatea făinii, cantitatea optimă de energie ce trebuie transmisă la frământarea aluatului mai depinde de umiditatea şi temperatura acestuia, de starea materiilor prime folosite în proces, de felul şi turaţia

of raw material used in the process, the type and speed of the kneading arm.

Beside the amount of energy introduced, it is of very high consequence the speed with which the energy is transmitted, respectively, the kneading time. When increasing speed at the kneading arm, the kneading time reduces. From this point of view, there is an optimal speed for introducing the necessary energy into dough.

The importance of designing and analyzing the shape of the kneading arm becomes determinant in the way of transmitting the energy, as well as the speed with which the energy is transferred to the dough in order to obtain a dough with superior quality.

The understanding of the kneading process for this kind of machine is useful in industrial bread making process because it helps the technological engineer to find solutions for quality problems which can appear because of defective forming of dough in the vat or caused by flour's physio – chemical characteristics like weak flours which necessitate slow kneading, flours with raised hydration capacity, at which it can be determined the optimal quantity of added water by controlling the value for maximum consistency, or the optimization of the entire kneading process by adapting the speed of the kneading arm (setting the hydraulic pressure into the radial engine with axial pistons for four configurable speeds) for the type of dough wished to be obtained.

brațului de frământare.

În afara cantității de energie, foarte importantă este viteza cu care este transmisă energia, respectiv timpul de frământare. La mărirea turației brațului de frământare, timpul de frământare se reduce. Din acest punct de vedere, există o viteză optimă de transmitere a energiei aluatului.

Importanța proiectării şi analizei formei brațului de frământare devine determinantă în modul cum este transmisă energia, precum şi viteza cu care aceasta este cedată aluatului pentru a obține o calitate superioară a acestuia.

Înțelegerea procesului de frământare la acest tip de utilaj este utilă în procesul de producție deoarece ajută inginerul tehnolog să găsească soluții la probleme de calitate care pot apărea din cauza formării defectuoase a aluatului în cuva malaxorului sau care au la bază caracteristicile fizico-chimice ale făinii, cum sunt făinuri mai slabe care necesită o frământare mai lentă, făinuri cu o capacitate de hidratare mare la care se poate determina cantitatea optimă de apă adăugată la făină, prin controlul valorii consistenței maxime, optimizarea întregului proces de frământare prin adaptarea turației brațului de frământare (setarea presiunii hidraulice în motorul radial cu pistoane axiale pentru cele 4 viteze configurabile) la tipul de aluat care se doreşte a fi obținut.

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ENERGY EFFICIENT TECHNOLOGIES FOR LIGNOCELLULOSIC ETHANOL PRODUCTION / *TEHNOLOGII EFICIENTE ENERGETIC PENTRU PRODUCEREA ETANOLULUI DIN BIOMASĂ LIGNOCELULOZICĂ*

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Abstract: *Currently, biofuels are the most significant alternative fuel aiming to provide clean power for transport, in case sustainable production technologies are employed. Due to the increased tendency of turning over the existing agricultural land to biofuel production, lignocellulosic feedstock is gaining increasing support against the use of first generation feedstock such as sugar cane, corn, wheat or sweet potatoes. However, despite the existing pilot plants, energy intensive technological processes like pretreatment and distillation, as well as high cost of enzymes, still prevent market roll-out of production facilities, extensive researches being conducted in order to find economically feasible alternatives.*
New close to market techniques, with improved performance in terms of energy and resources, are discussed: the relatively recent SPORL pretreatment, reported as the most effective in size-reduction energy consumption; pretreatment by means of extrusion - a technique in which biomass undergoes continuous mixing, heating and shearing, thus suffering physico-chemical disintegration; energy saving pass-through distillation that performs at room temperature, which also offers indirect advantages like the possibility of yeasts and enzymes recovery, and simplified exploitation and maintenance of the distillation equipment. The above mentioned subjects are selected based on their reported performances as well as on their market potential and estimated technical and economic feasibility.

Keywords: *lignocellulosic ethanol, energy efficiency, energy balance, pass-through distillation, extrusion pretreatment, SPORL*

INTRODUCTION

The general consensus that the use of fossil fuels has an important share in climate change triggered the adoption of policies and measures aiming to accelerate the implementation of low carbon technologies. In the transport sector, tax incentives, fuel blending rules, purchasing regulations and policies imposing maximum limits for engine emission were seen as solutions towards GHG reduction. Despite these efforts, the 34 billion tons of global CO_2 emissions in 2011 was 3% higher than in 2010, and 2.7% higher than the average annual increase during the last decade [37]. Moreover, transport emissions are expected to rise due to an increase in the number of passenger cars of up to 273 million in Europe by 2050, and 2.5 billion worldwide [40].

In order to overcome these negative effects, several legislative measures were taken by most of the developed and developing countries, and in particular at EU level. In USA, the Energy Independence and Security Act and the U.S. Renewable Fuels Standard are implemented in order to stimulate the use of biofuels for

Rezumat: *În prezent biocombustibilii reprezintă categoria cea mai importantă de combustibili alternativi, cu impact pozitiv asupra mediului în cazul în care tehnologiile de producție a acestora sunt sustenabile. Datorită tendințelor accentuate de utilizare a terenurilor agricole pentru culturi energetice, biomasa lignocelulozică a devinit tot mai atractivă în raport cu resursele de prima generație precum porumbul, grâul, cartoful, trestia de zahăr etc. Cu toate acestea, deşi există stații pilot funcționale pentru producerea de bioetanol lignocelulozic, costul ridicat al enzimelor sau consumurile energetice ridicate aferente unor procese precum pretratarea şi distilarea împiedică pătrunderea pe piață a acestor tehnologii. În consecință, cercetările din acest domeniu se orientează către identificarea unor soluții fezabile economic. Articolul prezintă trei procese noi, performante din punct de vedere al necesarului de resurse, cu un bun potențial de piață: metoda de pretratare SPORL, raportată ca fiind cea mai eficientă din punct de vedere al energiei consumate pentru mărunțirea biomasei; pretratarea continuă prin extrudare, în cadrul căreia biomasa este dezintegrată fizico-chimic printr-un proces de amestecare, încălzire şi strivire/forfecare mecanică; distilarea "pass-through" la temperatura camerei, cu avantaje precum consumul redus de energie, posibilitatea de reutilizare a enzimelor şi drojdiilor, sau uşurința în exploatare. Subiectele au fost selectate pe baza rapoartelor privind performanțele, potențialul de piață şi fezabilitatea tehnico-economică.*

Cuvinte cheie: *etanol lignocelulozic, eficiență energetică, distilare pass-through, pretratare prin extrudare, SPORL*

INTRODUCERE

Opinia generală conform căreia schimbările climatice se datorează în principal utilizării combustibililor fosili, a condus la adoptarea unor măsuri menite să accelereze implementarea tehnologiilor cu emisii reduse de gaze cu efect de seră (GES). În sectorul transporturilor, stimulentele fiscale, impunerea cotelor minime de biocombustibili, impunerea limitelor maxime pentru emisiile motoarelor, sau stimulentele pentru achiziționarea de vehicule nepoluante, sunt văzute ca soluții principale de reducere a GES. În pofida acestor inițiative, cele 34 mld. tone de emisii globale de CO_2 din 2011 au reprezentat cu 3% mai mult decât emisiile din 2010 şi cu 2,7% mai mult decât media anuală din ultimul deceniu [37]. În plus, estimările arată că emisiile din transport vor creşte datorită numărului tot mai mare de autovehicule: până la 273 milioane în Europa şi 2,5 miliarde la nivel mondial [40].

Pentru a depăşi aceste efecte negative, țările dezvoltate şi în curs de dezvoltare au impus diverse măsuri legislative. În SUA, Legea Independenței şi

transport [50]. EU has already a tradition in establishing similar measures, the reference one being the Strategic Energy Technology Plan (SET Plan) – an energy technology policy aiming to accelerate the deployment of low carbon technologies, including the use of biofuels in the transport sector [29]. Due to concerns over the sustainability and GHG reduction benefits of some biofuels, on April 2015, the European Parliament approved the ILUC [1] Directive, which caps the crop-derived biofuel production and proposes measures to accelerate the shift towards alternative sources. According to the new law, by 2020 the first-generation biofuels should account for a maximum of 7% of energy consumption in transport. The binding target of 10% renewable share in transport fuels by 2020 is still maintained, meaning that the difference should be covered from other resources. In this respect, an indicative 0.5% is established for advanced biofuels, the contribution of which will count double towards the 10% target [11]. This new law, coupled with a former decision on stopping subsidizing the first generation biofuels production after 2020, sends a direct message to industry that the future belongs to advanced, sustainable produced fuels.

The main alternative for petrol engines is bioethanol. Existing spark-ignition engines can use mixtures of gasoline and up to 10% bioethanol without being modified, with a more effective oxidation of hydrocarbon due to the ethanol high content of oxygen, thus diminishing GHG emissions. The flexi-fuel engines can use mixtures with up to 85% ethanol, while specially modified engines can use 100% ethanol [16], [18], [26], [30]. As mentioned earlier, current EU policies support the production of second generation ethanol from lignocellulosic materials, mainly in order to avoid the agricultural land use for biofuels production. However, in order to become economically viable, existing technologies for ethanol production from lignocellulosic biomass [2] need further improvement in terms of cost reduction, use of natural resources such as water and land, reduced GHG emissions and enhanced energy balance. This review presents three close-to-market techniques, more effective than similar ones, which can be used in the most energy consuming steps of the second generation bioethanol production technology, namely in pretreatment and distillation.

PRETREATMENT

The first step of the lignocellulosic ethanol production technology is pretreatment, followed by enzymatic hydrolysis, fermentation, distillation and dehydration. Pretreatment consists of physical, chemical, physico-chemical and/or biological methods that are used to perform structural disconnection of the biomass structure at molecular level, in order to allow enzymes from the subsequent enzymatic hydrolysis step to break down cellulose and hemicellulose into sugars for fermentation. The main components of lignocellulosic biomass are cellulose (35-50%), hemicellulose (20-35%), lignin (15-20%), extractives and ashes (15-20%) [35].

Cellulose molecules are made up of chains of β-glucose monomers, gathered into microfibrils. It has a strong, crystalline structure, interrupted from place to place by amorphous regions. Hemicelluloses are formed of a variety of C5 and C6 monosugars (xylose, glucose,

Securității Energetice şi Standardul privind Combustibilii Alternativi stimulează utilizarea biocombustibililor în transport [50]. În Uniunea Europeană, Planul Strategic privind Tehnologiile Energetice reprezintă documentul de referință care stabileşte politicile de accelerare a implementării tehnologiilor cu emisii reduse de carbon, inclusiv prin utilizarea biocombustibililor în transport [29]. Datorită beneficiilor discutabile privind sustenabilitatea biocombustibililor convenționali, Parlamentul European a adoptat în aprilie 2015 Directiva ILUC[1], care limitează utilizarea acestora şi propune măsuri concrete de trecere la surse alternative. Conform noii legislații, energia furnizată de biocombustibilii de generația I pentru transport trebuie limitată la maxim 7% până în anul 2020. Rămâne în vigoare limita minimă de 10% energie regenerabilă pentru transport, diferența urmând a fi acoperită din alte surse. Momentan, valoarea orientativă stabilită pentru biocombustilii avansați este de 0,5% [11]. Această directivă, precum şi o decizie anterioară de oprire a subvenționării biocombustibililor convenționali după 2020, transmite producătorilor faptul că viitorul aparține biocombustibililor avansați, produşi sustenabil.

Bioetanolul reprezintă alternativa principală pentru motoarele pe benzină. Pentru ca acestea să nu fie modificate constructiv, procentul de bioetanol în benzină nu trebuie să depăşească 10%. Datorită conținutului mare de oxigen din etanol procesul de oxidare a hidrocarburilor va fi mai eficient, reducându-se emisiile de GES. Motoarele “flexi-fuel” pot utiliza amestecuri cu până la 85% etanol, iar cele modificate pot funcționa cu 100% etanol [16], [18], [26], [30]. După cum s-a menționat, politicile europene sprijină producția de bioetanol lignocelulozic (bioetanol de generația a doua), în special pentru a evita utilizarea terenurilor agricole pentru culturi energetice. Totuşi, pentru a fi fezabile din punct de vedere economic, tehnologiile actuale de producere a etanolului din biomasă lignocelulozică[2] trebuie optimizate în vederea reducerii costurilor de producție, a resurselor naturale utilizate, pentru diminuarea GES şi îmbunătă-ția bilanțului energetic. Lucrarea prezintă trei tehnici promițătoare din punct de vedere al maturității tehnologice, cu o eficiență superioară față de procesele similare existente, care pot fi implementate în etapele tehnologice cele mai costisitoare din punct de vedere energetic: pretratarea şi distilarea.

PRETRATAREA

Pretratarea reprezintă prima etapă a tehnologiei de producere a etanolului lignocelulozic, fiind urmată de hidroliza enzimatică, fermentație, distilarea primară, rectificare şi anhidrizare. Pretratarea constă în aplicarea unor proceduri de natură fizică, chimică, fizico-chimică şi/sau biologică, destinate degradării structurii biomasei la nivel molecular, pentru a permite enzimelor din etapa de hidroliză enzimatică să descompună celuloza şi hemiceluloza în monozaharide fermentabile. Biomasa lignocelulozică este formată în principal din celuloză (35-50%), hemiceluloză (20-35%), lignină (15-20%), compuşi extractibili şi cenuşă (15-20%) [35].

Celuloza este o polizaharidă formată din molecule de glucoză unite în poziția 1-4, fiind organizată sub formă de microfibre. Structura cristalină, rezistentă a acesteia este întreruptă pe alocuri de zone amorfe. Hemiceluloza este formată dintr-o varietate de monozaharide C5 şi C6 (xiloză, glucoză, arabinoză, ramnoză, manoza,

[1] Indirect Land Use Change

[2] Different species of wood, cereal straw, corn stover, sunflower stalks, cellulose wastes, herbaceous biomass etc.

arabinose, rhamnose, mannose, galactose), have an amorphous structure and are linked to the cellulose fibrils by hydrogen bonds [1]. Lignin – a biopolymer with a highly disordered structure - confers mechanical strength to the cell wall. There are also hydrogen bonds between cellulose and lignin molecules, while chemical bonding is present between hemicelluloses and lignin [4]. Both lignin and hemicelluloses protect cellulose fibrils by forming a matrix around them.

Therefore, the efficiency of the enzymatic hydrolysis process is determined by a pretreatment step that (1) disrupts this matrix and exposes cellulose and hemicellulose to enzymes, (2) reduces the cellulose crystallinity and (3) increases the material's pores size and surface area, thus offering enzymes maximum access to carbohydrates [30]. Other important key factors to be considered for an optimum pretreatment method are energy and water consumption, minimum formation of fermentation inhibitors, low environmental and technological risks, feedstock versatility, potential for by-products, and economic feasibility.

A first usual pretreatment operation is mechanical grinding, which destroys the binding layer of lignin, hemicellulose, and cellulose, decreases the crystallinity of cellulose [5], and also increases the biomass specific area, thus exposing cellulose as much as possible to enzymatic attack. A subsequent thermo-chemical stage will promote hydrolysis and further degrade the feedstock structure at molecular level. The most common thermal and/or chemical methods are steam explosion, acid pretreatment, LHW (liquid hot water), AFEX (ammonia fiber explosion), wet oxidation, CO_2 explosion, ozonolysis, and more. They have achieved varying levels of success, but they still have technical and economic barriers to overcome before commercialization like equipment corrosion, high pressure or temperature requirement, high energy consumption, the necessity of hydrolyzate neutralization, low rate of cellulose conversion, expensive routes for chemicals recovery, high capital cost, etc. [14], [34], [35], [38], [45], [49]. These inefficiencies make them inappropriate for commercial application.

SPORL PRETREATMENT

In case of biomass with high lignin content, most of the existing pretreatment methods are not efficient; however, SPORL[3] and Organsolv can achieve more than 90% conversion of cellulose. Both of them are effective against hardwood and softwood but, when compared with SPORL, Organosolv has some major drawbacks: low concentration of hemicellulosic sugar, use of organic solvents that are hazardous to environment and health, complexity and cost of the recycling process of organic solvents that can inhibit enzymatic hydrolysis and fermentation, and high capital investment [7], [25], [39].

SPORL is reported to be the most energy efficient pretreatment method in terms of sugar production per unit of consumed energy. The first step consists of chipping woody biomass in large pieces of up to 38 mm length/width and a thickness of about 6 mm. Wood chips are then reacted for 10-30 minutes and at 160-190°C, with a solution of 1-8% bisulfate and 0.5-2.2% sulfuric acid (on oven dry wood), depending on wood type [14], [44], [53]. The substrate is created by means of a disk-refiner that separates the pretreated softened chips at a fiber interface level. In most of the pretreatment methods, the lower the particle size after the preliminary biomass mechanical grinding, the higher the enzymatic hydrolysis

galactoză). Are o structură amorfă, fiind legată de fibrele de celuloză prin legături de hidrogen [1]. Lignina este un biopolimer cu o structură dezordonată, care conferă rezistență mecanică peretelui celular, fiind legată chimic de moleculele de hemiceluloză şi celuloză [4]. Este dificil de degradat şi formează, împreună cu hemiceluloza, o structură spațială amplasată în jurul fibrelor de celuloză, protejându-le.

În acest context, eficiența procesului de hidroliză enzimatică este determinată de etapa de pretratare care (1) expune celuloza şi hemiceluloza acțiunii enzimelor prin dezintegrarea acestei structuri de protecție, (2) reduce gradul de cristalinitate al celulozei şi (3) creşte suprafața specifică şi dimeniunile porilor la nivel molecular, maximizând accesibilitatea enzimelor asupra carbohidraților [30]. Nu mai puțin importanți din punct de vedere al eficienței pretratării sunt şi consumul de energie şi apă, nivelul inhibitorilor de fermentație, riscul tehnologic şi de mediu, adaptabilitatea la tipurile de materie primă, generarea de produse secundare şi fezabilitatea economică.

În general, prima operație a procesului de pretratare constă în măcinarea biomasei. Procesul contribuie la distrugerea stratului de lignină, celuloză şi hemiceluloză, reducerea cristalinității celulozei [5] şi creşterea suprafeței specifice a biomasei, expunând în bună măsură celuloza în vederea atacului enzimatic. O etapă ulterioară de tratare termo-chimică inițiază procesul de hidroliză şi contribuie la degradarea suplimentară a biomasei la nivel molecular. La ora actuală, cele mai comune procedee termice şi/sau chimice sunt explozia de aburi, explozia fibrelor cu amoniac, explozia cu CO_2, tratarea cu catalizator acid sau alcalin, tratarea hidrotermică, ozonoliza şi multe altele. Acestea au atins diferite rate de succes, însă există bariere tehnice sau economice specifice fiecărei metode, care trebuie depăşite, cum ar fi corozivitatea, presiunile şi temperaturile înalte de lucru, consumul ridicat de energie, necesitatea neutralizării hidrolizatului, rata scăzută de conversie a celulozei, cheltuielile mari de capital etc. [14], [34], [35], [38], [45], [49]. Momentan, aceste ineficiențe le fac inadecvate aplicării comerciale.

METODA SPORL DE PRETRATARE

Majoritatea metodelor de pretratare existente au eficiență redusă în cazul biomasei cu conținut ridicat de lignină. Se remarcă metodele SPORL[3] şi Organosolv, cu o rată de conversie a celulozei de peste 90%. Ambele sunt eficiente pentru orice esență de material lemnos însă, comparativ cu SPORL, Organosolv are dezavantaje importante: concentrație scăzută de zaharuri hemicelulozice, utilizarea solvenților organici cu risc de mediul şi sănătate, cost ridicat şi complexitate a procesului de reciclare a solvenților, care altfel pot inhiba hidroliza enzimatică şi fermentația, cheltuieli ridicate de capital [7], [25], [39].

Din punct de vedere al producției de zaharuri pe unitatea de energie consumată, SPORL are cea mai ridicată eficiență. Primul pas al procesului constă în tocarea biomasei la dimensiuni mari, de până la 38 mm lungime/lățime şi aproximativ 6 mm grosime. Fragmentele de lemn reacționează apoi cu o soluție de 1-8% bisulfat şi 0,5-2,2% acid sulfuric (raportat la substanța uscată - SU), timp de 10-30 minute, la 160-190°C, în funcție de tipul de lemn [14], [44], [53]. Fragmentele, devente maleabile datorită tratamentului termo-chimic, sunt apoi dezintegrate prin defibrare într-o moară cu discuri. În cazul majorității metodelor de

[3] Sulfite Pretreatment to Overcome Recalcitrance of Lignocelluloses

yields. However, mechanical size reduction usually accounts for 50-60% of the total pretreatment cost, mostly due to its high energy requirements [5]. The SPORL approach of making the size-reduction process in two stages, namely before and after thermochemical treatment, led to important energy savings. Typical energy consumption in the process of mechanical disk-milling of wood is 200-600 Wh/od kg wood, which represents 10-30% of the ethanol energy obtained at a usual rate of 300 L/t wood [42], [53]. Using SPORL, a specific energy of less than 50 Wh/kg od wood was reported for size reduction when lodgepole pine was treated for 30 minutes at 180°C, with 2.21% sulfuric acid charge. Keeping the substrate for 48 h at a cellulase loading of 15 FPU/od g resulted in more than 90% enzymatic cellulose saccharification efficiency, with glucose yields of 370 g/kg od wood [53].

Besides energy efficiency and excellent results for cellulose recovery, there are several other features that make SPORL a potential solution for commercial implementation. The process parameters can be set up to generate negligible amounts of fermentation inhibitors like furfural and hydroxymethylfurfural (HMF). By weakening the hydrophobic links between enzymes and lignin, the process of cellulose saccharification is improved, which results in increased fermentation yields. Lignosulfonate is a byproduct of the thermo-chemical treatment with potential economic value that can be used as raw material by other industries like the production of dispersants, emulsifiers and adhesives. Most of the equipment and technology used for pulp making, disk milling, chemical recovery, and wastewater treatment is on the market for decades, being used in the pulp and paper industry. Current disk-refining technology can handle throughputs of up to 1,000 t/day. These last aspects lower the initial capital costs and increase the process scalability, allowing SPORL implementation on an industrial scale, in particular by integration into pulping mills [33], [53]. Figure 1 shows an example of cellulosic ethanol production technology using SPORL.

pretratare, eficiența hidrolizei enzimatice este invers proporțională cu dimensiunea particulei obținută prin măcinare. Datorită consumului de energie, reducerea dimensiunii reprezintă 50-60% din costul total al pretratării [5]. În cazul SPORL, reducerea dimensiunii în două etape, înainte şi după tratarea termo-chimică, aduce economii semnificative de energie. Consumul tipic în procesul de măcinare a lemnului este de 200-600 Wh/kg lemn (SU), adică 10-30% din energia etanolului produs, considerând o productivitate uzuală de 300 l/t lemn [42], [53]. Aplicând metoda SPORL, s-a determinat un consum specific de 50 Wh/kg lemn (SU) pentru reducerea dimeniunii lemnului de pin. Acesta a fost pretratat 30 min. la 180°C, în soluție de 2,21% acid sulfuric. Substratul a fost supus acțiunii celulazelor (15 FPU/g SU) timp de 48 ore, hidroliza având o eficiență de peste 90%, cu o producție de 370 g/kg lemn SU [53].

Pe lângă eficiența energetică şi rezultatele deosebite în ceea ce priveşte conversia celulozei, există şi alte caracteristici care promovează SPORL ca metodă cu înalt potențial comercial. Parametrii de proces pot fi configurați astfel încât să fie produse cantități neglijabile de inhibitori de fermentație, cum ar fi furfuralul şi hidroximetilfurfuralul (HMF). Prin slăbirea legăturile hidrofobe dintre enzime şi lignină se îmbunătățeşte procesul de zaharificare a celulozei, ceea ce are ca rezultat creşterea randamentului fermentării. Lignosulfonatul este un produs secundar al tratamentului termo-chimic, cu valoare economică, putând fi utilizat ca materie primă pentru producția de agenți de dispersie, emulgatori şi adezivi. Majoritatea echipamentelor şi tehnologia în sine, inclusiv procesele de recuperare a produselor chimice şi de tratare a apei uzate, se află pe piață de decenii, fiind specifice industriei hârtiei şi celulozei. Tehnologia actuală de defibrare cu mori cu discuri poate asigura capacități de prelucrare de 1000 t/zi. Aceste aspecte se traduc prin reducerea cheltuielilor de capital şi prin scalabilitate, procesul putând fi integrat în fabricile de celuloză [13], [53]. Figura 1 prezintă un exemplu de tehnologie de producere a etanolului celulozic folosind SPORL.

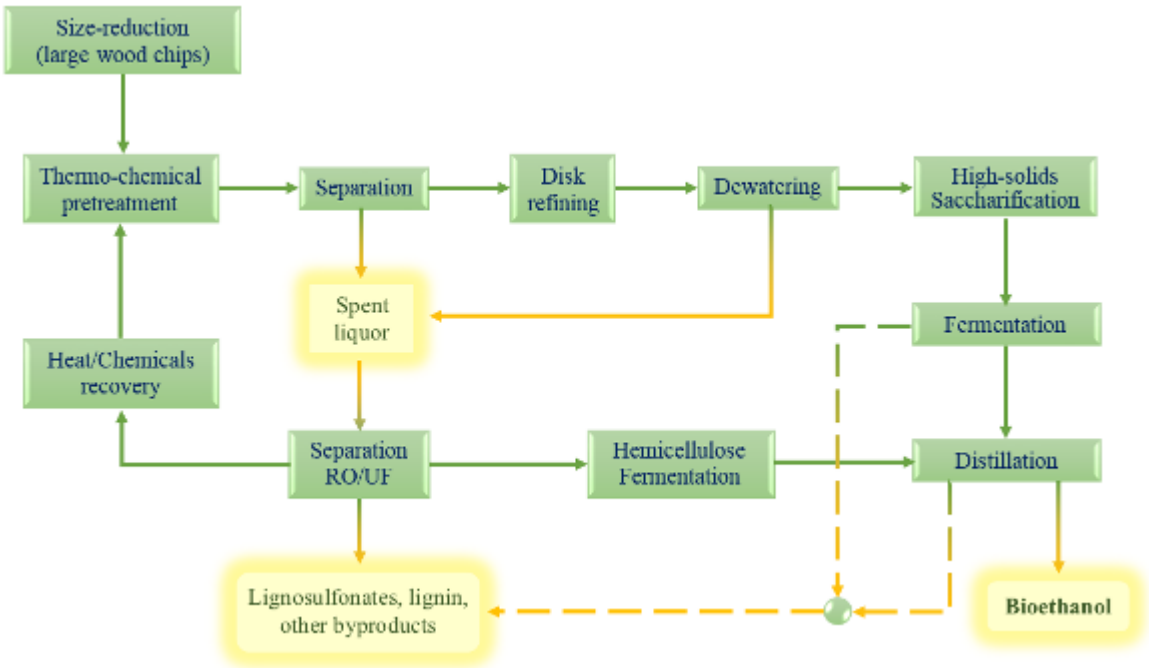


Fig. 1 – Example of a technological flow for cellulosic ethanol production, using SPORL pretreatment

PRETREATMENT BY EXTRUSION

Continuous pretreatment by means of extrusion is a new biomass deconstruction process in the area of cellulosic ethanol production, in which biomass undergoes chemical and physical changes through continuous crushing, mixing, heating and shearing [22], [35], [51]. Results consist of biomass defibrillation, fibrillation and shortening of the fibers, increased surface area, reduction of cellulose crystallinity, and cellulose swelling, providing good accessibility of carbohydrates to enzymatic activity [2], [27], [46], [48]. This process can be developed in a very large range of temperatures, with or without acid or base addition [30].

The main industrial applications of extrusion are the manufacture of polymeric products and certain areas of food industry. The two main types of extrusion equipment are single-screw and twin-screw extruders. Single-screw extruders have the advantage of simplicity, lower cost and ease of use in the production process. Moreover, they can be designed to take higher torsional loads during processing. Twin-screw extruders allow high-quality mixing and better defined biomass processing times. Currently, the twin-screw technology has achieved the capacity to handle considerably increased torque loads that makes them appropriate for high-capacity applications. The twin-screw extrusion technology can further be divided into non-intermeshing and fully intermeshing technologies, both with co-rotating or counter-rotating screws. Taking as reference the polymer industry, the current output levels of extruders can exceed 4,000 kg/h [36]. A typical screw design consists of a single-screw flight with three sections (feed, transition, and metering zone), that rotates inside a barrel (Figure 2). Better performances are obtained using variable pitch, a design that requires CNC manufacturing.

PRETRATAREA PRIN EXTRUDARE

Pretratarea prin extrudare este un proces nou de destructurare a biomasei pentru producerea de etanol lignocelulozic, în care biomasa suferă modificări chimice şi fizice printr-un proces continuu de strivire, amestecare, încălzire şi forfecare [22], [35], [51]. Se obține defibrarea biomasei la nivelul microfibrilelor, însoțită de scurtarea acestora, creşterea suprafeței specifice, reducerea cristalinității celulozei, asigurând astfel condiții foarte bune pentru hidroliza enzimatică [2], [27], [46], [48]. Procesul se poate desfăşura într-o gamă largă de temperaturi, cu sau fără adăugare de acizi sau baze [30].

Extrudarea este specifică fabricării produselor polimerice şi anumitor subdomenii ale industriei alimentare. Există două categorii principale de extrudere: cu unul, respectiv cu două şuruburi de extrudare. Extruderele cu un şurub sunt simple din punct de vedere constructiv, au cost redus şi sunt uşor de utilizat în procesul de producție. În plus, pot fi proiectate pentru a prelua sarcini de torsiune mari. Extruderele cu dublu şurub au avantajul calității superioare a amestecării şi controlul mai precis al timpului de procesare. În prezent, tehnologia cu dublu şurub poate face față unor sarcini de torsiune considerabile, devenind astfel adecvate pentru prelucrarea unor debite mari de material. Echipamentele cu dublu şurub pot fi cu şi fără întrepătrundere, ambele categorii putând avea şuruburi care se rotesc în acelaşi sens sau în sensuri contrare. Luând ca referință industria polimerilor, în prezent extruderele pot asigura debite de peste 4000 kg/h [36]. Un extruder tipic cu un singur şurub pentru prelucrarea biomasei, constă într-un transportor elicoidal cu o spiră, cu trei secțiuni (alimentare, tranziție şi evacuare), care se roteşte în interiorul unui cilindru (figura 2). Un pas variabil asigură performanțe superioare, însă necesită fabricarea pe maşini CNC.

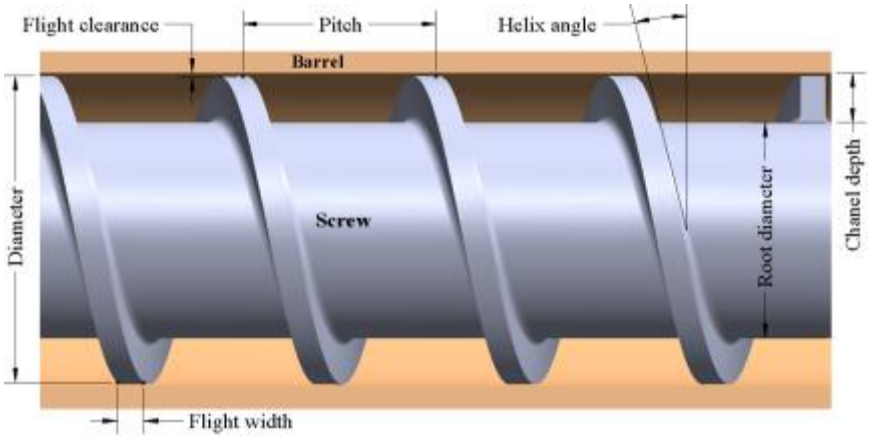


Fig. 2 – The main constructive parameters of an extruder [30]

Modern screw and barrel components are both modular, particularly in case of twin screws. Barrel length can be adjusted by adding or removing barrel sections. Each screw can be composed of a number of individual elements combined strategically for better performances and in accordance with the functional parameters of the process (Figure 3). The constructive features of each element type (length, pitch, helix angle) correspond to a specific role within the process [6], [30]:

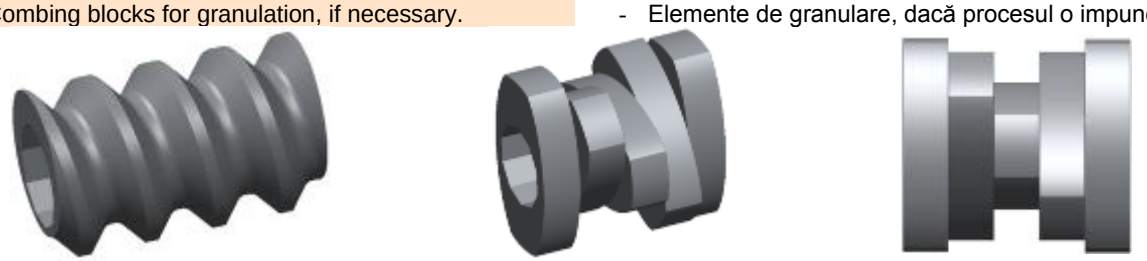
- Forward or reverse blocks of elements are designed to transport bulk material, without significant mixing or shearing effect; reverse screws can be used to convey the material backwards for improved shearing and mixing effects [41];
- Kneading elements intensify shear and mixing in order

Cilindrii şi şuruburile actuale sunt modulare, cu deosebire în cazul extruderelor cu dublu şurub. Lungimea cilindrului se reglează prin adăugarea sau eliminarea unor secțiuni. Şuruburile pot fi formate dintr-un număr variabil de elemente individuale, combinate strategic pentru performanțe superioare şi în concordanță cu parametrii procesului (figura 3). Caracteristicile constructive ale fiecărui tip de element (lungimea, pasul şi unghiul spirei) corespund rolului lor în proces [6], [30]:

- Elementele pentru transport înainte sau înapoi deplasează materialul, fără a produce amestecarea sau forfecarea semnificativă a acestuia; transportul în sens invers are rolul de a îmbunătăți procesele de forfecare şi amestecare [41];
- Elementele de malaxare intensifică forfecarea şi

to achieve a higher degree of pulverization of the material, but have lower transport effect; they are in forward, reverse or neutral orientations;
- Compression blocks;
- Combing blocks for granulation, if necessary.

amestecarea pentru o pulverizare superioară a materialului, însă cu efect redus de transport; pot fi cu deplasarea materialului înainte, înapoi, sau neutră;
- Elemente de compresiune;
- Elemente de granulare, dacă procesul o impune.



a) *b)*

Fig. 3 – Example of screw elements: a) transport element;
b) kneading module, showing the five elements and the rotation with 45° of each element

Channel depth directly influences the work applied to the biomass along the screw. It has the largest value in the feed area, and then progressively decreases along the compression zone. The ratio between the channel depth in the feed zone and the discharge zone defines the compression ratio – a parameter that affects both material flow and shear development inside the barrel [23].

Extruded material experiences a range of residence times and rates of shear development based on the type of twin-screw extruder, screw design and speed, and ratio between the length *L* and diameter *D* of the extruder (known as *L/D* ratio). Moisture content has similar effects as it influences the friction coefficient developed between the material and the surfaces of screw and barrel. Moisture degree also changes when feed ports, which can be added in any location along the barrel, are used for the addition of chemicals in liquid phase. Similar ports can be used downstream to remove liquor, vent gases, or extract samples of material. Cast heaters are used to adjust barrel temperature in order to meet the pretreatment requirements. Due to its influence on the degree of feed melting/softening, it indirectly affects the flow pattern and residence time. Both the diversity of extruder profiles that can be obtained by using different types of screw and barrel elements, and the possibility to easily set up process conditions (residence time, temperature, moisture, etc.), give the extrusion system high flexibility in searching for optimum pretreatment performance [30], [36], [46]. Extrusion equipment can be used with or without chemical catalyst. Table 1 exemplifies some experimental results in terms of sugar yield, obtained with no catalyst, and with alkali or acid catalysts.

Adâncimea canalului (figura 2) influențează direct efectul asupra biomasei. Aceasta are cea mai mare valoare în zona de alimentare, apoi scade progresiv de-a lungul zonei de compresie. Raportul dintre adâncimea canalului în zona de alimentare şi cea din zona de descărcare defineşte raportul de compresie - un parametru care afectează atât curgerea materialului cât şi efectul de forfecare asupra acestuia [23].

Durata şi intensitatea procesării depind de tipul extruderului cu dublu-şurub, de tipul şi turația şurubului şi de raportul dintre lungimea *L* şi diametrul *D* al extruderului. Umiditatea are efecte similare întrucât influențează coeficientul de frecare a materialului cu suprafețele şurubului, respectiv cilindrului. Valoarea umiditatății se modifică şi atunci când porturile de alimentare, care pot fi amplasate oriunde de-a lungul cilindrului, sunt folosite pentru adăugarea de aditivi lichizi. Extragerea fracțiilor lichide, evacuarea eventualelor gaze, sau extragerea de mostre de material, se pot face cu porturi similare celor de alimentare. Temperatura cilindrului poate fi reglată în conformitate cu cerințele tehnologice. Datorită efectului asupra viscozității materialului, temperatura influențează indirect durata procesului şi comportarea materialului din punct de vedere al curgerii. Diversitatea extruderelor, obținută prin combinații variate de elemente de şurub şi de cilindru, precum şi posibilitatea de a regla cu uşurință parametrii tehnologici, conferă acestor sisteme flexibilitatea necesară optimizării pretratării [30], [36], [46]. Extruderele pot fi utilizate cu sau fără catalizator chimic. În tabelul 1 sunt exemplificate câteva rezultate experimentale, în diverse condiții de procesare.

Table 1

Examples of experimental results performed with various types of extruders, obtained with no catalyst, and with alkali or acid catalysts

Biomass	Type of extruder	Pretreatment	Screw speed/ Barrel temperature	Glucose yield	Other data	References
Corn cobs	Single-screw	Physical; no catalyst	75 rpm/125°C	75%	49% xylose recovery	[21]
Switchgrass	Single-screw	Physical + NaOH (0.02g/g)	118 rpm/180°C	90.5%	81.5% xylose recovery; 88% combined sugar recovery	[19]
Soybean hulls	Twin-screw	Physical; no catalyst	350 rpm/80°C	95%	Moisture: 40%	[26]
Wheat straw	Extrusion type mixer	Physical + NaOH	35 rpm/98°C	92%	43% pentosans recovered; 72% removed lignin	[3]
Rice straw	Twin-screw	Physical + H_2SO_4 (3 wt%)	40 rpm/120°C	no data	Xylose yield: 83.7%	[6]

Information regarding energy consumption during the extrusion process is extremely scarce. A report on the extrusion of rice straw with a twin-screw extruder to prepare high monomeric xylose hydrolysate showed that

Informațiile privind consumul de energie în procesul de extrudare sunt extrem de rare. Un raport ştiințific privind procesarea paielor de orez cu un extruder cu dublu şurub pentru a obține substrat cu conținut ridicat de xiloză, a

best performances were achieved at 30 rpm and 120°C, with a specific mechanical energy consumption of 191.8 Wh/kg wood [6]. This value should not be compared with results from other mechanical size-reduction processes due to the fact that the biomass delivered by the extruder is disrupted at a level that cannot be achieved by other mechanical methods; resulting material is ready for enzymatic hydrolysis and this performance requires higher energy levels. In addition, very promising results were obtained at temperatures around 100°C (table 1), with residence periods of the order of minutes, which results in lower specific consumption of thermal energy than in case of other pretreatment methods. Research on micro/nanofibrillation of woody biomass through extrusion revealed that power consumption linearly decreases on a logarithmic scale when the discharge capacity of the extruder increases, demonstrating additional energy savings for industrial scale applications [27].

This novel technology has numerous advantages that make it a very promising alternative to existing pretreatment methods: continuous operation, availability of commercial systems of various capacities, simplicity in operation and maintenance, adaptability to various feedstocks, short processing times, effective mixing and destructuration of biomass, low-to-moderate optimal process temperatures (50-130°C) [2], rapid transfer of heat, little or no washing of pretreated material leading to lower inputs in terms of water and energy, easy to scale-up in industrial application, no solid loss or effluent disposal. Due to its advantages this technique can also be integrated in small-scale applications.

PASS-THROUGH DISTILLATION

In chemical industry, distillation is used for around 95% of all fluid separation, this process being considered as responsible for 3% of the world energy consumption [7]. In bioethanol plants, fouling of thin stillage evaporators and reboilers is a common problem at temperatures above 80°C. This issue translates in maintenance and redundant equipment. The plant cooling water temperature limits the condensing temperature at about 45…50°C during summer, and consequently the minimum boiling temperature at minimum 70°C. These temperatures destroy both the expensive enzymes that are denaturated above 60°C, and yeasts that start to die at more than 30°C. One solution to address this limitation, moving the temperature down to a safe 30°C, would be the use of refrigerated condensers. However, due to high capital costs and costs related to the refrigeration process, this solution is appropriate for small production volumes with high selling price, but not for large scale production of price competitive biofuels. Cost and energy problems are also experienced if vacuum pumps are intended to be used to reduce the pressure and initiate evaporation at low temperature, at the same time extracting the ethanol vapors from the evaporator. In industrial applications the vacuum pumps should be very large and would come with infeasible energy costs. The use of expensive ethanol-selective membrane based separation methods poses the same problem of fouling, which restricts the permeation rate and is difficult or impossible to remove.

Pass-through is a very new concept developed by Drystill – a Canadian technology provider company - that performs distillation at room temperature with half of the energy requirements when compared to current conventional distillation methods available on the market. It is based on a combination of existing, mature processes that have now being put together. A pilot plant based on

arătat că performanța optimă s-a obținut la 30 rot/min şi 120°C, cu un consum specific de energie mecanică de 191,8 Wh/kg lemn [6]. Această valoare nu trebuie comparată cu rezultatele aferente proceselor uzuale de măcinare, întrucât biomasa furnizată de extruder este dezintegrată la un nivel care nu poate fi obținut prin alte metode mecanice; materialul rezultat este pregatit pentru hidroliza enzimatică, această performanță necesitând un nivel mai ridicat de energie. In plus, s-au obținut rezultate foarte promițătoare la temperaturi de aproximativ 100°C (tabelul 1), cu perioade de procesare de ordinul minutelor, ceea ce conduce la un consum specific de energie termică mai mic decât în cazul altor metode de pretratare. Cercetările privind dezintegrarea biomasei lemnoase la nivel de micro şi nano fibrile prin extrudare au arătat că puterea necesară scade liniar pe o scară logaritmică cu creşterea debitului extruderului, demonstrând economii suplimentare de energie pentru aplicațiile industriale [27].

Această nouă tehnologie are numeroase avantaje care o promovează ca alternativă la metodele de pretratare existente: funcționarea continuă, existența sistemelor comerciale de diferite capacități, simplitate în operare şi întreținere, adaptabilitate la diverse tipuri de biomasă, durată scurtă de procesare, eficiență în amestecarea şi dezintegrarea biomasei, temperaturi de procesare scăzute sau moderate (50-130°C) [2], transfer rapid de căldură, spălarea uşoară sau lipsa etapei de spălare a materialul pretratat, ceea ce se traduce prin economie de apă şi energie, scalabilitate la nivel industrial, lipsa efluenților şi a pierderilor de materie solidă. Datorită avantajelor sale aceasta tehnica poate fi de asemenea integrată şi în aplicații la scară redusă.

DISTILAREA PASS-THROUGH

În industria chimică, separarea fluidelor se face în proporție de 95% prin distilare, acest proces fiind responsabil pentru 3% din consumul de energie la nivel mondial [7]. O problemă comună o reprezintă ancrasarea echipamentelor de distilare la temperaturi de peste 80°C, ceea ce se traduce în operații de întreținere şi echipament redundant. Temperatura apei de răcire limitează temperatura de condensare la aproximativ 45…50°C în timpul verii şi, în consecință, temperatura minimă de fierbere la cel puțin 70°C. La aceste valori sunt distruse atât enzimele (care rezistă până la maxim 60°C) cât şi drojdiile (rezistente până la maxim 30°C). O alternativă prin care se poate reduce temperatura procesului la 30°C ar putea consta în utilizarea sistemelor de condensare cu refrigerare. Această soluție presupune însă cheltuieli de capital ridicate şi costuri mari cu energia consumată pentru refrigerare, ceea ce o face adecvată pentru procese care implică volume mici de producție şi preț ridicat al produsului final, însă nu şi pentru producția pe scară largă şi prețuri competitive, cum este şi cazul biocombustibililor. Problemele ar fi similare şi în cazul utilizării pompelor de vacuum pentru reducerea presiunii şi inițierea evaporării la temperaturi joase, pompa având şi rolul de a extrage vaporii de etanol din evaporator. În aplicațiile industriale pompa de vacuum ar avea dimensiuni foarte mari şi consumuri energetice nefezabile. O altă variantă ar consta în aplicarea procedeelor de separare bazate pe utilizarea membranelor, care sunt însă caracterizate de prețul ridicat şi de problema încă nerezolvată a ancrasării.

Tehnologia “pass-through” are la bază un concept nou, pus la punct de compania canadiană Drystill, prin care distilarea se face la temperatura camerei, cu jumătate din energia necesară procesului convențional. Metoda îmbină o serie de tehnici existente pe piață, mature tehnologic. O instalație pilot a fost deja construită

this method was built by the chemical recycler Fielding Chemical Technologies Inc. in order to process complex hazardous high-solids aqueous waste streams without the use of self-sustaining combustion [12].

Pass-through distillation uses gas absorption technology, which makes use of a recirculating absorbent fluid in order to perform distillation at room temperature. An absorption step and a desorption one are introduced in order to perform evaporation and condensation at different pressures (Figure 4). The evaporator and the absorber operate at low pressure and temperature that, in an application for water distillation, were 30 torr and 30°C. In the absorber, a lithium bromide brine is sprayed to absorb the vapors, while the vacuum pump removes only the relatively small amounts of air and non-condensable gases that were captured within the feed, thus maintaining the low operating pressure. During the absorption, the latent heat of evaporation achieved within the evaporator and the heat of mixing are released by the absorbing vapors, adding mass and energy to the brine. As a result, the brine becomes diluted and its temperature raises.

de compania de reciclare a deşeurilor chimice Fielding Chemical Technologies Inc., în vederea procesării fluxurilor de ape uzate complexe, cu concentrație mare de compuşi solizi periculoşi [12].

Distilarea „pass-through" face apel la tehnologia cu absorbție de gaze, care utilizează un fluid absorbant recirculat între zona de evaporare şi cea de condensare. Pentru a efectua evaporarea şi condensarea la presiuni diferite, sunt introduse etapele de absorbție şi desorbție a vaporilor (figura 4). În zonele de evaporare şi absorbție procesul se desfăşoară la temperaturi şi presiuni mici. În faza de experimentare, sistemul a produs apă distilată la 30 torr şi 30°C. În spațiul de absorbție este pulverizată soluție de bromură de litiu (LiBr), care absoarbe vaporii proveniți de la evaporator. Pompa de vacuum are rolul de a menține presiunea scăzută, prin eliminarea unor cantități mici de gaze necondensabile aflate în materia primă. Căldura latentă de vaporizare acumulată de vapori în evaporator este cedată soluției de LiBr în timpul absorbției. În consecință, temperatura soluției de LiBr creşte, aceasta devenind totodată mai diluată.

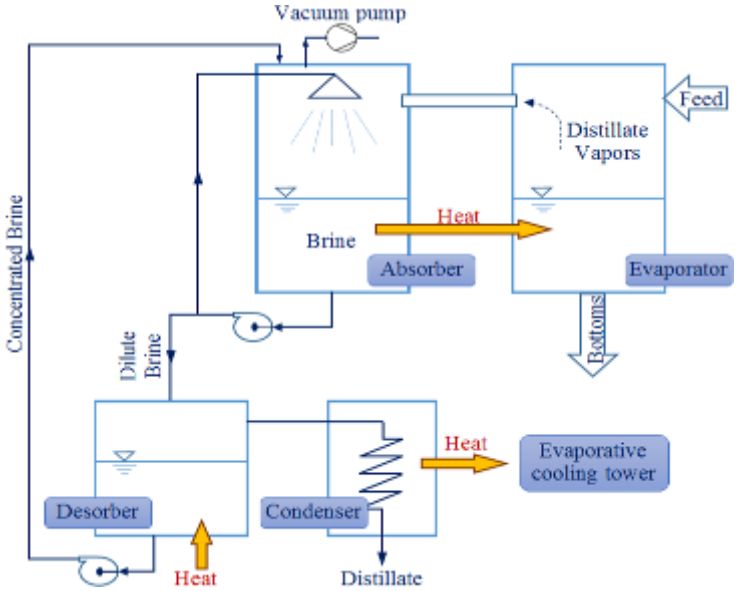


Fig. 4 – Simplified diagram of a pass-through distillation system (adapted from [32])

In order to maintain the operating temperature, a heat-pipes based heat exchanger is used to move heat from the absorber to the evaporator, providing the latter the necessary thermal energy to drive the evaporation process (Figure 5). This circular flow of heat between the absorber and evaporator, where the heat of evaporation is re-used for evaporation, defines a passive system that can perform at no additional external thermal energy. This is the first step of the equipment in achieving energy savings. In order to maximize the absorption process, vapors travel counter-current to the absorbent brine.

Heat pipes technology involves liquid-vapor phase change, offering high thermal conductivities (5,000 … 200,000 W/mK), low cost, as well as simple and reliable operation. Each heat pipe is vacuumed, filled with a working fluid and sealed. A metallic wick structure saturated with the working fluid is distributed over the entire inner surface of the pipe. The side of the pipe placed in the higher temperature area acts as an evaporator, while the other side is the condenser. The working fluid in the evaporator area takes up latent heat and evaporates. In the condenser the vapors transfer their heat and change into the liquid phase. Due to the capillary action of the wick, the working fluid is then

Pentru a menține constantă temperatura de lucru, un schimbător de căldură pasiv cu tuburi termice transferă căldura de la incinta de absorbție către evaporator, furnizându-i acestuia din urmă energia termică necesară evaporării (figura 5). Această recirculare a căldurii între incinta de absorbție şi evaporator, unde căldura de vaporizare este reutilizată pentru evaporare, defineşte un sistem pasiv care poate funcționa fără o sursă externă de energie termică. Este o primă realizare în materie de economie de energie a echipamentului. Pentru a maximiza absorbția, vaporii şi soluția de LiBr circulă în contracurent.

Funcționarea tuburilor termice se bazează pe schimbarea stării unui agent termic fluid. Aceste sisteme sunt caracterizate de conductivități termice de 5.000 … 200.000 W/mK, preț scăzut, simplitate constructivă şi fiabilitate. Fiecare tub este vidat, umplut cu agent termic şi sigilat. Pereții interiori sunt căptuşiți cu o structură metalică poroasă. Porțiunea de tub amplasată în zona mai caldă are rol de evaporator, iar cea din zona mai rece – rol de condensator. Agentul termic din zona de evaporare primeşte căldură, trece în stare de vapori şi migrează către zona rece a tubului, unde cedează căldura latentă şi trece din nou în stare lichidă. Ulterior, datorită efectului capilar al structurii poroase, lichidul

returning from the condenser to the evaporator.

revine în zona de evaporare.

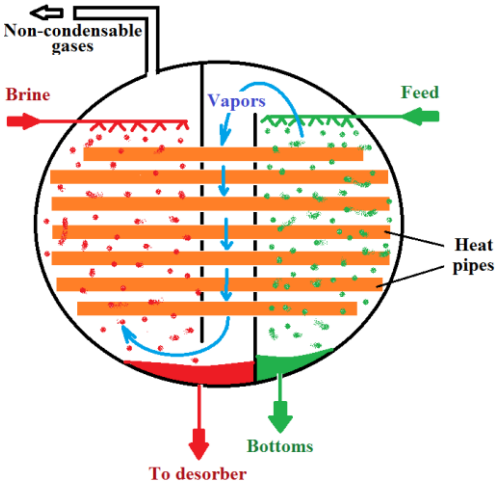


Fig. 5 – Material and vapors flow within the evaporator-absorber module (adapted from [32])

The last step takes place in the desorber and consists of separating the distillate from the diluted brine, thus restoring the brine concentration. The clean, thermally stable diluted brine, makes possible the use of multiple effect distillation (MED) through externally supplied heat (Figure 6). In MED, each evaporator vessel reuses the energy from the previous one. To make this process possible, distillation is performed at progressively lower temperatures and pressures. A typical reduction in energy consumption is 50% when compared to conventional distillation [10], performance ratio being proportional with the number of effects [9].

Etapa de desorbție constă în separarea distilatului din soluția diluată de LiBr. Puritatea şi stabilitatea termică a soluției fac posibilă utilizarea sistemelor de distilare cu efect multiplu (DEM), care folosesc abur primar ca sursă de energie termică şi sunt caracterizate prin faptul că fiecare evaporator utilizează energia de la evaporatorul anterior (figura 6). Funcționarea DEM este condiționată de utilizarea unor presiuni şi temperaturi care scad progresiv de la un evaporator la următorul. Comparativ cu distilarea clasică, se obține o reducere de aproximativ 50% a consumului de energie [10], această performanță fiind proporțională cu numărul efectelor [9].

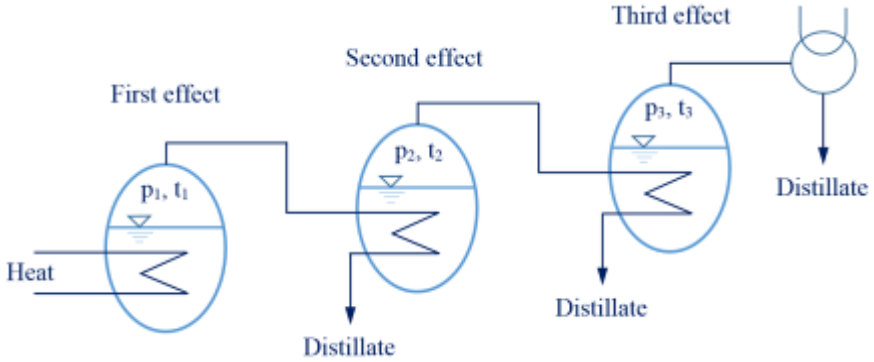


Fig. 6 – The operating principle of multiple-effect distillation (adapted from [31])

The pass-through distillation system has a very good chance to become a new standard among separation technologies due to the following main advantages [9], [24], [33]:

- Depending on system configuration, this technology can perform with up to 60% of the energy required by conventional distillation;
- Room-temperature operation in the evaporator-absorber module offers a solution towards the recovery of biocatalysts and enzymes;
- Water lost through evaporation in cooling tower is proportional to the energy that it should remove from the system. In pass-through distillation, up to 80% reduction in water consumption can be achieved due to the less energy used and also because of the replacement of energy-inefficient equipment (distillation columns, evaporators, rectifier columns, etc.);
- Possibility to work with high solids fermentable broth;
- Overall reduction in energy consumption proportionally translates into GHG reduction;

Tehnologia „pass-through" poate deveni o referință în domeniul metodelor de separare, datorită avantajelor care o caracterizează [9], [24], [33]:

- În funție de modul de configurare a echipamentului, se pot obține reduceri ale consumului energetic de până la 60%, comparativ cu distilarea convențională.
- Evaporarea şi absortia la temperaturi scăzute reprezintă un punct de pornire în vederea recuperării biocatalizatorilor, în special a enzimelor.
- Pierderea de apă în turnul de răcire este proporțională cu energia care trebuie eliminată din sistem. În distilarea „pass-through" consumul de apă se poate reduce cu până la 80%, datorită atât consumului mai mic de energie, cât şi înlocuirii echipamentelor ineficiente energetic (coloane de distilare, evaporatoare clasice, coloane de rectificare etc.).
- Evaporarea la temperaturi mici face posibilă distilarea borhotului concentrat.
- Reducerea consumului de energie se traduce şi într-o reducere proporțională a gazelor cu efect de seră.

- Lower maintenance and capital expenditure.

DISCUSSION AND CONCLUSIONS

Although there are few LCA studies on second generation bioethanol, the existing data show that the energy ratio is higher than one [28], [43], [44]. This means that second generation bioethanol provides more renewable energy in the form of ethanol than the fossil energy used for producing, transporting and processing the biomass [8], [15]. However, even if basic conversion technologies of lignocellulosic biomass into bioethanol are not new, market uptake is still burdened due to various factors, one of the most important being the operational and investment costs. In spite of these costs, some technologies are currently tested worldwide in pilot plants, but in the meantime new improved approaches and methods are developed for each intermediate technological step. Usually, these new breakthroughs are investigated individually or tested on an already existing, not yet mature, technological flow. As presented before, the new solutions provided in this paper are reported to be cost-effective, resource efficient, economically viable, and they address the efficiency of most energy-expensive technological steps: pretreatment and distillation. The experimental findings that support these conclusions lead to the idea that, if combined in the same technological flow and properly adjusted, these processes would significantly improve energy balance and, consequently, GHG emission levels, as follows:

- Usually pretreatment is preceded by biomass size-reduction. SPORL method achieves a reduction in energy consumption by up to 80% [38], [53] due to the very coarse chopping before thermo-chemical pretreatment followed by a fiberization of pretreated, softened material, as well as because lower energy levels are necessary for mixing chemicals and pulp during pretreatment. Thermal energy recovery from thermo-chemical process should also be considered. According to current practices from the paper industry, where pulping process is similar to that of the lignocellulosic ethanol production using SPORL, 50% of thermal energy can be recovered [52].
- In case of extrusion pretreatment, energy economies could be achieved directly or indirectly due to rapid heat transfer, short residence time, moderate temperature, no formation of fermentation inhibitors (which eliminates energy consumption for detoxification and water decontamination), no need for effluent disposal and no solid loss (in case of simple physical extrusion that works without liquid fraction) [20]. Using the recovered residual lignin for fueling the conversion process will further improve the overall energy balance.
- On the separation step, up to 60% energy economies can be achieved by replacing conventional distillation with multiple effect, pass-through distillation. This solution also triggers other indirect energy savings due to both lower water consumption and replacement of existing energy-inefficient equipment, as well as because ethanol can now be extracted from high-solids fermentable broth without the fouling related issues.

In the context of an increased worldwide trend towards new developments in cellulosic ethanol industry, the main key to make biorefineries economically viable and sustainable is the optimization of a technology made up of high efficiency, close-to-market individual processes.

- Întreţinere simplă şi cheltuieli de capital reduse.

DISCUŢII ŞI CONCLUZII

Deşi puţine, studiile LCA [4] privind bioetanolul de generaţia a doua demonstrează că raportul energetic este supraunitar [28], [43], [44]. Acest aspect arată că produsul final generează mai multă energie regenerabilă decât energia de natură fosilă consumată pentru producerea, transportul şi procesarea biomasei [8], [15]. Cu toate acestea, deşi tehnologiile consacrate de conversie a biomasei lignocelulozice în bioetanol nu sunt noi, introducerea lor pe piaţă este încă afectată de diverşi factori, unul dintre cei mai importanţi fiind costurile operaţionale şi cheltuielile de capital. Ritmul rapid de evoluţie a cercetărilor în acest domeniu face ca, în timp ce la nivel mondial sunt testate în instalaţii pilot cele mai promiţătoare tehnologii, laboratoarele să furnizeze abordări şi metode noi, îmbunătăţite, pentru anumite etape tehnologice. De obicei aceste noi descoperiri sunt investigate individual sau testat pe un flux încă imatur din punct de vedere tehnologic. Soluţiile noi prezentate aici sunt raportate ca fiind rentabile, eficiente din punct de vedere al consumului de resurse, viabile economic, ele abordând procesele cu cel mai mare consum de energie: pretratarea şi distilarea. Determinările experimentale care susţin aceste concluzii conduc la ideea că, dacă ar fi integrate în acelaşi flux tehnologic şi ajustate corespunzător, aceste procese ar îmbunătăţi semnificativ bilanţul energetic şi emisiile de gaze de seră întrucât:

- Uzual, pretratarea este precedată de reducerea mecanică a dimensiunilor biomasei. Din acest punct de vedere, metoda SPORL reduce consumul energetic cu până la 80% [38], [53] datorită tocării grosiere înainte de tratarea termo-chimică, urmată de defibrarea materialului devenit maleabil în urma tratării, dar şi ca urmare a nivelului scăzut de energie consumată pentru amestecarea în timpul tratării a substanţelor chimice şi a pastei lemnoase. În plus, conform practicilor curente din industria hârtiei, care uzează de un proces similar cu SPORL, există posibilitatea recuperării a 50% din energia termică utilizată în procesul termo-chimic [52].
- În cazul pretratării prin extrudare, reducerea consumului energetic se poate obţine direct sau indirect datorită transferului rapid de căldură către biomasă, perioadei scurte de pretratare, temperaturii moderate, lipsei inhibitorilor de fermentaţie (se elimină consumul de energie pentru detoxificare şi pentru decontaminarea apei utilizate în acest proces), lipsei efluenţilor şi a pierderilor de material (în cazul extrudării mecanice simple care nu necesită fracţie lichidă) [20]. Recuperarea ligninei reziduale şi utilizarea acesteia pentru producerea de energie termică necesară pretratării va furniza economii suplimentare de energie.
- Prin înlocuirea procesului convenţional de distilare cu tehnologia „pass-through” cu efect multiplu, se pot obţine economii de energie de până la 60%. Indirect, se obţin economii şi datorită consumului redus de apă, înlocuirii echipamentelor convenţionale ineficiente, dar şi posibilităţii de extragere a etanolului din borhot concentrat fără pericol de ancrasare.

În contextul tendinţelor actuale de implementare de noi tehnologii în industria etanolului celulozic, soluţia eficientizării economice a biorafinăriilor în condiţii de funcţionare sustenabilă constă în optimizarea tehnologiilor care includ procese de înaltă eficienţă, cu potenţial de piaţă.

[4] Life Cycle Assessment

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DETERMINATION OF SOME MECHANICAL PROPERTIES OF SOYBEAN STALK RELATED WITH DESIGN PARAMETERS

SOYA SAPININ TASARIM PARAMETRESİ İLE İLGİLİ BAZI MEKANİK ÖZELLİKLERİNİN BELIRLENMESI

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Abstract: *In this study, some engineering parameters such as strength and deformation were determined for soy bean stalk. The experiments were conducted on samples selected from Bati Akdeniz Agricultural Research Institute in Aksu, Antalya. Strength parameters consisted of maximum and bioyield force in shearing, shearing and bioyield stress, maximum energy in maximum force, maximum energy in bioyield point and modulus. Deformation parameters are also maximum bioyield deformation and maximum breaking dilatation.*

Key words: *Soybean, bending force, cutting force, deformation, design,*

Özet: *Bu çalışmada, soya saplarının dayanım ve deformasyon gibi bazı mühendislik parametreleri belirlenmiştir. Denemeler Batı Akdeniz Tarımsal Araştırma Enstitüsü Aksu, Antalya bulunan biriminden toplanan örnekler üzerinde yürütülmüştür. Dayanım parametreleri maksimum ve akma noktasındaki kesme kuvveti, kesme akma dayanımı, maksimum kesme kuvvetindeki maksimum enerji, akma noktasındaki maksimum enerji ve elastikiyet modülünü kapsamaktadır. Deformasyon parametreleri ise maksimum akma ve kesme noktasındaki deformasyondur.*

Anahtar Kelimeler: *Soya, eğme kuvveti, kesme kuvveti, deformasyon, tasarım*

INTRODUCTION

Mechanical parameters of agricultural materials and their products are important factors for the design of agricultural mechanization or automation equipment. Engineers must design agricultural handling and processing equipment and machines using empirical methods that increase development time and costs of production without a basis database and mechanical characteristics,

A review of the literature revealed no more clear information on mechanical properties of soybean stalk but a lot of researcher have been studied to find properties of other crops as well as factors which significantly affect the amount of these properties.

A lot of works have been conducted to determine the mechanical properties of plants. The maximum shear stress of sunflower stalks was 1.07 MPa (Ince et al., 2005). Halyk and Hurlbut, determined the mechanical properties of alfalfa stems (Halyk and Hurlbut 1968). Chattopadhyay and Pandey, studied shear, compression and bending properties of sorghum stalks (Chattopadhyay and Pandey 1999). Simonton, studied physical properties, strength in bending, and strength in compression for Geranium (Simonton 1992).

This study was peformed in determining strength parameters such as maximum force and bioyield force in shearing and bio yield stress, maximum energy in maximum force, maximum energy in bioyield point, modulus of elasticity and deformation parameters such as maximum bioyield deformation, maximum breaking dilatation of the soybean stalk obtained data would be useful in designing and developing harvesting

GİRİŞ

Bitkilerin ve bitkisel ürünlerin mekanik parametreleri tarımsal makinaların veya otomasyon ekipmanlarının tasarımı için kritik verilerdir. Bitkilere ait bu temel veriler ve mekanik karakteristikler bilinmeksizin yapılan makinaların ve ekipmanların tasarımı deneysel olmaktadır ki buda makinanın geliştirilmesi için gerekli olan zamanın ve maliyetin artmasına neden olmaktadır.

Yapılan literatur taramaları sonucunda soyanın mekanik özellikleri hakkında fazla açık bir bilginin olmadığını ortaya çıkarmıştır. Bunun yanında bir çok araştırmacı diğer ürünlerin bu tip özelliklerinin belirlenmesi amacıyla birçok çalışma yapmışlardır.

Bitkilerin mekanik özelliklerinin belirlenmesine yönelik çeşitli araştırmalar yürütülmüştür. İnce, ayçiçeği sapının maksimum kesme gerilimin 1.07 MPa olduğunu saptamıştır (Ince et al., 2005). Halyk ve Hurlbut, alfalfa gövdesinin mekanik özelliklerinin belirlenmesi üzerine çalışmışlardır (Halyk and Hurlbut 1968). Chattopadhyay ve Pandey, sorgum saplarının eğilme ve kesme sıkıştırma özelliklerini belirlemişlerdir (Chattopadhyay and Pandey 1999). Simonton, sardunyanın sıkıştırma altındaki fiziksel özellikleri, dayanım ve eğilme özellikleri üzerine çalışmıştır (Simonton 1992).

Bu çalışma soya saplarının maksimum kuvvet, akma kuvveti, kesme ve akma gerilimi, akma ve kesme noktalarındaki maksimum enerji, elastikiyet modülü, akma ve kesme noktalarındaki deformasyon gibi dayanım ve deformasyon parametreleri gibi mühendislik verilerinin belirlenmesi için yürütülmüştür. Elde edilen verilerin farklı tip hasat ekipmanlarının tasarımı ve var olan makinaların geliştirilmesi amacı ile kullanılması yararlı olacaktır.

equipment for soybean

MATERIAL AND METHOD

The experiments were conducted on samples selected from Bati Akdeniz Agricultural Research Institute in Aksu, Antalya.The tests were done at the Biological Test Devices, Laboratory of Agriculture Machinery, Akdeniz University, Antalya, Turkey. While Soybeans were harvested at moisture contents of 16.8% (d.b.). In order to determine the variable of soybean, cutting apparatus was used (Fig.1a). The cutting and bending system had three main components: a stable forced and moving platform (slot, knife), a driving unit and a strain-gauge load cell.

In this study, perpendicular cutting was used, since most researchers have used this method to determine the cutting forces of biological materials (Ince et al., 2005, Khazaei et al.,2002 and Srivastava et al., 2006).

The knife was loaded at the range of 20 mm min^{-1} and, as for shear test, a strain-gauge load cell measured the applied force and a force-deformation record obtained up to the specimen failure. The shearing stress τ in MPa was calculated based on Eq. (1) and also reported by previous studies (Galedar et al., 2008, Chen et al., 2004 and Mohsenin 1970).

In this study, 20 samples and 3 replications for each test were used.

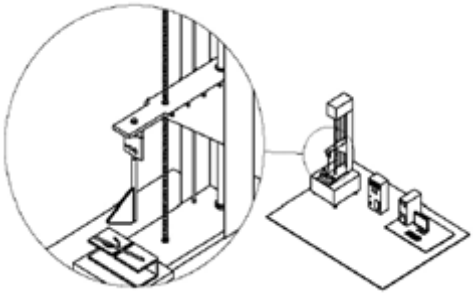
MATERYAL VE YÖNTEM

Denemeler Batı Akdeniz Tarımsal Araştırma Enstitüsü Aksu, Antalya'da bulunan biriminden toplanan örnekler üzerinde yürütülmüştür. Testler Akdeniz üniversitesi, Ziraat Fakültesi, Tarım Makinaları bölüm laboratuvarında bulunan biyolojik malzeme test cihazında yapılmıştır. Soya %16.8 (k.b) nem içeriğinde hasat edilmiştir. Soyanın değişkenlerinin belirlenmesi amacı ile kesme aparatı kullanılmıştır (Fig 1a). Test düzeneği kesme ve eğme sistemi taşıma platformu, güç ünitesi ve yürütme-load cell ünitesi olmak üzere 3 ana kısımdan meydana gelmektedir.

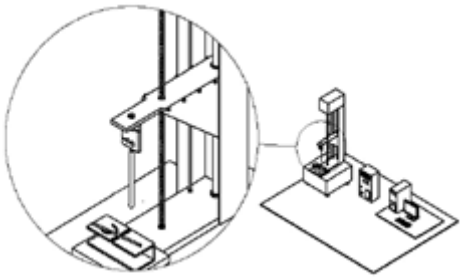
Yapılan bu çalışmada, birçok araştırmacının kullandığı metot kullanılarak biyolojik malzemenin kesme kuvvetinin belirlenmesinde dik doğrultuda bir kesme yapılmıştır (Ince et al., 2005, Khazaei et al.,2002 and Srivastava et al., 2006).

Kesme bıçağı 20 mm min^{-1}'lik bir hızla hareket ettirilmiş ve yük hücresiyle uygulanan kuvvet ölçülmüş ve kuvvet-deformasyon kaydı elde edilmiştir. Kesme gerilmesi τ MPa olarak Eşitlik 1 kullanılarak hesaplanmıştır ve ayrıca çeşitli çalışmalarda belirtilmiştir (Galedar et al., 2008, Chen et al., 2004 and Mohsenin 1970).

Bu çalışma 3 tekerrürlü olarak her test için 20 örnek kullanılarak yapılmıştır.



a)



b)

Fig 1. Biological test device, (a) cutting and (b) bending system's

$$\tau_s = \frac{F_{\max}}{A} \quad (1)$$

Where τ_s is the maximum shear strength, F_{max} is the maximum shear force and A is was the wall area of the specimen at the failure, mm^2.

A strain gage load cell measured the bending force and a force-deformation record obtained up to the failure of the specimen (Fig. 1b).

Most specimens were slightly elliptical in cross-section and second moment of area in bending about a major axis (I_b) was calculated based on equation (Eq. (2)), (Crook and Ennos 1994):

Burada; τ_s , maksimum kesme dayanımı, F_{max}, maksimum kesme kuvveti, A, soya sapının kesit alan, mm^2 dir.

Yük hücresi ile eğilme kuvveti ölçülmüş ve kuvvet-zaman kaydı elde edilmiştir (Fig. 1b).

Eğilme momenti ana eksen (I_b) boyunca Eşitlik 2'de verilen formül yardımı ile hesaplanmıştır (Crook and Ennos 1994):

$$I_b=\pi/4[ab^3-(a-t)(b-t)^3] \quad (2)$$

Where "*a*" is the semi major axis of the cross–section in mm, "*b*" is the semi minor axis of the cross-section in mm and "*t*" is the mean wall thickness in mm. Modulus of elasticity was assessed using a three–point bending test similar to those described by previous studies (Fig. 1b) (Mohsenin 1970).

The modulus of elasticity, *E*, was calculated based on equation (Eq. (3)), (Srivastava et al., 2006 and Crook and Ennos 1994).

Burada, "a" kesit alanının uzun ekseni, mm, "b" kesit alanının kısa ekseni ve "t" ortalama kalınlık mm'dir. Elastikiyet modülü daha önceki çalışmalarda belirtildiği gibi 3 nokta eğilme testi kullanılarak belirlenmiştir (Fig. 1b) (Mohsenin 1970).

Elastikiyet modülü, E, Eşitlik 3'de verilen eşitliğe göre hesaplanmıştır (Srivastava et al., 2006 and Crook and Ennos 1994).

$$E=F_bI^3/48\delta I_b \quad (3)$$

Where, F_b was the applied load, N; I was the distance between the metal supports, mm; δ was the deflection at the specimen, mm; and I_b the second moment of area, in mm^4.

Maximum breaking dilatation is described as the rate of the total dilation to first length of the soybean stalks. Maximum energy in maximum force and maximum energy in bioyield point were calculated as the area (evaluated by numerical integration) beneath the entire force displacement. Bioyield deformation and maximum breaking dilatation were calculated by using computer program. The bioyield forces, bio yield stress, bioyield deformation and maximum breaking dilatation were determined by using the force curves (Ince et al., 2005, Chattopadhyay and Pandey 1999, Galedar et al., 2008 and Chen at al., 2004).

Burada, F_b uygulanan yük, N; I destekler arasındaki mesafe, mm; δ örnek merkezindeki sapma, mm ve I_b eğilme momenti $mm^{4'}$ dür.

Maksimum deformasyon toplam uzamanın soya fasulyesi gövdesinin ilk uzunluğuna oranı olarak tarif edilmiştir. Maksimum kuvvetteki maksimum enerji ve akma noktasındaki maksimum enerji kuvvet-deformasyon eğrisinin altında kalan alan yardımı ile hesaplanmıştır. Akma deformasyon ve maksimum deformasyon bilgisayar programı kullanılarak hesaplanmıştır. Akma kuvveti, akma gerilimi, akma deformasyonu ve maksimum deformasyon kuvvet-deformasyon eğrisi kullanılarak belirlenmiştir (Ince et al., 2005, Chattopadhyay and Pandey 1999, Galedar et al., 2008 and Chen at al., 2004).

RESULT and DISCUSSION

A sample force-deformation curve of the soybean stalk was shown (Fig. 2). "The curve illustrated three sections: A, B and C, representing compression only, compression and cutting and cutting only, respectively. In section A, the force increased from zero at the moment of initial contact between the knife and the stem, and then decreased due to the failure in stem structure (collapse of the hollow core). The compression continued in section B along with cutting as the knife moved. When the force reached its peak, pure cutting took place in section C and the force dropped as the cutting was completed".

All of mechanical parameter of soybean stalk were shown in Table 1.

SONUÇ ve TARTIŞMA

Soya sapının Kuvvet-deformasyon eğrisi Şekil 2'de gösterilmiştir. "Eğri A, B, C sırasıyla sıkıştırma, sıkıştırma ve kesme ve sadece kesme olarak 3 bölge ye ayrılmıştır. A bölgesinde bıçak ve gövde arasındaki ilk temasta kuvvet sıfır noktasından artmaya baslar daha sonra gövde yapısı nedeniyle azalır. Bıçağın hareketiyle birlikte kesme işlemiyle sıkıştırma B bölgesinde devam eder. Kuvvet en üst noktaya ulaştığı zaman, C bölgesinde kesme gerçekleşir ve kuvvet kesme işleminin tamamlanmasıyla düşer".

Soya sapının tüm mekanik parametreleri Tablo 1'de gösterilmiştir.

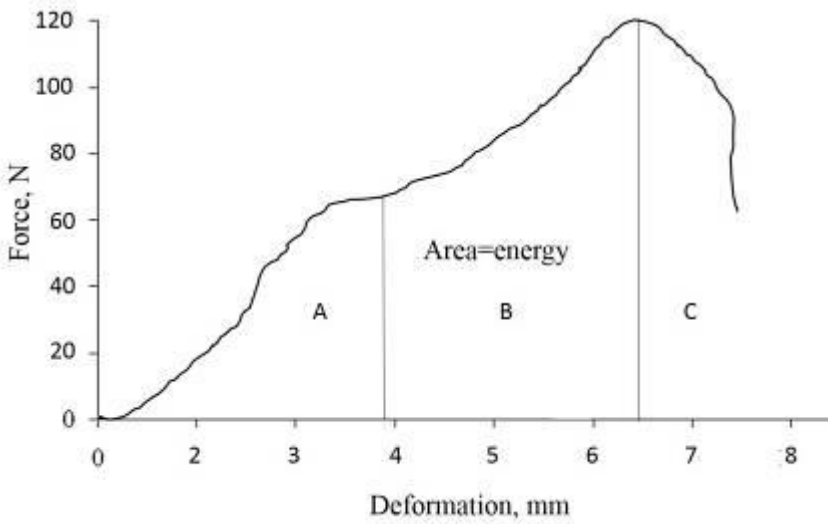


Fig 2. The force versus displacement curve for soybean stalk/Soya sapının kuvvete karşı yer değişimi eğrisi

Deformation Parameters

Changes in deformation parameters such as bioyield deformation and maximum breaking dilatation are shown in Table 1.

The highest bioyield deformation was 5.86 mm with an average of 3.92 mm and The maximum breaking dilatation was 6.44 mm. Maximum breaking dilatation increased ductility of the material (Gere and Timoshenko 1997).

Shear Strength

The values for F_{max} ranged from 81.35 to 119.87 N with an average of 108.54 N which is much higher than that of sesame stalk (a section) (99.77 N) (Yilmaz et al., 2009). The values of the shear stress for the soybean stalks are within the range of 8.89 to 11.06 MPa. The average value of the energy E_{cut} required to cut a soybean stalk was 819.17 J which was at the higher range of that for hemp (2.1 J) (Chen at al., 2004).

Deformasyon Paremetreleri

Akma noktası deformasyonu ve maksimum kesilme deformasyonu gibi deformasyonla ilgili parametreler Tablo 1'de gösterilmiştir.

En yüksek akma noktasındaki deformasyon 5.86 mm, ortalama değeri ise 3.92 mm'dir ve maksimum kesilme deformasyonu ise 6.44 mm'dir. Maksimum kesilme deformasyonu materyalin esnekliği ile artış gösterir (Gere and Timoshenko 1997).

Kesme Dayanımı

Maksimum kesme kuvveti değeri 81.35 ile 119.87 N arasında değişmekle birlikte ortalama değer 108.54 N ile susam sapının (a bölgesi) kesilme kuvvetinden (99.77 N) yüksektir (Yilmaz et al., 2009). Soya sapının kesme gerilimi değeri ise 8.89 ile 11.06 MPa arasında değişmiştir. Kesme enerjisi ise 819.17 J ile kenevir sapının kesme enerjisinden (2.1 J) yüksektir (Chen at al., 2004).

Table1/Tablo 1.

The average values of mechanical parameters for soybean stalk/Soya sapı için mekanik parametrelerin değerleri

	Minimum (En düşük)	Maximum (En yüksek)	Average/Ortalama
Shear force/Kesme kuvveti (N)	81.33	119.87	108.54
Shear stress/Kesme gerilmesi (MPa)	8.89	11.06	9.71
Energy in shear point/Kesme enerjisi (J)	661.09	976.98	819.17
Bioyield force/Akma kuvveti (N)	42.63	69.15	61.33
Bioyield stress/Akma gerilmesi (MPa)	6.65	8.47	7.71
Energy in bioyield point/Akma enerjisi (J)	312.17	581.44	416.21
Bending force/Eğme kuvveti (N)	23.11	30.09	28.74
Bending stress/Eğme gerilmesi (MPa)	15.84	24.27	19.71
Bioyield deformation/Akma deformasyonu (mm)	2.17	5.86	3.92
Breaking dilatation/Maksimum deformasyon (mm)	3.51	6.44	5.23

Bioyield strength

The values for bioyield force ranged from 42.63 to 69.15 N with an average of 61.33 N which is lower than that of sesame stalk (a section) (70.26 N) (Yilmaz et al., 2009). The values of the bioyield stress for the soybean stalks are within the range of 6.65 to 8.47 MPa. The average value of the bioyield energy required to cut a

Akma Dayanımı

Maksimum Akma noktası kesme kuvveti değeri 42.63 ile 69.15 N arasında değişmekle birlikte ortalama değer 61.33 N ile susam sapının (a bölgesi) kesilme kuvvetinden (70.26 N) düşüktür (Yilmaz et al., 2009). Soya sapının Akma noktası kesme gerilimi değeri ise 6.65 ile 8.47 MPa arasında değişmiştir. Kesme enerjisi ise 416.21 J ile

soybean stalk was 416.21 J which was at the higher range of that for sesame stalk (a section) (192.79 J) (Yilmaz et al., 2009).

Bending strenght

The average bending force is 28.74 N and bending force ranged from 23.11 to 30.09 N for soybean stalk. The average value of bending stress for soybean stalk is 19.71 MPa which was at the lower range of that for safflower stalk (41.66 MPa) (Shahbazi and Galedar 2012).

CONCLUSIONS

Some key points for this study can be summarized as follows.

1)The average value of max shearing force is 108.54 N and average shear stress is 9.71 MPa. The average value of the energy E_{cut} required to cut a soybean stalk was 819.17 J

2) The average value for bioyield force is 61.33 N and average bioyield stress is 7.71 MPa. The average value of the bioyield energy required to cut a soybean stalk was 416.21 J

3) The average bending force is 28.74 N and the average value of bending stress for soybean stalk is 19.71 MPa, .

4) Also, the highest bioyield deformation was 5.86 mm with an average of 3.92 mm and the maximum breaking dilatation was 6.44 mm for soybean stalk.

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susam sapının (a bölgesi) kesme enerjisinden (192.79 J) yüksektir (Yilmaz et al., 2009).

Eğme dayanımı

Soya sapının ortalama eğilme kuvveti 28.74 N ve bu değer 23.11 ile 30.09 N arasında değişim göstermektedir. Ortalama eğilme dayanımı değeri is 19.71 MPa ve aspir sapının eğilme dayanımından (41.66 MPa) daha düşük bir değerdedir (Shahbazi and Galedar 2012).

SONUÇLAR

Bu araştırma için bulunan bazı önemli noktalar aşağıda açıklanmıştır.

1)Ortalama kesme kuvveti 108.54 N ve ortalama kesme gerilmesi ise 9.71 MPa'dır. Soya fasulyesi sapının kesilmesi için gerekli olan enerji ise 819.17 J'dur.

2)Akma noktasındaki ortama kuvvet 61.33 N ve ortama akma gerilmesi ise 7.71 MPa'dır. Soya sapının akma noktasındaki kesme enerjisi ise 416.21 J'dur.

3)Soya sapları için ortalama eğme kuvveti 28.74 N ve ortama eğime gerilimi ise 19.71MPa'dır.

4)Ayrıca, akma noktasındaki en yüksek deformasyon 5.86 mm, ortalama 3.92 mm ve maksimum uzama ise 6.44 mm'dir.

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DETERMINATION OF SOME MECHANICAL PROPERTIES FOR OILSEEDS USING UNIAXIAL COMPRESSION TESTS
/
DETERMINAREA UNOR CARACTERISTICI MECANICE ALE SEMINȚELOR OLEAGINOASE UTILIZÂND TESTELE DE COMPRESIUNE UNIAXIALĂ

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Abstract: *Basic knowledge of the behavior of agricultural products to the mechanical forces application is essential for determination of necessary power for various work processes and for the design of machinery, equipment and agricultural installations. This paper presents the results obtained from uniaxial compression tests of sunflower seeds, rapeseeds and safflower seeds. Thus, data for the mechanical characteristics of the three types of oilseeds (force-deformation curve, forces, deformations and energy consumption at the point of shell rupture) were obtained.*

Keywords: *oilseeds, mechanical characteristics, compression test, force-deformation curve, rupture point, energy consumption*

INTRODUCTION

Oilseeds represent the main raw material for vegetable oils extraction. Among the most important oilseed grown in our country there are included sunflower seeds, rapeseeds and safflower seeds.

Oil raw materials are subjected to mechanical forces during the oil extraction process, those forces leading to the seeds deformation. Therefore, the mechanical behavior of oil seeds has an important role in the process of oil extraction, [13].

Compression test represents an objective method for determining the mechanical properties of cereal seed and one of the best techniques for determining the modulus of elasticity by studying their behavior to compression load using force-deformation curve [2,12].

Numerous works have been carried out by researchers in the field in order to highlight the physical and mechanical properties of oilseeds, [1,3,4,5,6,7,8,9,10,11,14].

Thus, numerous works in the literature have been carried out on various oil seeds (sunflower, Moringa, safflower, jatropha, rapeseeds) in order to determine various physical properties (weight, size, average diameter, surface area, sphericity, coefficient of static friction, moisture content) and mechanical properties (elasticity modulus, hardness, rupture force, deformation at the rupture point, consumed energy at rupture) thereof.

Some researchers have studied the dependence of physical and mechanical properties of safflower seeds, [5]. Thus, it was observed that there is a significant dependency between seed mass, mean diameter, sphericity and surface area with the mechanical properties of seeds. However, an insignificant dependence was observed between the mass, the sphericity and the average diameter with the safflower seeds deformation.

Other researchers, [6], studied the influence of the moisture content of sunflower seeds (and for the sunflower kernel) on the seeds behavior during compression tests and, also, the influence of seed

Rezumat: *Cunoaşterea fundamentală a comportamentului produselor agricole la solicitările forțelor mecanice este esențială pentru determinarea necesarului de putere pentru diferite procese de lucru, precum şi pentru proiectarea maşinilor, echipamentelor şi instalațiilor agricole. Lucrarea de față prezintă rezultatele obținute în urma testelor de compresiune uniaxială a semințelor de floarea-soarelui, rapiță şi şofrănel. Astfel, au fost obținute date cu privire la caracteristicile mecanice ale celor trei tipuri de semințe oleaginoase (curba forță-deformație, forțele, deformațiile şi consumul de energie în punctul de rupere a cojii).*

Cuvinte cheie: *semințe oleaginoase, proprietăți mecanice, test de compresiune, curba forță-deformație, punct de rupere, consum de energie*

INTRODUCERE

Semințele oleaginoase constituie principala materie primă pentru obținerea uleiurilor vegetale. Printre cele mai importante semințe oleaginoase cultivate în țara noastră, se numără semințele de floarea-soarelui, rapiță şi şofrănel.

Materiile prime oleaginoase sunt supuse unor forțe mecanice în timpul procesului de extragere a uleiului, aceste forțe conducând la deformarea semințelor. De aceea, comportamentul mecanic al semințelor oleaginoase are un rol important în procesul de extragere a uleiului, [13].

Testul de compresiune reprezintă o metodă obiectivă de determinare a proprietăților mecanice ale semințelor de cereale şi una dintre cele mai bune tehnici de determinare a modulului de elasticitate prin studiul comportării acestora la solicitările de comprimare, utilizându-se curba forță-deformație, [2,12].

Numeroase lucrări au fost realizate de cercetătorii din domeniu pentru a evidenția proprietățile fizice şi mecanice ale semințelor oleaginoase, [1,3,4,5,6,7,8,9,10,11,14].

Astfel, mai multe lucrări din literatura de specialitate au fost realizate asupra diferitelor semințe oleaginoase (semințe de floarea-soarelui, moringa, şofrănel, jatropha, rapiță) în vederea determinării diferitelor proprietăți fizice ale acestora (masa, dimensiunile, diametrul mediu, aria suprafeței, sfericitatea, coeficientul static de frecare, conținutul de umiditate) şi a proprietăților mecanice (modulul de elasticitate, duritatea, forța de rupere, deformația în punctul de rupere, energa consumată la rupere).

Unii cercetători au studiat dependența dintre proprietățile fizice şi mecanice ale semințelor de şofrănel, [5]. Astfel, s-a observat că există o semnificativă dependență între masa semințelor, diametrul mediu, sfericitatea şi aria suprafeței cu proprietățile mecanice ale semințelor. Însă, o dependență nesemnificativă a fost observată între masă, sfericitate şi diametrul mediu cu deformația semințelor de şofrănel.

position during compression. Thus, it was observed that the rupture force of the seeds and kernels decreased with increasing the moisture content and the force value was higher for the seed in vertical position compared to tests carried out with seeds in horizontal position. Another paper, [11], studied the influence of moisture content on the physical and mechanical properties of sunflower seeds and kernels.

Knowing the importance of the mechanical properties of oilseeds, this paper presents the results obtained from uniaxial compression tests of sunflower seeds, rapeseeds and safflower seeds.

MATERIAL AND METHOD

For conducting the experiments were used sunflower, rape and safflower oilseeds. For the three types of seeds were carried out measurements on samples of 10 seeds in order to determine moisture content, oil content, the principal dimensions and mass of the seed. The moisture content of the seeds was determined by MAC 110 thermobalance and had values from 4.65 to 4.77% for sunflower, 4.75 to 5.05% for rape or 5.19 to 5.49 % to safflower.

Using solvent extraction method was determined oil content of the seed and the following values were obtained: from 46.90 to 47.70% for sunflower, from 41.10 to 41.40 and from 34.23 to 37% for rapeseed, 01% for safflower. Measurement of the three main dimensions of seed (length, width and thickness), was performed using a digital caliper with precision of 0.01 mm, and then determined the individual seeds mass with Kern 572 electronic scales, having the accuracy 10^{-3} g.

To determine the mechanical properties of oilseeds (sunflower, rapeseed and safflower) was used the Hounsfield/Tinius Olsen mechanical tests machine, model H1 KS, which enables the mechanical properties for a wide range of materials (wood, vegetable products, metal, plastic, textile, leather, ceramics, etc.). The main components of the machine are: support columns; a fixed flat plate to support material sample; pressing head with movable flat plate parallel to the base plate; display, adjustment and control panel; force cell; data acquisition system (computer) with QMAT software (fig. 1).

The seeds subjected to uniaxial compression are arranged between two parallel planes plate of the device, and on the movable plate is placed the 1 kN force cell that is fixed to the movable traverse for registering the displacement. Resistant force of the tested material sample is measured by a force cell, which can be changed easily and quickly by means of a special mechanism, depending on the material being tested. For the displacement measuring, the device has an accuracy of ± 0.0001 mm, and the movement speed can take values between 0,001 mm/min and 1000 mm/min. From the research in the studied field, it was concluded that for the compression test on oilseed the movement speed has to be constant at the value of 1 mm·min^{-1}.

Alți cercetători, [6], au studiat influența conținutului de umiditate al semințelor de floarea-soarelui (dar şi al miezului de floarea-soarelui) asupra comportamentului semințelor în timpul testelor de compresiune, precum şi influența poziției semințelor în timpul comprimării. Astfel, s-a observat că forța la rupere pentru semințele şi miezul de floarea-soarelui a scăzut cu creşterea conținutului de umiditate, iar valoarea forței a fost mai mare pentru semințele aflate în poziție verticală, față de testele realizate în poziție orizontală. Şi în lucrarea [11], a fost studiată influența conținutului de umiditate asupra proprietăților fizice şi mecanice ale semințelor şi miezului de floarea-soarelui.

Cunoscând importanța proprietăților mecanice ale semințelor oleaginoase, lucrarea de față prezintă rezultatele obținute în urma testelor de compresiune uniaxială a semințelor de floarea-soarelui, rapiță şi şofrănel.

MATERIAL ŞI METODĂ

Pentru realizarea experimentelor au fost utilizate seminte oleaginoase de floarea-soarelui, rapiță şi şofrănel. Pentru cele trei tipuri de semințe au fost efectuate determinări pe eşantioane de câte 10 semințe pentru stabilirea conținutului de umiditate, a conținutului de ulei, a dimensiunilor principale şi a masei semințelor. Conținutul de umiditate al semințelor a fost determinat cu ajutorul termobalanței MAC 110 şi a avut valori de 4,65-4,77% pentru floarea-soarelui, 4,75-5,05% pentru rapiță, respectiv 5,19-5,49% pentru şofrănel.

Utilizând metoda extracției cu solvent, a fost determinat conținutul de ulei al semințelor, fiind obținute următoarele valori: 46,90-47,70% pentru floarea-soarelui, 41,10-41,40% pentru rapiță şi 34,23-37,01% pentru şofrănel. Măsurarea celor trei dimensiuni principale ale semințelor (lungime, lățime şi grosime), a fost realizată utilizându-se un şubler digital cu precizia de 0,01 mm, iar apoi s-a determinat masa individuală a semințelor cu o balanță electronica, Kern 572, cu precizia de 10^{-3} g.

Pentru determinarea proprietăților mecanice ale semințelor oleaginoase (floarea-soarelui, rapiță şi şofrănel) a fost utilizat aparatul pentru încercări mecanice Hounsfield/Tinius Olsen, model H1 KS, care permite determinarea unor proprietăți mecanice pentru o gamă variată de materiale (lemn, produse vegetale, metal, plastic, textile, pielărie, ceramică, etc.). Principalele părți componente ale utilajului sunt: coloanele de susținere; placa plană fixă de susținere a probei de material; capul de presare cu placă plană mobilă paralelă cu placa de bază; panoul de operare, reglare şi control; celula de forță; sistemul de achiziție de date (computer) cu software-ul QMAT, (fig.1).

Semințele supuse încercărilor la compresiune uniaxială sunt aşezate între cele două plăci plane paralele ale aparatului, iar pe placa mobilă se fixează celula de forță de 1 kN care este fixată pe bara transversală mobilă pentru înregistrarea deplasării. Forța rezistentă a probei de material supusă testării este măsurată cu celula de forță, care poate fi schimbată uşor şi rapid printr-un mecanism special, în funcție de materialul supus testării. Pentru măsurarea deplasării, dispozitivul are o precizie de ±0,0001 mm, iar viteza de deplasare poate fi cuprinsă între 0,001 mm/min şi 1000 mm/min. În urma cercetărilor din domeniu analizate, s-a ajuns la concluzia ca pentru testul de compresiune asupra semințelor oleaginoase să fie folosită o viteză de deplasare constantă cu valoarea de 1 mm·min^{-1}.

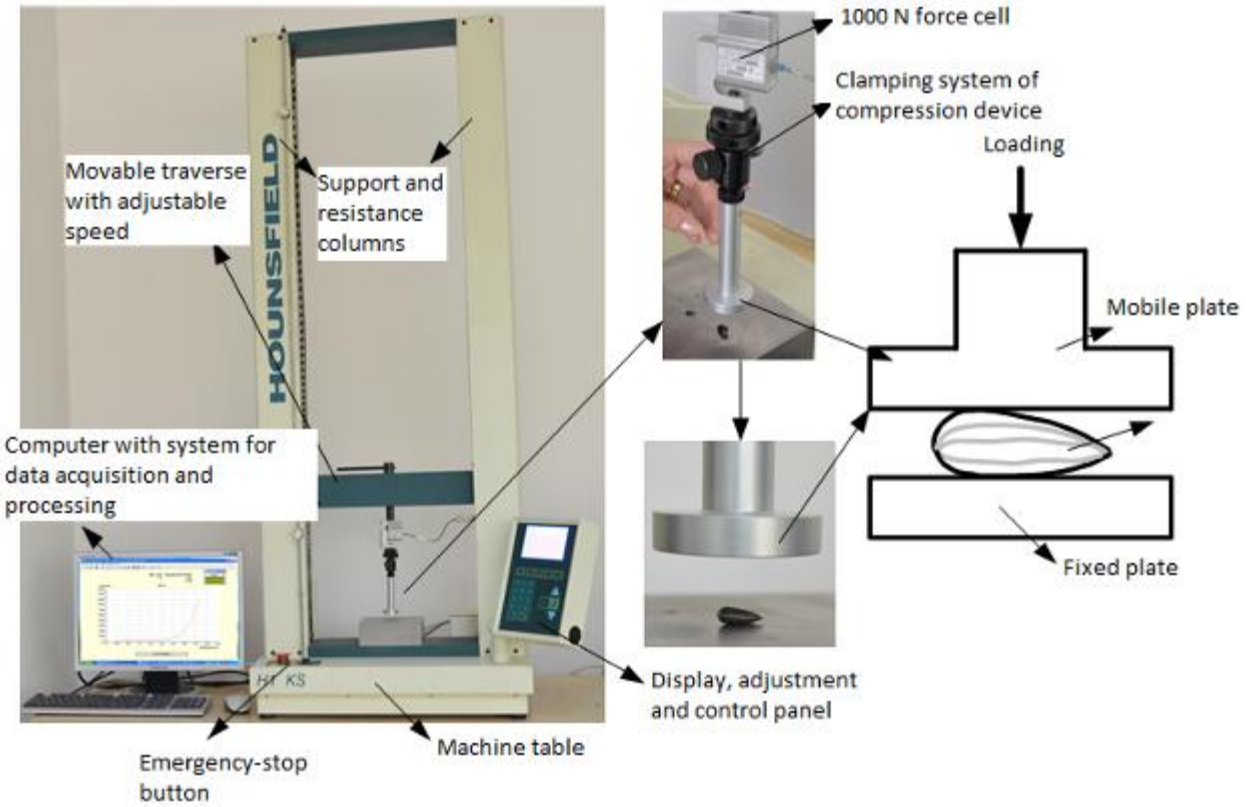

Fig. 1 – Hounsfield/Tinius Olsen model H1 KS device for mechanical tests

After the compression tests on the 30 oilseeds (10 sunflower seeds, 10 rapeseeds and 10 safflower seeds) for which has been previously determined dimensional characteristics, the characteristic force-displacement curves were obtained on which has been read the deformation values, force and energy consumed at different moments of compression and, also, the curve slope to shell rupture point (fig. 2).

The seeds were placed on the fixed plate of the machine in stable horizontal position and the speed of the mobile plate was set at 1 mm/min. The force and displacement values are obtained and saved by Qmat software of the mechanical testing device used in the compression test. Point "1" on the force-displacement curve (fig. 2) is the point where the oilseeds shell rupture occurred, here being observed a sharp drop of the force. Beyond that point, the seed kernel started to be compressed, this process taking place until the point "2" where the maximum force has been reached (about 1030 N), since the force cell was of 1 kN.

From the obtained graph the characteristic forces for the two points could be read, as well as the displacements and consumed energy at those moments. The energy consumption for each of the two points is determined by calculating the area under the curve, starting from the point where the force increases to the desired point. The curve slope up to the rupture force was traced starting from the point where the force begins to increase and to the point "1" when the shell rupture occurs.

După realizarea testelor de compresiune asupra celor 30 de semințe oleaginoase pentru care s-au determinat anterior caracteristicile dimensionale (10 semințe de floarea-soarelui, 10 de rapiță şi 10 de şofrănel), au rezultat curbele forță-deformație caracteristice pe care s-au citit valorile deformației, forței şi consumului de energie în diferite momente ale compresiunii, precum şi panta curbei până la momentul spargerii cojii (fig.2).

Semințele au fost aşezate pe placa fixă a aparatului, în poziție orizontală stabilă, iar viteza de deplasare a plăcii mobile a fost stabilită la 1 mm/min.Valorile forțelor şi deformațiilor sunt date şi salvate de către softul (Qmat) aparatului de încercări mecanice folosit în testul de compresiune. Punctul ”1” de pe curba forță-deformație (fig.2) este punctul în care a avut loc ruperea cojii semințelor oleaginoase, aici având loc o scădere bruscă a forței. Dincolo de acest punct, s-a trecut la comprimarea miezului semințelor, acest proces având loc până în punctul ”2” în care s-a atins valoarea maximă a forței (aproximativ 1030 N), având în vedere că celula de forță a fost de 1 kN.

De pe graficul obținut au putut fi citite forțele caracteristice pentru cele două puncte, precum şi deformațiile şi energia consumată până la momentele respective. Energia consumată pentru fiecare din cele două puncte se stabileşte prin planimetrarea suprafeței aflate sub curbă, plecând din punctul de creştere a forței până în punctul dorit. Panta curbei până la forța de rupere a fost trasată plecând din punctul în care forța începe să crească şi până în punctul ”1”, când are loc spargerea cojii.

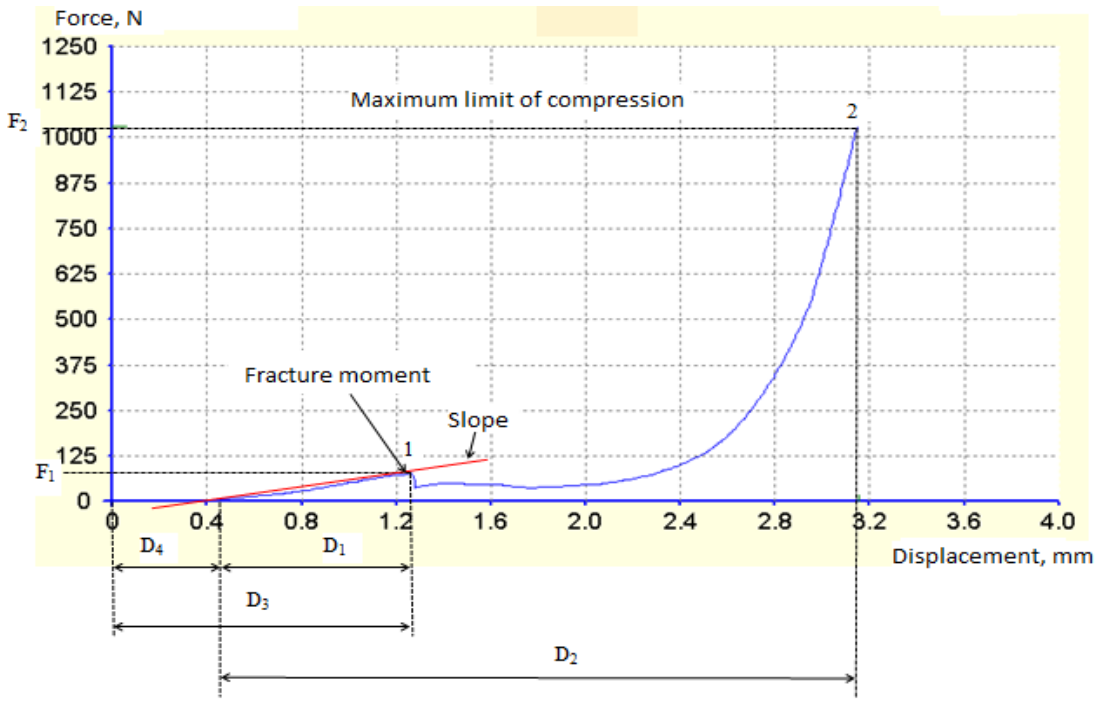

Fig. 2 – The force-strain curve and its characteristic points

RESULTS

In Tables 1, 2 and 3 are presented the values of force, deformation, consumed energy and slope read from the force-deformation curves for sunflower seeds, rapeseeds and safflower seeds.

From the analysis of force-deformation curves obtained on the computer for the 30 oleaginous seeds, 10 from each seeds type, it was found that not all had the same point of origin for the displacement. In order to start from the zero all the curves, both for horizontally and vertically positions, the acquired data were processed in Excel and experimental curves were redrawn.

REZULTATE

În tabelele 1, 2 şi 3 sunt prezentate pentru semințele de floarea-soarelui, rapiță şi şofrănel valorile forțelor, deplasărilor, energiilor consumate şi pantelor citite de pe curbele forță-deformație.

Din analiza curbelor forță-deformație, obținute pe calculator pentru cele 30 de semințe de plante oleaginoase, câte 10 din fiecare tip, s-a constatat că nu toate au avut acelaşi punct de origine al deplasării. Pentru ca toate curbele să pornească de la valoarea zero, atât pe orizontală, cât şi pe verticală, datele achiziționate au fost prelucrate în programul Excel şi au fost retrasate curbele experimentale.

Table1

Measured and calculated values for sunflower seeds from the compression tests

Nr. crt.	F_1, (N)	F_2, (N)	Deformation, (mm)					Slope, (N/mm)	Energy, (J)	
			D_{max}	D_1	D_2	D_3	D_4		E_1	E_2
1	51,3	1030	3,272	1,121	2,909	1,484	0,363	43,18	0,0201	0,4610
2	47,5	1027	3,060	0,945	2,720	1,285	0,340	48,58	0,0155	0,4140
3	58,8	1030	3,420	0,856	3,156	1,120	0,264	66,60	0,0205	0,3374
4	75,0	1029	3,312	0,944	2,964	1,292	0,348	77,50	0,0269	0,5260
5	46,3	1026	3,780	0,996	3,416	1,360	0,364	43,84	0,0175	0,4930
6	53,8	1030	2,860	0,779	2,520	1,119	0,340	72,20	0,0203	0,4228
7	60,0	1028	3,352	0,960	2,980	1,332	0,372	60,10	0,0217	0,4927
8	45,0	1029	3,752	1,056	3,388	1,420	0,364	40,13	0,0144	0,5390
9	51,3	1026	3,240	0,956	2,924	1,272	0,316	52,00	0,0202	0,4774
10	57,5	1030	3,832	1,144	3,424	1,552	0,408	48,80	0,0219	0,5200

Table2

Measured and calculated values for rapeseeds from the compression tests

Nr. crt.	F_1, (N)	F_2, (N)	Deformation, (mm)					Slope, (N/mm)	Energy, (J)	
			D_{max}	D_1	D_2	D_3	D_4		E_1	E_2
1	11,25	1029	1,88	0,336	1,550	0,662	0,326	26,04	0,0031	0,3524
2	7,50	1028	1,98	0,340	1,624	0,696	0,356	14,71	0,0022	0,3467
3	10,00	1030	1,93	0,462	1,594	0,798	0,336	16,23	0,0027	0,3395
4	8,75	1028	2,11	0,365	1,785	0,690	0,325	17,12	0,0020	0,3450
5	16,25	1026	2,30	0,621	1,993	0,928	0,3075	22,16	0,0039	0,3407
6	12,50	1026	2,13	0,363	1,823	0,670	0,3075	27,59	0,0037	0,3368
7	7,50	1026	2,30	0,298	1,945	0,653	0,355	16,78	0,0023	0,3358
8	11,25	1029	2,26	0,408	1,925	0,743	0,335	21,45	0,0030	0,3341
9	16,25	1029	2,17	0,611	1,883	0,893	0,2825	24,57	0,0036	0,3358
10	11,25	1030	1,97	0,336	1,614	0,692	0,356	26,04	0,0032	0,3355

Table3

Measured and calculated values for safflower seeds from the compression tests

Nr. crt.	F_1, (N)	F_2, (N)	Deformation, (mm)					Slope, (N/mm)	Energy, (J)	
			D_{max}	D_1	D_2	D_3	D_4		E_1	E_2
1	42,5	1024	3,128	0,5	2,84	0,788	0,288	80	0,0168	0,3924
2	26,3	1029	2,86	0,332	2,572	0,62	0,288	71,5	0,0155	0,3303
3	45	1024	3,208	0,628	2,876	0,96	0,332	67,7	0,0159	0,4167
4	42	737	2,800	0,74	2,536	1,004	0,264	53,7	0,0145	0,2805
5	36,3	1027	3,472	0,788	3,072	1,188	0,4	60,5	0,0168	0,4044
6	53,8	1029	2,940	0,596	2,584	0,952	0,356	83,9	0,0197	0,397
7	78,8	1030	3,152	0,856	2,752	1,256	0,4	87,6	0,0212	0,3966
8	52,5	1025	3,120	0,764	2,788	1,096	0,332	63,8	0,0187	0,3626
9	61,3	1027	3,328	0,504	3,024	0,808	0,304	114,1	0,0218	0,4538
10	45	1027	3,088	0,58	2,792	0,876	0,296	71,1	0,0202	0,4465

Further, there are presented the mean values force-deformation curves for the three types of seeds used in the experiments. Thus, in fig. 3 can be seen that the shell rupture for sunflower occurs between 1.112 and 1.504 mm for deformation and between 40.6 to 62 N for force, values which were read on the mean force-deformation curves.

In the case of rapeseeds, the mean values of deformation and force at rupture point were between 0.271 and 0.561 mm, respectively 8.75 and 9.88 N, values that are much lower than those for the of sunflower seeds. It also notes that the mean deformation and force values at shell rupture for safflower seeds have higher values than those for rapeseeds i.e., 0.512 to 0.944 mm, respectively 34.65 to 39.28 N.

The slope of force-deformation curve till the rupture point of the shell, represents the elasticity of the shell, but must take into account that under the shell is the kernel (in contact with the shell) that also opposes resistance to crushing (or shell rupture). For this reason we cannot express a direct relation between the curve slope and the shell or kernel elasticity.

În continuare, sunt prezentate curbele valorilor medii forță-deformație pentru cele trei tipuri de semințe utilizate la determinările experimentale. Astfel, în fig. 3 se poate observa că spargerea cojii de floarea-soarelui are loc între valorile 1,112-1,504 mm pentru deformație şi între 40,6-62 N pentru forță, valori citite de pe curbele medii forță-deformație.

În cazul semințelor de rapiță valorile medii ale deformațiilor şi forțelor la spargerea cojii au fost între 0,271-0,561 mm, respectiv 8,75-9,88 N, valori care sunt cu mult mai mici decât cele pentru semințele de floarea-soarelui. De asemenea, se observă că deformațiile şi forțele medii la spargerea cojii semințelor de şofrănel au valori mai mari decât cele pentru semințele de rapiță şi anume, 0,512-0,944 mm respectiv 34,65-39,28 N.

Panta curbei forță-deformație, până la punctul în care învelişul s-a spart, arată elasticitatea acesteia, dar trebuie să ținem seama că sub înveliş se află miezul (în contact cu coaja) care şi el opune rezistență la sfărâmare (sau la spargerea învelişului). Din acest motiv nu putem exprima o legătură directă între panta curbei şi elasticitatea cojii sau a miezului.

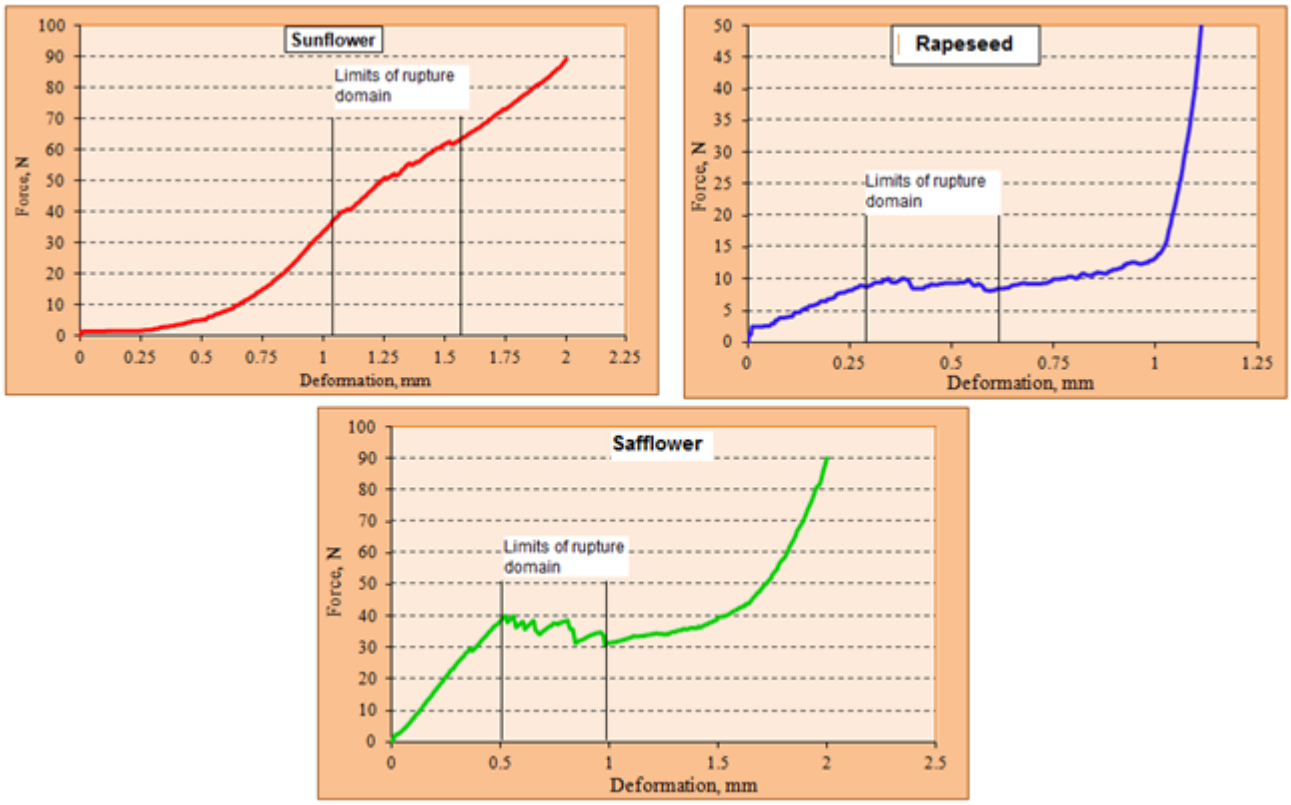

Fig. 3 - Average force-deformation curve for the three types of oilseeds

To establish a correlation between slope and rupture energy E_1 was performed in Microsoft Excel, a regression analysis using linear variation law. Fig. 4 presents the variation of rupture energy depending on the slope, for the three types of oilseeds. As a result of the regression analysis, it was found that the best correlation between slope and rupture energy is shown by rapeseeds (R^2=0.647), and the lowest correlation was obtained for sunflower seeds (R^2=0.528).

In fig. 4 is also shown another regression analysis using linear variation law in Microsoft Excel which has been made to establish a correlation between the force and the energy to the shell rupture point, F_1 and E_1, obtained from the compression tests on which the three types of oilseeds have been subject to. Analyzing the figure can be seen that the best correlation was obtained for sunflower seeds with R^2=0.873, while safflower seeds had the lowest correlation with R^2=0.605.

Relatively low values of correlation coefficients show the dispersion of experimental data points (curve slope-consumed energy) which are distributed in a very wide area. It is evident, therefore, that not all culture seeds are developed the same and the different climatic conditions are affecting this phenomenon. It is further said that at the same plant the seeds are not developed equally, which is closely related to seeds position on stalk, capitulum or on circular rows of the capitulum.

For this reason, the seeds do not have similar dimensions or mechanical characteristics in a narrow range of values.

A real image of these ranges of values could be obtained on a large number of experiments (on the same seeds culture) without a selection of them.

However, the obtained values can be helpful for processors, in order to achieve a proper adjustment of the machine, but also for designers and builders to

Pentru a stabili o corelație între panta şi energia la rupere E_1 a fost realizată în programul Microsoft Excel, o analiză de regresie utilizând legea de variație liniară. În fig.4 este prezentată variația energiei la rupere în funcție de panta, pentru cele trei tipuri de semințe oleaginoase. În urma analizei de regresie realizate, s-a constatat că cea mai bună corelație dintre panta şi energia la rupere este prezentată de semințele de rapiță (cu R^2=0,647), iar cea mai slabă corelație s-a obținut în cazul semințelor de floarea-soarelui (cu R^2=0,528).

Tot în fig.4 este prezentată o altă analiză de regresie utilizând legea de variație liniară în Microsoft Excel care a fost realizată pentru a stabili o corelație între forța şi energia în punctul de rupere a cojii, respectiv F_1 şi E_1, obținute la testele de compresiune la care au fost supuse cele trei tipuri de semințe oleaginoase. Analizând figura se poate observa că cea mai bună corelație s-a obținut pentru semințele de floarea-soarelui, cu R^2=0,873, în timp ce semințele de şofrănel au avut cea mai mică corelație, cu R^2=0,605.

Valorile relativ mici ale coeficienților de corelație arată dispersia valorilor punctelor experimentale (panta curbei-energie) care se distribuie într-un domeniu foarte larg. Este evident, deci, faptul că nu toate semințele aceleiaşi culturi sunt la fel de dezvoltate, iar condițiile pedo-climatice diferite sunt cele care influențează acest fenomen. Mai este de spus că nici la aceeaşi plantă semințele nu prezintă acelaşi grad de dezvoltare, aceasta fiind în strânsă legătură cu poziția seminței pe tulpină, pe capitul sau pe rândurile circulare ale capitulului.

Din acest motiv, semințele nu au nici dimensiuni apropiate şi nici caracteristici mecanice într-un domeniu restrâns de valori.

O imagine mai reală a acestor domenii de valori ar putea fi obținută pe un număr mai mare de experimente (semințe ale aceleiaşi culturi) fără o selecție a acestora.

optimal establish the actuators.

Totuşi, valorile obţinute pot fi de ajutor procesatorilor pentru reglarea corespunzătoare a maşinilor, dar şi proiectanţilor şi constructorilor pentru stabilirea optimă a elementelor de acţionare.

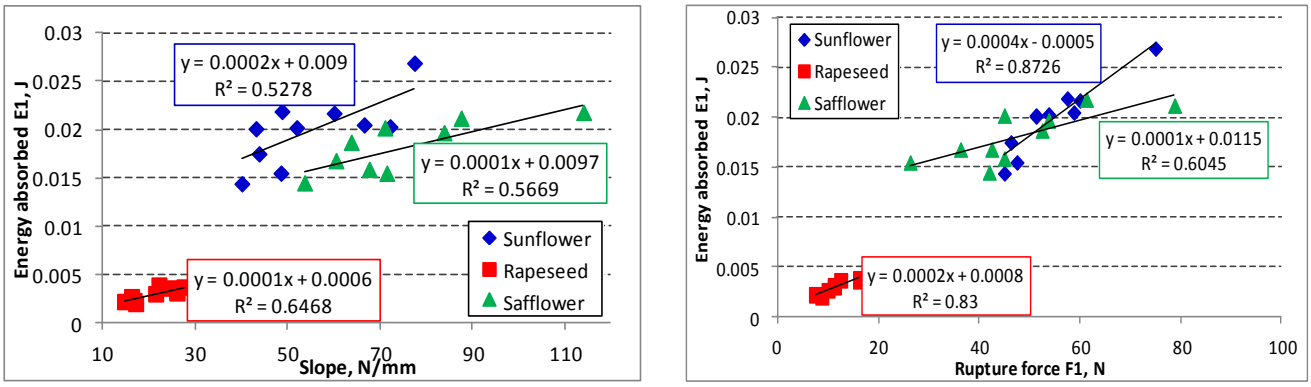

Fig. 4 - Variations of the energy absorbed E1 with the slope/rupture force, for the three types of oleaginous seeds

CONCLUSIONS

Using the force-deformation curves of the uniaxial compressive tests (realized on the thickness of the sunflower and safflower seeds) may be obtained precious information on the mechanical characteristics of seeds, regarding the shell rupture force (taking into account the influence of kernel resistance), total deformation until rupture, the necessary energy (or consumed to deformation), seeds elasticity (in assembly), deformation limits and shell rupture forces for a mixture of seeds, etc.

Thus, the necessary force for sunflower seeds shell rupture was within the limits of 45-75 N, while for safflower seed was in the range of 26.3-78.8 N and for rapeseed was from 7.5 to 6.3 N.

For these rupture forces registered by the device, total seeds deformation was 2.9-3.8 mm for sunflower, 2.8 to 3.5 mm for safflower and 1,9-2.3 mm in the case of rapeseeds.

Energy consumed for seeds rupture shows a linear correlation with the rupture force (with a high degree of correlation especially for rapeseed and sunflower), falling in the ranges $(1,4\text{-}2,7)\cdot10^{-2}$ J for sunflower, $(1,5\text{-}2,2)\cdot10^{-2}$ J for safflower and $(0,2\text{-}0,4)\cdot10^{-2}$ J for rapeseeds.

The elasticity of the seed as a whole, expressed by the value of the curve slope until the moment of breakage (rupture) of the shell shown also values in relatively wide limits. Thus, the sunflower seeds showed elasticity values within the limits of 40.1-77.5 N/mm, 53.7- 114.1 N/mm for safflower and between 14.7 and 27.6 N/mm for rapeseeds.

Knowing the values of the mechanical characteristics of oilseeds are really useful both for manufacturers, but especially for operators of equipments used for oil extraction from oilseeds.

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CONCLUZII

Cu ajutorul curbelor forţă-deformaţie din testele de compresiune uniaxială (pe grosimea seminţelor de floarea-soarelui şi de şofrănel) se pot obţine informaţii preţioase referitoare la caracteristicile mecanice ale seminţelor, atât în ceea ce priveşte forţele de spargere a cojii (ţinând seama şi de influenţa rezistenţei miezului), deformaţia totală până în acest moment, energia înmagazinată (sau depusă pentru deformare), elasticitatea seminţei (în ansamblu), limitele deformaţiei şi forţelor pentru spargerea cojii pentru un amestec de seminţe, etc.

Astfel, forţa depusă pentru spargerea învelişului la seminţele de floarea-soarelui s-a încadrat în limitele 45-75 N, în timp ce la seminţele de şofrănel acest interval a fost de 26,3-78,8 N, iar la seminţele de rapiţă forţa de spargere a fost de 7,5-6,3 N.

Pentru aceste forţe de spargere înregistrate de aparat, deformaţia totală a seminţelor a fost de 2,9-3,8 mm la floarea-soarelui, 2,8-3,5 mm la şofrănel şi s-au încadrat în intervalul 1,9-2,3 mm la rapiţă.

Energia de spargere a seminţelor prezintă o corelaţie liniară cu forţa depusă (cu un grad ridicat de corelaţie mai ales la rapiţă şi floarea-soarelui), încadrându-se în intervalele de valori: $(1,4\text{-}2,7)\cdot10^{-2}$ J la floarea-soarelui, $(1,5\text{-}2,2)\cdot10^{-2}$ J la seminţele de şofrănel şi $(0,2\text{-}0,4)\cdot10^{-2}$ J la seminţele de rapiţă.

Elasticitatea seminţelor în ansamblu, exprimată prin valoarea pantei curbei până la momentul spargerii (fisurării) învelişului a prezentat, de asemenea, valori în limite relativ largi. Astfel, pentru seminţele de floarea-soarelui elasticitatea a prezentat valori în limitele 40,1-77,5 N/mm, 53,7-114,1 N/mm la şofrănel şi între 14,7-27,6 N/mm la seminţele de rapiţă.

Cunoaşterea valorilor caracteristicilor mecanice ale seminţelor de plante oleaginoase sunt de un real folos atât constructorilor, dar mai ales utilizatorilor de maşini de procesat aceste seminţe în vederea extragerii uleiului.

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FALLING NUMBER VS. LIQUEFACTION NUMBER IN ALFA-AMYLASE ACTIVITY ESTIMATION FOR BAKERY FLOUR
/
INDICELE DE CĂDERE VS. INDICELE DE LICHEFIERE ÎN ESTIMAREA ACTIVITĂȚII ALFA-AMILAZICE DIN FĂINURILE DE PANIFICAȚIE

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Abstract: *One of the main indicators of quality of grain flours is the enzyme content. Amylases and proteases are the main enzymes which are found in the composition of the flour. Alpha-amylase and beta-amylase are the main amylases, which have a particularly important role in maintaining the fermentation process. The role of alpha-amylase enzyme is to act on the starch molecules, converting them into dextrins, to the action of beta-amylase is converted into maltose - substrate fermenter for yeast. Alpha-amylase activity in grain flour is determined by the method of the Falling Number (Hagberg). The method is based on reducing the viscosity of the gel obtained by thermal treatment of a suspension of flour in water, under the action of alpha-amylase. Speed liquefaction of flour with water sample depends on enzyme activity. The falling number is the total time (in seconds) required of mixing and falling of a stirrer through flour gel by a certain distance in a viscometer. For the assessment of the activity of alpha-amylase from a mixture of two or more types of flour, so that no errors and for the production of bakery products of good quality, it is recommended that the falling number to be converted in the liquefaction number.*

This paper presents the results of experimental researches on falling number and liquefaction number variation determined for a mixture of rye flour and wheat flour (FA 650).

Keywords: *falling number, liquefaction number, alpha-amylase activity, flour mixture, anzymes,*

Rezumat: *Unul dintre principalii indicatori de calitate ai făinurilor de cereale este conținutul în enzime. Principalele enzime care se găsesc în componența făinii sunt amilazele şi proteazele. Principalele amilaze sunt reprezentate de alfa-amilaza şi beta-amilaza, cu rol deosebit de important în întreținerea procesului de fermentare. Rolul enzimei alfa-amilaza este de a acționa asupra moleculelor de amidon, transformându-le în dextrine, care sub acțiunea beta-amilazei sunt transformate în maltoză – substratul fermentator pentru drojdie. Activitatea alfa-amilazei din făina de cereale se determină prin metoda indicelui de cădere (Falling Number, Hagberg). Metoda se bazează pe reducerea vâscozității gelului obținut prin prelucrarea termică a unei suspensii de făină în apă, sub acțiunea alfa-amilazei. Viteza de lichefiere a probei de făină cu apă depinde de activitatea enzimatică. Indicele de cădere reprezintă timpul total (exprimat în secunde) necesar amestecării si căderii unui agitator prin gelul de făină pe o anumită distanță, într-un vâscozimetru. În cazul estimării activității alfa-amilazei dintr-un amestec format din două sau mai multe tipuri de făină, pentru a nu exista erori şi pentru obținerea unor produse de panificație de bună calitate, este recomandat ca indicele de cădere să fie transformat în indice de lichefiere.*

În această lucrare sunt prezentate rezultatele cercetărilor experimentale privind variația indicelui de cădere şi a indicelui de lichefiere pentru un amestec de făină de secară cu făină albă de grâu (FA 650).

Cuvinte cheie: *indice de cădere, indice de lichefiere, activitate alfa-amilazică, amestec de făină, enzime,*

INTRODUCTION

To obtain good quality bakery products it is necessary to use high-quality flour. The quality of flour depends on the quality of cereal, which is given by the content and quality of protein, starch quality, carbohydrate, lipids and enzyme content. Nevertheless, the quality requirements of flour varies by type (cereal type – wheat, rye), destination, and technological process.

Biochemical composition of flour (enzyme content) is a good indicator in determining the quality of bakery products. The most important enzymes in the grain flour are amylases (acts on starch molecule) and proteases (proteins transformed into simple compounds). The best known of amylases which are in wheat flour composition are alpha-amylase and beta-amylase, with the very important technological role. They hydrolyse starch to soluble dextrins and maltose (sugar - fermenter substrate for the yeast), ensuring the formation of a quantity of gas necessary for the fermentation of the dough.

Amylase action continues during the baking process, on the gelatinized starch granules due to the presence of water and high temperature [1,4].

The optimum temperatures for action of alpha-amylase are 60-66°C, and the starch is gradually gelatinized starting with temperature of 55°C.

INTRODUCERE

Pentru obținerea unor produse de panificație de calitate bună este necesar să se folosească făină de bună calitate. Calitatea făinii depinde de calitatea cerealelor, care este dată de conținutul şi calitatea proteinelor, calitatea amidonului, glucidelor, lipidelor şi conținutul în enzime. Cu toate acestea, cerințele de calitate ale făinii diferă în funcție de tipul acesteia (tipul cerealei – grâu, secară), destinație, proces tehnologic de prelucrare.

Compoziția biochimică a făinii (conținutul în enzime) este un bun indicator în stabilirea calității produselor de panificație. Cele mai importante enzime din făina de cereale sunt amilazele (acționează asupra moleculei de amidon) şi proteazele (transformă proteinele în compuşi simpli). Cele mai cunoscute dintre amilazele care se găsesc în compoziția făinii de grâu sunt alfa-amilaza şi beta-amilaza, cu rol tehnologic foarte important. Acestea hidrolizează amidonul în dextrine solubile şi maltoză (zahărul - substratul fermentator pentru drojdie), asigurând astfel formarea unei cantități de gaze necesare procesului de fermentare a aluatului. Acțiunea amilazelor continuă şi în timpul procesului de coacere, asupra granulelor de amidon gelatinizate datorită prezenței apei şi temperaturii ridicate [1,4]. Temperaturile optime de

The degree of gelatinisation affect the quality characteristics of bread and duration of aging.

Thus,at a high alpha-amylase activity are obtained bakery products with sticky crumb, flattening trend, inelastically, sweet and dark crust.

When the alpha-amylase activity is low, it is obtained undeveloped bread with pale crust [1].

The quality of flour varies from year to year because the amylase activity is significantly affected by climaticr conditions as during the biological maturation of grain seeds, as weel as during harvesting.

Thus, the flours from grains harvested at high temperatures (vitreous, dry grains) are poor in enzymes content, and those from grain harvested under wet climate (sprouted grain) are richer in enzymes (activity of alpha-amylase is of 10-200 times higher than normal flour) [1].

The flour should have an optimal level of enzyme activity in order to obtain products of good quality.

Rye flour, compared to wheat flour, contains large amounts of alpha-amylase. At the same time, the rye starch, at the same alpha-amylase activity is degraded to a greater extent than wheat starch.

Rye flour starch is less resistant to the action of alpha-amylase than the starch from the wheat flour [1,6].

Rye starch gelatinization starts at a temperature lower than that of wheat starch [2,5].

These aspects cause greater amounts of dextrin and therefore obtain a rye bread with sticky and inelastically crumb [1]. Therefore, in most cases, in the production of rye bread is used wheat flour mixed with rye flour.

To determine the activity of alpha-amylase from cereal flours may be used various methods: viscosimetric, turbidimetric, colorimetric substrate colored gel diffusion and reducing sugar. The most used of the methods is the method of falling number or index number (Falling Number, Hagberg 1961). It is a worldwide standardized method for determining the activity of the enzyme alpha-amylase (AACC 56-81B, ICC 107/1, ISO / DOS 3093) in wheat, rye and flour obtained from these grains. The method of the falling number (Falling Number) is a viscosimetric method, based on the autolytic degradation of starch in the flour by alpha-amylase in a distilled water suspension of flour, under certain conditions of time and temperature [1,3,4]. Speed liquefaction of flour with water sample depends on the enzyme activity.

The falling number is the total time (in seconds) required of mixing and falling of a stirrer through flour gel by a certain distance in a viscometer.

The value of falling number is inversely relationship to the activity of alpha-amylase [1,3,4,6,8]. Thus, values of falling number comprised within the range 60÷150 s characterize a wheat flour with increased amylase activity, obtained from sprouted grain. It can be used only in combination with other flours with big falling number.

Flour with falling number of 150÷220 s has a higher amylase activity than normal and they require a correction by mixing with other flours with greater falling number or by using particular methods of bread manufacturing.

Flours showing falling number between 220÷280 s are those with normal amylase activity.

If the falling number is greater than 280 ÷ 300 s, then

acțiune a alfa-amilazei sunt 60-66°C, iar amidonul este progresiv gelatinizat începând cu temperatura de 55°C. Gradul de gelatinizare influențează caracteristicile de calitate ale pâinii şi durata de învechire. Astfel, la o activitate alfa-amilazică mare se obțin produse de panificație cu miez lipicios, tendință de aplatizare, neelastic, dulceag şi cu coaja de culoare închisă. Iar când activitatea alfa-amilazică este scăzută se obține pâine nedezvoltată cu coaja palidă [1].

Calitatea făinii este diferită de la an la an deoarece activitatea amilazei este afectată semnificativ de condițiile climatice atât din perioada de maturizare biologică a semințelor de cereale, cât şi din perioada de recoltare. Astfel, făinurile provenite din grâne recoltate la temperaturi ridicate (grâne sticloase, uscate) sunt mai sărace în enzime, iar cele care provin de grâne recoltate în condiții climatice umede (grâne încolțite) sunt mult mai bogate în enzime (activitatea alfa-amilazică este de 10-200 de ori mai mare decât la făina normală) [1].

Făina trebuie să aibă un nivel optim de activitate enzimatică pentru a se obține produse de calitate bună.

Făina de secară, în comparație cu făina de grâu, conține cantități mai mari de alfa-amilază. Totodată, amidonul de secară, la aceeaşi activitate a alfa-amilazei, este degradat într-o măsură mai mare decât amidonul de grâu. Amidonul făinii de secară este mai puțin rezistent la acțiunea alfa-amilazei decât amidonul din făina de grâu [1,6].

Gelatinizarea amidonului de secară începe la o temperatură mai scăzută decât cea a amidonului grâului [2,5]. Aceste aspecte determină cantități mai mari de dextrine şi, implicit, obținerea unei pâini de secară cu miez lipicios şi neelastic [1]. De aceea, în majoritatea cazurilor, la fabricarea pâinii de secară se foloseşte făina de grâu în amestec cu făina de secară.

Pentru determinarea activității alfa-amilazei din făinurile de cereale pot fi folosite diverse metode: vâscozimetrice, turbidimetrice, colorimetrice, cu substrat colorat, cu gel de difuziune şi glucid reducător. Cea mai utilizată dintre metode este metoda cifrei de cădere sau indicelui de cădere (Falling Number, Hagberg 1961). Este o metodă standardizată pe plan mondial pentru determinarea activitătii enzimei alfa-amilaza (AACC 56-81B, ICC 107/1, ISO/DOS 3093) la grâu, secară si făinuri rezultate din aceste cereale. Metoda indicelui de cădere (Falling Number) este o metodă vâscozimetrică, bazată pe degradarea autolitică a amidonului din făină, de către alfa-amilază, într-o suspensie de făină în apă distilată, în anumite condiții de timp si temperatură [1,3,4]. Viteza de lichefiere a probei de făină cu apă depinde de activitatea enzimatică.

Indicele de cădere reprezintă timpul total (exprimat în secunde) necesar amestecării si căderii unui agitator prin gelul de făină pe o anumită distanță, într-un vâscozimetru.

Valoarea indicelui de cădere este în relație inversă cu activitatea alfa-amilazei, [1,3,4,6,8]. Astfel, valori ale indicelui de cădere cuprinse în intervalul 60÷-150 s, caracterizează o făină de grâu cu activitate amilazică crescută, obținută din grâne germinate. Poate fi utilizată numai în amestec cu alte făinuri cu indice de cădere mare. Făinurile cu indice de cădere între 150÷220 s prezintă o activitate amilazică mai mare decât cea normală necesitând şi acestea o corecție prin amestecare cu alte făinuri cu indice de cădere mai mare sau prin folosirea unor metode particulare de fabricare a pâinii. Făinurile care prezintă indicele de cădere între 220÷280 s sunt cele cu activitate amilazică normală. Dacă indicele de cădere este mai mare de 280÷300 s, atunci activitatea amilazică a făinii este slabă, iar pâinea

flour amylase activity is weak, and bread made from them is not developed, has small volume and dried crumb, that flour must be corrected with the addition of enzymes [1].

Regarding rye flour, it is considered the normal amylase activity, if there is a falling number of 120÷160 s [5].

Falling number method is widely used in the milling and bakery industry for establishing wheat or flour mixtures with a certain value of falling number or for calculating additions of malt or enzymes in order to obtain higher quality bakery products. To estimate the composition of a mixture of grain or flour with a certain value of the falling number, it is necessary that falling number to be converted into liquefaction number [6,7,11].

Also, in the case of mixtures of flour, it is recommended that alpha-amylase activity to be expressed by the liquefaction number and not by falling number, because the falling number not linearly correlate with amylase activity [6,7,9].

MATERIAL AND METHOD

Determinations of the falling number (FN) were made with device type Falling Number, Sadkiewicz. It was determined falling number of the two kinds of flour - white wheat flour, type 650 (FA 650), and rye flour, as well as falling number for mixtures of these two types of flour in five different proportions (70%, 60%, 50%, 40%, 30%).

Flours used in determinations were obtained at the mill SC ILSA SA Calarasi, Romania.

Experimental measurements were performed according to AACC 56-81B No, ICC No 107/1, ISO/DOS 3093, working methods were presented in the paper [10].

Two determinations were made for each sample, taking the arithmetic result obtained.

Liquefaction number (LN) of samples consisting of mixtures of the two kinds of flour was calculated using the relationship [6,9]:

obținută din acestea nu este dezvoltată, are volum mic şi miez uscat, făina trebuind să fie corectată cu adaos de enzime [1].

În ceea ce priveşte făina de secară, este considerată cea cu activitate amilazică normală dacă se înregistrează un indice de cădere de 120÷160 s [5].

Metoda indicelui de cădere este folosită pe scară largă în industria de morărit şi panificație pentru stabilirea amestecurilor de grâu sau făinuri cu o anumită valoare a indicelui de cădere sau pentru calculul adaosurilor de malț sau enzime în vederea obținerii unor produse de panificație de calitate superioară. Pentru a estima compoziția unui amestec de cereale sau făinuri cu o anumită valoare a indicelui de cădere, este necesar ca indicele de cădere să fie transformat în indice de lichefiere [6,7,11]. De asemenea, în cazul amestecurilor de făinuri, se recomandă ca activitatea alfa-amilazei să se exprimă prin indicele de lichefiere şi nu prin indicele de cădere, deoarece indicele de cădere nu corelează liniar cu activitatea amilazică [6,7,9].

MATERIAL ŞI METODĂ

Au fost efectuate determinări ale indicelui de cădere (FN) cu aparatul de tip Falling Number, Sadkiewicz. S-a determinat indicele de cădere a două tipuri de făină – făină albă de grâu tip 650 (FA 650) şi făină de secară, precum şi pentru amestecuri din aceste două tipuri de făină în cinci procente diferite (70%, 60%, 50%, 40%, 30%).

Făinurile utilizate la determinări au fost obținute la moara SC ILSA SA Călăraşi, România.

Determinările experimentale au fost realizate conform AACC No 56-81B, ICC No 107/1, ISO/DOS 3093, metodica de lucru fiind prezentată în lucrarea [10].

Au fost făcute câte două determinări pentru fiecare probă, luându-se ca rezultat media aritmetică a valorilor obținute.

Indicele de lichefiere (LN) al probelor alcătuite din amestecuri din cele două tipuri de făină, a fost calculat cu relația [6,9]:

$$LN = \frac{6000}{FN - 50} \quad (1)$$

where: 6000 represents a constant; 50 represents the approximate time required to gelatinize the starch of the flour enough to be hydrolyzed by the enzymes, [s]; LN, FN represent liquefaction number and falling number respectively [s].

unde: 6000 ese o constantă; 50 reprezintă timpul aproximativ necesar ca amidonul din făină să gelatinizeze suficient pentru a putea fi hidrolizat de enzime, [s]; LN, FN reprezintă indicele de lichefiere, respectiv cifra de cădere [s].

RESULTS

The results from measurements and calculations are shown in Table 1.

It is observed that the lowest falling number value (76 s) was recorded for rye flour 100% and the highest value (320 s) of falling number has wheat flour FA 650 100%, without the addition of rye flour.

Based on the data presented in Table 1 was drawn graph (Figure 1) the falling number variation and liquefaction number variation according to the proportion of rye flour mixed with wheat flour FA 650.

REZULTATE

Rezultatele obținute în urma determinărilor şi calculelor efectuate sunt prezentate în tabelul 1.

Se observă că cea mai mică valoare a indicelui de cădere (76 s) a fost înregistrată în cazul făinii de secară 100%, iar cea mai mare valoare (320 s) a indicelui de cădere o are făina de grâu FA 650 100%, fără adaos de făină de secară.

Pe baza datelor prezentate în tabelul 1 s-a trasat grafic (figura 1) variația indicelui de cădere şi indicelui de lichefiere în funcție de procentul de făină de secară în amestec cu făina de grâu FA 650.

Table 1

Values of falling number and liquefaction number

Wheat flour FA 650 [%]	Rye flour [%]	Measured and calculation results		Moisture content of flour [%]
		Falling number* [s]	Liquefaction number	
100	0	320	22	13.2
70	30	138	85	
60	40	118	106	
50	50	102	127	
40	60	99	147	
30	70	81	168	
0	100	76	231	11.7

***Values represents mean of two determination**

The data in Table 1 and the allure of graph in Figure 1, indicates that the falling number values decrease with the increase in the percentage of rye flour in mixture with FA 650. At the same time, it can be seen that the liquefaction number values are in inverse relationship with the values of falling number: increases with increasing content of rye flour of mixture consisting of FA 650. Different percentages of rye flour mixed with FA 650 indicates and different amylase activity. As shown in the graph in Figure 1, the liquefaction number has a linear variation with alpha-amylase activity from the mixture of flour - the correlation coefficient being of 0.9508. Falling number not linearly correlate with the activity of alpha-amylase, the best correlation of 0.9376 being for a power function.

Datele din tabelul 1, precum şi alura graficului din figura 1, indică faptul că valorile indicelui de cădere scad cu creşterea procentului de făină de secară din amestecul cu FA 650. Totodată, poate fi observat faptul că valorile indicelui de lichefiere sunt în relație inversă cu cele ale indicelui de cădere: cresc cu creşterea conținutului în făină de secară a amestecului format cu FA 650. Procente diferite de făină de secară în amestec cu FA 650 ne indică şi activități amilazice diferite. După cum se observă pe graficul din figura 1, indicele de lichefiere are o variație liniară cu activitatea alfa-amilazei din amestecul de făină – coeficientul de corelație fiind de 0,9508. Indicele de cădere nu corelează liniar cu activitatea alfa-amilazei, cea mai bună corelație 0,9376 având-o după o funcție putere.

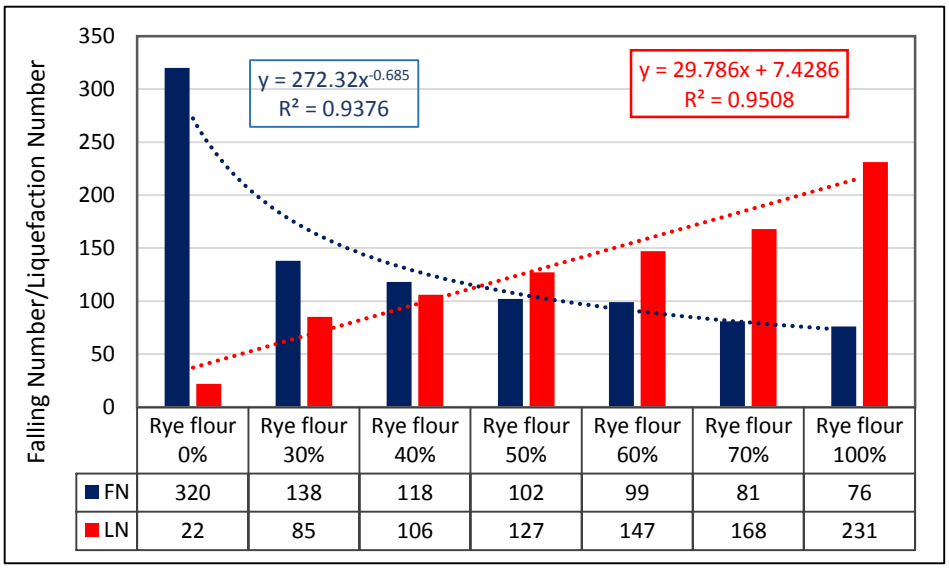

Fig. 1 - Variations of the liquefaction number and falling number for wheat and rye flour mixture

Figure 2 represents the graph of the variation of the falling number according to the liquefaction number for mixture consisting of the two kinds of flour – rye flour and wheat flour FA 650. The allure of graph is the same that is found in other specialty papers. The falling number value decreases with increasing of liquefaction number value. The variation of the falling number with liquefaction number is high in the range 76-138 s - the percentage of rye flour varies from 100% to 30%.

As the value of the falling number approaching that recorded for FA 650 without the addition of rye flour (> 260 s), there is observed a decrease of falling number variation depending on the liquefaction number. Thus, we can say, as shown in the literature, that the falling number values > 250 s, to the achievement of mixtures of flour, can be used directly value of falling number without the necessary liquefaction number calculation. Over this

În figura 2 este prezentat graficul de variație a indicelui de cădere funcție de indicele de lichefiere pentru amestecul alcătuit din cele două tipuri de făină – făină de secară şi făină de grâu FA 650. Alura graficului este aceeaşi pe care o regăsim şi în alte lucrări de specialitate. Valoarea indicelui de cădere scade cu creşterea valorii indicelui de lichefiere. Variația indiceui de cădere cu indicele de lichefiere este mare pe intervalul 76-138 s - procentul de făină de secară variază de la 100% la 30%. Pe măsură ce valoarea indicelui de cădere se apropie de cea înregistrată pentru FA 650 fără adaos de făină de secară (> 260 s), se observă o scădere a variației indicelui de cădere funcție de indicele de lichefiere. Astfel, putem afirma, aşa cum este prezentat şi în literatura de specialitate, faptul că la valori ale indicelui de cădere >250 s, la realizarea amestecurilor de făinuri, poate fi utilizată direct valoarea indicelui de cădere, fără a mai fi necesar

falling number value is not more large errors in estimating the alpha-amylase activity [7].

calculul indicelui de lichefiere. Peste această valoare a indicelui de cădere nu mai apar erori mari în estimarea activității alfa-amilazei [7].

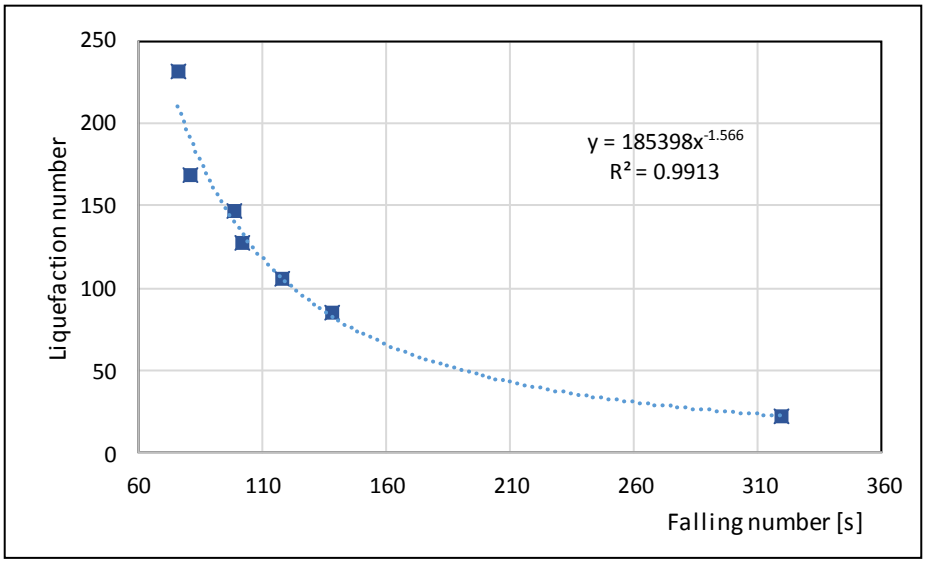

Fig. 2- Variation of the liquefaction number vs. falling number for wheat and rye flour mixture

CONCLUSIONS

Quality of bakery products depends in large measure of the enzymatic activity of flour from which they are obtained. Bread flour amylase activity influences the technological process of manufacturing bakery products, ensuring the proper conduct of fermentation of the dough and the baking process.

To determine the alpha-amylase enzyme activity of flour bread, the most used method is the falling number (Falling Number, Hagberg). For estimating the activity of alpha-amylase for one type of flour is enough to know the falling number of flour and can establish whether the activity of alpha-amylase is high (FN>280 s), low (FN <220 s) or optimum (FN = 220-280 s). If the estimation of the activity of alpha-amylase is made for the mixture of two or more types of flour, depending on the falling number of the batch mixture it is necessary to calculate the liquefaction number.

Analyzing the data allows the following conclusions:

- the falling number value is in inverse relationship with the value of liquefaction number;
- liquefaction number has a linear variation with alpha-amylase activity in flour mixture, while the falling number is not linearly correlate with the activity of alpha-amylase;
- on the graph of Variation of the liquefaction number vs. falling number for wheat and rye flour mixture, it was observed a decrease in the variation of the falling number function of liquefaction number, for falling number values > 260 s;
- to the achievement of mixtures of flour, for falling number values > 250 s, it can be used directly value of falling number without the necessary calculation of liquefaction number, because over this falling number value it is observed thet no longer appear large errors in estimating the alpha-amylase activity.

The research described in this paper may be of importance for specialists in milling and baking, regarding the estimation of the alpha-amylase from a mixture of two

CONCLUZII

Calitatea produselor de panificaţie depinde în mare măsura de activitatea enzimatică a făinii din care sunt obţinute. Activitatea amilazică a făinii de panificaţie influenţează procesul tehnologic de fabricare a produselor de panificaţie, asigurând desfăşurarea corespunzătoare a procesului de fermentaţie a aluatului, precum şi a procesului de coacere.

Pentru determinarea activităţii enzimei alfa-amilaza din făinurile de panificaţie, cea mai folosită metodă este cea a indicelui de cădere (Falling Number, Hagberg). În cazul estimării activităţii alfa-amilazei pentru un singur tip de făină, este suficient să se cunoască indicele de cădere al făinii şi se poate stabili dacă activitatea alfa-amilazei este ridicată (FN > 280 s), scăzută (FN <220 s) sau optimă (FN = 220-280 s). Dacă estimarea activităţii alfa-amilazei se face pentru un amestec de două sau mai multe tipuri de făină, în funcţie de indicele de cădere al loturilor de amestec este necesar să se calculeze indicele de lichefiere.

Din analiza datelor se desprind următoarele concluzii:

- valoarea indicelui de cădere este în relaţie inversă cu valoarea indicelui de lichefiere;
- indicele de lichefiere are o variaţie liniară cu activitatea alfa-amilazei din amestecul de făină, în timp ce indicele de cădere nu corelează liniar cu activitatea alfa-amilazei;
- pe graficul variaţiei indicelui de cădere funcţie de indicele de lichefiere, pentru amestecul de făină, s-a constatat o scădere a variaţiei indicelui de cădere funcţie de indicele de lichefiere, la valori ale indicelui de cădere > 260 s;
- la realizarea amestecurilor de făină, la valori ale indicelui de cădere >250 s, poate fi utilizată direct valoarea indicelui de cădere, fără a mai fi necesar calculul indicelui de lichefiere, deoarece peste această valoare a indicelui de cădere se constată că nu mai apar erori mari în estimarea activităţii alfa-amilazei.

Cercetările prezentate în lucrare pot avea importanţă pentru specialiştii în domeniul morăritului şi panificaţiei, în ceea ce priveşte estimarea alfa-amilazei dintr-un amestec de două sau mai multe tipuri de cereale sau făinuri, în

or more types of grain or flour, in order to obtain quality products.

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vederea obţinerii de produse de calitate. =

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THE INTERDEPENDENCE BETWEEN THE MASS AND APPLES MAXIMUM DIAMETER OF THREE VARIETIES OF APPLES AND THE CORRELATION BETWEEN PARAMETERS COLLISIONS AND INJURIES
/
INTERDEPENDENȚA DINTRE MASA ŞI DIAMETRU MAXIM ÎN CAZUL A TREI SOIURI DE MERE ŞI CORELAREA DINTRE PARAMETRII DE VĂTĂMARE ŞI CIOCNIREA ACESTORA

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Abstract: *Consumption of fresh horticultural products, from which emerges apples, has become a major requirement rational and balanced nutrition. The intake of minerals and vitamins, fruit occupies an important place in the daily diet of human society.*

The value and the quality of fruit is greatly reduced by mechanical injury which may occur both during the harvesting, the temporary storage, the transport as well at sorting - packaging and storage.

This paper aims to determine the correlation between the parameters of the collision and injuries that they produce and the moment when the injuries occur for three varieties of apples. In this context, It was carried out the evaluation of apples injuries observing that, the apple surface, depending on the severity of the injuries, it gets a residual strain, or a modification of coloring in brownish. Depending on the severity of such injuries were established levels of damage (destruction), of apples pulp, which can be correlated with degree of maturity fruit.

Also, experimental data confirm the mathematical model of the dimensions - mass dependence, in the case of the three apple varieties considered, being useful in the activity of adequate choice, of packaging alveolar formwork type for the fractions packing obtained by sorting by their individual weight.

Keywords: *impact, apples, pendulum, injuries*

Rezumat: *Consumul produselor horticole proaspete a devenit o cerință majoră a alimentației raționale şi echilibrate. Prin aportul de substanțe minerale şi vitamine, fructele ocupă un loc important în alimentația zilnică a societății umane.*

Valoarea şi calitatea fructelor este în mare măsură redusă prin vătămarea mecanică ce poate apare atât în timpul recoltării, depozitării temporare, transportului cât şi la sortare – ambalare si depozitare.

Lucrarea de fata şi-a propus determinarea corelației între parametrii ciocnirii şi vătămările pe care le produc şi sesizarea momentului când apar vătămările pentru trei soiuri de mere. In acest context, s-a efectuat evaluarea v ă t ă m ă rilor merelor la impact constatându-se c ă , suprafaț a mă relor, în funcț ie de gravitatea vă tă mă rilor, cap ă t ă o deforma ț ie remanent ă sau o modificare a coloritului în maroniu. În funcție de severitatea acestor vătămări s-au stabilit gradele de lezare (distrugere), a pulpei merelor, ce se pot corela cu gradul de maturitate al fructului.

De asemenea, datele experimentale au confirmat modelul matematic al dependentei dimensiuni – masa, in cazul celor 3 soiuri de mere luate in considerare, fiind util în activitatea de alegere adecvată a ambalajelor de tip cofraje alveolare pentru ambalarea fracțiilor obținute prin sortarea după masa lor individuală.

Cuvinte cheie: *impact, mere, pendul, vătămări*

INTRODUCTION

In the chain of activities after the harvest, for exploitation of the fresh fruits agricultural production, they go through a packaging -transport operations (handling) – storage - sorting chain; an important link is the operation of temporary or a long while storage, either for sale, either to preserve.

Both during the harvesting, the temporary storage in orchard, the transport as well at sorting - packaging processes, and at temporary or a long while storage, the fruits are subjected to various mechanical stress. The most common injuries of the apples, are produce by impacts (shocks), that take place between fruit themselves and / or between them and surfaces that come in contact with the respective mechanical systems, [11].

The value (class) and the quality of fruit is greatly reduced by mechanical injury, by crushing (contusion) of the tissue, by the occurrence of the internal cracks in the tissue and by the modification and deformation of the fruit geometric shape (permanent visible deformations), [10].

The tissue injury by contusion, are made mainly, due

INTRODUCERE

În lanțul de activități, după recoltare, pentru valorificarea în stare proaspătă a producției agricole de fructe, acestea suferă un lanț de operații de ambalare-transport (manipulare) – depozitare – păstrare – sortare; o verigă importantă o reprezintă operația de depozitare temporară sau îndelungată, fie în vederea comercializării, fie a păstrării.

Atât în timpul recoltării, depozitării temporare în livadă, transportului în mijloace de transport cât şi în procesele de sortare – ambalare, depozitare de scurtă sau lungă durată, fructele sunt supuse la diverse solicitări mecanice. Dintre solicitările la care sunt supuse fructele, cele mai frecvente sunt ciocnirile (şocurile, impacturile), care au loc între fructele însele şi / sau între acestea şi suprafețele cu care vin în contact în sistemele mecanice respective, [11].

Valoarea (clasa) şi calitatea fructelor este în mare măsură redusă prin vătămarea mecanică, prin strivirea (contuzia) țesutului, prin înțepare, prin apariția fisurilor interne şi crăpăturilor (ruperilor) țesutului şi prin deformarea şi modificarea formei geometrice (deformații permanente vizibile), [10].

Vătămarea prin contuzia țesutului, se datorează în principal şocurilor la care sunt supuse merele conducand la modificarea culorii în maroniu a pulpei însoțită de

the shocks to which the apples are subjected, resulting the brown discoloration in the pulp of the fruit - the major cause of quality loss and consequently the decrease of the sale as fresh products, [1, 7, 8, 9, 10,11].

The concerns are intensified, both worldwide and in our country, to develop a method (which can become standard) for determining a impact behavior parameter of fruit, well defined and underlain, that it provides important useful data, in choosing optimal working regimes of technical systems of sorting - packaging – handling, perfecting and improving their constructive, and in the fields of genetic improvement, in plant breeding, in the techniques of crop growth and development, in the choice of post-harvest treatment of fruit, etc, [3].

Therefore in this paper we determine the parameters that are needed to evaluate the quality of apples (modulus of elasticity of apples, apple texture firmness, the acceleration variation in apple collision (pendulum method), impact force variation, the interdependence between the mass and the maximum diameter of apples).

MATERIAL AND METHOD

To determine the correlation between parameters collisions and injuries they cause and notification when the injuries appears, the Pendulum method has been used. This method reproduces largely the real impact of fruits that takes place in mechanical systems.

The pendulum device was equipped with accelerometer and computing system for experiments to shock of fruits It is shown schematically in fig. 1 and 2. The device has the following parts: 1 – framework; 2 - carbon fiber rod pendulum; 3 - fixed seat on the stem for placing fruit; 4 – the shaft of rod mounted on the bearing; 5,6 - solid block of metal (approx. 10.5 kg), which occurs the collision of fruits; 7 - an accelerometer attached to the rod; 8 - DC measuring amplifier; 9 – computer; 10 – printer; 11 - the horizontality adjustment screws; 12 - release system pendulum rod from different initial positions for impact; 13 – monitor; 14 - signal conditioning; 15 - sector gradually to read the angle of rotation of the rod.

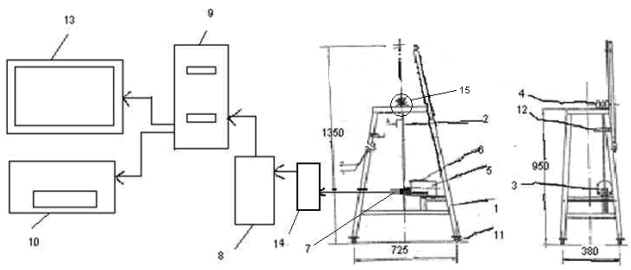

Fig. 1 – Installation and configuration diagram of the device comes with accelerometer and pendulum system calculation

There were defined four categories of injuries that were represented in fig. 3 view, namely: strong injury (fig. 3 – g, detail fig. 4), the middle injury (fig. 3 - d, e), gentle injuries (fig. 3 - c), beginning injury, (fig. 3-b). When examining the samples, were observed and absence of injuries (fig. 3- a).

Following the impact between apple and rigid flat

pătarea suprafeței fructului - cauza majoră a pierderilor de calitate şi în consecință a gradului de reducere a comercializării în stare proaspătă a merelor [1,7,8,9,10,11].

Sunt intensificate preocupările, atât pe plan mondial, cât şi în țara noastră, pentru dezvoltarea unei metode (ce poate deveni standard) pentru determinarea unui indice de comportare la ciocnire al fructelor, bine şi fundamentat definit, care să permită obținerea unor date foarte importante şi utile în alegerea regimurilor optime de lucru a sistemelor tehnice de sortare – ambalare – manipulare, în perfecționarea şi îmbunătățirea constructivă a acestora, în activitatea de proiectare, cât şi în domeniile ameliorării genetice, în selecția soiurilor, în tehnicile de creştere şi dezvoltare a culturilor, în alegerea tratamentului postrecoltare a fructelor, ş.a, [3].

De aceea, în prezenta lucrare vom determina parametrii care sunt necesari pentru evaluarea calității merelor (modulul de elasticitate a merelor, fermitatea texturii merelor, variația accelerației pendulului în momentul ciocnirii, variația forței de şoc în procesul de impact, interdependența dintre masa şi diametrul maxim al merelor).

MATERIAL ŞI METODĂ

Pentru determinarea corelației între parametrii ciocnirii şi vătămările pe care le produc şi sesizarea momentului când apar vătămările, a fost utilizata metoda pendulului. Aceasta metoda reproduce în bună măsură ciocnirea liberă şi reală a fructelor ce are loc în sistemele mecanice.

Aparatul-pendul existent a fost echipat cu accelerometru şi sistem de calcul pentru efectuarea experimentelor la şoc a fructelor. Acesta este prezentat schematic în fig. 1 şi in detaliu în fig. 2. Aparatul are următoarele părți componente: *1* - cadrul; *2* – tija pendulului din fibră de carbon; 3 - scaunul fixat pe tijă pentru aşezarea fructului; *4* - axul tijei montat pe rulmenți; 5,6 - bloc masiv din metal (aprox. 10,5 kg), pe care se produce ciocnirea fructului; 7 –accelerometru, fixat pe tijă; *8* - amplificator de măsură în curent continuu; *9* - calculator; *10* - imprimantă; *11* - şuruburile de reglaj a orizontalității; *12* - sistemul de eliberare a tijei pendulului, din diferite poziții inițiale pentru ciocnire, 13 - monitor, 14 – condiționer de semnal; 15 – sector gradat pentru citirea unghiului de rotație al tijei.

Fig. 2 – View the pendulum device equipped with accelerometer

Au fost definite 4 categorii de vătămări, care au fost reprezentate în vedere în fig. 3, şi anume: vătămări puternice (v. fig.3 –g, detaliu fig. 4), vătămări medii (v. fig. 3- d, e), vătămări uşoare (v. fig. 3 - c), început de vătămare, (v. fig. 3-b). La examinarea probelor au fost observate şi lipsa vătămărilor, (v. fig. 3- a).

În urma impactului dintre măr şi suprafața plană rigidă,

surface, can be observed, on the surface of apple, following the viewing with unaided eye, that, the neighboring area of the impact point of apple, depending on the seriousness of injuries, this one acquires a residual deformation, or the change in brown coloring. The inspection (examination) was performed at 3 and 5 days after impact, to be more visible, by sectioning of impact area and visual analysis of the change in brown of crushed cells (damaged).

This damages was classified depending by the size of the mark on the surface of apples. The result of impact size gives us severity of the injuries. Various grades of damage can be observed, as noted in the views of fig. 3 and fig. 4.

se observă, pe suprafața mărului, în urma vizualizării cu ochiul liber, că, în zona vecină punctului de impact a mărului, în funcție de gravitatea vătămărilor, acesta capată o deformație remanentă, (uneori vizibilă) sau de modificare a coloritului în maro. Examinarea s-a efectuat la 3 şi 5 zile după ciocnire pentru a fi mai vizibile, prin secționarea în zona de impact şi analiza vizuală a modificării în maro a celulelor strivite (vătămate).

Aceste vătămări au fost clasificate în funcție de dimensiunea urmei de pe suprafața mărului. Astfel, dimensiunea urmei de impact ne dă gravitatea vătămărilor. Diferitele grade de vătămare se pot observa, aşa cum s-a menționat, în vederile reprezentate în fig.3 şi fig.4.

a) absence of injuries

b) beginning injury

c) gentle injuries

d) middle injury

e) middle injury

f) strong injury

g) strong injury

Fig. 3 – Different levels of damage after collision

Fig. 4 - Deformation, crushing and brown color in the sample after impact

To perform the experiments regardind the behavior on apples impact on fixed rigid planar surfaces, were chosen three varieties: Jonathan, Golden Delicious and Idared, fig.5, varieties that are provided in the future development strategy of apples cultivation in our country, [5, 6].

Pentru efectuarea experimentărilor privind comportarea la ciocnire a merelor pe suprafețe plane rigide fixe au fost alese trei soiuri: Jonathan, Golden Delicious şi Idared, fig.5, soiuri care sunt prevăzute în strategia dezvoltării viitoare a cultivării merelor la noi în țară, [5,6].

Fig. 5 - Apples used to test with their coding (G – Golden Delicious, I –Idared, J – Jonathan)

These have had the mass in the range: 74-157 g for the Jonathan, 87-159 g for the Golden - Delicious and 99-177 g Idared, and in terms of geometrical sizes - equatorial diameter D are situeted between 56.125 mm and 75.75 mm for Jonathan variety, between 61.11 mm and 76.31 mm for Idared variety, between 58.16 mm and 71.845 mm for Golden Delicious variety, and the height H are situeted between 49.34 mm and 63.10 mm for Jonathan variety, between 47.24 mm and 64.18 mm for Idared variety, and between 52.95 mm and 68.15 mm for Golden Delicious variety.

To perform the impacts were chosen 4 impact velocities: 1.04 m/s, 0.83 m/s, 0.67 m/s and 0.5 m/s.

As experimentation methodology were established nine groups of apples, for each of the 4 collision velocity, and for each variety, using 36 apples. These were weighed, measured, and then subjected to impact. The initial velocities of impact correspond of angles launching θ_i : 25°, 20°, 16°, 12°.

Fruits were selected nearest geometric shape spherical, with values close to unity. In the relation dimension - mass, is useful to know the relation m = f

Acestea au avut mase situate în domeniile: 74 – 157 g pentru Jonathan, 87 – 159 g pentru Golden – Delicious şi 99 – 177 g pentru Idared, iar în ceea ce priveşte dimensiunile geometrice – diametrul ecuatorial D şi înălțimea H – diametrul ecuatoarial s-a situat între 56,125 mm şi 75,75 mm pentru soiul Jonathan, între 61,11 mm şi 76,31 mm pentru soiul Idared, între 58,16 mm şi 71,845 mm pentru soiul Golden Delicious; înălțimea H are valori cuprinse între 49,34 mm şi 63,10 mm pentru soiul Jonathan, între 47,24 mm şi 64,18 mm pentru soiul Idared şi între 52,95 mm şi 68,15 mm pentru soiul Golden Delicious.

Pentru efectuarea ciocnirilor s-au ales 4 viteze de ciocnire: 1,04 m/s, 0,83 m/s, 0,67 m/s si 0,5 m/s.

Ca metodologie de experimentare au fost constituite grupe de câte nouă mere, pentru fiecare din cele 4 viteze de ciocnire, şi pentru fiecare soi, folosindu-se câte 36 de mere. Acestea au fost cântărite, măsurate şi apoi supuse la ciocnire. Vitezele inițiale de ciocnire corespund unghiurilor de lansare θ_i: 25°, 20°, 16°,12°.

Au fost selectate fructe cu forma geometrică cea mai apropiată de forma sferică, având valorile apropiate de

(D_{emax}) to estimate one of the two sizes when it is known other size.

Mass of fruits is defined, in fact, account their geometrical dimensions that are directly influenced by: species, variety, pedo-climatic conditions, culture technology.

Relation of interdependence after [2,4] is:

unitate. În relația dimensiuni – masa, este utilă cunoaşterea relației m = f(D_{emax}) care permite estimarea uneia din cele două mărimi atunci când se cunoaşte cealaltă mărime.

Masa fructelor este definită, de fapt, de dimensiunile lor geometrice care sunt direct influențate de: specie, soi, condiții pedo-climatice, tehnologie de cultură.

Relația de interdependență după [2,4] este:

$$m = A \cdot D_{\max}^{a} \quad (1)$$

where: *m* is the average fruit mass [g];

D_{max} - the maximum equatorial diameter [mm];

A and *a* - experimentally determined coefficients, which depend on growth conditions, species, variety, culture technology.

în care: *m* este masa medie a fructelor [g];

D_{max} – diametrul ecuatorial maxim [mm];

A şi *a* – coeficienți determinați experimental, care depind de condițiile de dezvoltare, specie, soi, tehnologie de cultură.

RESULTS

After analyzing the injuries there were obtained for each of thouse three varieties, results shown in table 1, for Jonathan variety, table 2, for Idared variety, and table 3, for Golden Delicious variety. In these tables have been noted V.P. - strong injuries; V.M - middle injuries; VU - gentle injuries, IV - beginning of injury, NV - absence of injuries. In the last column of these tables are given numeric percentage of injured fruits (considered V.P + V.M + V.U + I.V), of the total fruit collided (9 fruits), for each of velocities Vi (1.04 m/s, 0.83 m/s, 0.67 m/s, 0.5 m/s), used in experiments on each variety.

REZULTATE

În urma analizei vătămărilor s-au obținut pentru fiecare din cele 3 soiuri, rezultatele prezentate în tabelul 1, pentru soiul Jonathan, tabelul 2, pentru soiul Idared, şi tabelul 3, pentru soiul Golden Delicious. În aceste tabele s-au notat V.P. – vătămări puternice; V.M – vătămări medii; V.U – vătămări uşoare, I.V – început de vătămare, N.V – nevătămate. În ultima rubrică a acestor tabele sunt date ponderile procentuale numeric a fructelor vătămate (considerate V.P + V.M + V.U + I.V) din totalul fructelor ciocnite (9 fructe), pentru fiecare din vitezele V_i (1,04 m/s, 0,83 m/s, 0,67 m/s, 0,5 m/s), utilizate la experimentări, pentru fiecare soi

Table 1

The values of parameters for Jonathan variety - initial velocity, mass, initial kinetic energy, the quadratic mean deviation for initial kinetic energy, also for peak force, the injury level, and the share of injuries (p)

Cod No.	Initial velocity (m/s)	m (g)	E_{ci} (J)	E_{ci} mean (J)	σ E_{ci}	F_{max} mean (N)	σ F_{max}	Injury level	p (%)
J1	1.04	83.87	0.045357	0.0572	0.0067	79.60	36.49	V.M	100
J2		92.55	0.050051					V.M	
J3		98.61	0.053328					V.P	
J13		112.87	0.06104					V.P	
J14		119.89	0.064837					V.P	
J15		115.60	0.062516					V.M	
J25		116.32	0.062906					VP	
J26		111.34	0.060213					VP	
J27		102.10	0.055216					VP	
J4	0.83	127.83	0.044031	0.0373	0.0047	71.76	2.34	V.M	89
J5		91.97	0.031679					V.M	
J6		103.96	0.035809					V.M	
J16		133.17	0.04587					V.P	
J17		108.62	0.037414					V.M	
J18		99.09	0.034132					V.M	
J28		106.62	0.036725					VM	
J29		99.16	0.034156					V.U	
J30		104.82	0.036105					VM	
J7	0.67	78.84	0.017696	0.0245	0.0067	55.59	7.08	N.V	67
J8		96.46	0.02165					N.V	
J9		74.23	0.016661					I.V	
J19		112.95	0.025352					I.V	
J20		101.65	0.022815					I.V	
J21		104.06	0.023356					NV	
J31		155.33	0.034864					V.M	
J32		101.49	0.022779					VU	
J33		157.43	0.035335					IV	
J10	0.5	92.39	0.011549	0.0125	0.0018	38.96	4.06	N.V	11
J11		101.06	0.012633					N.V	
J12		82.77	0.010346					N.V	
J22		121.79	0.015224					NV	
J23		108.73	0.013591					NV	
J24		120.38	0.015048					NV	
J34		99.17	0.012396					NV	
J35		89.93	0.011241					IV	
J36		86.53	0.010816					NV	

Table 2

The values of parameters for Idared variety - initial velocity, mass, initial kinetic energy, the quadratic mean deviation for initial kinetic energy, also for peak force, the injury level, and the share of injuries (p)

Cod No.	Initial velocity (m/s)	m (g)	E_{ci} (J)	E_{ci} mean (J)	σ E_{ci}	F_{max} mean (N)	σ F_{max}	Injury level	p (%)
I1	1.04	105.66	0.057141	0.0649	0.0111	98.50	7.68	VM	100
I2		116.74	0.063133					VU	
I3		99.57	0.053847					VU	
I13		158.04	0.085468					VP	
I14		124.78	0.067481					VM	
I15		115.59	0.062511					VM	
I25		107.48	0.058125					VP	
I26		104.04	0.056265					VP	
I27		148.90	0.080525					VP	
I4	0.83	121.62	0.041892	0.0434	0.0060	69.69	14.46	IV	77.8
I5		115.68	0.039846					IV	
I6		160.03	0.055122					VM	
I16		127.17	0.043804					VM	
I17		120.49	0.041503					VM	
I18		137.05	0.047207					VP	
I28		112.11	0.038616					VM	
I29		139.36	0.048003					VP	
I30		100.76	0.034707					VM	
I7	0.67	113.01	0.025365	0.0313	0.0045	64.92	8.32	-	55.6
I8		113.61	0.0255					IV	
I9		146.91	0.032974					-	
I19		134.83	0.030263					IV	
I20		149.81	0.033625					VM	
I21		149.74	0.033609					VM	
I31		120.41	0.027026					NV	
I32		160.82	0.036096					NV	
I33		166.01	0.037261					VM	
I10	0.5	161.83	0.020229	0.0181	0.0038	45.34	12.47	IV	44.4
I11		165.69	0.020711					IV	
I12		139.19	0.017399					NV	
I22		157.23	0.019654					IV	
I23		119.56	0.014945					NV	
I24		130.83	0.016354					NV	
I34		177.48	0.022185					IV	
I35		83.27	0.010409					NV	
I36		171.71	0.021464					IV	

Table 3

The values of parameters for Golden Delicious variety - initial velocity, mass, initial kinetic energy, the quadratic mean deviation for initial kinetic energy, also for peak force, the injury level, and the share of injuries (p)

Cod No.	Initial velocity (m/s)	m (g)	E_{ci} (J)	E_{ci} mean (J)	σ E_{ci}	F_{max} mean (N)	σ F_{max}	Injury level	p (%)
G1	1.04	121.47	0.065691	0.0694	0.0081	68.35	13.48	VP	100
G2		119.21	0.064469					VP	
G3		127.55	0.068979					VP	
G13		150.75	0.081526					VP	
G14		135.52	0.073289					VP	
G15		129.54	0.070055					VM	
G25		146.66	0.0793					VP	
G26		101.08	0.0546					VM	
G27		124.02	0.0670					VP	
G4	0.83	116.84	0.040246	0.039	0.0042	37.99	13.92	VM	89
G5		131.80	0.045399					VP	
G6		113.88	0.039226					VM	
G16		116.58	0.040156					VM	
G17		92.71	0.031934					VU	
G18		121.93	0.041999					VM	
G28		97.85	0.0337					IV	
G29		119.77	0.0412					VM	
G30		108.11	0.0372					VU	
G7	0.67	124.42	0.027926	0.0267	0.0033	25.98	4.48	VM	77.8
G8		106.43	0.023888					VU	
G9		131.35	0.029482					VM	
G19		87.40	0.019617					IV	
G20		123.36	0.027688					VU	
G21		133.44	0.029951					VM	
G31		113.50	0.0254					VM	
G32		124.69	0.0279					VM	
G33		127.95	0.0287					VM	
G10	0.5	98.78	0.012348	0.015	0.0025	26.61	5.16	NV	33.3
G11		106.04	0.013255					IV	
G12		110.65	0.013831					NV	
G22		139.17	0.017396					VU	
G23		159.32	0.019915					VM	
G24		136.23	0.017029					IV	
G34		100.72	0.0125					NV	
G35		117.15	0.0146					VU	
G36		115.96	0.0144					IV	

From this three tables, it can be seen that the initial velocity of 1.04 m/s share of the injury is 100% for the three varieties of apples.

Starting with the initial velocity collision of 0.83 m/s for Golden Delicious and Jonathan varieties, have the same share of injuries, namely 89%, instead for the variety Idared, the share of injuries for this initial collision velocity is 77.8%.

At the initial velocity of 0.67 m/s for Jonathan apple varieties have a 67% share of damage, for the variety Idared 55.6%, and 77.8% for Golden Delicious.

Interesting to notice that 77.8% share of injury to Golden Delicious collision occurs at the initial velocity of 0.67 m/s, instead for the Idared variety the same share of injury occurs at the initial velocity of collision - 0.83 m/s. At this initial velocity, for the Idared variety, there are also undamaged apples.

For initial velocity collision of 0.5 m/s, we have a 11% share of injury for Jonathan variety, 44.4% for Idared variety and 33.3% for Golden Delicious variety.

Using our measurement data, it have been determined the values of the coefficients „A" and „a", for the three varieties of apples, together with the corresponding coefficients correlation R^2. These values are given in table 4.

Din cele trei tabele, se poate observa că pentru viteza inițială de 1,04 m/s ponderea vătămărilor este de 100% în cazul celor trei soiuri de mere.

Începând cu viteza inițială de ciocnire de 0,83 m/s, pentru soiurile Golden Delicious şi Jonathan, avem aceeaşi pondere a vătămărilor, şi anume de 89%, în schimb pentru soiul Idared, ponderea vătămărilor pentru această viteză inițială de ciocnire este de 77,8%.

La viteza inițială de 0,67 m/s pentru soiul de mere Jonathan avem o pondere de vătămare de 67%, pentru soiul Idared de 55,6%, şi pentru soiul Golden Delicious de 77,8%.

Interesant de observat este că ponderea de vătămare de 77,8%, pentru soiul Golden Delicious apare la viteza inițială de ciocnire de 0,67 m/s, în schimb pentru soiul Idared aceeaşi pondere de vătămare apare la viteza inițială de ciocnire de 0,83 m/s. La această viteză inițială, pentru soiul Idared există şi mere nevătămate.

Pentru viteza inițială de ciocnire de 0,5 m/s, avem o pondere de vătămare de 11% pentru soiul Jonathan, de 44,4% pentru soiul Idared şi de 33,3% pentru soiul Golden Delicious.

Utilizând datele măsurătorilor proprii, au fost determinate valorile coeficienților „A" si „a", pentru cele 3 soiuri de mere, împreună cu coeficienții de corelație R^2 corespunzători. Aceste valori sunt date în tabelul 4.

Table 4

Values of the coefficients A, a (eq. 1) and of the correlation coefficients R^2 for the apple varieties: Jonathan, Golden Delicious and Idared

The variety	$A \cdot 10^{-3}$	a	R^2
Jonathan	15.77	2.11	0.899
Golden Delicious	1.48	2.696	0.876
Idared	0.81	2.817	0.829

With these values were represented graphically the variations of estimated masses for 3 varieties of apples (fig. 6 - 8) compared with the experimental data. The values of correlation coefficients $R^2 \geq 0.83$ are acceptable for use eq. 1 at estimating the D_{max} for imposed masses of fruit. For example, we consider the mass m = 115 g, which on the basis eq. 1 is obtained D_{max} = 67.7 mm for Jonathan apples; 65.2 mm for Golden Delicious apples and 67.4 mm for Idared apples, compared with the values obtained by measurements, have a deviation of less than 1%, which shows a good concordance between estimated and measured values.

We also note that the value of 65 mm of Jonathan apples diameter for a mass of 115 g, differ by 4% compared to the estimated value, which is fully acceptable.

Cu aceste valori s-au reprezentat grafic variațiile maselor estimate ale celor 3 soiuri de mere în fig. 6 – 8, comparativ cu datele experimentale. Valorile coeficienților de corelație $R^2 \geq 0,83$ sunt acceptabile pentru utilizarea ec. 1 la estimarea D_{max} pentru mase impuse ale fructelor. Pentru exemplificare, vom considera masa m = 115 g, pentru care pe baza ec. 1 se obține D_{max} de 67,7 mm pentru mere Jonathan ; 65,2 mm pentru mere Golden Delicious şi 67,4 mm pentru mere Idared, valori care în raport cu cele obținute prin măsurători au o abatere sub 1%, ceea ce arată o bună concordanță între valorile estimate şi cele măsurate.

Menționăm, de asemenea, că valoarea de 65 mm a diametrului merelor Jonathan pentru masa de 115 g, diferă cu 4% față de valoarea estimată, ceea ce este pe deplin acceptabil.

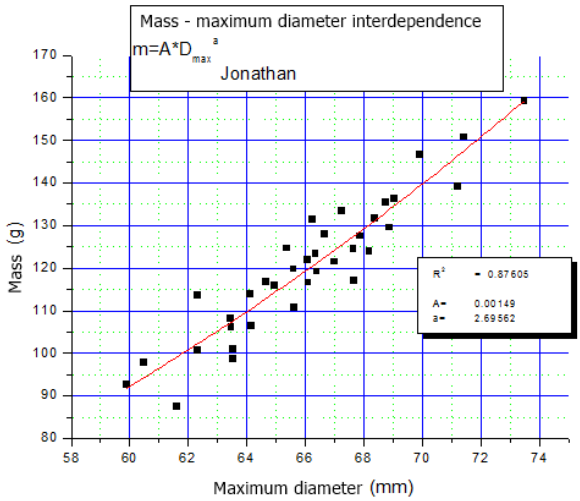

Fig. 6 The interdependence between the mass and the maximum diameter of the Jonathan apples variety

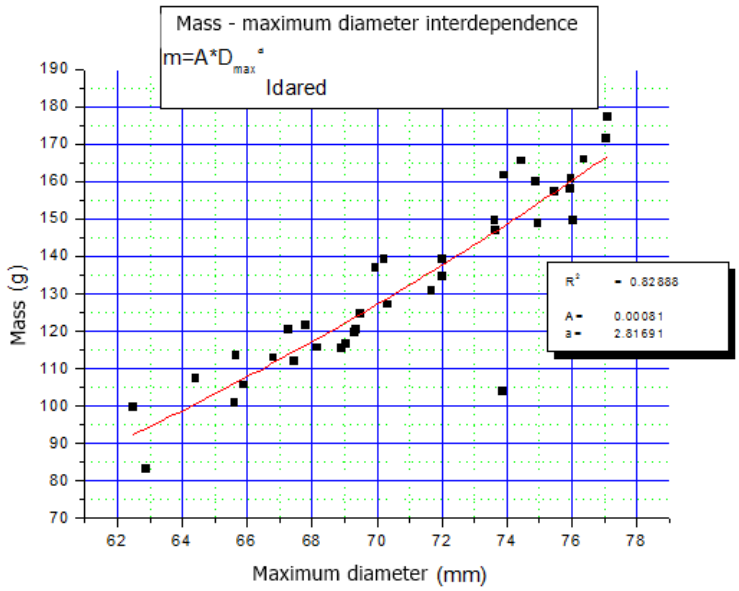

Fig. 7 The interdependence between the mass and the maximum diameter of the Idared apples variety

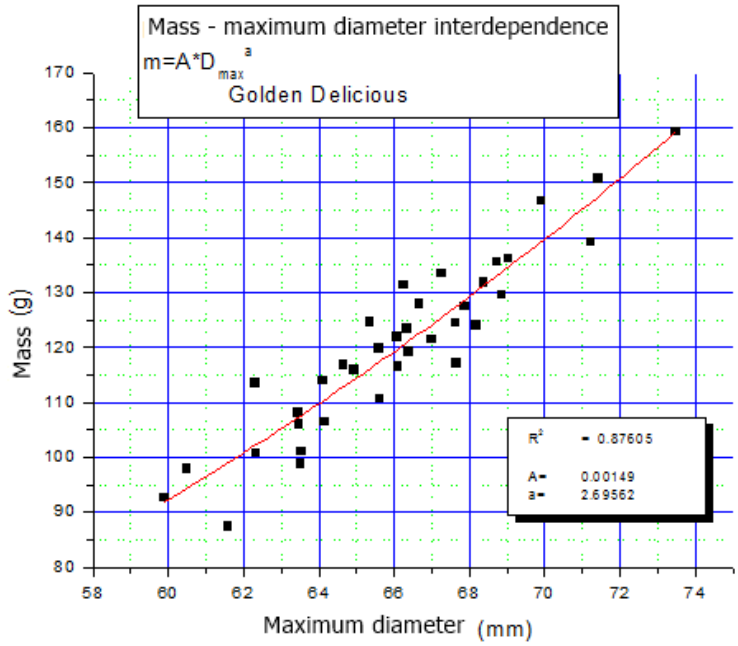

Fig. 8 The interdependence between the mass and the maximum diameter of the Golden Delicious apples variety

We highlight that such relations are useful in the activity of adequate choice, of packaging alveolar formwork type for the fractions packing obtained by sorting by their individual weight.

Depending on the structure of the pulp, texture and chemical composition, at the same values of diameter, fruit mass values differs to some extent.

CONCLUSIONS

The researches envisaged have proposed to develop a method for assessing the quantities that characterize the shock from impact of apples to anticipate the extent of damage to fruit during sorting processes - packaging - handling.

The most useful tool for experimental research of the impact between apples and hard objects is represented by pendulum device, in which it was implemented an accelerometer, coupled to a signal conditioning, to an

Evidențiem faptul că astfel de relații sunt utile în activitatea de alegere adecvată, a ambalajelor de tip cofraje alveolare pentru ambalarea fracțiilor obținute prin sortarea după masa lor individuală.

În funcție de structura pulpei, textură şi compoziție chimică, la aceleaşi valori ale diametrului, valorile maselor fructelor diferă într-o oarecare măsură.

CONCLUZII

Cercetările preconizate şi-au propus dezvoltarea unei metode de evaluare a mărimilor ce caracterizează nivelul şocului la ciocnire a merelor în vederea anticipării gradului de vătămare a fructelor în timpul proceselor de sortare – ambalare – manipulare.

Instrumentul cel mai util pentru cercetarea experimentală a impactului dintre mere şi corpuri dure îl reprezintă dispozitivul cu pendul, în care a fost implementat un accelerometru, cuplat la un condiționer

amplification and electrical signals filtering system and then to a data acquisition plate, connected to the computer, the apparatus being used to obtain accurate results at impact study.

This system of data acquisition and processing uses Labview application, to calibrate the device, to see the results and to process data obtained from experiments performed.

Following the analysis of the obtained experimental data, it was found that for the initial velocity of 1.04 m/s, share of the injury is 100% for the three varieties of apples.

For the initial collision velocity exceeding 0.5 m/s, we can say that the variety Idared is "hard" compared to the other two varieties, and can be used for the technological flow, technical equipments and installations, which would apply speed collision between apple exceeding 0.5 m/s. For the initial collision velocities equal to 0.5 m/s, the Golden Delicious variety, cope better at collisions, compared to the other two varieties.

Also, experimental data confirm the mathematical model of the dimensions - mass dependence, in the case of the three apple varieties considered, being useful in the activity of adequate choice, of packaging alveolar formwork type for the fractions packing obtained by sorting by their individual weight.

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de semnal, la un sistem de amplificare şi filtrare a semnalelor electrice, şi apoi la o placă de achiziție de date, conectată la un calculator, aparatul fiind utilizat în obținerea unor rezultate precise la studiul impactului.

Acest sistem de achiziție şi prelucrare a datelor utilizeaza aplicația Labview, pentru a calibra aparatul, a vizualiza rezultatele şi a prelucra datele obținute la experimentările efectuate.

In urma analizei datelor experimentale obtinute, s-a constatat că pentru viteza inițială de 1,04 m/s ponderea vătămărilor este de 100% în cazul celor trei soiuri de mere.

Pentru viteze inițiale de ciocnire mai mari de 0,5 m/s, putem să spunem, că soiul idared este mai „dur" în comparație cu celelalte două soiuri, putându-se folosi pentru fluxul tehnologic echipamente tehnice si instalatii, care ar putea aplica viteze de ciocnire între mere mai mari de 0,5 m/s. Pentru viteze inițiale de ciocnire egale cu 0,5 m/s, soiul Golden Delicious se comporta mai bine le ciocniri, în comparație cu celelalte două soiuri.

De asemenea, datele experimentale confirma modelul matematic al dependentei dimensiuni – masa, in cazul celor 3 soiuri de mere luate in considerare, fiind util în activitatea de alegere adecvată a ambalajelor de tip cofraje alveolare pentru ambalarea fracțiilor obținute prin sortarea după masa lor individuală.

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THEORETICAL CONTRIBUTIONS TO THE STUDY OF THE DYNAMICS OF ELECTROMAGNETICALLY DRIVEN VIBRATING SEPARATORS USED FOR THE PRIMARY PROCESSING OF CEREALS SEEDS
/
CONTRIBUȚII TEORETICE LA STUDIUL DINAMICII SEPARATOARELOR VIBRATOARE ACTIONATE ELECTROMAGNETIC IN SCOPUL PRELUCRARII PRIMARE A SEMINTELOR DE CEREALE

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Abstract: *Within this paper is presented a mathematical model that allows establishing a movement equation for the work surface of an electromagnetically driven vibrating separator and the determination of the movement parameters specific for this type of separator. Considering a particle of material placed on the work surface, the kinematics of the process is presented depending on the throwing characteristic and, through graphic analysis, the optimal working regime of the electromagnetic vibrating system is emphasized. Also there are mentioned the advantages of using electromagnets for driving the vibrating sieves of technical equipment used for cereal cleaning in view of their processing.*

Keywords: *grains, cleaning, vibrating sieves, electromagnet, vibration amplitude control*

INTRODUCTION

The primary processing represents an important link of the process of capitalization of vegetal-origin products.

The continue progresses obtained in terms of improving the *primary processing methods* and techno-material base periodically determine the substantial increase of exigencies related to lack of foreign substances, seeds uniformity, sanitary state, lot's homogeneity in order to achieve a high quality level of agro-food products [1,7].

The cereal seeds primary processing before the seeds exploitation represents a complex technological process, including several constructive types of technical equipment for separating and removing the impurities existing in the mass seeds (suction separators, winnowers, vibrating separators) [1, 7, 9, 11].

Gravimetric separators built in the shape of oscillating tables provided with sieves, receive oscillating movements that can be generated either with crank-gear mechanisms, vibrating devices with unbalanced eccentric tables or with vibrating devices with electromagnets. [1, 2, 8, 12].

Literature in recent years attests that equipping with vibrating systems driven by electromagnets or by electric motor-vibrators gives to the vibrating platforms used in the transport, separation and dosing of granular agricultural products, high yield and low energy consumption [6, 10].

The paper has as objective to present a mathematical model for determining the movement equation for the work surface of an electromagnetically driven vibrating separator.

MATERIAL AND METHOD

Vibration feeders operation is based on the *micro-cast* effect (fig.1). Particle (seed mass) agitation through

Rezumat: În cadrul acestei lucrări este prezentat un model matematic care permite stabilirea ecuației de mişcare a suprafeței de lucru a unui separator vibrator acționat electromagnetic şi determinarea parametrilor mişcării specifici acestui tip de separator. Considerând o particulă de material aşezată pe suprafața de lucru este prezentată cinematica procesului funcție de caracteristica de aruncare şi este pus în evidență prin analiză grafică regimul optim de funcționare al sistemului vibrant elecromagnetic. De asemenea sunt evidențiate avantajele utilizării electromagneților la acționarea sitelor vibratoare ale echipamentelor tehnice de curățire a cerealelor în vederea procesării.

Cuvinte cheie: *semințe, curățire, site vibratoare, electromagnet, controlul amplitudinii vibrațiilor*

INTRODUCERE

Prelucrarea primară constituie o verigă importantă a procesului de valorificare a produselor de origine vegetală.

Progresele continue pe linia îmbunătățirii *metodelor de prelucrare primară* şi a bazei tehnico-materiale determină periodic sporirea substanțială a pretențiilor față de lipsa corpurilor străine, uniformitatea semințelor, starea sanitară, omogenitatea loturilor în scopul atingerii unui nivel calitativ ridicat pentru produsele agroalimentare [1, 7].

Pregătirea semințelor de cereale şi plante tehnice înainte de procesare reprezintă un proces tehnologic complex, care include mai multe tipuri constructive de echipamente tehnice pentru separarea şi eliminarea impurităților existente în masa de semințe (separatoare aspiratoare, tarare, separatoare vibratoare, etc.) [1, 7, 9, 11].

Separatoarele gravitaționale realizate sub forma unor mase oscilante prevăzute cu site, primesc mişcări oscilatorii ce pot fi generate cu mecanisme bielă-manivelă, cu dispozitive vibratoare cu mase excentrice neechilibrate sau cu dispozitive vibratoare cu electromagneți [1, 2, 8,12].

Literatura de specialitate din ultimii ani atestă că echiparea cu sisteme vibratoare acționate cu electromagneți sau cu motovibratoare electrice conferă platformelor vibratoare utilizate in transportul, separarea si dozarea produselor agricole granulare si pulverulente, un randament ridicat cu un consum energetic redus [6, 10].

Lucrarea isi propune ca obiectiv prezentarea unui model matematic pentru determinarea ecuaţiei de mişcare a suprafeţei de lucru a unui separator vibrator acționat electromagnetic.

MATERIAL ŞI METODĂ

Funcționarea echipamentelor tehnice de separare cu vibrații se bazează pe efectul de "micro – aruncare" (figura 1). Agitarea particulelor (masa de seminte) prin vibrații se

vibrations is usually induced by the means of a chute or of a vibrating platform, tilted in relation to the horizontal plane. The particles are accelerated starting from an established frequency/amplitude vibration ratio; this regime (conditions) of acceleration is used to achieve an upward oriented parabolic throwing movement for the particles, which after a certain displacement hit the chute again [5].

induce de regulă prin intermediul unui jgheab sau platformă vibratoare, înclinată față de orizontală. Particulele sunt accelerate pornind de la un raport frecvență/amplitudine a vibrațiilor stabilit; acest regim (condiții) de accelerare se utilizează pentru a realiza o mişcare de aruncare parabolică orientată în sus a particulelor, care după o deplasare anume lovesc din nou jgheabul [5].

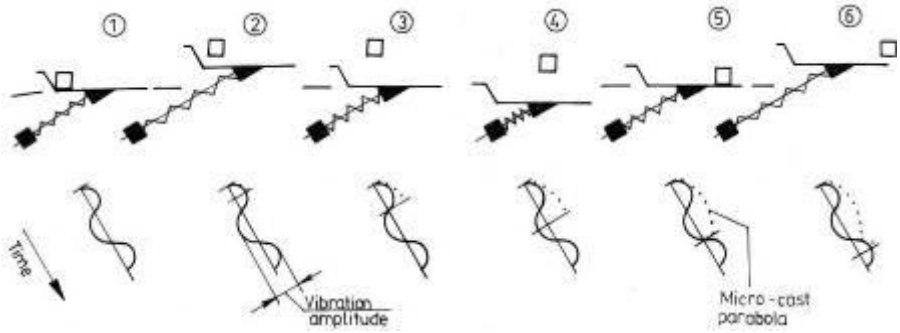

Fig. 1 – Vibration feeders by the micro-cast principle

The most important parameters that influence this process of dislocating particles are the frequency and amplitude of vibrations, the angle between the axle of the excitation and the axle of the chute, the properties of the solid material such as particle dimensions, their shape and distribution, as well as friction [5,10].

The vibrating separator with electromagnetic drive can have the platform (vibrating table) supported on elastic bearer or suspended on springs. For the construction in figure 2, the vibrating table 1 is suspended through the means of helicoidally springs 2 and driven with an electromagnetic vibrator 3 with simple or double construction, with a mobile (induced) part and a reactive (inductor) one. Since the inductor of the vibrator has a significant mass, it is necessary to analyze the transporter as an oscillating system with two masses [2, 7]. In case of using more electromagnetic actuations, the separator with vibrating platform represents a dynamic system with more masses.

Parametrii cei mai importanți care influențează acest proces de dislocare a particulelor sunt frecvența şi amplitudinea vibrațiilor, unghiul dintre axa excitației şi a jgheabului, proprietățile materialului solid cum ar fi dimensiunile particulelor, distribuția şi forma acestora, precum şi frecarea [5,10].

Separatorul vibrator cu acționare electromagnetică poate avea platforma (masa vibratoare) sprijinită pe reazeme elastice sau suspendată pe arcuri. La construcția din figura 2 masa vibrantă 1 este suspendată prin intermediul unor arcuri elicoidale 2. şi antrenată cu un vibrator electromagnetic *3,* în execuție simplă sau dublă, cu parte mobilă (indus) şi reactivă (inductor). Întrucât inductorul vibratorului are o masă semnificativă, este necesar ca transportorul să fie analizat ca un sistem oscilant cu două mase [2, 7]. În cazul folosirii a mai multor acționări electromagnetice, separatorul cu platformă vibrantă reprezintă un sistem dinamic cu mai multe mase.

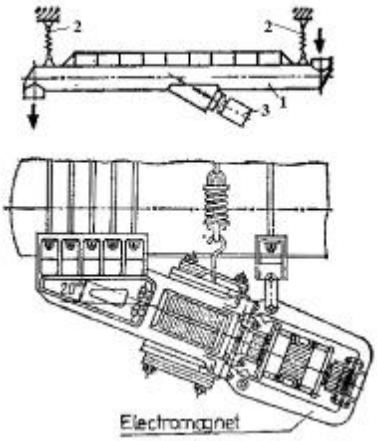

Fig. 2 – Separator with platform actuated with electromagnetic vibrator:
1 - vibrating platform(table); 2 - elastic elements for suspension (springs); 3 - electromagnet for actuation

The simplified diagram for calculating the electromagnetically driven vibrator separator is shown in figure 3. Starting from the principle of d'Alambert transposed for the mechanical system with a degree of liberty, the motion equation for the system in figure 4 takes the form:

Schema simplificată de calcul a unui separator vibrator acționat electromagnetic este prezentată în figura 3. Plecând de la principiul lui d'Alembert transpus sistemului mecanic cu un grad de libertate, ecuația de mişcare a sistemului din figura 3 capătă forma:

$$m\ddot{S} + \mu c\dot{S} + c_1 S = F(t) \quad (1)$$

where:
m is the reduced mass of the separator which includes the mass for mobile part and the adjusting mass;
$c_1 = (c + c_0)$ – reduced rigidity (equivalent) of the system, formed of principal elastic elements' rigidity *c* and rigidity c_0 of vibrator elastic connections.

în care:
m este masa redusă a platformei vibratoare a separatorului, care include şi masa indusului şi masa de reglare;
$c_1 = c + c_0$ – rigiditatea redusă a sistemului, compusă din rigiditatea *c* a elementelor elastice principale şi rigiditatea c_0 a legăturilor elastice ale vibratorului

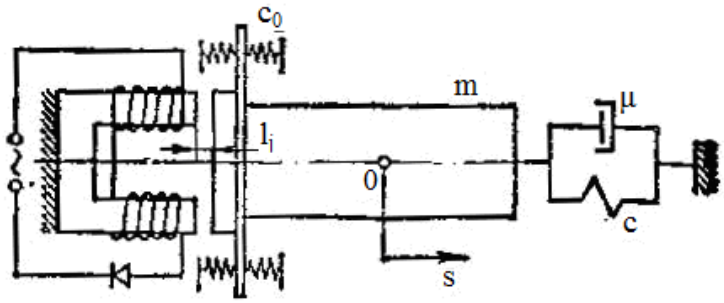

Fig. 3 – Calculus diagram for the separator with platform driven by an electromagnetic vibrator

By replacing the expression of traction force *F*(*t*) in equation (1) with the expression that takes into account the sinusoidal law of the feeding current variation and influence of air variability (interstice) l_3 we obtain a differential movement equation which is very difficult to solve. In order to simplify this problem it is supposed a certain constant size of air. In this case, the relation (1) acquires the form of a non-homogenous linear equation:

Înlocuind expresia pentru forța de acțiune a electromagnetului *F*(*t*) din ecuația (1) cu expresia care ia în considerare legea sinusoidală de variație a curentului electric de alimentare a electromagnetului şi influența jocului de aer (întrefierul) variabil l_3 se obține o ecuație diferențială de mişcare, a cărei rezolvare este complicată. De aceea, pentru simplificare, se considera că jocul de aer variabil este egal cu o anumită mărime constantă. În această situație, relația (1) capătă forma unei ecuații liniare neomogene:

$$m\ddot{S} + \mu c\dot{S} + c_1 S = F(1 + \cos 2p_T t) \quad (2)$$

where: $F = k_F B_m^2 S_c / 2$ is the static component of vibrator excitation force, in N;
$k_F = 3{,}98 \cdot 10^5$ – proportionality coefficient;
B_m – amplitude of magnetic induction, in T;
S_c- the area of crossing section of coil core, in m^2;
p_T – feeding alternating current frequency, in 1/s.
The particular solution for equation (2) is:

în care: $F = k_F B_m^2 S_c / 2$ – componenta constantă a forței de excitație a vibratorului, în N;
$k_F = 3{,}98 \cdot 10^5$ – coeficient de proporționalitate;
B_m – amplitudinea inducției magnetice în joc (*T*);
S_c – aria secțiunii transversale a miezului (m^2);
p_T – frecvența curentului alternativ (1/s).
Soluția particulară a ecuației (2) are forma:

$$S = A_0 + A_1 \cos(2p_T t - \varphi) \quad (3)$$

where: $A = F/c_1$ is the constant displacement of mass center *O* of mass m; A_1 – amplitude of oscillations of center *O*;
φ – angle of phase difference between variable parts of mass center *O* and disturbing force, given by the relations:

în care: $A_0 = F/c_1$ este deplasarea constantă a centrului de masă *O* al masei *m*;
A_1 – amplitudinea oscilațiilor centrului *O*; φ – unghiul de defazaj dintre componentele variabile ale centrului de masă *O* şi forța perturbatoare *F* date de relațiile:

$$A_1 = (F/m)\sqrt{(c_1/m - 4p_1^2)^2 + 4\mu^2 c^2 p_T^2 / m^2} \; ; \quad (4)$$

$$\varphi = arctg \frac{2\mu c p_T}{c_1 - 4mp_r^2} . \quad (5)$$

The resonance of the oscillating system appears for the resonant frequency: $p_T = 0{,}5.\sqrt{c_1/m}$. [2]

For a current with industrial frequency of 50 Hz (3000 1/min^{-1}), the electro-magnet oscillates at double frequency (6000 1/min^{-1}), which in the majority of cases is not possible. That is why, in practice, in order to decrease the

Rezonanța sistemului oscilant apare pentru frecvența critică $p_T = 0{,}5.\sqrt{c_1/m}$. [2]

Pentru curentul cu frecvența industrială de 50 Hz (3000 1/min^{-1}), electromagnetul oscilează cu frecvență dublă (6000 1/min^{-1}), ceea ce în marea majoritate a cazurilor este inadmisibil. De aceea, în practică, pentru

frequency of the platform of the separator until it reaches 3000 1/min^{-1}, a redresser for a semi-period is introduced, but the redressed tension modifies the action of magnetic flow and the character of the movement of the oscillating platform.

The separators driven with electro-magnetic consists in a mechanical device for transport with the help of which the layer of solid material is displaced, comprised of a chute or pipe, as well as by the unit for actuating/entraining for exerting vibrations, sustained by a suspension with helical springs. (fig. 4) [6,8]

micşorarea frecvenţei platformei separatorului până la 3000 1/min^{-1} se introduce un redresor de o semiperioadă, însă tensiunea redresată modifică acţiunea fluxului magnetic şi caracterul mişcării platformei oscilante.

Separatoarele acţionate cu vibratoare electromagnetice constă dintr-un dispozitiv mecanic de transport cu ajutorul căruia se deplasează stratul de material solid, alcătuit dintr-un jgheab sau ţeavă, precum şi din unitatea de acţionare/antrenare pentru excitarea vibraţiilor susţinută de o suspensie cu arcuri elicoidale(fig. 4) [6,8].

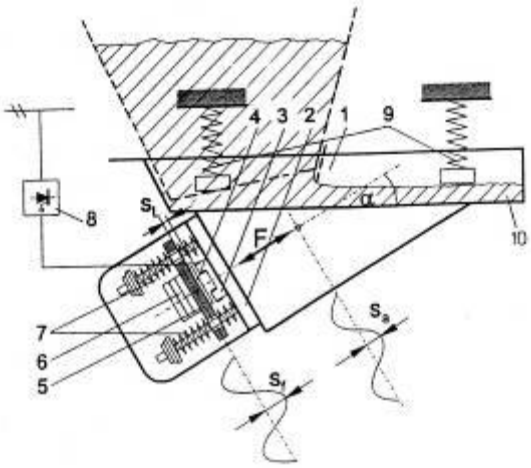

Fig. 4 – Schematic diagram for an electromagnetic driven vibrating separator:
1 –vibrating platforms; 2 – vibrating casing; 3 – magnet; 4 - mobile plate with magnetic core; 5,6 - additional masses;
7 – spring; 8 – control/command device; 9 –suspension springs.
s_f – amplitude of the vibration of the electromagnet plate; s_a – actual amplitude of the chute

The magnetic systems for actuating/driving used as free vibrators or together with suspensions for directing, operate in resonance conditions having safer values of the excitation energy, thus allowing to achieve some very compact units.

From a dynamic point of view, the vibrating systems of the separators represent dynamic systems of the spring – mass type [6,10], for which are considered two masses tied together with springs;

- *the first mass* m_a, represents the mass of the subassembly for feeding granular material, consisting in vibrating platform 1, the mass of the solid material 10 and the magnetic vibrator (formed by the elements 2-4).
- *the second mass* m_f, represents the mass of the free part, consisting in the mobile bodies 5 and 6.

The unit for electronic control/command (pos. 8) is powered by a normal source of alternative electric current. A normal excitation of 50 Hz generates a frequency of vibrations of 100 Hz. Using control/command with thyristors it achieves frequencies of 25 and 50 Hz. This way, an efficient control of the vibration amplitude of the dynamic vibrating system is achieved.

Under de action of vibrations generated by the electromagnet, the platform 1, suspended elastically on the bearer through the springs 9, is submitted to vibrations with the elongation *S*, oriented on a given direction *α*. The actual amplitude S_a of the platform 1 depends on the constructive, functional and adjusting parameters, as well as on the type of material that is transported.

The displacement of the vibrating mass can be considered with sufficient approximation, as a harmonic sinusoidal oscillating movement, with elongation *S* given by relation:

Sistemele de acţionare/antrenare magnetice utilizate ca vibratoare libere sau împreună cu suspensii de direcţionare funcţionează în condiţii de rezonanţă având valori mai sigure ale energiei de excitaţie, permiţând astfel realizarea unor unităţi foarte compacte.

Din punct de vedere dinamic, sistemele vibrante ale separatoarelor reprezintă sisteme dinamice tip arc – masă [6,10], la care se iau în considerare două mase legate între ele prin arcuri ;

- *prima masă* m_a, reprezintă masa subansamblului de alimentare a materialelor granulare, constând din platforma vibratoare 1, masa materialului solid 10 şi vibratorul magnetic (format din elementele 2-4).
- *a doua masă* m_f, reprezintă masa părţii libere, constând din corpurile mobile 5 şi 6.

Unitatea de control/comandă electronică (poz. 8) este legată la o sursă normală de curent alternativ, o excitaţie normală de 50 Hz generează o frecvenţă a vibraţiilor de 100 Hz, iar cu control/comandă cu tiristoare realizează şi frecvenţe de 25 şi 50 Hz: În acest fel se realizează un control eficient al amplitudinii vibraţiilor sistemului dinamic vibrant.

Sub acţiunea vibraţiilor generate de electromagnet, platforma 1, suspendată elastic pe suport prin arcurile 9, este supusă la vibraţii cu elongaţia *S*, orientate pe o direcţie dată α. Amplitudinea efectivă S_a, a platformei 1 depinde de parametrii constructivi, funcţionali şi de reglaj cât şi de felul materialului transportat.

Mişcarea masei vibratoare a platformei poate fi considerată, cu suficientă aproximaţie, ca o mişcare oscilatorie armonică sinusoidală, elongaţia *S* a mişcării oscilatorii este dată de relaţia:

$$S = S_a \sin(\omega t)\,, \tag{6}$$

where: S_a is the oscillating amplitude; ω – oscillating pulsation, in Hz.

The velocity of the oscillating movement is given by relation:

în care: S_a este amplitudinea oscilației; ω – pulsația oscilației: $\omega = 2\pi f$ (unde f este frecvența oscilației, în Hz.)

Viteza mişcării oscilatorii este dată de relația:

$$v = S_a \omega \cos(\omega t),$$

(7)

where $v_0 = S_a \omega$ is the amplitude of the velocity.

The acceleration of the oscillating movement is expressed by relation:

în care $v_0 = S_0 \omega$ este amplitudinea vitezei.

Accelerația mişcării oscilatorii este exprimată de relația:

$$a = -S_a \omega^2 \sin(\omega t),$$

(8)

where $a_0 = -S_a \omega^2$ is the amplitude of acceleration.

The oscillation frequency of the vibrator is given by the relation:

în care $a_0 = -S_a \omega^2$ este amplitudinea accelerației.

Frecvența de oscilație a vibratorului este dată de relația:

$$f = \omega/2\pi.$$

(9)

If the value of the amplitude's acceleration a_0 is in ratio with the gravitation acceleration g, the characteristic of the machine K_M, can be calculated with the following equation:

Dacă valoarea amplitudinii accelerației a_0 a platformei se raportează la accelerația gravitațională g, se obține caracteristica de transport K_M, dată de relația:

$$K_M = \frac{a_0}{g} = -\left|\frac{S_0 \omega^2}{g}\right|$$

(10)

Because for the vibrating platforms the direction of oscillating movement is tilted compared to the angle α in relation to the transport surface (fig. 5), the components on a horizontal direction of the elongation and the acceleration are obtained through the following relations:

Deoarece la platformele vibratoare direcția mişcării oscilatorii este înclinată cu unghiul α în raport cu suprafața de transport (fig. 5) componentele pe direcție orizontală ale elongației şi accelerației se obțin cu relațiile:

$$S_h = S \cos\alpha$$

(11)

$$a_h = a \cos\alpha,$$

(12)

and the components on a vertical direction are given by the relations:

iar componentele pe direcție verticală sunt date de relațiile:

$$S_v = S \sin\alpha;$$

(13)

$$a_v = a \sin\alpha.$$

(14)

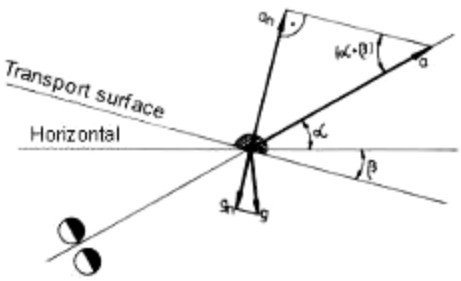

Fig. 5 - Diagram for the acceleration acting on the particles in the vibrating process

Given the angle of inclination β of the working surface in ratio to the horizontal, the characteristic of the machine is the throwing characteristic K_w, which is expressed depending on the characteristic of the machine K_m through the relation:

Ținând seama de unghiul β de înclinare a suprafeței de lucru în raport cu orizontala caracteristica maşinii reprezintă caracteristica de aruncare K_W care se exprimă în funcție de caracteristica maşinii K_M prin relația:

$$K_w = K_M \frac{\sin(\alpha+\beta)}{\cos\beta} \quad . \tag{15}$$

From relation (15) one can notice that the values of the throwing characteristic $K_w = a_n/g$ represents, at a certain scale, the value of the normal acceleration at the a_n transport surface. Considering a particle of material placed on the transport surface, depending on the value of the throwing characteristic K_w, three different domains of process kinematics are distinguished. If the coefficient $K_w < 1$, the particle remains on the transport surface. Due to the inertia force a certain sliding of the particle on the support surface occurs. This represents the work field of shock sliding.

Din relația (15) se observă că valoarea caracteristicii de aruncare $K_W = a_n/g$ reprezintă, la o anumită scară, valoarea accelerației normale la suprafața de lucru a_n. Dacă se consideră o particulă de material aşezată pe suprafața de lucru, în funcție de valoarea caracteristicii de aruncare K_W se disting trei domenii distincte ale cinematicii procesului. Dacă coeficientul $K_W < 1$, particula staționează pe suprafața de lucru. Datorită forței de inerției se produce desigur o anumită alunecare a particulei pe suprafața de sprijin. Acesta reprezintă domeniul de lucru al alunecării cu şoc.

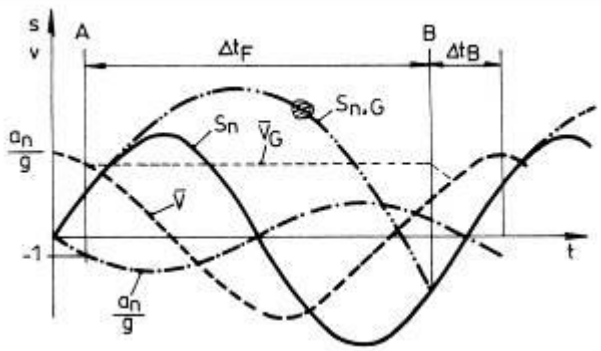

Fig. 6 - Trajectory of the material on the working surface and the movement conditions for the vibrating chutes [4]

If $1 < K_W < 3.3$, then in the moment A, the particle detaches from the support surface on an ascending direction (fig. 6). During the throwing time Δt_F, the particle of material will project a parabolic trajectory, and in point B it meets again the working surface and, in case of an ideal plastic collision, it remains in the time interval Δt_B in contact with the working surface, after which the process is repeated. The layers of material, with a good approximation, are considered to have a behavior adequate for a plastic collision.

In the case of a vibrating system shown in figure 4, at which the electromagnet is fed with electric current with industrial frequency of 50Hz, the chute bearing material oscillates at a double frequency (6000 1/min^{-1}), which in the majority of cases is not possible. To decrease the frequency of the platform unit 3000 1/min^{-1}, a semi-period redresser is introduced, but the tension redressed modifies the action of the magnetic field and the character of the movement of the chute. This movement is described by another equation with a disturbing force represented by a Fourier trigonometric series.

The undamped natural frequency f_e of the spring-mass system in figure 4 can be determined in the basis on m_a and m_f masses and of the C constant of the spring.

Dacă $1 < K_W < 3{,}3$, atunci în momentul A particula se desprinde de suprafața de sprijin pe direcția ascendentă (fig. 6). În timpul de aruncare Δt_F particula de material va descrie o traiectorie parabolică şi în punctul B întâlneşte din nou suprafața de lucru şi, în cazul unei ciocniri plastice ideale, rămâne în intervalul de timp Δt_B în contact cu suprafața de lucru, după care procesul se repetă. Straturile de material, cu o bună aproximație, se consideră că au o comportare corespunzătoare unei ciocniri plastice.

În cazul sistemului vibrant dat în figura 4, la care electromagnetul este alimentat cu curent cu frecvența industrială de 50 Hz, jgheabul purtător de material oscilează cu frecvență dublă (6000 1/min^{-1}), ceea ce în marea majoritate a cazurilor este inadmisibil. Pentru micşorarea frecvenței platformei până la 3000 1/min^{-1} se introduce un redresor de o semiperioadă, însă tensiunea redresată modifică acțiunea fluxului magnetic şi caracterul mişcării jgheabului. Această mişcare este descrisă de o altă ecuație cu o forță perturbatoare reprezentată printr-o serie trigonometrică Fourier.

Frecvența naturală f_e neamortizată a sistemului arc-masă din figura 4 poate fi determinată în baza maselor m_a şi m_f şi a constantei C a arcului:

$$f_c = \frac{1}{2\pi} \cdot \sqrt{\frac{C}{m_r}} \, , \tag{16}$$

where m_r is the reduced mass of the system in figure 4, calculated with the relation from the theory of vibrations [3]:

unde m_r este masa redusă a sistemului din figura 4, calculată cu relația din teoria vibrațiilor [3]:

$$m_r = \frac{m_a \cdot m_f}{m_a + m_f}$$

(17)

This vibrating system with two masses answers to a frequency of excitation f_a, the amplitude rising as f_a approaches the natural f_e natural frequency (for f_a/f_e = 1 appears resonance). As is observed in figure 7 the natural frequency decreases as the damping increases, the amplifying factor V being strongly influenced by the damping.

In order for the vibration separators to work at values close to the resonance, the system should be calibrated adequately (masses pos. 6 in figure 4). The actual damping is induced by friction, for example friction in the interior of solid materials, and external friction on surfaces.

Acest sistem vibrator cu 2 mase răspunde la o frecvență de excitație f_a, amplitudinea crescând pe măsură ce f_a se apropie de frecvența naturală f_e (pentru f_a/f_e = 1 apare rezonanța). Aşa cum se observă din figura 7 frecvența naturală descreşte odată cu creşterea amortizării, factorul de amplificare *V* fiind puternic influențat de amortizare.

Pentru ca separatoarele cu vibrații să funcționeze la valori apropiate de rezonanță sistemul trebuie calibrat în mod corespunzător (masele poz. 6 din fig. 4). Amortizarea efectivă este indusă de frecare; de exemplu frecarea din interiorul materialelor solide, şi frecarea externă pe suprafețe.

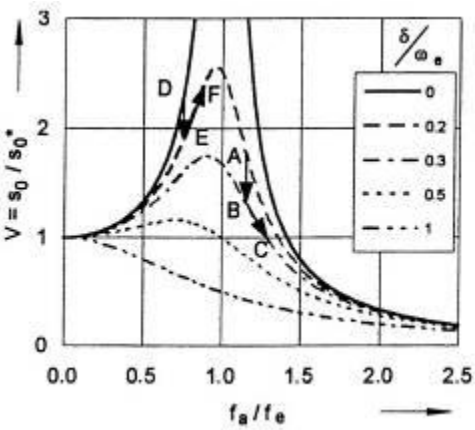

Fig. 7 - Factor of amplifying the amplitudes of vibrations (V) depending on the ration of excitation frequencies (f_a/f_e).[10]

Figure 7 highlights the fact that the functioning of the vibrating system at a value of excitation slightly under-critical is the most recommended, because increased damping of the vibrating system and of the mass of solid material situated on the separator's working surface – which usually coincide – have a stabilizing effect (see fig. 7, DE, EF). For operating regimes with critical and over-critical values, one should take into consideration the emergence of a disturbance (AB, BC). In order to achieve magnetic excitation and to control of the amplitude of the electromagnetic vibrator, there are available some electronic modules for the optimal excitation frequency (25, 50, 100 Hz) that can be adjusted to a pre-established value for the amplitude of vibrations through the means on tension.

CONCLUSIONS

The theoretical study of the system of sieves mounted on a vibrating frame operated by electrovibrators can be achieved by replacing the real systems with equivalent vibrating dynamic systems with external excitation, comprising one or two vibrating masses. By solving the differential movement equations of vibrating systems with one or two vibrating masses and their applicability for concrete situations, we can study by computer simulation the kinematic and dynamic behavior of systems endowed with existing or in course of designing vibrating sieves.

In order for the vibration separators to work at values close to the resonance, the system should be calibrated adequately, the amplifying factor being strongly influenced by the damping.

The results of theoretical researches performed on

În fig. 7 se pune în evidență că funcționarea sistemului vibrant la o valoare a excitației uşor subcritică este cea mai recomandată, deoarece o amortizare crescută a sistemului vibrator şi a masei de material solid aflată pe suprafața de lucru a separatorului – care de regulă coincid – au un efect stabilizator (v. fig. 7, DE, EF). La regimuri de funcționare la valori critice şi supracritice trebuie luat în considerare apariția unei destabilizări (AB, BC).

Pentru realizarea excitației magnetice şi controlul amplitudinii vibratorului electromagnetic sunt disponibile module electronice pentru frecvența de excitație optimă (25, 50, 100 Hz) şi reglarea la o valoare prestabilită a amplitudinii vibrațiilor prin intermediul tensiunii.

CONCLUZII

Studiul teoretic al sistemelor de site montate pe cadru vibrator antrenat de electromagneți poate fi realizat prin înlocuirea sistemelor reale cu sisteme vibratoare dinamice echivalente cu excitare externă, cuprinzând una sau două mase vibratoare.

Prin rezolvarea ecuațiilor diferențiale de mişcare şi a aplicabilității lor în situații concrete, se poate studia, prin simulare computerizată, comportamentul cinematic şi dinamic al sistemelor dotate cu site vibratoare existente sau în curs de proiectare.

Pentru ca separatoarele cu vibrații să funcționeze la valori apropiate de rezonanță sistemul trebuie calibrat în mod corespunzător, factorul de amplificare fiind puternic influențat de amortizare.

Rezultatele cercetărilor teoretice realizate în baza celor prezentate în lucrare permit optimizarea parametrilor

basis of those presented in the paper allow the optimization of constructive and functional parameters of systems of vibrating sieves, in view of manufacturing state-of the art installation.

Taking into account the technical and economic advantages (higher separation technological effect, specific consumption of reduced materials and energy) of the vibrating systems with electromagnets it is recommended to be used not only at vibrating conveyors for grain matters (including seeds) but also at driving the vibrating sieves of technological installations for primary processing of grain seeds.

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constructivi şi funcţionali ai sistemelor cu site vibratoare, în vederea producerii de instalaţii de ultimă generaţie.

Luând în considerare avantajele tehnice şi economice (efect tehnologic de separare superior, consumuri specifice de materiale şi energie reduse) ale sistemelor vibratoare cu electromagneţi, utilizarea lor este recomandată nu doar pentru transportoarele vibratoare pentru produse granulare (incluzând seminţele), dar şi pentru acţionarea sitelor vibratoare ale instalaţiilor tehnologice pentru procesarea primară a seminţelor de cereale.

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PROCESSING TECHNOLOGIES OF THE FRUITS BELONGING TO THE DRUPACEOUS AND POMACEOUS GROUP WITHIN THE FRUIT TREE FAMILY FARMS
/
TEHNOLOGII DE PRELUCRARE A FRUCTELOR APARTINAND GRUPEI DRUPACEELOR SI POMACEELOR IN CADRUL FERMELOR POMICOLE FAMILIALE

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Abstract: *Processing and fruit processing technologies in order to obtain fruit jams can be defined as complex processes that meet the requirements of the beneficiaries of fruit crops within the family farms. The degree of mechanization and automation of the installations for the production of jams are designed according to the processing type, with a wide range of equipment specific to the selected procedures, the intended purpose being influenced by the size of the orchards cultures from their own household.*
The paper presents a technical plant used in the separation process of the pulp from pips of cherries, sour cherries, plums

Keywords: *stones separation, cherries, plums, plant*

Rezumat: *Tehnologiile pentru procesarea şi prelucrarea fructelor în vederea obținerii gemurilor din fructe pot fi definite ca procese complexe, care răspund cerințelor beneficiarilor de culturi pomicole în cadrul fermelor familiale. Gradul de mecanizare şi automatizare a instalațiilor pentru obținerea gemurilor sunt concepute în funcție de tipul de prelucrare, cu o gamă variată de utilaje, specifice procedeelor alese, scopul propus fiind influențat de mărimea culturilor de livezi din gospodăria proprie.*
In lucrare este prezentata o instalatie tehnica utilizata in procesul de separare a pulpei de sâmburii din cireşe, vişine, prune

Cuvinte cheie: *separare samburi, cirese, prune,instalatie*

INTRODUCTION

In the current context, in which at the level of family farms is not achieved the recovery of fruit production not acceptable for fresh consumption, and the fact that in the years with record productions there is the impairment risk of the fresh fruits from the drupaceous and pomaceous group, is imposed as a necessity the approach of innovative technologies and technical equipment that can solve these problems. The scientific research addresses this issue by creating new constructive solutions and of automation for the technical equipment from the addressed area and reduction of losses during the processing of the raw materials from the food chain, which can ultimately lead to increased the diversity and natural fruit products competitiveness.

Fruit processing technologies can be defined as complex processes, used for the preparation of fruit jams, to the holders offruit crops within the family farms. The degree of mechanization and automation of the installations for the production of jams is designed depending on the processing type with a wide range of equipment specific to the selected procedures, the intended purpose being influenced by the size of the orchards crops from the own household. Lately, due to requirements of the market, more and more producers of fruits are interested that during the processing of fruits to obtain a complete separation of the pulp of stones. The pulp separation of stones from cherries, sour cherries and plums mechanically ensures the food security and food safety in exploitation, guarantees the stability of orchard holdings and significant revenues for the agricultural farmers.

MATERIAL AND METHOD

INTRODUCERE

In contextual actual, in care la nivelul fermelor familiale, nu se realizeaza valorificarea productiei de fructe neacceptata la consum in stare proaspata, precum si faptul ca, in anii cu productii record exista riscul deprecierii fructelor prospete din grupa drupaceelor si pomaceelor, se impune ca o necesitate abordarea unor tehnologii si echipamente tehnice innovative care sa rezolve aceste probleme. Cercetarea stiintifica urmareste rezolvarea acestor probleme prin elaborarea de noi soluții constructive si de automatizare pentru echipamentele tehnice din domeniul abordat şi reducerea pierderilor în timpul procesării materiilor prime din lanțul alimentar,care pot conduce, în final, la cresterea diversitatii si competitivitatii produselor naturale din fructe.

Tehnologiile de prelucrare a fructelor pot fi definite ca procese complexe, folosite pentru prepararea gemurilor din fructe, la posesori de culturi pomicole în cadrul fermelor familiare. Gradul de mecanizare şi automatizare al instalațiilor pentru obținerea gemurilor sunt concepute în funcție de tipul de prelucrare, cu o gamă variată de utilaje, specifice procedeelor alese, scopul propus fiind influențat de mărimea culturilor de livezi din gospodăria proprie. În ultimul timp, datorită cerințelor din piață tot mai mulți producători de fructe sunt interesați ca în timpul procesării fructelor să se obțină o separare completă a pulpei de sâmburi. Separarea pulpei de sâmburi din cireşe, vişine şi prune pe cale mecanizata asigură securitatea alimentara si siguranța alimentelor în exploatare, garanteza stabilitatea exploatațiilor de livezi şi venituri importante pentru fermierii agricoli.

MATERIAL ŞI METODĂ

The installation for pips removal, Figure 1, is intended for the mechanization of the operation to remove pips from fruits in order to their superior capitalization (jam, juices, etc.) and it is used in the technological flow specific to processing of fruits, in order to obtain of some varieties of type jam, honey or juices.

The installation consists mainly of the following subassemblies: 1. machine body; 2. rubber drums; 3. drums with discs; 4. drum scraper with discs; 5. drum scraper in rubber; 6. guillotine; 7. transmission (engine, gearbox, sprockets, chain); 8. troughs for takeover pips, pulps, syrup and feeding trough; 9. separator.

Instalația pentru scos sâmburi, figura 1, este destinată mecanizării operației de scos sâmburi din fructe în vederea valorificării superioare a acestora (gem, sucuri, etc.) şi este utilizată în fluxul tehnologic specific procesării fructelor pentru obținerea unor sortimente de tip gem, dulceata sau sucuri naturale.

Instalația este compusă în principal din următoarele subansamble: 1.corpul maşinii; 2. tamburi de cauciuc; 3. tamburi cu discuri; 4. răzuitor tambur discuri; 5 răzuitor tambur cauciuc; 6. ghilotina;7. transmisie (motor, reductor, roți de lanț, lanț); 8. jgheaburi pentru preluare, sâmburi, pulpe, sirop şi jgheab de alimentare; 9. separator.

Fig. 1 – The plant for pips removal from fruits

The rubber drum is made of alimentary rubber (hardness 40 ° Shore) and the drum with disks composed of disks in 10TiNiCr180 performes the fruit catching between them.

The disks presses the fruit pulp and the rubber drum deforms and holds the pips. The scraper drum with disks is composed of a set of cutters appropriately spaced by spacer rings, which eliminates the fruit pulp between the spaces between the disks.

The scraper drum in rubber serves to detach the pips that do not fall by themselves in the trough, and to eliminate the juice which remains on the rubber drum.

The subassembly guillotine running a back and forth motion vertically and facilitating the fruit pressing between the two drums space, where occurs the pips removal.

Driving of the guillotine subassembly is achieved by an eccentric and two reciprocating rods and the whole mechanism slides vertically. The installation contains troughs and trays for taking over the pips, fruit pulp and juice resulted after removal of pips. All these are made of austenitic steel (10TiNiCr180)

The operating principle of the plant for seeds removal is based on cutting the fruit up to stone and removing of it entire by means of a rubber roller, followed by the collection of the pitted fruit and the fruit juice recovery resulted in the process of pips removal.

Tamburul din cauciuc este executat din cauciuc alimentar (duritate 40 share) iar tamburul cu discuri compus din discuri din 10TiNiCr180 realizeaza prinderea fructelor între ele.

Discurile apasă pulpa fructelor, iar tamburul de cauciuc se deformează şi reține sâmburii. Răzuitorul tambur cu discuri este compus dintr-un set de cuțite distanțate corespunzător prin inele distanțiere, care elimină pulpa fructelor dintre spațiile dintre discuri.

Răzuitorul tambur din cauciuc are rolul de a desprinde sâmburii care nu cad singuri în jgheab, precum şi eliminarea sucului care rămâne pe tamburul de cauciuc.

Subansamblul ghilotină execută o mişcare de dute-vino pe verticală şi facilitează apăsarea fructelor între spațiul celor doi tamburi, unde are loc eliminarea sâmburilor.

Acționarea subansamblului ghilotină se realizează printr-un excentric şi două biele şi întregul mecanism culisează pe verticală. Instalația conține jgheaburi şi tăvi pentru preluarea sâmburilor, pulpei fructelor şi sucul rezultat în urma scoaterii sâmburilor. Toate acestea sunt executate din oțel austenitic (10TiNiCr180)

Principiul de funcționare al instalației pentru scos sâmburi se bazează pe tăierea fructelor până la sâmbure şi îndepărtarea acestuia întreg, cu ajutorul unui tambur

Before processing the fruit stalks must be removed and the fruits washed for not containing any dust particles or other impurities adherent on the outer surface of these. Fruits are introduced manually (or mechanically) through the feeding hopper from where fall between the two drums. The soft part of the fruits (the pulp) enters between the stainless steel disks, and the pips are running ahead between the two drums.

The stones reach the pips and pulp separator and from here in the collector trough of pips and syrup. The fruit pulp falls on the collecting trough, and what remains between the disks it is scraped by the blades of a scraper and sent on the same collecting trough. In order to achieve the experimentation in operating conditions, was ensured the raw material, consisting in sour cherries and plums.

The qualitative indices of raw material, involved in the working process of the pips removal plant, are considered to be the following:

- the degree of maturation;
- the percentage of impurities (after washing and drying);
- healthy fruits (are excluded the products affected by rotting or with deteriorations because of which become unfit for consumption); free from diseases;- without damages caused by deseases; - without abnormal external moisture.

The experiments and tests conducted were aimed at highlighting the way in which take place the process of removing the pips from fruits, as well as the the establishment of the settings to be made for obtain a maximum efficiency of the process of the pips separation.

The tests were carried out in two stages: in the first processing the sour cherries and in the second processing plums (two varieties). The main technical and functional characteristics of the plant:

- Working capacity	300-400 kg/h
- Electric motor power	1.5 kw
- Type of reducer	i=20 (BONFIGLIOLI)
- The motor speed	1420 rev/min
- The speed of the drums	41/31 rev/min
- No. of guillotine double strokes	70/52 ds/min
- Length	1200 mm
- Width	950 mm
- height	1500 mm
- Weight	530 kg

RESULTS

Conditions for experimenting the functioning of the installation:

- Processed product	sour cherries and plums
- Maturation degree	ripened
- Percentage of impurities (after washing and drying)	1.1%
- Quantity of products per sample	8.00 kg

- Tests carried out for the regulation of the plant: 3 for sour cherries and 3 for plums
- Tests performed after the plant adjustment: 3 for sour cherries and 3 for plums

The plant adjustment was done for the following parameters:

- speed of drum with disks	33.21 rev/min
- rubber drum speed	33.21 rev/min
- peripheral speed of drums	31.3 m/min

din cauciuc, urmată de colectarea fructelor fără sâmbure şi recuperarea sucului din fructe rezultat în procesul de desâmburare.

Inainte de procesare codițele fructelor trebuie eliminate şi fructele spălate pentru a nu conține particule de praf sau alte impurități aderente pe suprafața exterioară a acestora.Fructele se introduc manual (sau mecanizat) prin pâlnia de alimentare de unde cad între cei doi tamburi. Partea moale a fructelor (pulpa) intră între discurile de inox, iar sâmburii sunt rulați mai departe între cei doi tamburi.

Sâmburii ajung la separatorul de sâmburi şi pulpă, si de aici în jgheabul colector de sâmburi şi sirop.Pulpa fructului cade pe jgheabul colector, iar ce rămâne între discuri este raclată de lamele unui răzuitor şi trimisă pe acelaşi jgheab colector. În vederea realizarii experimentarii in conditii de exploatare, s-a asigurat materia primă care a constat in vişine şi prune.

Indicii calitativi ai materiei prime, care intervin in procesul de lucru ai instalatiei de scos samburi, se consideră a fi urmatorii:

- gradul de maturare;
- procentul de impurități (după spălare şi uscare);
- fructe sanatoase (se exclud produsele atinse de putregai sau cu alterari din cauza carora devin improprii pentru consum); fără boli;- fără deteriorări cauzate de boli; - fără umezeală externă anormală.

Experimentările şi probele efectuate au avut ca scop evidențierea modului în care are loc procesul de scoatere al sâmburilor din fructe, precum şi stabilirea reglajelor care trebuie efectuate pentru obținerea unei eficiențe maxime al procesului de separare al sâmburilor.

Probele s-au efectuat în două etape, în prima procesând vişine, iar în a doua procesând prune (două soiuri). Principalele caracteristici tehnice şi funcționale ale instalatiei:

- Capacitatea de lucru	300-400 kg/h
- Putere motor electric	1,5 kw
- Tipul reductorului	i=20 (BONFIGLIOLI)
- Turația motorului	1420 rot/min
- Turația tamburilor	41/31 rot/min
- Numărul curse duble ale ghilotinei	70/52 cd/min
- Lungime	1200 mm
- Lățime	950 mm
- Inălțime	1500 mm
- Greutate	530 kg

REZULTATE

Condiții pentru experimentarea funcționării instalației:

Produs de prelucrat	vişine şi prune
Gradul de maturare	coapte
Procentul de impurități (după spălare şi uscare)	1,1%
Cantitatea de produse per probă	8,00 kg

Probe efectuate pentru reglarea instalației: 3 vişine şi 3 prune

Probe efectuate după reglarea instalației: 3 vişine şi 3 prune

Reglarea instalației s-a realizat pentru următorii parametri:

- turația tamburului cu discuri	33,21 rot/min
- turația tamburului cauciucat	33,21 rot/min

- frequency guillotine slider 57.36 ds/min
- distance between drums 3 mm
- guillotine distance to drums 3 mm
- the separator distance to the drum with disks: 2 mm
- the separator distance up to the rubberized drum: 1 mm
- Supplying of the installation was carried out manually.
- Time of supply / sample (8.00 kg) 1 min.

Determinations for the processed products - sour cherries:

- Percentage of impurities in the source material, 1.5%
- The amount of sour cherries (charge)
- processed on sample 8.00 kg
- The average weight of 100 sour cherries 0.262 kg
- Average number of sour cherries
- on sample (8.00 kg) 3050
- The average mass of a sour cherry 2.62 gr.
- The average weight of 100 pips 30 gr.
- Pips percentage of total product for processing 11.43%

Pulp percentage of total product for processing 88.57%

- viteza periferică a tamburilor 31,3 m/min
- frecvența culisei ghilotinei 57,36 cd/min
- distanța dintre tamburi 3 mm
- distanța ghilotinei până la tamburi 3 mm
- distanța separatorului până la tamburul cu discuri: 2 mm
- distanța separatorului până la tamburul cauciucat: 1 mm
- Alimentarea instalației s-a efectuat manual.
- Timpul de alimentare / probă (8,00 kg) 1 min.

Determinări pentru produsele prelucrate - vişine:

- Procent de impurități în materia prima, 1,5%
- Cantitatea de vişine (sarja)
- prelucrată pe probă 8,00 kg
- Masa medie a 100 de vişine . 0,262 kg
- Număr mediu de vişine
- pe probă (8,00 kg) . 3050
- Masa medie a unei vişine . 2,62 gr.
- Masa medie a 100 de sâmburi . .30 gr.
- Procent de sâmburi din total
- produs de prelucrat 11,43%
- Procent de pulpă din total 88,57%

produs de prelucrat

Table 1

Dimensions measured for the raw material used - sour cherries

Crt. No.	Dimensions measured				
	for 10 sour cherry (mm)		for 10 pips(mm) (corresponding to sour cherries)		
	Diameter	Height	Thickness	Length	Height
1	14,5	16,8	6,1	7,7	8,8
2	15,3	17,8	7,5	9,0	9,6
3	14,2	17,3	6,8	7,6	8,3
4	14,1	17,5	7,1	8,2	9,1
5	12,7	16,5	6,8	8,5	9,0
6	15,1	17,6	7,3	8,8	9,8
7	13,6	16,8	6,6	8,0	8,8
8	15,1	18,2	7,6	8,6	9,4
9	13,8	17,7	7,2	8,5	9,3
10	14,2	18,6	7,3	9,5	9,4
Average size	**14,26**	**17,48**	**7,03**	**8,4**	**9,15**

Table 2

Results obtained at experiments with sour cherries

Crt. No. / *Nr. Crt.*	Parameter determined	sample 1	sample	sample
1	Amount of processed product , kg	8.00	8.00	8.00
2	Amount of separated pips , kg	1.153	1.130	1.096
3	Amount of pulp and juice resulted, kg	6.806	6.838	6.802
4	Amount of residual product in the plant /kg	0.041	0.032	0.102
5	Percentage of processed products resulted , %	99.475	99.6	98.725
6	Amount of pips existing into separated pulp , kg	0.042	0.048	0.052
7	Percentage of unseparated pips , %	3.5	4.1	4.5
8	Percentage of residual pulp on the pips surface ,%	12.66	12.23	12.54

Determinations for processed products - golden plums

- Percentage of impurities in the raw material 0,9%
- Amount of processed plums: 8.00 kg per sample (charge)
- Average weight of 100 plums 4.25 kg
- Average number of plums per sample (8.00 kg) 188
- Average mass of a plum: 42.5 gr.
- Average mass of 100 pips 170 gr.
- Percentage of pips of the total product to be processed: 4.16%
- Percentage of pulp of the total product to be processed (Table 3) : 95.84%.

Determinations for processed products - greyish plums

Percentage of impurities in the raw material 0,9%
Amount of processed plums per sample (charge): 8,00 kg
Average weight of 100 plums: 2,40 kg
Average number of plums per sample (8.00 kg): 333
Average mass of a plum: 24 gr.
Average mass of 100 pips 106.6 gr.
Percentage of pips of the total product to be processed: 4.83%
Percentage of pulp of the total product to be processed: 95.17%

Determinări pentru produsele prelucrate - prune aurii

- Procent de impurități în materia prima 0,9%
- Cantitatea de prune prelucrată: 8,00 kg pe probă (sarja)
- Masa medie a 100 de prune 4,25 kg
- Număr mediu de prune pe probă (8,00 kg) 188
- Masa medie a unei prune: 42,5 gr.
- Masa medie a 100 de sâmburi 170 gr.
- Procent de sâmburi din total produs de prelucrat: 4,16%
- Procent de pulpă din total produs de prelucrat (tabelul 3) : 95,84%.

Determinări pentru produsele prelucrate - prune brumării

Procent de impurități în materia prima 0,9%
Cantitatea de prune prelucrată pe probă (sarja): 8,00 kg
Masa medie a 100 de prune: 2,40 kg
Număr mediu de prune pe probă (8,00 kg): 333
Masa medie a unei prune 24 gr.
Masa medie a 100 de sâmburi 106,6 gr.
Procent de sâmburi din total produs de prelucrat: 4,83%
Procent de pulpă din total produs de prelucrat: 95,17%

Table 3

Dimensions measured for the raw material used - plums

Crt. No.	Dimensions measured					Obs.
	for 10 plums (mm)		for 10 pips (mm) (corresponding to plums)			
	Diameter	Height	Thickness	Length	Height	
1	40.0	51.1	8.5	14.6	26.1	golden plums
2	38.1	51.3	7.2	14.9	25.8	
3	40.2	48.3	6.3	15.0	25.7	
4	36.5	46.2	7.2	16.1	26.2	
5	39.7	50.3	7.1	15.3	27.5	
6	39.1	49.6	7.3	16.0	28.3	
7	39.6	50.1	7.5	15.4	29.1	
8	40.1	51.1	8.1	16.1	26.5	
9	40.3	50.6	7.2	15.6	25.2	
10	40.1	48.9	7.0	15.9	25.3	
Average size	**39.4**	**49.7**	**7.5**	**15.5**	**26.6**	
1	31.0	40.0	7.0	12.0	23.0	greyish plums
2	33.0	44.0	8.0	12.0	24.0	
3	31.0	40.0	8.0	12.0	22.0	
4	32.0	42.0	7.0	13.0	23.0	
5	33.0	41.0	8.0	13.0	22.0	
6	31.0	43.0	7.0	13.0	24.0	
7	33.0	43.0	8.0	13.0	24.0	
8	34.0	45.0	8.0	13.0	22.0	
9	31.0	36.0	7.0	12.0	22.0	
10	30.0	35.0	7.0	12.0	23.0	
Average size	**31.9**	**40.8**	**7.5**	**12.5**	**22.9**	

Table 4

Results achieved at experiments with golden plums

Crt. No.	Parameter determined	sample 1	sample 2	sample 3
1	Amount of processed product , kg	8.00	8.00	8.00
2	Amount of separated pips , kg	0.333	0.338	0.340
3	Amount of pulp and juice resulted , kg	7.612	7.630	7.618
4	Amount of residual product in the plant , kg	0.055	0.032	0.041
5	Percentage of processed products resulted , %	95.15	96.03	98.02
6	Amount of pips existing into separated pulp , kg	0.0	0.0	0.0
7	Percentage of unseparated pips ,%	0.0	0.001	0
8	Percentage of residual pulp on the pips surface %	1	1.2	1.3

Table 5

Results achieved at experiments with greyish plums

Crt. No.	Parameter determined	sample 1	sample 2	sample 3
1	Amount of processed product , kg	8.00	8.00	8.00
2	Amount of separated pips , kg	0.386	0.390	0.380
3	Amount of pulp and juice resulted , kg	7.510	7.568	7.557
4	Amount of residual product in the plant , kg	0.055	0.042	0.063
5	Percentage of processed products resulted , %	93.93	95.60	96. 25
6	Amount of pips existing into separated pulp , kg	0.0	0.0	0.0
7	Percentage of unseparated pips ,%	0.0	0.001	0.0
8	Percentage of residual pulp on the pips surface %	1	1.1	1.07

Analyzing the results obtained it is found that when processing the cherry sours it finds that there are pits into the separated pulp and also that the pulp resulted after separation is crushed. In case when it is desired to achieve from the pulp resulting from sour cherries (cherries) sweetness or other preparations the plant is ineffective. Starting from these observations made during the experiments with sour cherries, was drafted a patent application for a new constructive solution in order to eliminate this problem, Figure 2.

Analizand rezultatele obtinute se constata ca in cazul procesarii visinelor se constata ca existentă în pulpa separată samburi si totodata pulpa rezultata in urma separarii este zdrobita. In situatia cand se doreste sa se realizeze din pulpa rezultata din visine (cirese) dulceata sau alte preparate instalatia nu este eficienta. Pornind de la aceste observatii rezultate in timpul experimentarilor cu visine, s-a elaborat o cerere de brevet pentru o solutie constructiva noua care sa elimine aceasta problema, figura 2.

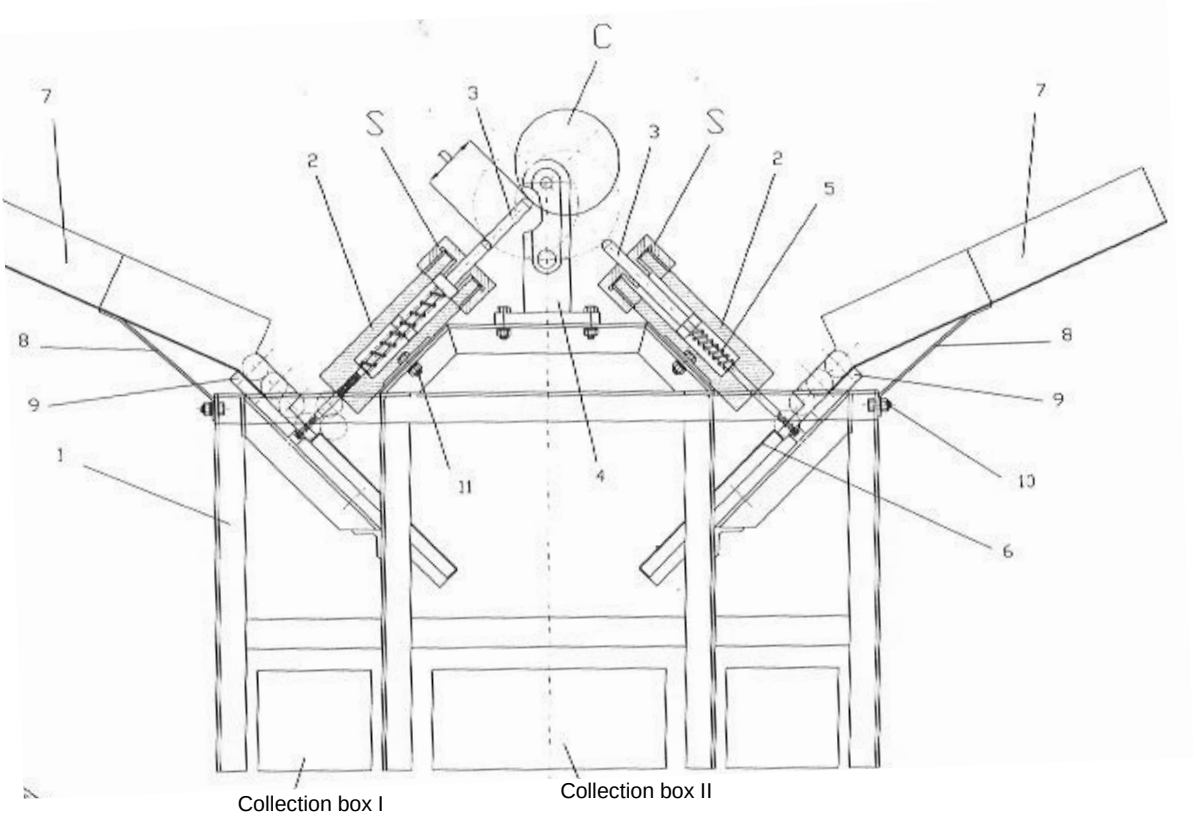

Fig. 2- Plant for pips removal from cherries and sour cehrries

The plant for pips removal from cherries and sour cehrries, according to the invention, is composed of a frame 1 on which is mounted an even number of devices for removing the pips fixed to the frame by means of the fasteners 11 by some supports 14 fitted with sliding bearings 12 in which it is attached a camshaft 13 driven by an electric gear motor with variable speeds. The frame is provided with supplying and control boxes 7, collection boxes I for pips and collection boxes II for fruits pulp.

Devices for removing the pips consist of a cylindrical body 2 provided with a screwed cap, through which is inserted a piston rod 3 provided with a spring 5, which has at the top a convex spherical profile with which is achieved a punctiform contact with the cam surfaces from the camshaft that provid by rotating its displacement with a distance in the direction of the cylinder axis and a perfect mobility regarding the influence of freedom degrees, and at the lower part of the rod are provided on the cylindrical surface are provided on the cylindrical surface with the inclination opposite to the rod forward direction towards a plate of settlement 9 limiting the distance to where the fruit can advance and a stopper 6 whereon the useful product falls freely into the collection box II.

The installation for removal of pips cherries and sour cherries, according to the invention, offers the following advantages:

- the fruit pulp separation of pip is achieved completely;
- the fruit pulp is obtained entire at separation;
- the productivity increases with the number of devices designed for installation and with the number of revolutions/min chosen for the camshaft;
- completely eliminates the degradable materials (rubber rollers).
- eliminates the discomfort and the health risks;

CONCLUSIONS

Instalaţia pentru scos sâmburii cireşelor şi vişinelor, conform inventiei, este compusă dintr-un cadru 1,pe care se montează un număr par de dispozitive de desâmburare fixate cu ajutorul elementelor de filetare11, de cadru prin nişte suporţi 14 prevăzuţi cu lagăre de alunecare 12 în care se fixează un ax cu came13 antrenat de un motoreductor electric cu turatii variabile. Cadrul este prevăzut cu cutii de alimentare 7 şi dirijare, cutii de colectare I pentru sâmburi şi cutii de colectare II pentru pulpa fructelor.

Dispozitivele de desâmburare constau dintr-un corp cilindric 2 prevăzut cu capac filetat, prin care se introduce o tijă piston 3 prevăzută cu un arc 5, care are la partea superioară profil sferic convex cu care se realizează un contact punctiform cu suprafaţa camelor de pe axul cu came care asigură prin rotire deplasarea acesteia cu o distanţă pe direcţia axei cilindrului şi mobilitate perfectă privind influenţa gradelor de libertate, iar la partea inferioară a tijei sunt prevăzute pe suprafaţa cilindrică asperităţi de forma unui con de brad cu înclinaţia inversă direcţiei de înaintare a tijei spre o placă de aşezare 9 care limitează distanţa până unde poate avansa fructul şi un opritor 6 pe care produsul util cade liber spre cutia de colectare II.

Instalaţia pentru scos sâmburii cireşelor şi vişinelor , conform inventiei, prezintă următoarele avantaje:

- separarea pulpei fructului de sâmbure se realizează complet;
- pulpa fructului se obţine întreagă la separare;
- productivitatea creşte cu numărul de dispozitive concepute pentru instalaţie şi numărul de rotaţii/min ales pentru axul cu came;
- elimină complet materialele degradabile (tamburii de cauciuc).
- elimină disconfortul şi riscurile asupra sănătăţii;

CONCLUZII

By analyzing and interpreting datas obtained for the testings with cherries and plums shows the following:

- the qualitative indexes of the raw material, involved in the working process of the plant for the pips removal influence the final results of the pips separation of the fruit pulp;
- in case of sour cherries processing it is found that there are pips into the separated pulp and at the same time the pulp resulted after the separation is crushed;
- in the case of plums processing, the plant realizes a very good separation of the pips of the fruit pulp, without pips into the separated pulp and with a very small percentage of waste pulp from the pips surface;
- after the washing and drying operation of the resulted pips, it was found that they contain after the separation operation, about 11.2 percent of their weight of adherent pulp to their outer surface.

The presented data may be important for all the farmers owning orchards and aim the fruit processing on the farm in order to capitalize their own fruit production and obtaining of impotrant revenues for them.

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Din analiza şi interpretarea datelor obținute pentru probele cu visine si prune se constată următoarele:

- indicii calitativi ai materiei prime, care intervin in procesul de lucru ai instalatiei de scos samburi influenteaza rezultatele finale ale procesului de separare a samburilor de pulpa fructului:
- in situatia procesarii visinelor se constata ca existentă în pulpa separată samburi si totodata pulpa rezultata in urma separarii este zdrobita.
- in cazul prelucrarii prunelor instalatia realizeaza o separare a samburilor de pulpa fructului foarte buna, fara samburi in pulpa separata si cu un procent din pulpa reziduala de pe suprafata samburilor foarte mic
- după operația de spălare şi zvântare a sâmburilor rezultați s-a constatat ca aceştia conțin după operația de separare, circa 11,2 la sută din greutatea lor pulpa aderenta pe suprafața exterioară a lor.

Datele prezentate pot fi importante pentru toți fermierii care detin plantatii pomicole si umaresc prelucrarea fructelor in cadrul fermei in vederea valorificarii productiei proprii de fructe si obtinerea de venituri importante pentru ei.

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STUDIES AND RESEARCH REGARDING THE PROCESS OF HERBS DRYING TECHNOLOGY
/
STUDII ŞI CERCETĂRI REFERITOARE LA PROCESUL TEHNOLOGIC DE USCARE A PLANTELOR MEDICINALE

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Abstract: *This paper aims at studying the technological process of dehydration of medicinal and aromatic crop plants and spontaneous flora, in order to determine the most suitable drying process and the technical-functional equipment. The artificial dehydration of food products medicinal and aromatic plants, although it is characterized by relatively high costs, is widely used because dried products have the weight and volume reduced and may be retain and use for a long time after harvest, maintaining food quality or the therapeutic quality (in the case of medicinal plants). At the same time can ensure the rigorous control of technological operations, so the final product complies with current food safety regulations.*

Keywords: *technological process, dehydration, medicinal plants.*

INTRODUCTION

Artificially drying of food products, medicinal and aromatic plants, is widely used because dried products have low weight and volume, can be easily stored and retains much better nutritional and therapeutic qualities. At the same time can assure a rigorous control of technological operations, so the final products comply with current food safety regulations [8,11].

Medicinal and aromatic plants are used as such in the form of vegetable products for preparing teas, decoctions, infusions and other preparations used for health care or nutritional purpose.

The teas constitute the most efficient way for extracting the active ingredients from the plant and, unlike the drugs do not cause unwanted side effects. But medicinal and aromatic plants are a source of raw materials for the extraction of active ingredients and oils, with particular value for many industries [3,4,8].

The main areas for use of the medicinal and aromatic plants as well as products and active ingredients extracted from them are: in food in the form of teas, food additives, spices, colorings, sweeteners, preservatives, alcoholic or non-alcoholic drinks , for flavoring food products (chewing gum, chocolate) or nonfood (detergents) and maintenance for medical treatments, including aromatherapy cosmetics and perfume industry, deodorants products, shampoos, bath lotions, toilet soaps, toothpaste, mouthwash and as natural pesticides for plant protection [3,8,11].

Convection drying was and is the most widespread method of removing moisture from the plants because of the simplicity of the technological process and the many variants applicable (including the possibility of

Rezumat: *Lucrarea de față are ca obiect studierea procesului tehnologic de deshidratare a plantelor medicinale şi aromatice de cultură şi din flora spontană, cu scopul de a stabili procesul de uscare cel mai potrivit şi caracteristicile tehnico-funcționale ale echipamentului. Deshidratarea artificială a produselor alimentare, a plantelor medicinale şi aromatice, deşi se caracterizată prin costuri relativ ridicate, este folosită pe scară largă deoarece produsele uscate au greutatea şi volumul reduse şi se pot păstra şi utiliza o perioadă îndelungată după recoltare, cu menținerea calităților alimentare sau terapeutice (în cazul plantelor medicinale).Totodată se poate asigura un control riguros al operațiilor tehnologice, astfel încât produsul final să respecte reglementările actuale de siguranță alimentară.*

Cuvinte cheie: *proces tehnologic, deshidratare, plante medicinale.*

INTRODUCERE

Uscarea artificială a produselor alimentare, a plantelor medicinale şi aromatice, este folosită pe scară largă deoarece produsele uscate au greutatea şi volumul reduse, pot fi uşor de depozitat şi îşi păstrează mult mai bine calitățile nutritive şi terapeutice . Totodată se poate asigura un control riguros al operațiilor tehnologice, astfel încât produsul final să respecte reglementările actuale de siguranță alimentară [8,11].

Plantele medicinale şi aromatice se utilizează ca atare, sub formă de produse vegetale pentru pregătirea ceaiurilor, decocturilor, infuziilor şi a altor preparate utilizate pentru îngrijirea sănătății sau cu scop alimentar. Ceaiurile constituie modalitatea cea mai eficientă de extragere a principiilor active din plante şi, spre deosebire de medicamente, nu produc efecte secundare nedorite. Dar plantele medicinale şi aromatice reprezintă surse de materii prime pentru extragerea de principii active şi de uleiuri volatile, cu o valoare deosebită pentru mai multe domenii industriale [3,4,8].

Principalele domenii de utilizare ale plantelor medicinale şi aromatice, cât şi a produselor şi a principiilor active extrase din ele, sunt: în alimentație, sub formă de ceaiuri, aditivi alimentari, condimente, coloranți, îndulcitori, conservanți, pentru prepararea de băuturi alcoolice sau nealcoolice, pentru aromatizarea unor produse alimentare (gumă de mestecat, ciocolată) sau nealimentare (detergenți), pentru tratamente medicale şi de întreținere, inclusiv aromaterapie, în cosmetică şi industria parfumurilor pentru produse deodorante, şampoane, loțiuni de baie, săpunuri de toaletă, paste de dinți, apă de gură şi pentru protecția plantelor ca pesticide naturale [3,8,11].

Uscarea convectivă a fost şi este cea mai răspândită metodă de eliminare a umidității din plante datorită simplității procesului tehnologic şi a multiplelor variante aplicabile (inclusiv posibilitatea de asociere cu un alt

association with another drying principle), in short time and with a relatively low cost [2,4,5,9,10].

Warm air constitutes the heating agent of the drying process, but he has the role of driving the processed material moisture evaporated. Heat and mass transfer during the drying process is conditioned by the drying agent parameters (speed, temperature and relative humidity of the warm air) and the linkage between the moisture and material [7,9].

Should be taken into account that the dehydration of vegetable products is influenced by a number of factors such as the variety of the plant, the plant that must be dried and its physical and chemical properties, the drying aerial parts of the plant high content of essential oils helps to rapid removal of water from the plant, humidity initial and final preparation mode (the crumbling degree), the drying process used, the limits imposed of temperature and speed of drying in order to not affect the therapeutic value of the active substances, weather conditions (temperature , the relative humidity of the air) in which the dehydration process is carried out.

The duration the dehydration process is chosen according to the physic and chemical characteristics of the plant so that after drying the moisture content not exceeding generally 14%. For plants rich in oils (like peppermint, thyme, or basil) drying temperature should not exceed 35 °C [9].

principiu de uscare), şi pentru că asigură realizarea unei deshidratări de calitate, în timp scurt şi cu un cost relativ scăzut [2,4,5,9,10].

Aerul cald constituie agentul termic al procesului de deshidratare, dar el are şi rolul de antrenare a umidității evaporate din materialul procesat. Transferul de căldură şi de masă în timpul procesului de uscare este condiționat de parametrii agentului de uscare (viteza, temperatura şi umiditatea relativă a aerului cald), precum şi de legătura umiditate-material [7,9].

Trebuie avut în vedere faptul că procesul de deshidratare a produselor vegetale este influențat de o serie de factori cum sunt: soiul plantei, partea de plantă care trebuie uscată şi caracteristicile fizico-chimice ale acesteia, la uscarea părților aeriene ale plantei conținutul ridicat de uleiuri volatile care ajută la eliminarea rapidă a apei din plantă, umiditatea inițială şi cea finală, modul de pregătire (gradul de mărunțire), procedeul de uscare utilizat, limitele impuse temperaturii şi vitezei de uscare pentru a nu afecta valoarea terapeutică a substanțelor active, condițiile atmosferice (temperatură, umiditatea relativă a aerului) în care se efectuează deshidratarea.

Durata procesului de deshidratare se alege în funcție caracteristicile fizico-chimice ale plantei, astfel încât conținutul de umiditate după uscare să nu depăşească, în general, 14%. Pentru plantele cu un conținut bogat de uleiuri volatile (cum sunt menta, cimbru, sau busuiocul) temperatura de uscare nu trebuie să depăşească 35°C [9].

Table 1.

The parameters of drying technology for several species of medicinal and aromatic plants

The name of the plant	The drying part oh the plant	Drying temperature[°C]	Drying efficiency
Cornflower *(Centaurea cyanus)*	Flowers	max. 35°C	3 ÷ 4,5 : 1
Artichokes *(Cynara scolymus)*	Leaves	40 ÷ 45°C	6 ÷ 8 : 1
Basil*(Ocimum basilicum)*	Aerial part	max. 35°C	6 :1
Chicory*(Cichorium intybus)*	Aerial part Root	40 ÷ 50°C	5 ÷ 7 : 1 4 ÷ 5 : 1
Thyme *(Thymus vulgaris)*	Aerial part	max. 35°C	4 ÷ 5 : 1
Milfoil *(Achillea millefolium L.)*	Flowers	30 ... 35°C	3,5 ÷ 4 : 1
Hyssop *(Hyssopi herba)*	Aerial part	max. 35°C	4 :1
Lavender *(Lavandula angustifolia)*	Flowers	max. 35°C	5 ÷7 : 1
Minth *(Mentha piperita)*	Leaves	max. 35°C	4 ÷ 6 : 1
Chamomile *(Matricaria camomilia)*	Flowers Aerial part	30 ÷ 35°C	5 : 1 3 ÷ 4 : 1
Plantago *(Plantago lanceolata)*	Leaves	40 ÷ 50°C	6 ÷ 9 : 1
Lemon balm *(Melissa officinalis L.)*	Leaves Aerial part	max. 30°C	4,5 ÷ 5,5 : 1 4 ÷ 5 : 1
Sage *(Salvia officinalis)*	Leaves	30 ÷ 40°C	4 :1
St John's wort *(Hypericum perforatum L.)*	Flowers	30 ÷ 35°C	3 ÷ 4 :1

MATERIALS AND METHOD

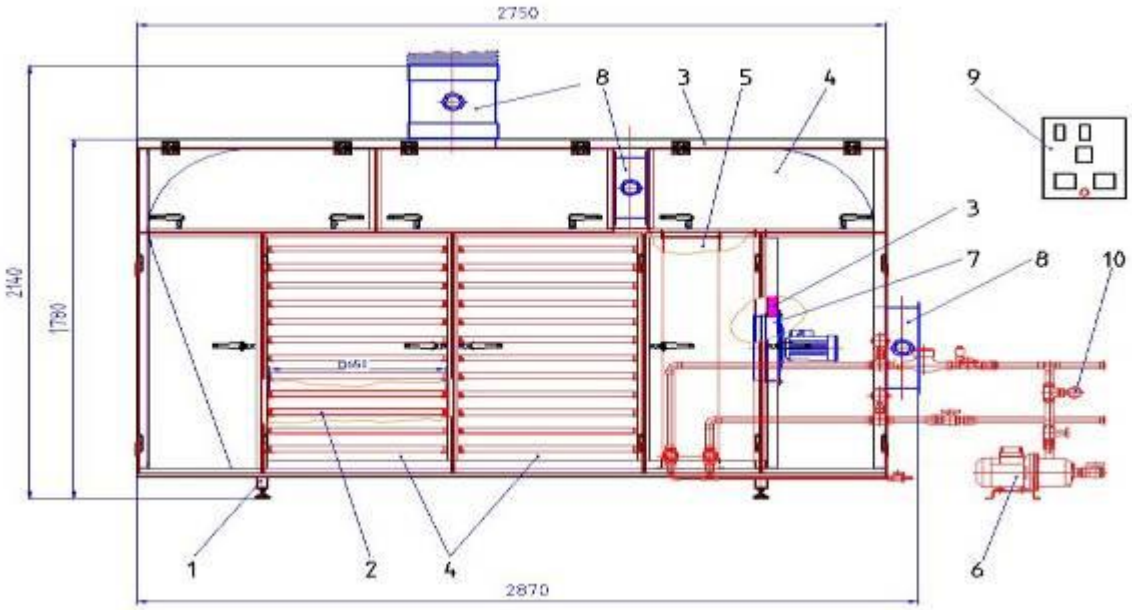
Installation for dewatering of medicinal and aromatic plants on which have been made studies consists of a metal frame, trays placing the material to be dehydrated, enclosure walls and partitions, doors, and inspection cover, heat exchanger, a whole of the water supply, axial fan, valves for air control, electrical installation for

MATERIAL ŞI METODĂ

Instalația de deshidratare a plantelor medicinale şi aromatice pe care s-au efectuat studiile este alcătuită dintr-un schelet metalic, tăvi de aşezare a materialului care urmează a se deshidrata, pereți de închidere şi de compartimentare, uşi şi capace de vizitare, schimbător de căldură, ansamblu de alimentare cu apă, ventilator

command and control, measurement devices for the drying process parameters.

axial, clapete de reglare şi dirijare a aerului, instalaţie electrică de acţionare, comandă şi control, aparatură de măsură a parametrilor procesului de uscare.



1. **Metal frame**
2. **Trays**
3. **Walls**
4. **Doors and covers**
5. **Heath Exchanger**
6. **Whole of the water supply**
7. **Axial fan**
8. **Air dampers**
9. **Electrical installation**
10. **Measuring instruments**

Fig. 1 - Technological scheme of dehydrating medicinal and aromatic plants installation

Functioning of installation for dehydrating medicinal and aromatic plants is illustrated in technological scheme shown in Fig.1.

The Installation for dehydration works in batches, the duration of dehydration of a batch depends on the type of vegetable material is vegetable it's being dried, being lower for larger herbaceous plants and fruit.

As shown in the technological scheme, the axial fan provides airflow through the radiator battery, which is heated by the hot water provided by boiler and then through plant material stacked in trays into the drying room. Because the bottom of the trays are provided with holes, some of the air flows vertically passing through the vegetable material placed on the trays, so that the drying process takes place in the entire volume of the product. The Register of adjustment with damper on the fan inlet allows manual adjustment of the flow of cold air (atmospheric air) and other valves are adjusted, all manually the flow rate of humidity laden air exhausted to atmosphere or recirculated warm air flow.

After prescribing drying parameters, automatic drying cycle was started. At the end of the process, the fan and the water pump was stopped.

The amount of air circulated through the installation can be adjusted, during operation of the installation in automatic mode, using inverter or handling dampers. Air velocity through trays product is an important parameter, especially for medicinal and aromatic plants drying, too high speed can lead to lighter fragments with high degree

Modul de funcţionare a instalaţiei de deshidratare a plantelor medicinale şi aromatice este ilustrat în schema tehnologică din Fig.1.

Instalaţia de deshidratare funcţionează în şarje, durata deshidratării unei şarje depinde de materialul vegetal ce se usucă, fiind mai mică pentru plante ierboase şi mai mare pentru fructe. După cum se vede în schema tehnologică, ventilatorul axial asigură circulaţia aerului prin bateria de radiatoare, pe care îl încălzeşte apa caldă furnizată de boiler şi apoi trece printre tăvile cu material vegetal stivuite în camera de uscare. Deoarece fundul tăvilor este prevăzut cu găuri, o parte din aer circulă pe verticală, trecând prin materialul vegetal aşezat pe tăvi, astfel încât procesul de deshidratare are loc în toată masa de produs. Registrul de reglaj cu clapete de pe admisia ventilatorului permite reglarea manuală a debitului de aer rece (aer atmosferic), iar cu celelalte clapete se reglează, tot manual, debitul de aer încărcat de umiditate evacuat în atmosferă sau debitul de aer cald recirculat.

După prescrierea parametrilor de uscare, sa pornit ciclul automat de deshidratare. La terminarea procesului, ventilatorul sa oprit şi sa oprit şi pompa de apă.

Cantitatea de aer vehiculată prin instalaţie poate fi reglată, în timpul funcţionării instalaţiei în regim automat, cu ajutorul invertorului sau prin manevrarea clapetelor de aer. Viteza aerului printre tăvile cu produs este un parametru foarte important, în special la uscarea plantelor medicinale şi aromatice, o viteză prea mare

of dehydration.

The progress of the dehydration by using electric devices mounted on the cabinet door which indicates the temperature and humidity of the air leaving the drying room. Depending on the sizes of these parameters are are made adjustments of ventilator sucked air flow and it was established the moment when starts the recirculation and the flow rate of recirculated air.

Recirculated air mode was obtained by the partial opening of the register control over the drying chamber and partial closing the admission register.

RESULTS

In the first experiment was use a herb called Chrysanthemum (Chrysanthemum), it has a detoxifying action and immunostimulatory over the body [11].

The plant was placed in the drawers by 600g in each drawer, the initial sample weight being 9 kg. To keep the plant active principles, it was dried at 40 ° C.

The product was characterized by:

the average initial moisture was a_{1m} = 67.34% humidity a_{2m} final average was 7.93%

The 9 kg of plant load is the effective load at disposal for testing in following inputs conditions:

Initial mass of the sample: M_0 = 9 kg

Initial humidity: a_{1m} = 67,34 %

Total amount of water in the sample:

M_{TA} = 6,06 kg

The amount of dry substance: SU = 2,94 kg

Final humidity: y a_{2m} = 7,93 %

The initial temperature: t_0 = 20°C

The average drying temperature: t_m = 40° C

It was determined the specific energy consumption:

q = 10.205 kj/kg evaporated water [1,6]

Registrations performed on the first experiment measured values are presented in table 2.

putând antrena fragmentele mai uşoare, cu grad avansat de deshidratare.

Evoluția procesului de deshidratare a fost urmărit cu ajutorul aparatelor montate pe uşa dulapului electric care indică temperatura şi umiditatea aerului la ieşirea din camera de uscare. În funcție de mărimile afişate ale acestor parametri se fac ajustări ale debitului de aer aspirat de ventilator şi s-a stabilit momentul când se începe recircularea aerului şi ponderea debitului de aer recirculat. Recircularea aerului sa obținut prin deschiderea parțială a registrului de reglare de deasupra camerei de uscare şi închiderea, tot parțială, a registrului de admisie.

REZULTATE

În cadrul primului experiment sa folosit planta medicinală numită Chrysanthemum (Crizantemă), aceasta are o acțiune detoxifiantă şi imunostimulatoare asupra organismului [11].

Planta a fost aşezată în sertare câte 600g în fiecare sertar, masa inițială a probei fiind de 9 kg. Pentru a se păstra principiile active din plantă, aceasta sa uscat la temperatura de 40°C.

Produsul s-a caracterizat prin:

Umiditatea medie inițială care a fost a_{1m} = 67,34 %, Umiditatea medie finală a fost a_{2m} = 7,93 %.

Sarcina de 9 kg de plantă este sarcina efectivă avută la dispoziție pentru experimentare, în condițiile următoarelor date de intrare:

Masa inițială a probei: M_0 = 9 kg;

Umiditatea inițială: a_{1m} = 67,34 %;

Cantitatea totală de apă din probă:

M_{TA} = 6,06 kg

Cantitatea de substanță uscată: SU = 2,94 kg

Umiditatea finală: a_{2m} = 7,93 %

Temperatura inițială: t_0 = 20°C;

Temperatura medie de uscare: t_m = 40° C

S-a determinat consumul specific de energie:

q = 10.205 kj/kg apă evaporată [1,6]

Înregistrarea mărimilor măsurate efectuate la primul experiment se prezintă în tabelul nr.2

Table 2.

Sizes measured while performing the first experiment

Den. no.	Drying time [min]		Power [% P_n] .	Medium temperature [°C]	Measured sizes		Calculated sizes		Observation
	Between measurements Δt	Cumulated			Table sample m [g]	Qty. of evaporated water in the measurement range Δm [g]	Humidity [%]	Drying speed [%humid/min]	
0	0	0	0	20	100	0	67,34	0	
1	30	30	36	38	99,5	0,5	67,178	0,08	Preheating
2	30	60	36	40	94,63	4,87	60,34	0,3	
3	60	120	36	40,1	82,35	12,28	54,36	2,143	Constant speed drying
4	60	180	36	40	71,57	10,78	44,11	2,143	
5	60	240	36	39,9	58,44	13,13	35,4	2,143	
6	60	300	36	40,5	49,02	9,42	22,82	2,143	
7	60	360	36	40,3	42,32	6,7	20,48	0,81	Final drying
8	60	420	36	40	37,50	4,82	12,90	0,34	
9	60	480		29	35,47	2,03	7,93	0,06	Cooling

During the second experiment has been use a different type medicinal plant Aloe Vera (Aloe Barbadensis) this herbs are used for its antiseptic and anti-inflammatory properties [11].

The total amount of plant introduced into the dryer was 10.8 kg. The plant has been distributed in the dryer drawers each 720 g / drawer.

The load of 10.8 kg of the plant was the actual load and was considered productivity due to the following inputs:

Initial sample mass: M_0 = 10,8 kg
Initial humidity: a_{1m} = 77,08 %
total amount of water in the sample:
M_{TA} = 8,32 kg
the amount of dry substance: SU = 2,48 kg
final humidity: y a_{2m} = = 8,42 %
the initial temperature: t_0 = 25°C
the average drying temperature: t_m = 42° C
It was determined the specific energy consumption:
q = 9.113 kj/kg evaporated water [1,6]
Registrations performed on the first experiment measured values are presented in table 3.

În cadrul celui deal doilea experiment s-a utilizat un alt tip de planta medicinală Aloe Vera (Aloe Barbadensis), plantă medicinala folosită pentru proprietățile sale antiseptice şi antiinflamatorii [11].

Cantitatea totală de plantă introdusă în uscător a fost de 10,8 kg. Planta a fost distribuită în sertarele uscătorului câte 720 g/sertar.

Sarcina de 10,8 kg de planta a fost sarcina efectivă şi a fost considerată productivitate în condițiile următoarelor date de intrare:

masa inițială a probei: M_0 = 10,8 kg
umiditatea inițială: a_{1m} = 77,08 %
cantitatea totală de apă din probă:
M_{TA} = 8,32 kg
cantitatea de substanță uscată: SU = 2,48 kg
umiditatea finală: a_{2m} = 8,42 %
temperatura Inițială:T_0 = 25°C
temperatura medie de uscare: T_m = 42°C
S-a determinat consumul specific de energie:
q = 9.113 kj/kg apă evaporată [1,6]
Mărimile măsurate efectuate la cel de-al doilea experiment se prezintă în tabelul nr.3

Table 3

Sizes measured while performing the second experiment

Den. no.	Drying time (min)		Power (% P_n)	Medium temperature (^{0}C)	Measured sizes		Calculated sizes		Observation
	Between measurements Δt	Cumulated			Table sample m (g)	Qty. of evaporated water in the measurement range Δm (g)	Humidity (%)	Drying speed (%humid/ min)	
0	0	0	0	25	100	0	77,08	0	
1	20	20	36	39	99,58	0,42	76.98	0,07	Preheating
2	30	50	36	40	95,71	2,87	76,05	0,27	
3	60	110	36	42	85,45	10,26	73,17	2,67	Constant speed drying
4	60	170	36	41,8	76,58	8,87	70,07	2,67	
5	60	230	36	42,1	63,08	13,50	63,66	2,67	
6	60	290	36	41,9	52,46	10,62	56,30	2,67	
7	60	350	36	41,6	44,78	7,68	48,81	2,67	
8	60	410	36	42	35,85	8,93	36,03	2,67	
9	60	470	36	41,7	30,58	5,27	24,05	0,9	Final drying
10	60	530	36	40	26,96	3,62	14,98	0,34	
11	60	590		30	25,04	1,93	8,42	0,06	Cooling

Fig. 2 - Drawers of the installation for dehydration of medicinal plants

Fig. 3 - Picture of the installation for dehydration of medicinal plants

CONCLUSIONS

The products of medicinal and aromatic plants represent a high economic value on both domestic and foreign markets because they have a wide range of use.
To achieve them are unnecessary especially when local resources are exploited Parameters of heating agent (hot water) ensures high enough temperatures for the drying agent in order to dry plants with higher and lower moisture and plants and those plants that present a wood structure. At the same time there are sufficient reserves as temperature and flow of heat to dehydrate fruits and vegetables properly prepared, if necessary even by slicing. Partial recirculation of hot air in the final phase of dehydration cycle by adjusting the air dampers provided on the circuit contributes to drying products with low power consumption, and automation of the process of drying and the provision of measuring devices in circuits of water and air enables and control the temperatures, bearings and drying cycle duration for each product.

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CONCLUZII

Produsele obținute din plante medicinale şi aromatice reprezintă o valoare economică mare şi au căutare, atât pe piața internă cât şi pe cea externă, deoarece au o gamă largă de utilizare. Pentru obținerea lor nu sunt necesare învestiții deosebite, în special dacă se valorifică resursele locale. Parametrii agentului termic (apă caldă) asigură temperaturi ale agentului de uscare suficient de mari pentru a usca atât plante cu umiditate mai mare cât şi plante cu umiditate mai mica precum şi acele plante care prezintă o structură lemnoasa. În acelaşi timp există suficiente rezerve, ca temperatură şi debit de căldură, pentru a se deshidrata şi fructe sau legume pregătite corespunzător, daca este cazul chiar prin feliere. Recircularea parțială a aerului cald în faza finală a ciclului de deshidratare, prin reglarea clapetelor prevăzute pe circuitul de aer, contribuie la uscarea produselor cu un consum redus de energie, iar automatizarea procesului de uscare şi prevederea unor aparate de măsură pe circuitele de apă şi aer permit stabilirea şi controlul temperaturilor, a palierelor şi a duratei ciclului de uscare pentru fiecare produs în parte.

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OPTIMIZATION DESIGN OF FRUIT PINKING END-EFFECTOR BASED ON ITS GRASPING MODEL
/
基于抓取模型的水果采摘末端执行器优化设计

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Abstract: *The development of intelligent fruit harvesting robots is important in improving agricultural production. In this paper, we initiated the R&D of a mechanical end-effector for fruit harvesting on the basis of the intelligence of agricultural robots. First, we provided a detailed description of the hardware components and software control of the mechanical end-effector, analyzed the mechanism of servo controlling and established a mathematical modeling of the mechanical end-effector junctions by analyzing the harvesting movement. Thereafter, the coordinates of the target fruits are disassembled and analyzed in the context of the mathematical model for precise locating and harvesting. Finally, a trail experiment of harvesting kiwifruit was conducted. The outcome implies that each module in the harvesting robot system functions well. The proposed mathematical modeling method and servo control can provide accurate harvesting movements to the mechanical end-effector.*

Keywords: *picking, end-effector, motion optimization, models*

摘要: *智能化果蔬采摘机器人的开发，对于提高农业生产力有极大的应用价值与现实意义。本论文根据农业机器人的智能化发展需要，研发了能对果实进行采摘的末端执行器。对果实采摘末端执行器的硬件构造和软件设计进行了描述，分析了舵机的控制原理，并通过对末端执行器采摘果实动作的分析，对采摘末端执行器各关节进行数学建模，然后将目标果实坐标通过数学建模进行拆解分析，使得末端执行器可以准确移动到果实的位置并进行准确采摘。最后进行了猕猴桃的采摘作业试验，试验结果表明:系统各模块运转良好，提出的建模方法与舵机控制方法可实现采摘末端执行器的精确移动和准确采摘。*

关键词: *采摘；末端执行器；运动优化；模型*

INTRODUCTION

Great efforts have been made in the past decades in the use of robots for selective harvesting, which is the most time-consuming process in agricultural operations. In natural environments, the growth of fruits depends on soil, season, and weather, which varies enormously and hinders precise locating and harvesting. Therefore, the research and development of high-end robots with accuracy and efficiency has become increasingly significant in agricultural harvesting [2,8,10,11]. Such a study has been performed for more than 40 years in many countries [16,21,18,6]. Japan, the United States, and some developed European countries have been working relentlessly on the R&D of harvesting robots. In Japan, eggplant-harvesting robots spend 64.1 s in picking one eggplant and have success rates of 62.5% [7]. Grape-harvesting robots are not only capable of harvesting but also of spraying, bagging, and clipping [1]. Kiwifruit-harvesting robots have harvesting speeds of 74.6 s for each fruit and suction attachment success rates of 95.3% [3]. Wageningen University designed cucumber-harvesting robots that utilize near-infrared visual system to identify cucumbers with success rates of approximately 70% [15]. Mushroom-harvesting robots designed in the United Kingdom can harvest one mushroom in 1.5 s with a success rate of 75% [4]. Melon-harvesting robots designed in Israel and the United States can achieve a success rate of over 85% during identification and harvesting [5]. The apple-harvesting

引言

过去的几十年里，人们在农业运作最为耗时的选择性采摘果实方面已经做出了巨大的努力。在自然环境中，水果的生长依赖于土壤、季节和天气，这些因素变化极大，阻碍了精确的定位和收获。因而，研究和开发有着高精度和高效率的农业采摘高端机器人的是非常重要的[2,8,10,11]。40 年前在许多国家已经进行这方面的研究[16,21,18,6]。日本、美国和一些发达国家一直致力于研发采摘机器人。日本茄子采摘机器人花费 64.1 秒采摘一个茄子，成功率达到 62.5%[7]。葡萄采摘机器人不仅能够采摘，而且可以喷药、套袋和裁剪[1]。猕猴桃采摘机器人对每个果实采摘速度达到 74.6 秒，成功率达到 95.3%[3]。瓦赫宁根大学设计的黄瓜收获机器人，利用近红外视觉系统，以确定黄瓜并成功采摘的概率约为 70%[15]。英国设计的磨菇采摘机器人采摘一个磨菇的时间是 1.5 秒，成功率达到 75% [4]。以色列和美国设计的甜瓜采摘机器人可以实现在识别和采摘，成功率达到 85%以上[5]。韩国庆北

robots developed by Kyungpook National University in South Korea can identify cucumbers from the tree crown with a success rate of 85% and harvesting speed of 5 s for each cucumber [17]. The mushroom-harvesting robots by Silsoe Research Institute in the United Kingdom can harvest at the speed of 6.7 s for each mushroom with a success rate of 75% [13]. In China, the study of harvesting robots has made significant progress in recent years. China Agricultural University has developed cucumber-harvesting robots and vegetable-grafting robots [20, 9], Nanjing Agricultural University has furthered the visual navigation system to enable automatic operations [22], and Zhejiang University has designed and optimized the visual positioning and harvesting components of robots [19]. All of these studies have accelerated the development of agricultural informatization and automation in China. In the present paper, the position coordinates of fruits were obtained from a binocular system. The necessary movement at each end-effector junction was controlled according to the 3D coordinate analytic algorithm. The revolving angle of each servo was manipulated to stretch the mechanical arm to the target fruit and for harvesting.

国立大学研制的苹果收获机器人，在树冠上能识别 85%的黄瓜，并用 5 秒的时间采摘一个果实[17]。由英国 Silsoe 研究院研发的磨菇采摘机器人用 6.7 秒的时间采摘一个磨菇，成功率达到 75% [13]。近年来，中国在采摘机器人方面的研究取得巨大进展。中国农业大学已经研发了黄瓜采摘机器人和蔬菜嫁接机器人[20, 9]。南京农业大学在运用自动操作的可视化导航系统方面已经取得一定成就[22]。浙江大学设计并优化了机器人的视觉定位和采摘组件[19]。所有这些研究加速中国农业的自动化和信息化。在本文，从双目系统获得水果的位置坐标。在末端执行器连接处必须的移动由 3D 坐标分析算法控制。操纵每一个伺服的旋转角度，以拉伸机械臂触及采摘目标水果。

MATERIALS AND METHODS

The Harvesting End-effector

The system uses an end-effector (Figure 1) that is made of aluminum alloy brackets and servos. The entire end-effector is equipped with two MG995 servos and three MG996R servos. The picking tool has a highly mimicking design. In harvesting, only No.3, No.4, No.5, No.6, and No.7 servos are involved, whereas the No.2 servo is a back-up that is temporarily immovable and is vertically upward. The No.3 servo controls the base rotation, thereby controlling the movement direction of the picking robot. The No.4 and No.5 servos control the main body of the arm, which is equivalent to the hand control of humans controlling lifting and other actions. The No.6 servo, the equivalent of a human's wrist, controls the vertical movement when picking fruits. The No.7 servo controls the opening or closing of metal pincers, similar to a human's fingers. The respective location of each servo in the harvesting end-effector is shown in Figure 1(a).

材料与方法

采摘末端执行器

系统采用的采摘末端执行器如图 1 所示，它由铝制合金结构的支架和舵机构成，整个采摘末端执行器配置了两个 MG995 与三个 MG996R 舵机。该采摘工具高度模仿人体手臂，采摘过程只涉及末端执行器的 3、4、5、6、7 号舵机，而 2 号舵机为后备移动舵机，是暂时性固定不动竖直向上的。3 号舵机控制着末端执行器的底座转动，从而控可采摘的方向；4、5 号舵机控制着末端执行器的主要躯干，相当于人体手臂部分，控制着抬举等动作；6 号舵机控制着末端执行器采摘果实的上下移动，相当于人体手腕关节；7 号舵机则控制着采摘终端金属钳子的伸张，相当于人体手部位置。末端执行器的各舵机具体位置如图 1(a)所示。

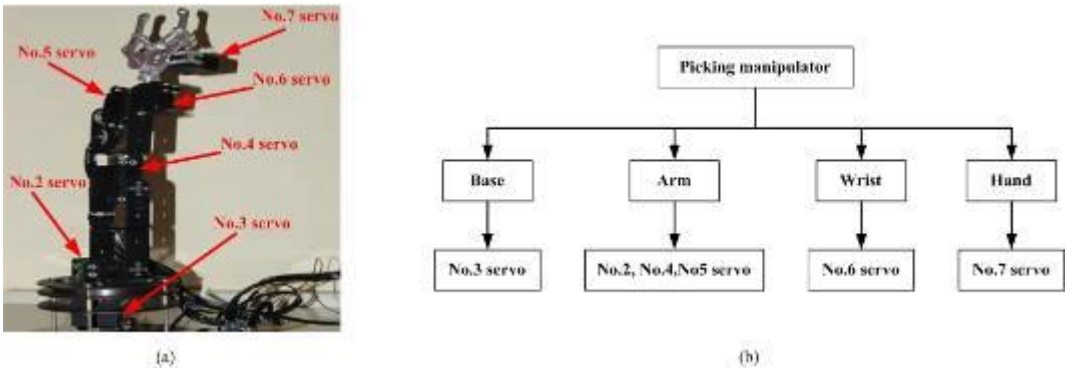

Fig.1- Picking robot chart. (a) The specific location of each servo. (b) Picking end-effector joint control.

Control of Harvesting End-effector and Motion Analysis

Control of each joint

The servo control uses a PWM signal with a unique time width between high and low levels [12]. Given that the servo system uses a digital servo type, it has a low

采摘末端执行器的控制及动作分析

各关节控制

本系统的舵机控制采用 PWM 进行控制。PWM 信号为脉宽调制信号[12]，其特点在于它的高电平与低电平之间

requirement for PWM signal. Furthermore, the servo system does not need to receive real-time instruction and can be auto-locked and positioned. These characteristics have outperformed the ordinary stepper motor [14]. The timing diagram of the PWM signal is shown in Figure 2.

的时间宽度。鉴于伺服系统采用数字式伺服系统，其对 PWM 信号的要求较低，不需要接收实时指令，可以自动锁定和定位。这些特性都优于普通的步进电机[14]。图 2 为 PWM 信号的时序图。

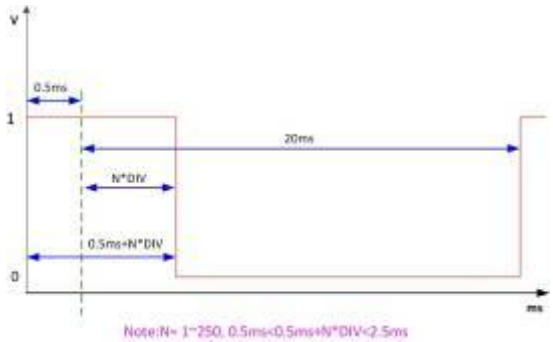

Fig.2- PWM timing diagram at one cycle

The servo system used for the harvesting end-effector has no requirement for low-level time, thus indicating that the use of a low time of 0.5 ms is allowable and that a cycle of the PWM waveform can be 1 ms standard square wave. The system controller uses an 8-bit micro-controller and 256 data resolution, which will be divided into 250 parts after the servo limit parameter experiment. Thereafter, when the width between 0.5 ms to 2.5 ms is 2000 μs, the width will be divided into 250 parts, thus resulting to 8 μs. The PWM control precision can be used to control the revolving and positioning of the servo at an increasing basis. Given that the servo can revolve at 185°, the servo's control precision is 0.74°. By controlling the servo's revolving angle according to PWM wave high-level duration, we obtained the data shown in Table 1 to Table 5. The 0° angle in the Tables represents the critical point in the positive and negative directions of the space coordinates. Table 1 to Table 5 shows that the revolving angle of servo has a linear relation with PWM wave high-level duration.

系统的采摘末端执行器所使用的舵机对低电平时间并没有要求，使用 0.5ms 的低电平时间也是允许的，即 PWM 波形的一个周期可以是 1ms 的标准方波。该系统控制器采用一个 8 位微控制器，其数据分辨率为 256，那么经过舵机极限参数实验，得到应该将其划分为 250 份。那么 0.5ms 到 2.5ms 的宽度为 2000us，由 2000us/250 得 PWM 的控制精度为 8us，因此可以以 8us 为单位递增控制舵机转动与定位。鉴于舵机可旋转 185 度，控制精度为 0.74 度，根据 PWM 波高电平持续时间控制舵机转动不同的角度，进而根据实际的实验测量数据得出表 1 至表 5 中的数据。表中 0 度均表示为采摘末端执行器建立的空间坐标系中正负方向的临界点。从表 1 至表 5 可清晰看出舵机转动的角度与 PWM 波高电平持续的时间成线性关系。

Table 1

Relation between No.3 servo's revolving angle and PWM wave high-level duration

Angle (°)	−72	−45	−30	0	60
High-level voltage (μs)	2000	1775	1588	1380	1000

Table 2

Relation between No.4 servo's revolving angle and PWM wave high-level duration

Angle (°)	−50	−35	0	45	90
High-level voltage (μs)	2100	2000	1760	1380	1000

Table 3

Relation between No.5 servo's revolving angle and PWM wave high-level duration

Angle (°)	−45	0	90	143
High-level voltage (μs)	500	800	1470	2100

Table 4

Relation between No.6 servo's revolving angle and PWM wave high-level duration

Angle (°)	−14	0	90	173
High-level voltage (us)	500	620	1380	2000

Table 5

Relation between No.7 servo's revolving angle and PWM wave high-level duration

Angle (°)	0	24	37	49
High-level voltage (μs)	2100	1850	1720	1600

Classification and coordinate composition of harvesting movement

In harvesting, only the No.3, No.4, No.5, No.6, and No.7 servos are involved, whereas the No.2 servo is a back-up that is temporarily immovable and is vertically upward. The No.6 and No.7 servos control the picking and stabilization of the kiwifruit, respectively. Thus, the No.6 and No.7 servos do not involve the end-effector's accurate movements to the target kiwifruit. The No.3 servo controls the base rotation, thereby controlling the revolving angle according to the X and Y space coordinates of the target kiwifruit. The flow chart of the programming is shown in Figure 3.

采摘动作的分类及其坐标分解

在采摘过程中，只有采摘末端执行器的 3、4、5、6、7 号舵机参与工作，而 2 号舵机是后备移动舵机，暂时是固定不动竖直向上的。6、7 号舵机则分别控制猕猴桃抓取与夹稳，因此 6、7 号舵机不涉及采摘末端执行器的精确移动至目标猕猴桃的过程。3 号舵机控制着采摘末端执行器基座的旋转，可以根据目标猕猴桃空间坐标的 X、Y 数据确定 3 号舵机的转动角度。程序设计流程图如图 3 所示。

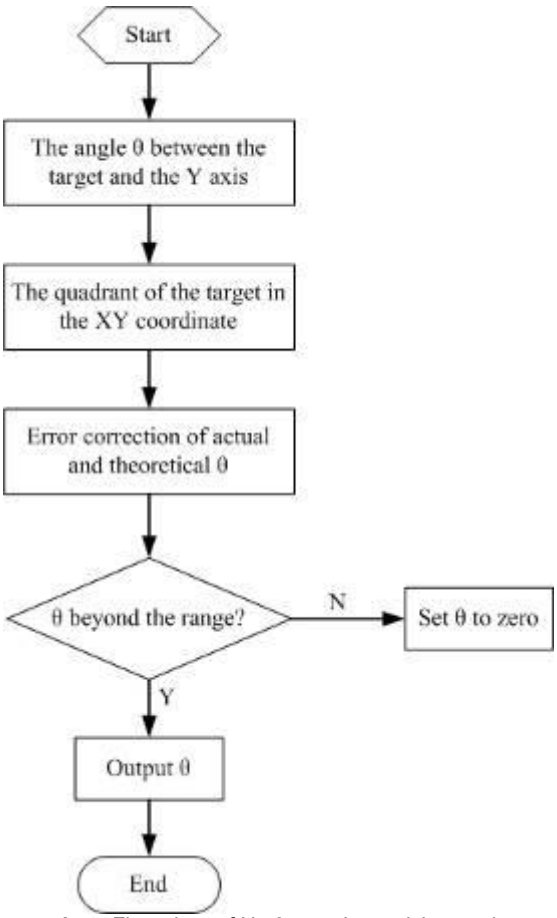

Fig.3- Flow chart of No.3 servo's revolving angle

Only determining the rotational angle of the No.3 servo is insufficient to move the end-effector's clamp to the target kiwifruit. This movement needs the analysis of the revolving angles of the No.4 and No.5 servos. The force manipulators that are controlled by the No.4 and No.5 servos are named as ahead arm and rear arm, respectively. As shown in Figure 4, the target kiwifruit is set as point A, the No.4 servo as one point, and the No.5 as another point. A triangle is formed by connecting the three points.

仅确定 3 号舵机的转动角度还不能把采摘末端执行器采摘的钳子移动到目标猕猴桃的位置，还需要分析 4、5 号舵机转动的角度。在这里分别命名 4、5 号舵机控制的力臂为前臂与后臂，把目标猕猴桃设为 A 点，4 号舵机作为一个点，另外再把 5 号舵机设为一个点，然后把 A 点与 4、5 号舵机点相连接形成了三角形关系，如图 4 所示。

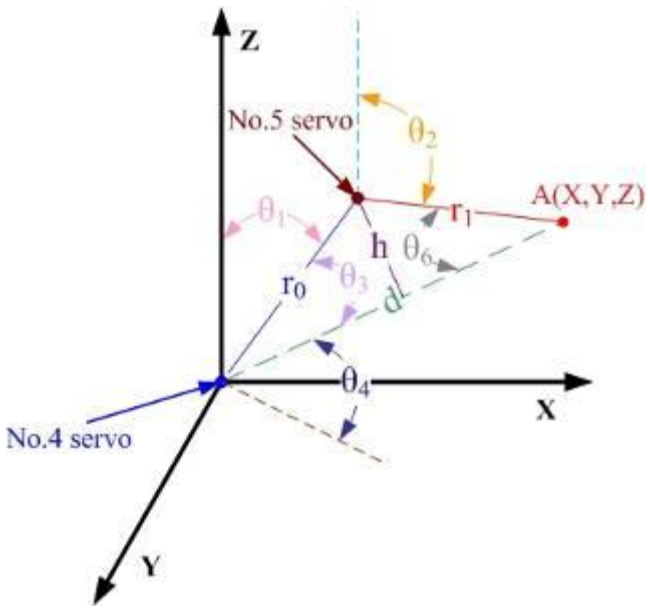

Fig.4- Mathematical modeling of revolving angles of No.4 and No.5 servos

In Figure 4, θ_1 and θ_2 are the revolving angles of the No.4 and No.5 servos, respectively; r_0 and r_1 represent the distances from the No.4 to No.5 servos and No.5 to No.6 servos, respectively. The distance *d* from point A to original point "O" in Figure 4 can be obtained by using the XYZ coordinates transmitted by the binocular system.

在图 4 中，θ_1 与 θ_2 是 4、5 号舵机为采摘目标猕猴桃而需要转动的角度，r_0、r_1 分别代表末端执行器 4 号与 5 号舵机间距离、5 号与 6 号舵机间的距离，通过双目系统传送过来的 XYZ 坐标即可求出 A 点到原点"O"的距离。

$$d=\sqrt{X^2+Y^2+Z^2} \tag{1}$$

The triangle's height *h* can be calculated by Heron's formula:

通过海伦公式可以求得该三角形的高。

$$h=\frac{2\sqrt{p(p-r_0)(p-r_1)(p-d)}}{d} \tag{2}$$

where *p* is the half perimeter defined by the following:

在这里 *p* 为半径，其定义为：

$$p=\frac{1}{2}(r_0+r_1+d) \tag{3}$$

By using r_0, r_1, and height *h* with anti-trigonometric function, angles θ_3 and θ_6 in this triangle can be acquired as follows:

利用 r_0, r_1, 和高 *h*，通过下式求他们的反三角函数可求得 θ_3 和 θ_6。

$$\theta_3=\arcsin(\frac{h}{r_0}) \tag{4}$$

$$\theta_6=\arcsin(\frac{h}{r_1}) \tag{5}$$

By using the Z coordinates of the target kiwifruit, angle θ_4 of line segment OA and the horizontal plane can be calculated as follows:

根据目标猕猴桃的坐标 Z 可得出 OA 线与水平面的夹角 θ_4，如下式所示：

$$\theta_4=\arcsin(\frac{|Z|}{d}) \tag{6}$$

Finally, according to the law of the right angle, θ_1 and θ_2 are given by the following:

最终根据直角取余法则求出 θ_1，同理可得 θ_2。

$$\theta_1=90^\circ-\theta_3-\theta_4 \tag{7}$$

$$\theta_2=90^\circ-\theta_4+\theta_6 \tag{8}$$

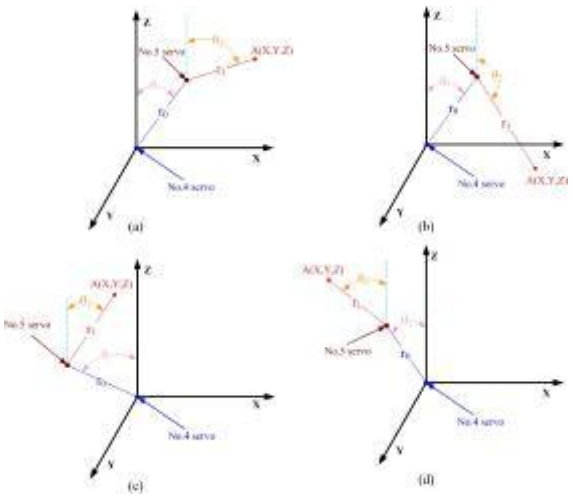

Fig.5- Flow chart of receiving the coordinates by the end-effector's controller

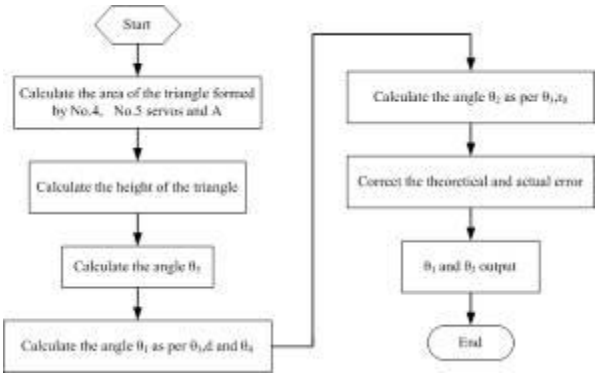

Fig.6- Flow chart of picking feedback

The calculation algorithm of the steering revolving angle of the No.4 and No.5 servos is limited to the right ahead and above direction. Thus, θ_1 has a positive degree value and θ_2 is less than 90°. However, in actual conditions, the harvesting system is operated on the ground where complicated directions are involved such as ahead above, rear above, ahead below, and rear below. According to various experiments, the picking robot only needs four postures to achieve 360° of harvesting operation. The four postures are quite similar to a human's hand–wrist movements in all directions. As shown in Figure 5, the end-effector has four corresponding picking postures. The picking postures are distinguished on the basis of the revolving angle of over ±90°. Figure 6 shows the programming flow chart of how an end-effector controls the revolving angle of the No.4 and No.5 servos according to the space coordinates of the target fruit.

Communication Between the End-effector and PC

The control system communicates with a PC through serial ports. When a PC detects a kiwifruit, it calculates the space coordinates of the target fruit. The PC will then transmit 9600 b/s baud rate of data to the control system of the robot end-effector. Given that the communication between the PC and the end-effector's controller can only transmit one 8 bit binary data, a special algorithm needs to be applied to the data conversion to protect the data validity within the scope of 8 bit binary data and the data must be stored in the end-effector's controller. The program of the specific data receiving the unit of the harvesting end-effector is shown in Figure 7. When the communication of serial ports is interrupted, RI is the zero setting and the flag denotes the flag bit of the data transmitted. The data transmitted from the PC is the X-axis coordinate, which is followed by Y and Z coordinates.

When the picking end-effector completes a set of assigned actions according to the given coordinates and finally picked up the target kiwifruit, the end-effector will respond with an "OK" feedback to the PC as a signal for the picking order of the next target. The "OK" feedback procedure code is shown in Figure 8. First, ES is set to zero and "O" is placed in SBUF for data storage. Thereafter, TI is tested if it has a value of one to determine if the PC received the data. The same procedure is adopted to "K," and ES is set to one.

对 4、5 号舵机转动角度的计算仅限于目标猕猴桃位于采摘末端执行器三维坐标系的正前上方，即 θ_1 为正角度、θ_2 小于 90 度。然而，在实际情况下，系统的采摘过程是基于地面的，因此所有的采摘过程中猕猴桃会随机的位于末端执行器的前上方、后上方、前下方、后下方等各种情况，根据大量实验得出末端执行器只需四种采摘姿势便可采摘到 360°全方位的猕猴桃，这些姿势与人的手一样，在各个方向上都很相似，如图 5 所示，采摘末端执行器针对四种情况做出的四种采摘姿势。采摘姿势区分的依据是根据 4 号舵机和 5 号舵机转动正负角度大于 90 度而区分。采摘末端执行器根据目标果实的空间坐标控制 4 号舵机和 5 号舵机转动角度的程序设计流程图如图 6 所示。

末端执行器与 PC 之间的通信

采摘末端执行器上的控制系统是通过串口与 PC 进行通信的，当 PC 检测出猕猴桃并计算出目标猕猴桃的具体空间坐标,PC 端便以 9600b/s 的波特率将数据传送到采摘末端执行器上的控制系统。由于 PC 端与采摘末端执行器上的控制器的通信一次只能传送一个 8 位的二进制数据，因此需在 PC 端通过一些特殊的数据转换算法使得数据在 8 位二进制数据的范围内以保护数据的有效性，然后在采摘末端执行器控制器中还原数据。采摘末端执行器控制器具体的数据接收程序如图 7 所示，当进入串口通信中断程序，RI 置零，flag 为数据传送个数的标记位，PC 端首先传送过来的数据是 X 轴的坐标，然后依次为 Y、Z。

当采摘末端执行器完成一组动作到达系统给定的空间坐标位置并把目标猕猴桃采摘下来后，采摘末端执行器将反馈一个"OK"给予 PC 端，从而 PC 可更有效率的传送下一个目标采摘指令。采摘末端执行器反馈"OK"的具体程序代码如图 8 所示。首先 ES 置 0，然后将数据"O"放入 SBUF 数据存储，通过检测 TI 是否为 1 即刻检测出 PC 端是否接受到数据，以同样的方法将"K"也反馈给 PC 端，最后将 ES 复位为 1。

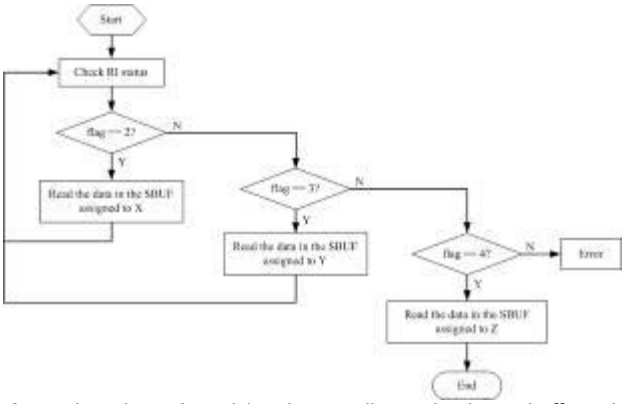

Fig.7- Flow chart of receiving the coordinates by the end-effector's controller

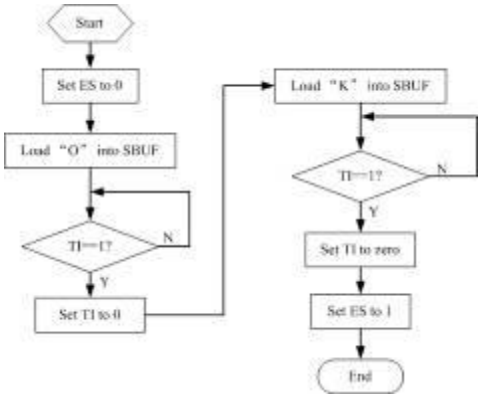

Fig.8- Flow chart of picking feedback

RESULTS

This paper selects clusters of fruits to be picked. The process is shown in Figure 9.

结果

本文选取一类水果进行采摘，其过程如图 9 所示。

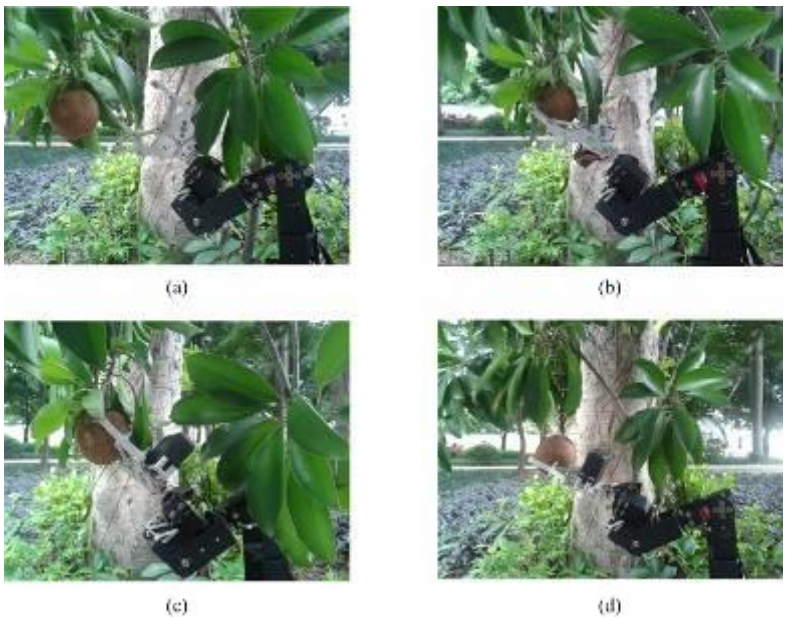

Fig.9- Fruit picking process. (a) Start grabbing; (b) Finish grasping; (c) Start spinning; (d) Finish picking.

Table 6 shows how the PWM cycle affects the servo operation. When the PWM cycle is 2000 μs, the end-effector moves extremely fast, which is applicable for harvesting large fruits. When the cycle is 3000 μs, the speed is moderate, thus neither wearing off the machine because of the fast speed nor enabling harvesting because it is too slow. Therefore, the default PWM cycle utilized in this system is 3000 μs.

表 6 为 PWM 周期对舵机的影响，当 PWM 周期为 2000μs 的时候，末端执行器的运动极为快速，适用于大果实的采摘；当 PWM 波周期为 3000μs 的时候，末端执行器速度较为合适，不会因为速度太快而造成机械的磨损加剧，也不至于太慢导致无足够的力度采摘目标果实。因此本系统末端执行器的 PWM 周期默认为 3000μs。

Table 6

PWM cycle and servo control

PWM Cycle (us)	1500	2000	3000	7000
How the end-effector works	No movement	Extremely fast movement, normal operation	Moderately fast movement, normal operation	Slow movement, insufficient strength

Table 7 shows the test results of the precise movement of the end-effector to the target coordinates. This table shows that the end-effector is able to reach the space coordinates of the target transmitted by the binocular system, accurately analyze the direction of the coordinates, and determine the picking posture when harvesting. Moreover, picking robot can judge if the space coordinates are within the range of harvesting, which is in line with the system design. It means the end-effector can determine if the target can be picked; if not, the end-effector will have no movement and give the feedback to the PC end.

表 7 为采摘末端执行器移动至目标坐标的测试情况。从该表不难观察出采摘末端执行器能准确到达双目系统传送过来的目标空间坐标，并且能准确分析给定坐标位于采摘末端执行器的哪个方位，从而判断出使用何种采摘姿势进行采摘。另一方面，采摘末端执行器对于空间坐标是否在采摘范围的判断符合本系统设计的结果，能准确地判断出目标坐标是否具备可采摘性，若不可采摘，末端执行器不做出任何采摘动作并且反馈给 PC 端。

Table 7

Test results of the picking end-effector

Space coordinates of the target(mm)	(150, 150, 156)	(100, 200, 156)	(100, 400, 256)	(–50, 100, 160)
Tested Results	Accurate picking	Accurate picking	Target can not be picked	Accurate picking

CONCLUSIONS

The research on fruit picking robots is thriving in China and abroad because of its significance in the development of science and technology and human civilization. The picking end-effector is metal structure composed of five servos that control each junction of the end-effector to adapt complicated situations. The picking end-effector is more flexible and stable than other manipulators. In this paper, the movement in harvesting fruits is discussed; and each junction of the end-effector has mathematical modeling through which the coordinates of the target fruit is disassembled and analyzed so the end-effector can reach to the target precisely. Finally, experiments have verified the validity of the end-effector and its efficiency in agricultural operation.

结论

果实采摘机器人是当前国内外热门研究的课题，其发展对促进科学技术的发展与人类文明发展进程有着重大的实际意义。本论文的果实采摘末端执行器的结构为金属支架，通过控制五个舵机从而控制末端执行器的各个关节，使其能适用于各种复杂的情景，比其他采摘末端执行器更灵活、更稳定。另外本论文通过分析末端执行器采摘果实的动作，对它进行数学建模，然后将目标果实坐标通过数学建模进行拆解分析，使得末端执行器可以准确移动到果实的位置。最后通过采摘试验验证了该采摘末端执行器的有效性以及作业流程的合理性。

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ELECTROMAGNETIC MONITORING OF GROWTH AND FRUCTIFICATION OF SOME VARIETIES OF APPLE IN THE ORCHARD
/
MONITORIZAREA ELECTROMAGNETICĂ A CREŞTERII ŞI FRUCTIFICĂRII UNOR SOIURI DE MĂR ÎN LIVADĂ

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Abstract:
The paper presents the experimental researches conducted to follow the evolution of physiological process of apple species in different stages of development and to determine the influence of external electromagnetic factors.

Keywords: *electromagnetic field, monitoring, growth stimulation.*

INTRODUCTION

Using electrical current in orchards dates for approximately 100 years, from the time of electroculture. Today, a very low frequency field is used, where the Schumann frequency has a reference of about 50 years. This frequency acts on the metabolism of living beings, and its lack in the living environment causes severe disruptions, initially noticed in space missions.

MATERIAL AND METHOD

Biologic material

In order to be monitored within the experiment, 2 trees from 5 different varieties of apple were established: Luna, Generos, Topaz, Goldrush and Fujion.

The **method** applied consisted in periodical photographing each trees, verifying, codifying and archiving the recordings, processing images using software products in order to obtain scientific data, processing the scientific data and interpreting results through:

*** Periodically photographing each tree** from approximately the same place, with an approximate periodicity of one week and with an preferred orientation from the west, to avoid contre-jour. A special attention was given to the maintenance of the vertical position of the objective (by marking reference point on the vertical leg of the tripod and on the inclined legs) and the positions of adjusting the objective (by highlighting reference points on the objective). Ignoring these details has determined the failure of some shots during the experiment conducted in 2014, when at montage was noticed a vertical movement of the tree).

*** Verifying, encoding and archiving recordings** made by using light in the visible spectrum were successive operations for each working session in the orchard; images obtained after each recording session were also organized chronologically by variety, receiving codes that comprise tree identity and the date of conducting measurement. Folders built followed either a moment, either an individual, a variety or a supervised element.

*** Processing images with software products to obtain scientific data** was carried out towards the end of the growing period with several software products, producing scientific data on physiological processes monitored. A chronological sequence of photographs highlights how each tree has evolved. Next, the series of representative frames for each of the 10 trees subjected to the experiment are presented, organized into distinct varieties. The result of this stage is the constituted by the

Rezumat:
Lucrarea prezintă cercetările experimentale realizate pentru urmărirea evoluției unor procese fiziologice la specia măr în diferite stadii de dezvoltare şi determinarea influenței factorilor externi de natură electromagnetică.

Cuvinte cheie: *câmp electromagnetic, monitorizare, stimularea dezvoltării.*

INTRODUCERE

Utilizarea curentului electric în livadă datează de aprox. 100 de ani, de pe vremea electroculturii. Azi se foloseşte câmpul de frecvență extrem de joasă în care frecvența Schumann are o referință de vreo 50 de ani. Această frecvență acționează asupra metabolismului ființelor, iar lipsa ei din mediul de viață produce dereglări grave, remarcate inițial în misiunile spațiale.

MATERIAL ŞI METODĂ

Materialul biologic

Pentru a fi monitorizaţi în cadrul experimentului au fost stabiliţi câte 2 arbori din 5 soiuri diferite de măr: Luna, Generos, Topaz, Goldrush şi Fujion.

Metoda aplicată a constat în fotografierea periodică a fiecărui arbore, verificarea, codificarea şi ahivarea înregistrărilor, procesarea imaginilor cu produse software pentru obţinerea de date ştiinţifice, procesarea datelor ştiinţifice şi interpretarea rezultatelor obţinute prin:

*** Fotografierea periodică a fiecărui arbore** din aproximativ acelaşi loc, cu o periodicitate aproximativă de o săptămână, şi cu o orientare de preferinţă din direcţia vest, pentru evitarea poziţiilor contre-jour. O atenţie deosebită a fost acordată menţinerii poziţiilor pe verticală a obiectivului (prin marcarea unor repere pe piciorul vertical al trepiedului şi pe picioarele oblice) şi poziţiilor de reglaj ale obiectivului (prin evidenţierea unor repere pe obiectiv). Ignorarea acestor detalii a determinat ratarea unor cadre din cadrul experimentului desfăşurat în anul 2014, care la montaj au determinat o mişcare pe verticală a arborelui).

*** Verificarea, codificarea şi ahivarea înregistrărilor** realizate prin utilizarea luminii din spectrul vizibil au fost operaţii succesive fiecarei sesiuni de lucru în livadă; fotografiile obţinute după fiecare sesiune de înregistrări au fost organizate în ordine cronologică şi după soi, primind coduri care cuprind identitatea arborelui şi data efectuării măsurătorilor. Folderele construite au urmărit, fie un moment, fie un individ, fie un soi, fie un element supravegheat.

*** Procesarea imaginilor cu produse software pentru obţinerea de date ştiinţifice** a fost realizată spre sfârşitul perioadei de vegetaţie cu mai multe produse de soft, producând date ştiinţifice privind procesele fiziologice monitorizate. O succesiune cronologică de fotograme evidenţiază static modul în care a evoluat fiecare arbore. Se prezintă în continuare seriile de fotograme reprezentative pentru fiecare dintre cei 10 arbori supuşi experimentului, organizaţi pe soiuri distincte. Rezultatul acestei etape îl constituie tabelul cu valorile determinate

table with the values determined by optical measurements on photographs.

*** Scientific data processing and interpreting results**. The data in the tables constituted in the previous stage are taken by graphical representation subroutines after the parameters of interest. It is represented, for example, the evolution in time of trunk diameter, of its sections at height quotas of 20 cm, 100.0 cm and 200.0 cm, and of trunk volume; special attention was given to the evolution of fruits for which is represented the increase of their diameter in absolute values or through ratios, their approximate value, etc.

An intense statistic processing activity has provided important and interesting analytic expressions for the regression functions, the values of coefficients or of the correlation ratio and the level of significance, only retaining significant cases.

The equipment used for this experiment:
- electronic camera with std. objective;
- professional tripod with anchors for positioning the peak of the tripod;
- medallions for marking with fixing brackets;
- 3 m roulette and electronic caliper;
- computer with high performance video card;
- image processing programs.

prin măsurători optice pe fotograme.

*** Procesarea datelor ştiinţifice şi interpretarea rezultatelor.** Datele din tabelele constituite la etapa anterioară sunt preluate prin subrutine grafice de reprezentare după parametrii de interes. Se reprezintă, de exemplu, evoluţia în timp a diametrelor trunchiului, a secţiunilor acestuia la cotele de înălţime de 20 cm, 100,0 cm, 200,0 cm şi a volumului trunchiului; o atenţie specială s-a acordat evoluţiei fructelor, pentru care se reprezintă creşterea diametrului acestora în valori absolute sau prin raportare, volumul aproximativ al acestora, etc.

O activitate intensă de prelucrare statistică a furnizat importante şi interesante expresii analitice pentru funcţiile de regresie, valorile coeficienţilor sau raportului de corelaţie şi nivelul de semnificaţie, reţinându-se doar cazurile semnificative.

Aparatura utilizată în acest experiment:
- aparat foto electronic cu obiectiv std.
- trepied profesional cu ancore de poziţionare a vârfului trepiedului
- medalioane de marcare cu bride de fixare
- ruletă 3 m şi şubler electronic
- computer cu placă video performantă
- programe procesare imagini

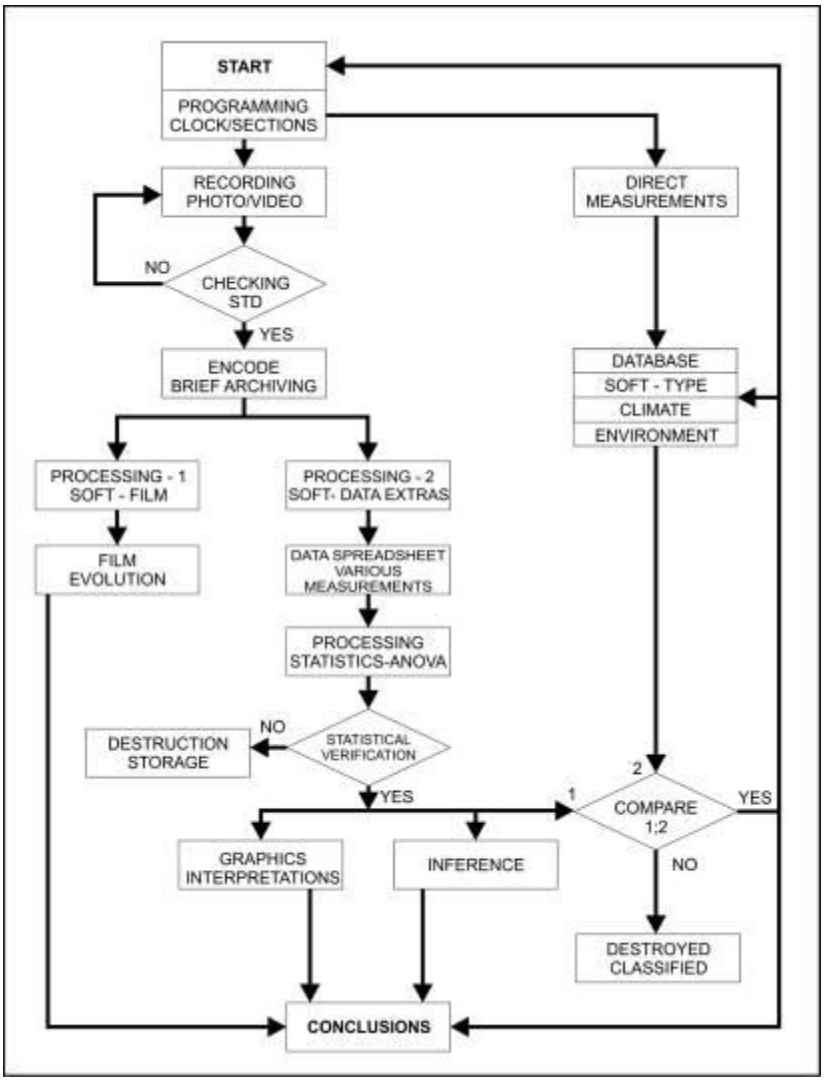

Fig.1 - Flowchart of the method for electromagnetic monitoring in orchards

RESULTS

REZULTATE

Fig. 2, 3, 4 – Examples of tree studies with the photographing equipment in May, respectively August 2015

Fig. 5 – Photographs

Table 1

Tree no. 1 Variety LUNA V 1.1						
Code	Data of taking the photogram	Diameter above graft	Diameter at h=60	Diameter at h = 100	H axle height at the last branch	Diameter of the last branch
	date	cm	cm	cm	cm	cm
A	10.01.2015	2.914	1.453	1.268	117.7	0.568
B	25.04.2015	3.084	1.950	1.278	125.6	0.623
C	03.05.2015	3.425	2.163	1.320	130.0	0.714
D	10.05.2015	3.450	2.165	1.383	130.0	0.720
E	19.05.2015	3.465	2.170	1.385	130.0	0.720
F	27.05.2015	3.470	2.168	1.389	131.0	0.720
G	31.05.2015	3.475	2.170	1.390	131.0	0.725
H	06.06.2015	3.500	2.175	1.400	131.0	0.726
I	20.06.2015	3.512	2.180	1.400	131.0	0.726
J	27.06.2015	3.515	2.182	1420	131.0	0.727
K	12.07.2015	3.525	2.190	1.430	131.0	0.728
L	21.07.2015	3.530	2.240	1.450	131.0	0.729
M	02.08.2015	3.580	2.290	1.490	131.0	0.730
N	15.08.2015	3.610	2.200	1.510	131.0	0.731
O	26.08.2015	3.640	2.230	1.530	131.0	0.732

Using the flowchart for the method of electromagnetic monitoring in orchard (Fig. 1) and the measurements conducted with the equipment in figure 2 for each of the studied varieties (ex. Fig. 2 and Fig. 3) were obtained the photographs (Fig. 5) of the seasonal evolution of trees and fruits on a determined period, out of which was processed for a single tree the movie of the entire evolution.

In table 1 is given an example of collecting the data of measurements for one of the 10 fruit trees studied, which have demonstrated the efficiency of the electromagnetic field in their overall development.

CONCLUSIONS

❖ By analyzing photographs was demonstrated that there is a very strong correlation between the growth of the reference fruit and the trunk diameter at 100 cm height above the ground.

❖ The other measurements of the trunk above the grafting point and the axle at 1 m height were not correlated with the growth of fruits.

❖ We recommend using a measuring level for the trunk

Folosind schema logică a metodei de monitorizare electromagnetică în livadă (Fig. 1) şi măsurătorile efectuate cu aparatura din Fig. 2 pentru fiecare din soiurile studiate (ex. Fig. 2 şi Fig. 3) s-au obţinut fotogramele (Fig.5) evoluţiei sezoniere ale pomilor şi fructelor pe o perioadă determinată, din care s-a procesat pentru un singur arbore filmul întregii evoluţii.

În tabelul 1 se dă un exemplu al culegerii datelor măsurătorilor pentru unul din cei 10 pomi fructiferi studiaţi care au demonstrat eficienţa câmpului electromagnetic în dezvoltarea de ansamblu a acestora.

CONCLUZII

❖ Prin analizarea fotogramelor s-a demonstrat că există o corelaţie foarte semnificativă între creşterea diametrului fructului etalon şi diametrul trunchiului la 100 cm înălţime deasupra solului.

❖ Celelalte măsurători ale trunchiului deasupra punctului de altoire şi ale axului la 1 m înălţime nu au fost corelate cu creşterea fructelor.

❖ Recomandăm folosirea nivelului de măsurare a

at the height of 100 cm for characterizing the growth vigor of trees and of other productivity indices.

❖ We recommend using the method as solution for the rapid determination on tree growth.

❖ The method of monitoring trees in plantations through the means of electric fields is the application of an existing method well valorized both scientifically and practically, from researching and exploring celestial bodies to identifying and measuring some characteristics of elementary particles (fog chamber), not missing from military or social security applications, this method offers generous and valuable data on the behavior in time of objects subjected to monitoring.

❖ The method of monitoring trees in plantations through electromagnetic fields offers generous and valuable data regarding their behavior in time. It can also be applied through 3D scanning systems of through aerial scanning. The results could be much more spectacular, by the holographic reproduction of the studied trees and the virtual intervention on it, could result not only valuable data, but would be represent a consistent saving of time and resources for identifying the adequate responses from the trees to the experimental conditions that are imposed.

❖ The data gathered complete the databases built for the supervised varieties and ensure references for studies dedicated for those varieties of for comparing them.

❖ The processing of data given by the method can be automated and specialized and leads to the emergence of programs dedicated for apple varieties or/and for their stocks; these software products are constituted as high performance instruments in researching and obtaining new varieties, as well as for exploiting the varieties cultivated.

❖ Using monitoring through electromagnetic fields in tree exploitations could ensure the rapid highlighting of the occurrence of diseases or pest attacks, with the chance of rapid intervention for destroying outbreaks in early stages.

❖ Using monitoring through electromagnetic fields in tree exploitations could ensure the highlighting of the evolution of production and estimating it, with consequences on the economical performances and concrete measurements for adequate valorization.

❖ **The most valuable gain could be the one of approaching the researcher to the archetype of trees, with huge results in finding answers needed for adapting to the current changes in the environment.**

trunchiului la înălţimea de 100 cm pentru caracterizarea vigorii de creştere a pomilor şi a celorlalţi indici de productivitate.

❖ Recomandăm utilizarea metodei ca soluţie de determinare rapidă a creşterii pomilor.

❖ Metoda supravegherii arborilor din plantaţii prin intermediul câmpurilor electromagnetice este o aplicaţie a unei metode existente şi bine valorificate atât ştiinţific, cât şi aplicativ, de la cercetarea şi explorarea corpurilor cereşti până la identificarea şi măsurarea unor caracteristici ale particulelor elementare (camera de ceaţă), fără a lipsi aplicaţiile militare sau de securitate socială; această metodă oferă date generoase şi valoroase privind comportarea în timp a obiectelor supuse monitorizării.

❖ Metoda supravegherii arborilor din plantaţii prin intermediul câmpurilor electromagnetice oferă date generoase şi valoroase privind comportarea în timp a acestora. Ea poate fi aplicată şi prin sisteme de scanare 3D sau prin scanare aeriană. Rezultatele ar putea fi mult mai spectaculoase, prin reproducerea holografică a pomilor studiaţi şi intervenţia în virtual asupra acestuia; ar rezulta nu numai date valoroase, dar ar fi o consistentă economie de timp şi de resurse pentru identificarea unor răspunsuri adecvate ale arborilor faţă de condiţiile experimentale care le sunt impuse.

❖ Datele culese completează bazele de date construite pentru soiurile supravegheate şi asigură referinţe în studiile dedicate acelor soiuri sau comparării acestora;

❖ Procesarea datelor oferite de metoda poate fi automatizată şi specializată şi conduce la apariţia unor programe dedicate soiurilor de măr şi/sau portaltoilor acestora; aceste produse software se constituie ca instrumente performante în cercetarea şi obtinerea de soiuri noi, precum şi în exploatarea soiurilor cultivate.

❖ Utilizarea monitorizării prin câmpuri electromagnetice în exploataţii pomicole ar putea asigura evidenţierea rapidă a apariţiei bolilor sau a atacurilor daunătorilor, cu şansa intervenţiei rapide pentru distrugerea focarelor în faze incipiente.

❖ Utilizarea monitorizării prin câmpuri electromagnetice în exploataţii pomicole ar putea asigura evidenţierea evoluţiei producţiei şi estimarea acesteia, cu consecinţe asupra performanţelor economice şi măsurilor concrete de valorificare adecvată.

❖ **Cel mai valoros câştig ar putea fi acela al apropierii cercetătorului de arhetipul arborilor, cu imense rezultate în găsirea răspunsurilor de care este nevoie pentru adaptarea la actualele schimbări ale mediului**.

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OPTIMIZATION OF ENERGY CONSUMPTION BY MIXING LIQUIDS USED IN THE FOOD INDUSTRY
/
OPTIMIZAREA CONSUMULUI ENERGETIC LA MALAXAREA UNOR LICHIDE UTILIZATE IN INDUSTRIA ALIMENTARĂ

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Abstract: *The paper-work presents a series of theoretical and practical aspects connected to the method of boarding the energetic study of mechanical blenders with applications in food industry. The mathematical shaping and the development of studied cases were accomplished for newtonian food liquids. The presented method can be applied for the projection and for the accomplishement of blenders for newtonian liquids in food industry, with or without the observance of similitude conditions.*

Keywords: *mixing liquids, food industry, homogeneousing turbulence isotropic, turbulence nonisotropic*

INTRODUCTION

Mixing of is one of the most well known procedures in food industry, because it influences the expected result of different stages of processing.

The main purpose of mixing of is homogeneousing. This takes place by submitting all the components of an assembly of motions finally resulting the transformation of particles' disposal and their dispersal in the blending mass.

Homogeneousing also manifests by reducing both concentration gradients and of temperature.

We distinguish mixings in liquid phase, with liquid-gas phase, gas-solid, liquid-solid etc.

The variety of used stirrers in food industry is considerable. In figure 1 is shown a classification of stirrers according to the state of materials subjected to mixing and respectively with their structure and driving.

MATERIAL AND METHOD

The influenced factors of mixing process

The knowledge of influenced factors upon the mixing process are important to the optimization of power consumption.

Rezumat:*-Lucrarea prezintă o serie de aspecte teoretice şi practice legate de metoda de abordare a studiului energetic al malaxoarelor mecanice cu aplicatii in industria alimentara. Modelarea matematica si dezvoltarea cazurilor studiate au fost realizate pe lichide alimentare newtoniene. Metoda prezentată poate fi aplicată pentru proiectarea şi exploatarea malaxoarelor pentru lichide newtoniene din industria alimentară, cu sau fără respectarea condiţiilor de similitudine.*

Cuvinte cheie: *malaxare lichide, industrie alimewntară, omogenizare, turbulenţă izotropă, turbulenţă neizotropă*

INTRODUCERE

Amestecarea este una din cele mai răspândite operaţii din industria alimentară, deoarece influenţează rezultatul dorit al diverselor faze de fabricaţie.

Scopul principal al amestecării este omogenizarea. Aceasta are loc prin supunerea tuturor componentelor unui ansamblu de mişcări rezultând în final modificarea dispunerii particulelor şi a dispersării acestora în masa amestecului.

Omogenizarea se manifestă atât prin reducerea gradienţilor de concentraţie cât şi de temperatură.

Se disting astfel amestecări în fază lichidă, cu fază lichid – gaz, gaz – solid, lichid - solid etc.

Diversitatea amestecătoarelor folosite în industria alimentară este apreciabilă. În figura 1 este redată o clasificare a amestecătoarelor în funcţie de starea materialelor supuse amestecării şi respectiv în funcţie de construcţia şi acţionarea acestora.

MATERIALE ŞI METODĂ

Factorii de influenţă ai procesului de amestecare

Cunoaşterea factorilor de influenţă asupra procesului de amestecare sunt determinanţi pentru optimizarea consumului de putere.

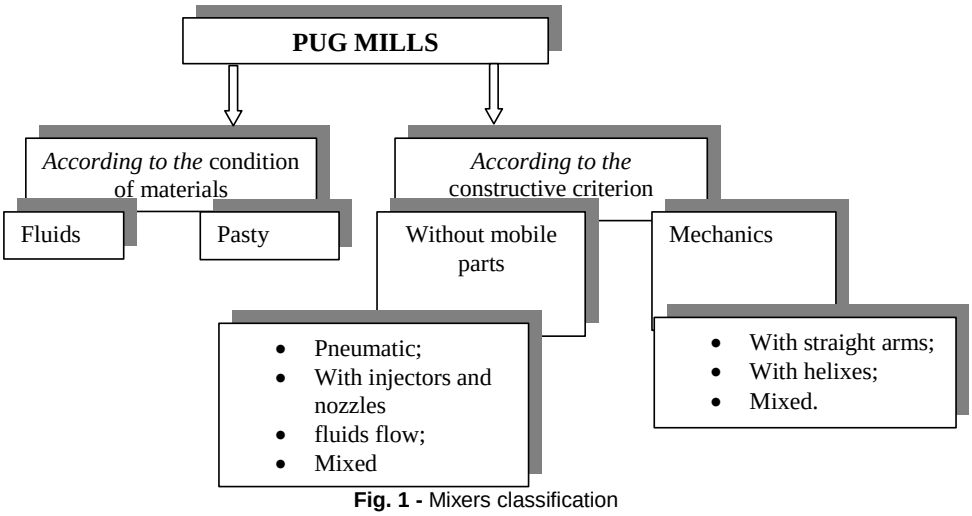

Fig. 1 - Mixers classification

The most important factors which influence the mixing process and also its efficiency are:

- the nature of introduced materials and of resulted products as a result of mixing operation;
- the way of realization the mixing operation.

Taking into consideration that the main subject of the present paper are fluids, we can classify them in two major groups as follows: newtonian and nonnewtonian fluids. In the first category we can classify gases and newtonian liquids, and in the second one the liquids and the nonnewtonian pasture. The main properties wchich influences newtonian fluids are: density, viscosity, diffusion and reciprocal solubility. The nonnewtonian ones are influcend by: density, viscosity displayed most of the time through consistency and cohesion. In general the pasty materials have an increased consistency and cohesion and thus they semnificatively influenced the mixing process.

From a hydrodynamic point of view, mixing consists in realization of a turbulent motion as a rule. In the case of newtonian food fluids, the turbulence results from a forced convection which is obtained through an efficient motion of fluid.

In the mixing process the type of flowing and the geometrical configuration where take place the flowing can be considered important factors. It is very important to exist the conditions created by the turbulence when the fluid slips with different momentary velocities.

It is known the fact that the nature of flowing in a mixer is determined on the basis of modified Reynolds criterion in which the fluid velocity (in the case of mechanical mixers) is estimated as a marginal velocity at

The exterior end of the machine which is in a motion of rotation and the diameter of the rotary machine is adopted as a distinctive length. In the case of mixing, the limit of laminated flowing experimentally determined is Re = 10...20.

The velocity fluctuation can be considered as being momentary value of turbionary motion. Thus, results two types of turbulence: isotropic and nonisotropic.

In the case of isotropic turbulence, the velocity fluctuations have an equal probality in all the directions. Each of one of these velocities has, at any moment, the same number of positive and negative values.

The nonisotropic turbulence is a state in which the velociy fluctuations are neither equal as probable and they don't have an equal size in all directions.

Prandtl has introduced as a measure of turbulence a size named mixing length. It represents the measure of the distance which a swirl covers in the surrounding fluid from a layer in motion untill its velocity becomes equal with the environment, and loses its personality. The mixing length is as much bigger as the turbulence is more intense. It is not constant n the in the whole mass of fluid.

The mixing length, l_a is obtained from Prandtl equation and has the expression: [1,2]

Cei mai importanți factori care influențează procesul de amestecare precum şi eficacitatea acestuia sunt:

- natura materialelor introduse şi a produselor rezultate în urma operației de amestecare;
- modul de realizare a operației de amestecare.

Având în vedere că obiectul prezentei lucrări îl constituie fluidele, acestea se pot clasifica în două mari grupe şi anume: fluide newtoniene şi fluide nenewtoniene. În prima categorie se încadrează gazele şi lichidele newtoniene iar în cea de-a două lichidele şi pastele nenewtoniene. Principalele proprietăți prin care influențează fluidele newtoniene sunt: densitatea, vâscozitatea, difuziunea şi solubilitatea reciprocă. Cele nenewtoniene influențează prin: densitate, vâscozitate manifestată de cele mai multe ori prin consistență şi coeziune. De regulă materialele păstoase au consistență şi coeziune mărite şi prin acestea influențează semnificativ procesul de amestecare.

Din punct de vedere hidrodinamic, amestecarea constă în realizarea unei mişcări de regulă turbulente. În cazul fluidelor alimentare newtoniene, turbulența rezultă dintr-o convecție forțată care la rândul său se obține printr-o mişcare eficientă a fluidului.

În procesul de amestecare caracterul curgerii şi configurația geometrică în care are loc curgerea pot fi considerați factori determinanți. Este foarte important să existe create condițiile de turbulență când fluidul se deplasează cu viteze momentane diferite.

Este cunoscut faptul că natura curgerii într-un amestecător este determinată pe baza criteriului lui Reynolds modificat în care viteza fluidului (în cazul amestecătoarelor mecanice) se estimează ca viteză periferică la capătul exterior al dispozitivului aflat în mişcare de rotație iar diametrul dispozitivul rotativ se adoptă ca lungime caracteristică. În cazul amestecării, limita de curgere laminară determinată experimental este Re = 10…20.

Fluctuația de viteză poate fi considerată ca fiind valoarea momentană a mişcării turbionare. Astfel, rezultă două tipuri de turbulență: izotropă şi neizotropă.

În cazul turbulenței izotrope, fluctuațiile de viteză au o probabilitate egală în toate direcțiile. Fiecare din aceste viteze are, în orice moment, acelaşi număr de valori pozitive şi negative.

Turbulența neizotropă este o stare în care fluctuațiile de viteză nu sunt nici egal de probabile şi nici nu au o mărime egală în toate direcțiile.

Prandtl a introdus ca măsură a turbulenței o mărime numită lungime de amestecare. Ea reprezintă o măsură a distanței pe care un vârtej o parcurge în fluidul înconjurător de la un strat în mişcare până ce viteza sa devine egală cu mediului înconjurător, pierzându-şi individualitatea. Lungimea de amestecare este cu atât mai mare cu cât turbulența este mai intensă. Ea nu este constantă în întreaga masă a fluidului.

Lungimea de amestecare , l_a se obține din ecuația lui Prandtl şi are expresia: [1,2]

$$l_a = \sqrt{\frac{\sigma_t}{\rho}} \frac{1}{\frac{dv}{dy}} \qquad (1)$$

in which:

σ_t - the tangential tension of turbulence;
ρ - fluid density;
dv/dy - the velocity gradient in the considered point.

The equipment where the mixing is produced influences the process through the connection elements with the shape and the size of the pot, the mixing device and its position towards the pot.

în care:

σ_t - tensiunea tangențială de turbulență;
ρ - densitatea fluidului;
dv/dy - gradientul de viteză în punctul considerat.

Instalația în care se produce amestecarea influențează procesul prin elementele de legătură cu forma şi mărimea vasului, a organului de amestecare şi poziția sa față de vas.

The mixing device must worked out in the pot a force shearing big enough so that to result limit layers as thin as possible, essential to turbulence. At the same time the mixing device must attract the new product in the area of high velocities.

Another factor which influence the process of mixing is the size of the pot or the quantity of processed material. The most striking results are observed to mixers with desultory operation. It is recommended that in such situations to be used stirring devices with low capacities.

RESULTS

Elements of dynamics specific to mechanical mixers, with arms

These types of mixers realize the homogenising of raw material with the help of some mobile elements named: arms, blades, propellers, anchors, etc.

In the case of liquids, the mechanical mixers produce a certain working conditions of flowing.

The way in which device stirring conveys the liquid motion, it has developed two categories of machines:

- machines which convey the quantity of motion by stress shearing, so that this transmission to be made to a right angle towards direction of motion stirring device.
- machines which convey the quantity of motion through the pressure of blades upon the liquid, that is in the direction of motion of stirring device.

The latter type is the most frequently used. All the stirring devices with blades are part of this category. The rotary blades exert a pressure upon the liquid bulling a part of it in the environment, starting at the same time a rotating motion in the liquid. Also, behind the blades is created a diminuation of pressure which permits the entrainment of an important part of the liquid submitted to the mixing process. The bulling and the entrainment of the liquid create some vortex flows. Due to the increase of speed rotation, the liquid between the blades is submitted to some centrifugal forces, which creates in the end its radial jumping-up. This liquid penetrates in the surrounding layers through a transfer quantity of motion. Then it follows an increase of section cross of liquid current and slow loss of velocity at the same time with the increase of the distance towards the blade.

Regarding the main directions of current lines we notice three types of flowing:

- tangential flowing where the liquid flows in parallel with the paddle direction;
- radial flowing where the liquid is removed through centrifugal forces in a radial direction towards the rotary axis;
- axial flowing in which the liquid penetrates the stirring device and removes itself from it after parallel direction with the rotary axis.

In the case of stirring devices with perpendicular arms on the rotary axis, the stirring devices are located central towards the pot in general.

As a consequence of some series of experimental tests, for a stirring device which scheme is presented in figure 2, we observed that for a proper working we must respect the followings rapports of basis dimensions:

- d/D = 0,5…0,9;
- h/d=0,08…0,12;
- H/D=0,8…1,3 şi
- h1/d=0,05…0,3.

Organul de amestecare trebuie să realizeze în vas forța de forfecare suficient de mare pentru a rezulta straturi limită cât mai subțiri, indispensabile turbulenței. Totodată dispozitivul de amestecare trebuie să atragă produsul nou în zona vitezelor mari.

Un alt factor de influență asupra procesului de amestecare îl constituie mărimea vasului sau cantitatea de material procesată. Cele mai pregnante rezultate se observă la amestecătoarele cu funcționare discontinuă. Se recomandă ca în astfel de situații să se utilizeze vase de amestec cu capacități reduse.

REZULTATE

Elemente de dinamică specifice amestecătoarelor mecanice, cu brațe

Aceste tipuri de amestecătoare realizează omogenizarea materiilor prime cu ajutorul unor elemente mobile care se numesc: brațe, palete, elice, ancore etc.

În cazul lichidelor, amestecătoarele mecanice produc un anumit regim de curgere.

După modul în care agitatorul transmite mişcarea lichidului, s-au dezvoltat două categorii de dispozitive:

- dispozitive care transmit cantitatea de mişcare prin tensiunea tangențială, astfel încât această transmitere să se facă la un unghi drept față de direcția de mişcare a agitatorului.
- dispozitive care transmit cantitatea de mişcare prin presiunea paletelor asupra lichidului, adică în direcția de mişcare a agitatorului.

Acest din urmă tip este cel mai frecvent folosit. Toate agitatoarele cu palete fac parte din această categorie. Paletele rotative exercită o presiune asupra lichidului dislocând o parte din el în mediul înconjurător, inițiind în acelaşi timp şi o mişcare de rotație în lichid. Deasemenea, în spatele paletelor se creează o scădere a presiunii care favorizează antrenarea unei părți însemnate din lichidul supus procesului de amestecare. Dislocarea şi antrenarea lichidului dă naştere unor curenți turbionari. Datorită creşterii vitezei de rotație, lichidul dinte palete este supus unor forțe centrifuge, care provoacă în final refularea radială a acestuia. Acest lichid pătrunde în straturile înconjurătoare printr-un transfer de cantitate de mişcare. Urmează o creştere a secțiunii transversale a curentului de lichid şi o pierdere treptată a vitezei odată cu mărirea distanței față de paletă.

În funcție de direcțiile principale ale liniilor de curent se remarcă trei tipuri de curgere:

- curgere tangențială în care lichidul curge paralel cu traseul paletei;
- curgere radială în are lichidul este îndepărtat prin forțe centrifuge după o direcție radială față de axa de rotație;
- curgere axială în care lichidul intră în dispozitivul de agitare şi se depărtează de accesta după o direcție paralelă cu axa de rotație.

În cazul amestecătoarelor cu brațe perpendiculare pe axa de rotație, dispozitivele de agitare se amplasează de regulă central față de vas.

În urma unor serii de încercări experimentale , pentru un amestecător a cărui schemă este prezentată în figura 2, s-a observat că pentru o funcționare corespunzătoare trebuie respectate următoarele rapoarte ale dimensiunilor de bază:

- d/D = 0,5…0,9;
- h/d=0,08…0,12;
- H/D=0,8…1,3 şi
- h1/d=0,05…0,3.

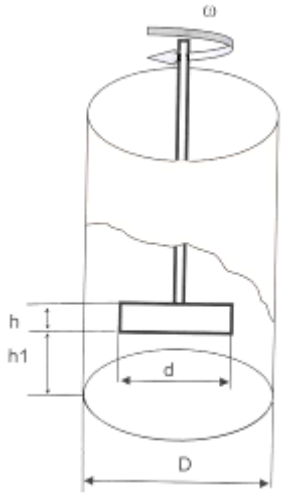

Fig. 2 - The mixer scheme with assured similarity

It is recommended a diversity of peripheral velocities of 1,25…2,5 m/s in funcion of the product.

In order to find out the consumption of power used for mixing up newtonian fluids in food industry, we start from Newton equation written for the elementary force exerted by the surface element dA upon the liquid in the regime period:

Se recomandă în funcție de produs o plajă a vitezelor periferice de 1,25…2,5 m/s.

Pentru determinare puterii consumate la amestecarea fluidelor newtoniene din industria alimentară, se porneşte de la ecuația lui Newton scrisă pentru forța elementară exercitată de elementul de suprafață dA asupra lichidului în perioada de regim:

$$dF = \xi \cdot \frac{v^2 \cdot \rho \cdot dA}{2} \tag{2}$$

where:

ξ is the dimensionless resistance coefficient;

v – motion velocity of a certain point of the arm surface;

ρ - specific mass of liquid;

dA - elementary projection of area of the motion blade on straight-down plane on direction of motion.

If we consider the blade from figure 3 we can write:

în care:

ξ este coeficient de rezistență adimensional;

v - viteza de deplasare a unui punct oarecare de pe suprafața brațului;

ρ- masa specifică a lichidului;

dA – aria proiecției elementare a paletei în mişcare pe un plan perpendicular pe direcția de mişcare.

Dacă se consideră paleta din figura 3 se poate scrie:

$$dA = h \cdot dx; \quad v = 2.\pi.n.x; \tag{3}$$

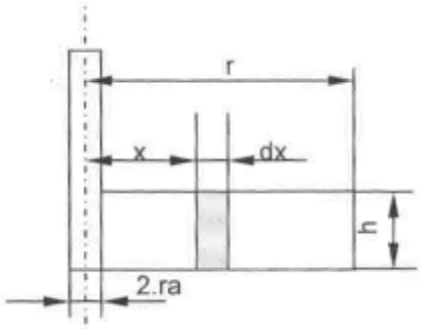

Fig. 3 - The scheme for the differential calculation of straight paddle

On the whole arm of the blade equation (2) becomes:

Pentru întregul braț al paletei ecuația (2) devine:

$$F = \xi \cdot \frac{(2 \cdot \pi \cdot n)^2}{2} \cdot \rho \cdot h \cdot \int_{ra}^{r} x^2 \cdot dx \tag{4}$$

If we consider that the starting point of aplication of resulted forces is at half of arm's width and the distance x_0 from ax, result:

Dacă se consideră că punctul de aplicație al rezultantelor forțelor se află la jumătatea lățimii brațului şi distanța x_0 față de ax, rezultă:

$$x_0 = \frac{\int x \cdot dF}{F} \tag{5}$$

Power can be writen in a first stage:

Puterea se poate scrie într-o primă fază:

$$P_1 = F \cdot v_0 \tag{6}$$

Where v_o is the velocity point of application of resulted forces:

În care v_o este viteza punctului de aplicație a rezultantei forțelor:

$$v_0 = 2 \cdot \pi \cdot n \cdot \frac{\int x \cdot dF}{F} \tag{7}$$

Expression of theoretical consumed power becomes:

Expresia puterii teoretice consumate devine:

$$P_1 = \xi \cdot \rho \cdot h \cdot \pi^3 \cdot n^3 \cdot (r^4 - r_a^4) \tag{8}$$

Because r_a is incomparable more little than r, it can be neglected towards this one. Also if we consider 2.r=d şi h/d =a, with a unique constant ξ' we obtain:

Deoarece r_a este incomparabil mai mic decât r, se poate neglija față de acesta. Deasemenea dacă se consideră 2.r=d şi h/d =a, cu o constantă unică ξ' se obține:

$$P_1 = \xi' \cdot \rho \cdot n^3 \cdot d^5 \tag{9}$$

The experimental unique constant ξ' depends on Reynolds modified criterion:

Constanta experimentală unică ξ' depinde de criteriul lui Reynolds modificat:

$$\xi' = \frac{c}{Re_M^m} = \frac{c}{\left(\frac{n \cdot d^2}{\nu}\right)^m} \tag{10}$$

Introducing this expression in the power equation given by the relation(9) result:

Introducând această expresie în ecuația puterii dată de relația (9) rezultă:

$$P_1 = c \cdot \rho \cdot \nu^m \cdot n^{3-m} \cdot d^{5-2 \cdot m} \tag{11}$$

Because of the fact that in many situations is more likely to use the equation in function of dynamic coefficient of viscosity η, we write: [1]

Datorită faptului că în multe situații se preferă utilizarea ecuației în funcție de coeficientul vâscozității dinamice η, aceasta se scrie: [1]

$$P_1 = c \cdot \eta^m \cdot \rho^{1-m} \cdot n^{3-m} \cdot d^{5-2 \cdot m} \tag{12}$$

The last two expressions of the consumed power used for mixing are used for the classical model presented in figure 2 and 3, meaning in the case of satisfied similarity.

The constants c and m are experimental and they can be found in tables from literature of specialty.

In the situations in which the stirring device doesn't correspond to geometrical features of similarity given by the results of experimental essays, we correct them by applying multiplication factors of power expression.

We observe two cases for wchich the multiplication factors are [1,5]:

a. Stirring device with paddles and nonsatified similarity:

Ultimele două expresii ale puterii consumate pentru amestecare sunt folosite pentru modelul clasic prezentat în figura 2 şi 3, adică în cazul unei similitudini satisfăcute.

Constantele c şi m sunt experimentale şi se găsesc în tabele din literatura de specialitate.

În situațiile în care amestecătorul nu corespunde caracteristicilor geometrice de similitudine date de rezultatele încercărilor experimentale, se aplică corecții prin factori de multiplicare a expresiei puterii.

Se remarcă două cazuri pentru care factorii de multiplicare sunt [1,5]:

a. Agitator cu brațe şi similitudine nesatisfăcută:

$$K = \left(\frac{D}{3 \cdot d}\right)^{1,1} \cdot \left(\frac{H}{D}\right)^{0,6} \cdot \left(\frac{4 \cdot h}{d}\right)^{0,33} \tag{13}$$

b. Stirring device with propeller or turbine and nonsatified similarity:

b. Agitator cu elice sau turbină şi similitudine nesatisfăcută:

$$K = \left(\frac{D}{3 \cdot d}\right)^{0,93} \cdot \left(\frac{H}{D}\right)^{0,6} \tag{14}$$

These relations can be applied in the conditions: D/d=2,5…4, H/D=0,6…1,6, h/d=0,2…0,67 and h1/D=0,2…0,5.

Aceste relații se pot aplica în condițiile: D/d=2,5…4, H/D=0,6…1,6, h/d=0,2…0,67 şi h1/D=0,2…0,5.

The programme demonstration and the presenation of results

Based upon the mathematical model presented above where were analised the power consumption at mixing for milk and for saccharose solution.

For milk we used the following constants:ρ=1032,6 kg/m^3, η=0,001804 Pa.s and for the saccharose solution of

Rularea programului şi prezentarea rezultatelor

Pe baza modelului matematic prezentat mai sus s-au analizat consumurile de putere la amestecare pentru lapte şi soluție de zaharoză.

Pentru lapte s-au utilizat următoarele constante: ρ=1032,6 kg/m^3, η=0,001804 Pa.s iar pentru soluția de

30%: ρ=1448,5 kg/m^3, η= 3,187 Pa.s la 20^{0}C.

The other constants and geometrical dimensions of stirring device were chosen in this way: c=6,8, m=0,2,

d=0,3 respective 0,4 m, D=3,8.d, H=3,5.D, h=0,4.d and n=1,25…2,5m/s. [1,5]

In order to realize a comparative analyse we initiate the following working program shown in figure 4.

zaharoză de 30%: ρ=1448,5 kg/m^3, η= 3,187 Pa.s la 20^{0}C.

Celelalte constante şi dimensiunile geometrice ale agitatoarelor s-au adoptat astfel: c=6,8, m=0,2,

d=0,3 respectiv 0,4 m, D=3,8.d, H=3,5.D, h=0,4.d iar n=1,25…2,5m/s. [1,5]

Pentru a putea efectua o analiză comparativă s-a procedat după programul de lucru redat în figura 4.

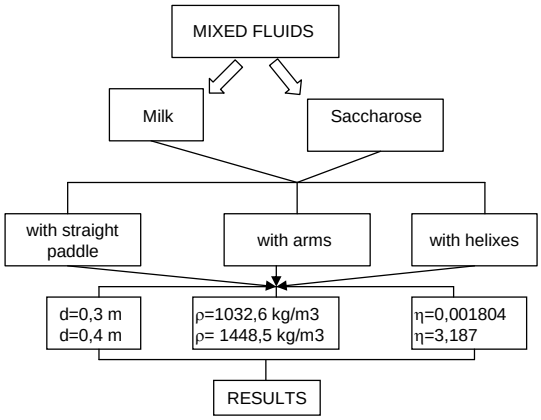

Fig. 4. The working programme for the comparative analysis

From the point of wiev of types of constructive stirring devices were analysed three specific cases:

- classic mixer with straight paddles and respected the similarity conditions;
- mixer with straight paddles which doesn't correspond to imposed similarity conditions;
- mixer with propeller which doesn't correspond to imposed similarity conditions.

For each case were traced the power variation of mixing depending on revolution, according to model presented in figure 5. , where index 1 correspond to milk mixing with rotor of 0,3 m diameter, index 2 for saccharose solution with a concentration of 30% and a rotor with the same diameter , index 3 for milk and a rotor of 0,4 m diameter, and index 4 for saccharose solution and a rotor with the same diameter.

Din punct de vedere al tipurilor constructive de agitatoare s-au analizat trei cazuri şi anume:

- agitator clasic cu palete drepte cu respectarea condițiilor de similitudine;
- agitator cu brațe drepte care nu corespunde condițiilor de similitudine impuse;
- agitator cu elice care nu corespunde condițiilor de similitudine impuse.

Pentru fiecare caz în parte s-au trasat variațiile puterilor de amestecare în funcție de turație, după modelul prezentat în figura 5. , unde indicele 1 corespunde agitării laptelui cu rotor de 0,3 m diametru, indicele 2 pentru soluția de zaharoză cu concentrația de 30% şi rotor cu acelaşi diametru, indicele 3 pentru lapte şi rotor de 0,4 m diametru iar indicele 4 pentru soluția de zaharoză şi rotor de acelaşi diametru.

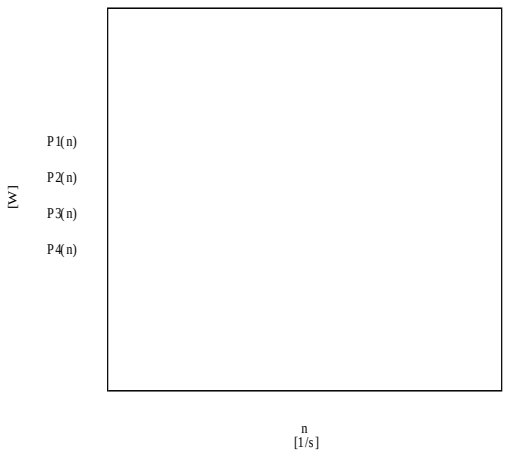

Fig. 5 - The variations of consumed powers depending on turning round

We can observe an important increase of consumed power in case 4, also at a minimal revolution and also to the maximum one taken in consideration.

In order to be able to compare the evolutions of consumed powers at proper mixing, we draw the diagrams fom figures 6 and 7.

Se poate observa o creştere accentuată a puterii consumate în cazul 4, atât la turația minimă cât şi la cea maximă luată în calcul

Pentru a putea compara evoluțiile puterilor consumate la amestecarea propriu-zisă, s-au trasat diagramele din figurile 6 şi 7.

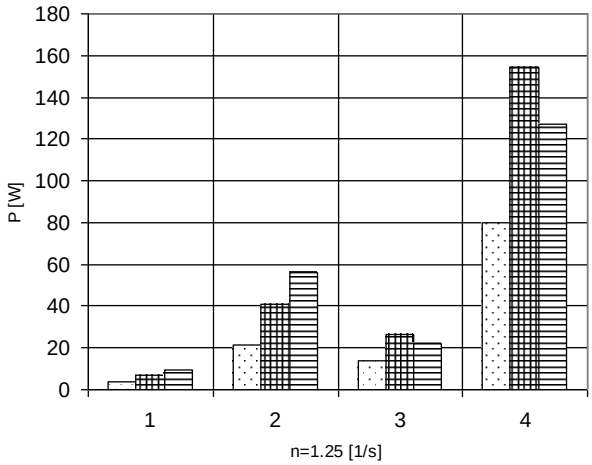

Fig. 6. The variations of power consumption at minimum turning round

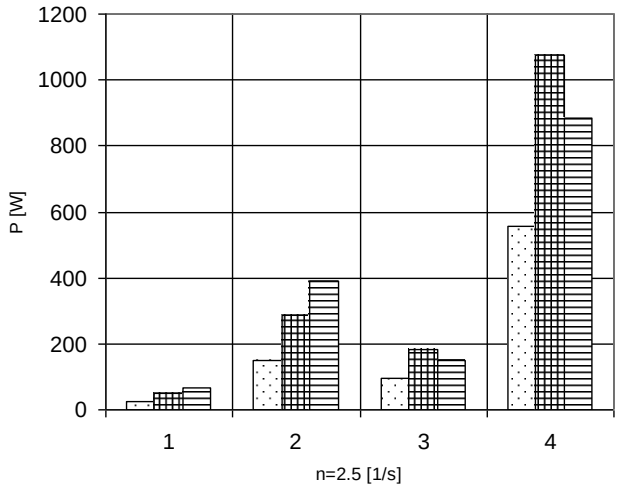

Fig. 7 - The variations of power consumption at maximum turning round

In figure 6 we observe the evolution of consumed powers at a revolution of 1.1 rot./s., and in figure 7, at a revolution of 2,5 rot. /s.

CONCLUSIONS

The four power variations were grouped in three certain variants: one variant for mixer with straight paddles and respected the similarity conditions, one for the mixer with arms and conditions of similarity unrespected and finally one for the mixer with propeller and conditions of similarity unrespected.

It can be observed that the minimal power is consumed (irrespective of revolution) at the mixer with straight paddles (case a). For case b, the mixer with arms and unrespected similarity the power consumptions are much more increased to the maximum recommended values of revolution, going beyond over the values for the mixer with propeller .

To these consumed powers we add cca. 10…20% for the pots with rugged walls, cca. 10% for the hydraulic resistance created in laggings, up to 100% for the existence of thermic treating coil and the consumed power in transmission depending on the type and its complexity.

For other types of mixers than the ones analyses above, the geometrical features and the recommended constants are presented in table 1.

În figura 6 se observă evoluția puterilor consumate la turația de 1,1 rot./s., iar în figura 7, la turația de 2,5 rot./s.

CONCLUZII

Cele patru variații de putere au fost grupate în trei variante şi anume: o variantă pentru cazul agitatorului cu palete drepte şi condiții de similitudine respectate, una pentru agitatorul cu brațe şi condiții de similitudine nerespectate şi în final una pentru agitatorul cu elice şi cerințe de similitudine nesatisfăcute.

Se observă că puterea minimă se consumă (indiferent de turație) la agitatorul cu palete drepte (cazul a). Pentru cazul b, al agitatorului cu brațe şi similitudine nerespectată consumurile de putere cresc mult spre valorile maxime recomandate ale turațiilor, depăşind chiar valorile pentru cazul agitatorului cu elice.

La aceste puteri consumate se adaugă cca. 10…20% pentru cazul vaselor cu pereți rugoşi, cca. 10% pentru rezistența hidraulică creată de tecile de termometru, până la 100% pentru existența serpentinelor de tratare termică şi puterea consumată în transmisie care este în funcție de tipul şi complexitatea acesteia.

Pentru alte tipuri de amestecătoare decât cele care au fost analizate mai sus, caracteristicile geometrice şi constantele recomandate sunt prezentate în tabelul 1.

Table 1

The geometrical features and the recommended constants

Crt. no.	Mixer type	Constants		Observations
		c	m	
1.	With two paddles in vertical position	111 14,35 6,8	1 0,51 0,20	Re<20; h/d=0,885; D/d=2; H/d=2; h1/d=0,36 10^2<Re<5.10^4; h/d=0,885; D/d=2; H/d=2; h1/d=0,36 Re>5.10^4; h/d=0,25; D/d=3; H/d=3; h1/d=0,33
2	With two arms inclined down to 45^0	4,05	0,20	h/d=0,25; D/d=3; H/d=3; h1/d=0,33
3	With four arms in vertical position	8,52	0,20	h/d=0,25; D/d=3; H/d=3; h1/d=0,33
4	With four arms inclined down to 45^0	5,05	0,20	h/d=0,25; D/d=3; H/d=3; h1/d=0,33
5	With four arms inclined up to 45^0	4,42	0,20	h/d=0,25; D/d=3; H/d=3; h1/d=0,33
6	With six arms in vertical position	12,50	0,25	h/d=0,066; D/d=1,11; H/d=1,11; h1/d=0,11
7	Anchor with two arms	6,2	0,25	h/d=0,066; D/d=1,11; H/d=1,11; h1/d=0,11

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EXPERIMENTAL RESEARCH OF SOYBEAN DRYING PROCESS INTENSIFICATION / ЕКСПЕРИМЕНТАЛЬНЕ ДОСЛІДЖЕННЯ ІНТЕНСИФІКАЦІЇ ПРОЦЕСУ СУШІННЯ СОЇ

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Abstract: *One of the methods to intensify the process of drying soybean seeds is to increase the contact area of the drying agent with the material being dried. This result is achieved with the unit for pre-conditioning of the material to dry (patent № 87184, Ukraine). The experimental device is made in order to investigate the influence of structural parameters of this unit on seedcoat deformation.*

The aim is to study the influence of the seed area deformation coefficient k on speed of the soybean drying process.

The article provides two mathematical models enabling to set the time it takes to reach conditional moisture content of soybean seeds in the drying chamber with the preliminary deformation of the seedcoat in the unit for pre-conditioning of the seeds before drying. These models take into account the following parameters: 1- the initial moisture content of seeds, quantity of seeds in the loading hopper and geometric parameters of the device (number of blades on the disk, the angular velocity of the disk), 2 - original material moisture content, temperature and velocity of the drying agent.

The calculation is made and the curves are obtained providing the following characteristics (at different initial parameters): 1- coefficient of the the seedcoat area deformation k while passing the material through the device to its preconditioning stage; 2 - change of soybean seeds drying speed with a certain coefficient k while drying in a drying unit. The analysis of the results showed that the coefficient k of seedcoat area deformation significantly affects the rate of moisture content removal from soybean seeds and confirmed the feasibility of preconditioning of the material before drying in this way in order to intensify this process. Also, the proposed mathematical model allows to establish rational design parameters of the developed device.

Keywords: *device for preconditioning, area deformation coefficient, drying, soybeans, mathematical model, the regression equation*

Резюме: *Одним методів інтенсифікації процесу сушіння насіння сої є збільшення площі контакту сушильного агента із матеріалом, що сушиться. Досягти такого результату дозволяє пристрій попередньої підготовки матеріалу до сушіння (Патент на корисну модель № 87184, Україна). Для дослідження впливу конструктивних параметрів даного пристрою на величину деформації оболонки насінини виготовлена експериментальна установка.*

Метою роботи є дослідження впливу коефіцієнта зміни площі насінини k на швидкість процесу сушіння сої.

В статті запропоновані дві математичні моделі, які в комплексі дозволяють встановити час, необхідний для досягнення кондиційної вологості насінням сої в сушильній камері з попереднім деформуванням оболонки в пристрої для підготовки насіння до сушіння. Дані моделі враховують такі параметри: 1-початкова вологість насіння, кількість подачі насіння в завантажувальний бункер та геометричні параметри пристрою (кількість лопаток на диску, колова швидкість диска), 2-початкова вологість матеріалу, швидкість та температура сушильного агенту.

Проведено розрахунки і одержано графічні залежності, що характеризують (при різних вихідних параметрах): 1- коефіцієнта зміни площі насінини k при проходженні матеріалу через пристрій попередньої підготовки до сушіння; 2- зміну швидкості сушіння насіння сої з певним коефіцієнтом k при сушінні в сушильній установці. Аналіз результатів показав, що коефіцієнт зміни площі насінини k суттєво впливає на швидкість видалення вологи з насіння сої і підтвердив доцільність попередньої підготовки матеріалу до сушіння таким способом для інтенсифікації процесу. Запропонована математична модель дозволяє встановити раціональні конструктивні параметри розробленого пристрою.

Ключові слова: *пристрій для попередньої підготовки, коефіцієнт зміни площі, сушіння, соя, математична модель, рівняння регресії*

INTRODUCTION

The problem of energy saving in agriculture requires the introduction of new technologies aiming to intensify processing of agricultural products [1,11].

One of the most energy-intensive processes in soybean refining is its drying [2,10]. Thus, the study of methods of cultivation of soybean seeds that ensure fast and high quality moisture removal at minimum energy consumption is important.

More efficient drying of agricultural materials is enabled through preconditioning. One of such drying intensification methods of the drying process is to increase the contact area of the drying agent with wet material, which in its turn allows more intensive moisture

ПЕРЕДУМОВА

Проблема енергозбереження у сільському господарстві потребує впровадження нових технологій, спрямованих на інтенсифікацію процесів переробки сільськогосподарської продукції [5,11].

Одним з найбільш енергоємних процесів у технології переробки сої є її сушіння [1,3]. Тому актуальним є дослідження методів обробітку насіння сої, які б забезпечували швидке та якісне видалення надлишкової вологи при мінімальних енерговитратах.

Забезпечити більш ефективне сушіння сільськогосподарських матеріалів дозволяє їх попередня підготовка. Одним із таких методів інтенсифікації процесу сушіння є збільшення площі контакту сушильного агента із вологим матеріалом, що, в свою чергу, дає змогу більш інтенсивно виводити вологу внаслідок втрати цілісності

removal due to loss of integrity of the seedcoat [4,12]. The soybean treated in this way (patent № 87184, Ukraine) [8,9] can be used in oil production [3].

During development and design of the devices that would provide the necessary preconditioning of agricultural materials for drying, it is necessary to choose the rational design parameters, tooling, as well as consider the properties of the material to be processed. The studies will allow to improve the technical and economic performance of the dryers.

In order to define the regularity of the influence of structural and process parameters on the deformation area of the seedcoat (coefficient k) on the drying speed, it is appropriate to apply the mathematical method of experiment planning. Development of the pattern that interconnect the preconditioning device and drying unit will justify rational mode and design parameters of the proposed mechanism.

MATERIALS AND METHODS

To investigate the operational mode of the proposed technology, the stationary experimental unit was designed under laboratory conditions (Fig. 1).

The unit comprises a housing 4 in the form of a cylinder, with the observation window on the top. The disc 8 mounted on a shaft has the blades for better distribution of the seed flow. The metal deck 7 is placed in the housing, to which the vertical knife plates are attached ensuring the necessary cut of the seed. The disk with blades is driven by the electromotor via belt transmission 2

зовнішньої оболонки насінини [4,10]. Оброблена таким способом соя (Патент на корисну модель №87184, Україна) [8,9] може бути використана для виробництва олії [2].

Під час розробки і проектування пристроїв, які б забезпечували необхідну попередню підготовку сільськогосподарських матеріалів до сушіння, необхідно зробити вибір раціональних конструктивних параметрів, робочих органів, а також враховувати властивості матеріалу, з яким вони взаємодіють. Дані дослідження дозволять підвищити техніко-економічні показники роботи сушарок.

З метою встановлення закономірності впливу конструктивних та технологічних параметрів на величину деформації оболонки насінини (коефіцієнт *k*) та на швидкість сушіння доцільно застосувати математичний метод планування експерименту. Розробка моделі, що взаємопов'язує параметри пристрою підготовки насіння сої та сушильної установки дозволить обґрунтувати раціональні режимні і конструктивні параметри запропонованого механізму.

МАТЕРІАЛИ І МЕТОДИ

Для дослідження режиму роботи запропонованої технології в лабораторних умовах була сконструйована стаціонарна експериментальна установка (фіг. 1.).

Дана установка містить корпус 4 у вигляді циліндра, у верхній частині якого вмонтоване віконце для візуального спостереження. На диску 8, який закріплений на валу, встановлені лопатки, які призначені для кращого розподілу потоку насіння. За діаметром диску в корпусі розміщена металева дека 7, до якої прикріплені вертикальні ножові пластини і забезпечують необхідний надріз насінини внаслідок удару об них. Диск з лопатками приводиться в рух за допомогою електродвигун 1 через пасову передачу 2.

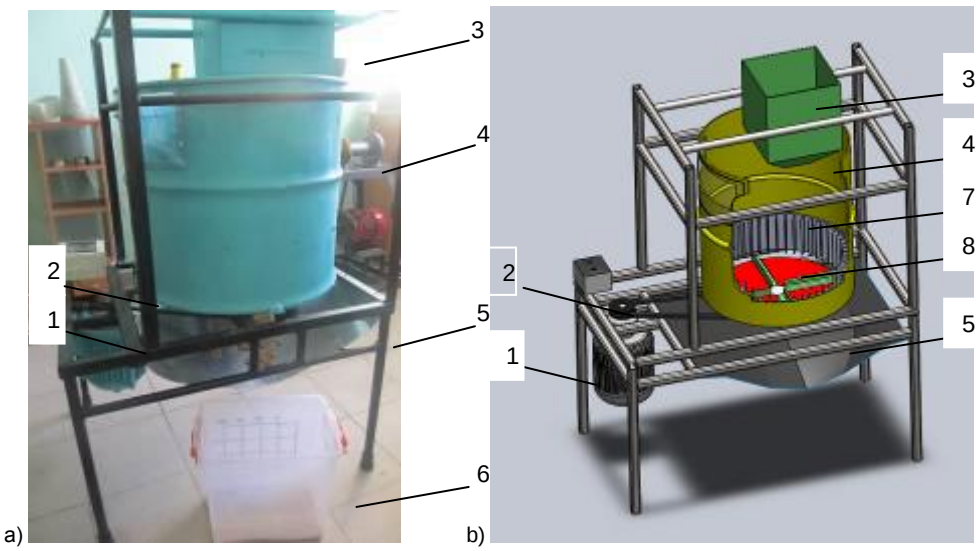


Fig. 1 - Experimental unit: a - picture; b - scheme
1 – electromotor ; 2 – belt transmission; 3 – loading hopper; 4 – casing; 5 – unloading tray ; 6 – seed collection container; 7 – cylindrical deck with knife plates; 3 – disk with blades.

The material is loaded to the unit through the loading hopper 3 and removed through the unloading tray 5 into the seed collection container 6.

Analysis of the literature and previous researches determined the factors that have a decisive influence on the change of area deformation coefficient k, i.e. the initial moisture content of seeds, number of seeds in the

Подача матеріалу в установку здійснюється через завантажувальний бункер 3, а його відвід – через вивантажувальний лоток 5 у місткість для збору 6.

Аналіз літературних джерел та попередніх досліджень дозволили встановити фактори, які мають визначальний вплив на зміну коефіцієнта *k:* початкова вологість насіння, кількість насіння в бункері та геометричні параметри пристрою (кількість

hopper and geometric parameters of the device (number of blades on the disk, the angular velocity of the disk). On drying time τ: the initial moisture content of the material, speed and temperature of the drying agent.

Thus, an experiment was conducted to define the effect of the studied factors on area deformation coefficient k (four-factor) and the soybean seeds drying time (three-factor), (Tables 1,2).

лопаток на диску, колова швидкість диска). На час сушіння τ: початкова вологість матеріалу, швидкість та температура сушильного агенту.

Таким чином, проводили експеримент для визначення впливу досліджуваних факторів на коефіцієнта *k (4-факторний)* і на час сушіння насіння сої τ (*3-факторний*), (таблиці 1,2).

Table 1

Factors and their levels of variation

Levels of variation	Factors			
	Moisture *W , %*	**Feed** *Q, kg/hour*	**Angular velocity** V, *m/s*	**Number of blades** *n ,pcs*
	x_1	x_2	x_3	x_4
Upper/ *(+1)*	23	500	55	6
Basic *(0)*	19	350	40	4
Lower *(–1)*	15	200	25	2
Variability interval, ε	4	150	15	2

Table 2

Factors and their levels of variation

Levels of variability	Factors		
	Moisture, *W , %*	**The temperature of the drying agent,** *°C*	**Velocity of the drying agent** *Vca, m/s*
	x_1	x_2	x_3
Upper/ *(+1)*	23	45	2,2
Basic / *(0)*	19	40	1,9
Lower / *(–1)*	15	35	1,6
Variability interval, ε	4	5	0,3

To reduce the number of experiments and obtain the regression equation, the mathematical method of the experiment planning based on Box-Behnken quadric plan [5] was used.

Planning stage included the following steps: factor encoding, scheduling, randomization tests, implementation plan of the experiment, testing of reproducibility of the experiments, calculation of regression coefficients, assessment of the significance of regression coefficients and adequacy of the test model.

The experiment consisted of 27 tests at threefold repetition in each of them.

In result, the seed cut was obtained at which the contact area of the material and drying agent is grown and moisture removal was intensified.

Deformation coefficient of the seed area is a factor that reflects the growth in the seed area before and after the cut. It was determined by the following formula:

Для скорочення кількості дослідів та отримання рівняння регресії було застосовано математичний метод планування експерименту за симетричним некомпозиційним планом Бокса–Бенкіна другого порядку [6,7,12].

Планування експериментальної роботи включало наступні етапи: кодування факторів, складання плану - матриці експерименту, рондомізація дослідів, реалізація плану експерименту, перевірка відтворюваності дослідів, розрахунок значень коефіцієнтів регресії, оцінка значущості коефіцієнтів регресії та перевірка адекватності отриманої математичної моделі.

Експеримент складався із 27-и дослідів за трикратної повторюваності у кожному з них.

У результаті роботи експериментальної установки був здійснений надріз насінини, що призводить до збільшення площі контакту матеріалу із сушильним агентом та інтенсивності видалення вологи під час проведення трифакторного експерименту.

Коефіцієнт зміни площі насінини - це показник, який відображає приріст площі насінини до і після надрізу. Він визначався за наступною формулою:

$$k = \frac{S_{beg} + \Delta S}{S_{beg}}, \qquad (1)$$

where S_{beg} - initial seed area before cut;
ΔS - area growth after the seed cut.

The samples with moisture content 15%, 19%, 23% were selected, with maximum coefficient k. These samples were used for the threefactor experiment.

The method of the threefactor experiment is to dry the soybean up to 12% (with different coefficient k) at speed and temperature of the drying agent determined during experiment planning. In the experiment, the time τ was recorded during which the excessive moisture was removed from the deformed soybean.

The experiment consisted of 15 tests based on the threefold repetition in each of them.

RESULTS

Experiment results were processed using the software based on Mathcad.

1. *Four-factor experiment*. Homogeneity of variances tested was evaluated by the Cochrane criterion. Since,

$G^{calc.} = 0.187 < G^{tabl.}(0.05;15;2)$ $G^{tabl.}(0.05;15;2) = 0.198$

the process is reproduced.

During the determining of confidence intervals for regression coefficients, the Student test was used, tabulated value of which at a 5 -% level of significance and the number of degrees of freedom of variance of experiment reproducibility was $f_1=2$ is = 4.3 [5].

The significance of regression coefficients was tested according to the established confidence intervals and covariance.

As a result, the regression equation acquired the form:

де $S_{поч}$ - початкова площа насінини до надрізу;
ΔS - приріст площі, що утворився після надрізу насінини.

У дослідах відбиралися зразки з вологістю 15%, 19%, 23%, для яких коефіцієнт *k* був максимальним. Дані зразки використовувалися для проведення трифакторного експерименту.

Методика проведення трифакторного експерименту полягала сушінні сої до 12% (з різним коефіцієнтом *k*) при визначених планом експерименту швидкості та температурі сушильного агенту. Протягом всього експерименту фіксувався час τ за який відбулося видалення надлишкової вологи з деформованого насіння сої.

Експеримент складався із 15-и дослідів за трикратної повторюваності у кожному з них.

РЕЗУЛЬТАТИ

Обробка даних результатів експериментів здійснювалася за допомогою програми, створеної у середовищі Mathcad.

1. *Чотирифакторний експеримент*. Оцінку однорідності ряду дисперсій перевіряли за критерієм Кохрена. Оскільки,

$G^{розр.} = 0{,}187 < G^{табл.}(0.05;27;2) = 0.198,$

то процес відтворюється.

Під час визначення довірчих інтервалів коефіцієнтів регресії використовували критерій Ст'юдента, табличне значення якого за 5-% рівня значущості та числі ступенів вільності дисперсії відтворюваності досліду $f_1=2$ становило $t=4.3$ [5].

Перевірку значущості коефіцієнтів регресії проводили за встановленими їх довірчими інтервалами та коваріаціями.

У результаті рівняння регресії набуло вигляду:

$$y = 1{,}005 + 1{,}251\cdot 10^{-3}\cdot x_1 - 9{,}086\cdot 10^{-4}\cdot x_2 + 2{,}228\cdot 10^{-3}\cdot x_3 + 6{,}292\cdot 10^{-4}\cdot x_1\cdot x_3 - \\ -5{,}267\cdot 10^{-4}\cdot x_2\cdot x_3 - 1{,}026\cdot 10^{-3}\cdot x_1^2 - 1{,}19\cdot 10^{-4}\cdot x_3^2 - 5{,}178\cdot 10^{-4}\cdot x_4^2 \quad (2)$$

where: x_1 - encoded value of moisture of soybean seeds;
x_2 - encoded value of amount of the fed soybean seeds;
x_3 - encoded value of the angular velocity of the disk;
x_4 – encoded value of the number of blades.

Adequacy test of hypotheses of obtained regression equation was performed by the Fisher criterion. The estimated value of this criterion in the dispersion of inadequacy $S^2_{inadeq.}$ =4.211·10^{-7} and dispersion S^2_y =4.869·10^{-4} reproducibility of the experiment was: $F^{calc.}$ = 9.189. Tabular value of Fisher's exact test adopted by the 5 -% of significance, according to [5], was: $F^{tabl.}(0.05;f_2;f_1) = 19{,}5$, where f_2 = 17 number of degrees of freedom variance inadequacy $f_1 = 2$ - the number of degrees of freedom variance reproducibility of the experiment.

Since, $F^{calc.}$ =9.189< $F^{tabl.}(0.05;f_2;f_1) = 19{,}35$, the hypothesis by the adequacy of the regression equation is confirmed.

Final regression equation of the factors in specie

де: x_1 – кодоване значення вологості насіння сої;
x_2 – кодоване значення кількості подачі матеріалу;
x_3 – кодоване значення колової швидкості диска;
x_4 – кодоване значення кількості лопаток.

Перевірку гіпотези адекватності отриманого рівняння регресії проводили за критерієм Фішера. Розрахункове значення даного критерію при дисперсії неадекватності $S^2_{неад.}$ =4,211·10^{-7} і дисперсії відтворюваності досліду S^2_y =4,869·10^{-4} становило: $F^{розр.}$ =9,189. Табличне значення критерію Фішера за прийнятого 5-% значущості, згідно [5], склало: $F^{табл.}(0.05;f_2;f_1) = 19{,}5$, де f_2 = 17 - число ступенів вільності дисперсії неадекватності; $f_1 = 2$ - число ступенів вільності дисперсії відтворюваності досліду.

Оскільки, $F^{розр.}$ =9,189< $F^{табл.}(0.05;f_2;f_1) = 19{,}35$, то гіпотеза адекватності рівняння регресії підтверджується.

Остаточно рівняння регресії із факторами у натуральному вигляді набуло вигляду:

acquired the form:

$$k = 0,0000033 \cdot Q + 0,000074 \cdot V + 0,0023 \cdot W + 0,00104 \cdot n - 5,29 \cdot V^2 - \\ -0,000064 \cdot W^2 - 0,00013 \cdot n^2 - 2,341 \cdot Q \cdot V + 0,0000105 \cdot V \cdot W + 0,974 \quad (3)$$

where: Q - amount of the fed soybean seeds, kg/ h;
V - the angular velocity of the disk m/s;
W – moisture content, %;
n – number of blades on the disk.

In order to track the dynamics of the coefficient k the response surfaces (Fig. 2, a-f) were constructed.

The analysis of regression equation determined that the change in the coefficient k is mostly affected by the initial soybean moisture content W and angular velocity drive V, and, in a less degree, the amount Q of fed soybean seeds and number of blades on the disk n.

Considering the obtained response surfaces according to equation regression and previous studies, we can conclude that the optimal values of the studied factors under which the maximum acceptable value of the coefficient k is obtained were: initial moisture content of soybean W = 17 ... 19%, the angular velocity drive V= 35…45 m/s, feeding Q = 200 ... 300 kg/h and the number of blades n = 4.

де: Q - подача насіння сої, кг/год;
V - колова швидкість диска, м/с;
W - вологість, %;
n – кількість лопаток на диску.

Для відслідковування динаміки зміни величини коефіцієнта k були побудовані поверхні відгуку (фіг. 2, a-f).

В результаті аналізу рівняння регресії встановлено, що на зміну величини коефіцієнта зміни площі k найбільший плив має початкова вологість сої W та колова швидкість диска V, і, в меншій мірі, кількість подачі Q насіння сої і кількість лопаток на диску n .

Зважаючи на одержані згідно з рівнянням регресії поверхні відгуку, а також попередні дослідження можна зробити висновок, що оптимальні значення досліджуваних факторів при яких буде отримано максимально допустиме значення коефіцієнта зміни площі k склали: початкова вологість сої W=17...19%, колова швидкість диска V=35…45 м/с, подача Q=200…300 кг/год та кількість лопаток n=4.

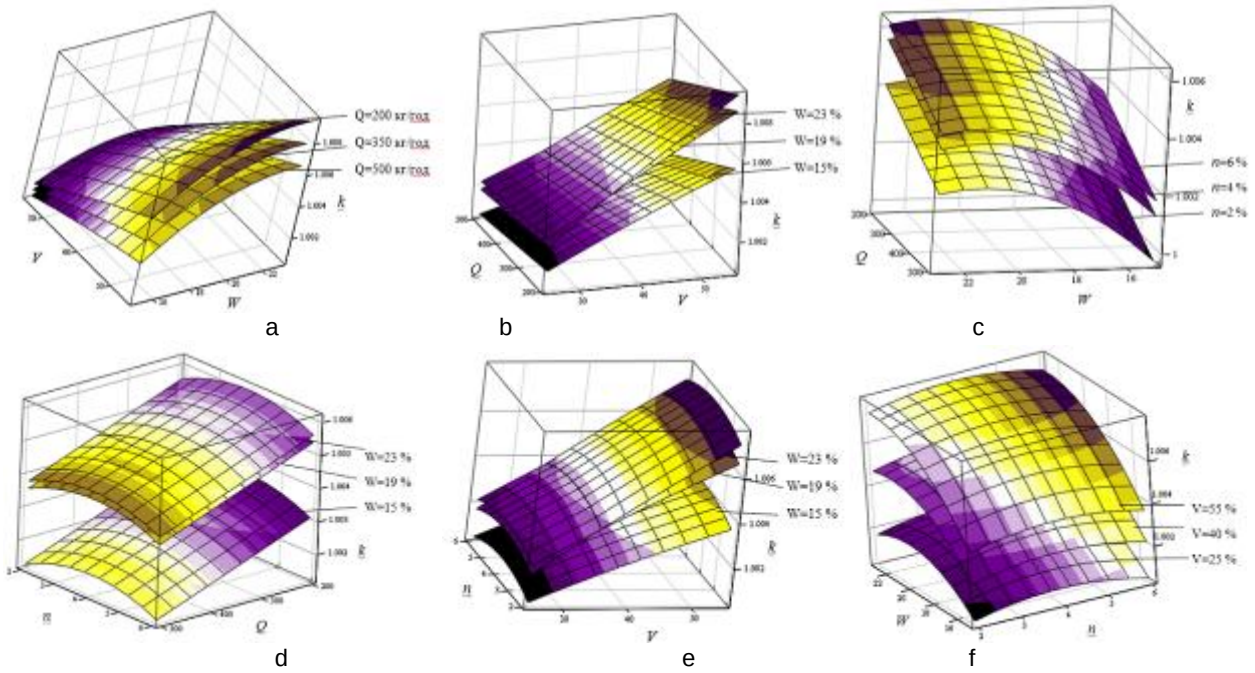


Fig. 2 - Response surface of the area deformation coefficient k depending on:
a) initial soybean moisture content W , angular velocity of the disc V at feeding quantity Q=200;350 and 500 kg/hour and number of blades n=4; b) angular velocity of the disc V, feeding quantity Q at initial moisture content W=15;19 and 23 % i n=4 ; c) seed moisture content W and feeding quantity Q at the blade quantity n=2;4 and 6 and disc angular velocity V=40 m/s; d) feeding quantity Q, number of blades n at seed moisture content W=15;19 and 23% and V=40 m/s ; e) disc angular velocity V, number of blades n at moisture content W=15;19 and 23% and feeding quantity Q-350 kg/h; f) quantity of blades n, seed moisture content W at disc angular velocity V=25;40 and 55 rpm and Q=350 kg/hour.

2. *Three-factor experiment*.

After the four-factor experiment was carried out, the samples were selected with the required W value, with maximum k coefficient: W=23% - k=1.0055; W=19% - k=1.0053; W=15% - k=1.003.

Homogeneity of variances was tested by the Cochrane

2. *Трифакторний експеримент.*

Після проведення чотирифакторного експерименту були відібрані зразки з необхідними значенням W, максимальні значення коефіцієнта k для яких склали: W=23% - k=1,0055; W=19% - k=1,0053; W=15% - k=1,003.

criterion.
Since,
$G^{calc.} = 0.176 < G^{tabl.}(0.05;15;2)$ $G^{tabl.}(0.05;15;2)$ =0.335
the process is reproduced.

During the determining of confidence intervals for regression coefficients, the Student test was used, tabulated value of which at a 5 -% level of significance and the number of degrees of freedom of variance of experiment reproducibility was $f_1=2$ is = 4.3 [5].

Test for the significance of regression coefficients was performed according to their established confidence intervals and covariance.

As a result, the regression equation acquired form:

Оцінку однорідності ряду дисперсій перевіряли за критерієм Кохрена. Оскільки,
$G^{розр.}$ =0,176< $G^{табл.}(0.05;15;2)$ =0.335, то процес відтворюється.

Під час визначення довірчих інтервалів коефіцієнтів регресії використовували критерій Ст'юдента, табличне значення якого за 5-% рівня значущості та числі ступенів вільності дисперсії відтворюваності досліду f1=2 становило t=4.3 [5].

Перевірку значущості коефіцієнтів регресі проводили за встановленими їх довірчими інтервалами та коваріаціями.

У результаті рівняння регресії набуло вигляду:

$$y = 12,222 + 3,292 \cdot x_1 - 4,25 \cdot x_2 - 0,278 \cdot x_1^2 + 1,306 \cdot x_2^2 + 1,889 \cdot x_3^2 \quad (4)$$

where: x_1 - encoded value of moisture of soybean seeds;
x_2 - encoded value of the temperature of the drying agent;
x_3 - encoded value of the velocity of the drying agent

Adequacy test of hypotheses of obtained regression equation was performed by the Fisher criterion. The estimated value of this criterion in the dispersion of inadequacy $S^2_{inadea.}$ =1.982 and dispersion S^2_v =0.259 reproducibility of the experiment was: $F^{calc.}$ =7.645. Tabular value of Fisher's exact test adopted by the 5 -% of significance, according to [5], was: $F^{tabl.}(0.05;f_2;f_1)=19,38$, where f_2 = 8 number of degrees of freedom variance inadequacy $f_1=2$ - the number of degrees of freedom variance reproducibility experiment.

Since, $F^{calc.}$ =7.645< $F^{tabl.}(0.05;f_2;f_1)=19,38$, the hypothesis by the adequacy of the regression equation is confirmed.

Final regression equation of the factors in the specie acquired the form:

де: x_1 – кодоване значення вологості насіння сої;
x_2 – кодоване значення температури сушильного агенту;
x_3 – кодоване значення швидкості сушильного агенту.

Перевірку гіпотези адекватності отриманого рівняння регресії проводили за критерієм Фішера. Розрахункове значення даного критерію при дисперсії неадекватності $S^2_{неад.}$ =1,982 і дисперсії відтворюваності досліду S^2_y =0,259 становило: $F^{розр.}$ =7,645. Табличне значення критерію Фішера за прийнятого 5-% значущості, згідно [5], склало: $F^{табл.}(0.05;f_2;f_1)=19,38$, де f_2 = 8 - число ступенів вільності дисперсії неадекватності; $f_1=2$ - число ступенів вільності дисперсії відтворюваності досліду.

Оскільки, $F^{розр.}$ =7,645< $F^{табл.}(0.05;f_2;f_1)=19,38$, то гіпотеза адекватності рівняння регресії підтверджується.

Остаточно рівняння регресії із факторами у натуральному вигляді набуло вигляду:

$$\tau = 1,48 \cdot W - 0,017 \cdot W^2 + 0,052 \cdot t^2 - 5,029 \cdot t + 20,99 \cdot Vca^2 - 79,76 \cdot Vca + 183,67 \quad (5)$$

where: t - temperature of drying agent, ºC;
V_{ca} – velocity of drying agent, m/s;
W – moisture content of soybean seeds, %.

In order to track the dynamics of the drying time, the response surfaces (Fig. 3, a-c) were constructed.

The analysis of regression equation determined that the change in the drying time τ is mostly affected by the initial soybean moisture content W, temperature of the drying agent t_{ca} and, in a less degree, the feeding velocity of the drying agent V_{ca}.

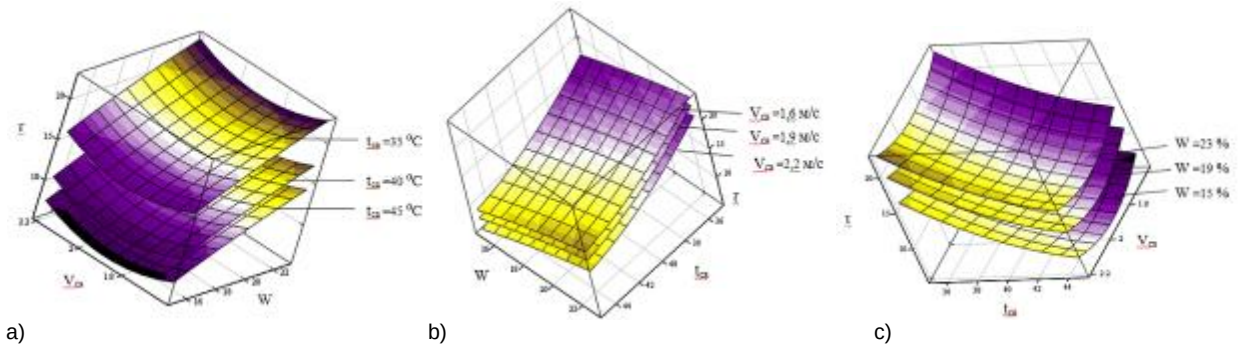
Considering the obtained response surfaces and previous studies, we can conclude that the optimal values of the studied factors under which the minimum acceptable value of the drying time were: initial moisture content of soybean W = 17 ... 19%, area deformation coefficient k=1.0053, temperature of the drying agent t_{ca}=42-45^{0}C and feeding velocity of the drying agent V_{ca} =1.9-2.0 m/s.

де: t - температура сушильного агенту, ºC;
V_{ca} – швидкість сушильного агенту, м/с;
W – вологість насіння сої, %.

Для відслідковування динаміки зміни часу сушіння були побудовані поверхні відгуку (фіг. 3, а-с).

В результаті аналізу рівняння регресії встановлено, що на зміну часу сушіння τ найбільший плив має початкова вологість сої W, температура сушильного агенту t_{ca}, і, в меншій мірі, швидкість подачі сушильного агенту V_{ca}.

Зважаючи на одержані поверхні відгуку, а також попередні дослідження можна зробити висновок, що оптимальні значення досліджуваних факторів при яких буде досягнуто мінімальне значення часу сушіння склали: початкова вологість сої W=17...19% з коефіцієнтом деформації k=1,0053, температура сушильного агенту t_{ca}=42-45^{0}C і швидкість подачі сушильного агенту V_{ca} =1,9-2,0 м/с.



a) b) c)

Fig. 3 - *Responce surface of drying time t depending on : a) drying agent velocity Vca and initial moisture content of the soybean seads W at the temperature of the drying agent tca=35;40 and 45 ºC; b) initial moisture content of the soybean seeds W and the temperature of the drying agent tca at the drying agent velocity Vca=1,6;1,9 and 2,2 m/s; c) temperature of the drying agent tca and drying agent velocity Vca at the initial moisture content of the soybean seeds W=15;19 and 23 %.*

CONCLUSION

The results of complex experimental studies allow the conclusion that all factors are significant against the area deformation coefficient of the seed and drying time.

Two proposed mathematical models resulted in determining time within 5.7 ... 22.7 minutes, necessary to achieve condition moisture of the soybean seeds after previous deformation of the seedcoat.

Increasing the initial moisture content of soybean seeds *W* leads to longer drying time τ. The difference in drying expositions is 3-4 minutes, which is less than the difference in expositions of drying of material without pre-conditioning (8-12 min) as the coefficient k is different for variuos *W* values and confirms its influence on the speed of moisture removal from the seed.

Thus, considering the proposed mechanism to prepare soybean before drying, as part of the loading mechanism of the dryer, we argue it will allow to reduce the energy consumption through increasing the contact area of the drying agent and material and changes in the intensity in moisture removal from the seed. Therefore, it is feasible to apply the proposed energy saving method of the soybean seed drying to produce oil. Reduction in oil yield was not observed.

ВИСНОВОК

Отримані результати комплексу експериментальних досліджень дозволяють зробити висновок, що всі фактори є значущими відносно коефіцієнта зміни площі насінини та часу сушіння.

Результатом запропонованих двох математичних моделей є встановлення часу, який знаходиться в межах 5,7…22,7 хв., що необхідний для досягнення кондиційної вологості насіння сої в сушильній камері з попереднім деформуванням оболонки плоду.

Підвищення початкової вологості насіння сої *W* призводить до збільшення часу сушіння τ. Різниця експозицій сушіння складає 3-4 хв, що є меншою різниці експозицій сушіння попередньо непідготовленого матеріалу (8-12 хв). Це пояснюється тим, що коефіцієнт *k* є різним для досліджуваних значень вологостей *W* і підтверджує його вплив на швидкість видалення вологи з насінини.

Отже, розглядаючи запропонований механізм підготовки сої до сушіння, як складову частину завантажуючого пристрою сушарки, можна стверджувати, що це дозволить зменшити енерговитрати, шляхом збільшення площі контакту сушильного агенту і матеріалу та зміни інтенсивності видалення вологи з насінини. Тому доцільним є застосування запропонованого енергозберігаючого методу сушіння насіння сої для отримання олії. Зменшення виходу олії при цьому не спостерігалось.

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RESEARCHES RESULTS OF GRAIN PNEUMATIC COLLECTOR WHICH IS KNOCKED OUT BY REEL PALLETES
/
РЕЗУЛЬТАТИ ДОСЛІДЖЕНЬ ПНЕВМОВЛОВЛЮВАЧА ЗЕРНА, ЩО ВИБИВАЄТЬСЯ ПЛАНКАМИ МОТОВИЛА

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Abstract: *The article presents the results of researches of crop shortfall causes during its harvest. It is established that a significant cause of grain loss is a non-simultaneous ripening in its spike. As a result during of reel pallets impacts on stems, the largest and most valuable grains that ripen earliest, knocked out of the spike and fall to the ground. It is established that these losses are significant and irreversible because the current technical condition of combine harvesters cannot eliminate them.*

To eliminate this shortcoming the design of pneumatic collector proposed in the article. The principle of its work is based on the vacuum created in confuser. Due to vacuum all grain that knocked out from the spike by reel palletes, sucked and accumulated in the cyclone.

The experimental values of vacuum in pneumatic collector confuser coincide with the research results of the analytical way. Established the numerical values of vacuum in pneumatic collector confuser provides 100% grain collecting by different speeds of its movement and reels rotary speed. It's adequate to combine harvesters operating regime in the real conditions of harvesting.

Given in the article the analytical dependencies make it possible to determine with sufficient precision the pressure losses in the suction path of pneumatic collector and the power necessary to drive its fan.

Keywords: *reel, pallete, spike, grain, impact, pneumatic collector, confuser, cyclone, pipeline, air, pressure, loss.*

Резюме: *В статті наведено результати досліджень причин недобору врожаю під час його збирання. Встановлено, що істотною причиною втрати зерна є неодночасне його дозрівання в колосі. Як наслідок під час ударів планок мотовила по стеблах, найбільш крупні і найцінніші зернівки, які найпершими дозрівають, вибиваються з колоса і падають на землю. Встановлено, що ці втрати є значними і незворотними, оскільки сучасний технічний стан зернозбиральних комбайнів не дозволяє їх усунути.*

Для усунення цього недоліку в статті запропоновано конструкцію пневмовловлювача. Принцип його роботи ґрунтується на розрідженні, що створюється в конфузорі. Завдяки розрідженню все зерно, що вибивається з колоса планками мотовила, засмоктується і накопичується в циклоні.

Отримані експериментальним шляхом значення розрідження в конфузорі пневмовловлювача практично співпадають з результатами досліджень отриманих аналітичним шляхом. Встановлені чисельні значення глибини розрідження в конфузорі пневмовловлювача забезпечують 100% вловлювання зерна при різних швидкостях його переміщення і частотах обертання мотовила. Вони є адекватними до режиму роботи комбайна в реальних умовах збирання врожаю.

Наведені в статті аналітичні залежності дають можливість з достатньою точністю визначити втрати тиску у всмоктувальному тракті пневмовловлювача та потужність необхідну для приводу його вентилятора.

Ключові слова: *мотовило, планка, колос, зерно, удар, пневмовловлювач, конфузор, циклон, трубопровід, повітря, тиск, втрати.*

INTRODUCTION

In the structure acreage of world agriculture the cereal crops occupy more than half. Its main areas are in Asia, North America, Europe, Australia and Africa. Ukraine over the past five years at a rapid pace increased its grain production and proved its total yield more than 60 million tons, which gave it the opportunity to take the second place on the world market among the countries-exporters of grain.

However, in order to stay on the market and among the world leaders it's necessary to continue to increase the volume of its production. But given the fact that in the structure of grain production in Ukraine about of 50% are the spiked cereals, almost two-thirds of which prone to lodging, the timing of the harvest increased, and the process of machines operation is much more complicated. As a result, it leads to losses of grain which reaches 10...30%, and sometimes more, as the lodged grain stay below the headers cutting height [3].

To prevent the lodged grain currently used two methods - chemical and biological. The main point of the first is that plants are treated with special chemicals that inhibit the plants growth and favor to thickening of the stem, root development and make it resistant to lodging

ПЕРЕДУМОВА

В структурі посівних площ світового сільського господарства більше половини займають зернові культури. Основні їх площі знаходяться у країнах Азії, Північної Америки, Європи, Австралії та Африки. Україна впродовж останніх п'яти років інтенсивними темпами нарощувала обсяги виробництва зерна і довела його валовий збір більше 60 млн. т., що дало їй можливість зайняти серед країн імпортерів зерна друге місце на світовому ринку.

Однак для того, щоб втриматись на цьому ринку і залишитись в числі світових лідерів необхідно і на далі нарощувати обсяги його виробництва. Але враховуючи те, що в структурі зернової продукції України біля 50% займають колосові культури, з яких майже дві третини схильні до вилягання, терміни збирання врожаю збільшуються, а процес роботи машин різко ускладнюється. Як наслідок, це призводить до втрат зерна, які сягають 10…30%, а інколи і більше, оскільки полеглий хлібостій залишається нижче висоти зрізу жниварки [3].

Щоб запобігти виляганню стеблостою в даний час застосовують два способи – хімічний і біологічний. Суть першого полягає в тому, що рослини обробляють спеціальними хімічними препаратами, які стримують ріст рослин і сприяють потовщенню стебла, розвитку кореневої системи та роблять його стійким до вилягання [1, 3]. Проте цей спосіб не

of cereals [1, 3]. However, this method is not always effective. More promising is the use of short stemmed, dwarf varieties which are characterized by high resistance to lodging of cereals and high yield. However, these varieties require shallow depth of seed placement - not more than 2 cm [7, 8], because they cannot grow in all areas.

Another cause of significant losses of grain is the ripening heterogeneity of grain in the spike. Thus, at the time of harvest ripens earliest and lose contact with the spike the largest and most valuable grains, which are located in its upper part. As a result during the impacts on the stem of the reel palletes these grains are knocked out of the spike and fall to the ground. Simple calculations shows if of each spike is knocked out of 2 grain, and in the time of harvest on fields of 1 m^2 on the average there are 500...600 stems [3], then on each hectare of at 6...8 hundredweight of grains are knocked out. Practically, these losses are irreversible, because the current technical condition of combine harvesters does not permit to eliminate it.

The conducted structural and biological analysis of standing crop of spiked cereals shows that 70% of full grain stored in 30-centimeter layer of spikes, and the rest - in the low-growing stems, called undergrowth, where the grain by its properties are small, feeble and useful only to feed [2]. It is obvious that these biological characteristics of spiked cereals should form the basis for developing a new principle of its harvesting - namely, the volume reduction of biological mass that is feed for the threshing and for the cleaning.

Therefore there is a need to develop new working bodies that could fully ensure the effective harvesting not only of erect and lodged grain but also collect the grain knocked out by reel palletes and would create conditions for a sharp increase of the productivity of combine harvesters.

MATERIAL AND METHOD

We believe the most effective way to defect correction is the use of two-tier cutting of grain with separate threshing of the upper and lower tiers of spikes part and pneumatic lifting of the lodged grain and pneumatic collecting of the grain which is knocked out by the reel palletes, based on creating of a vacuum in the area of reel. Process scheme of grain pneumatic collector which is knocked out by combine harvesters reel pallets is shown in Fig. 1.

завжди є ефективним. Більш перспективним є застосування короткостеблових, карликових сортів, які відзначаються значною стійкістю до вилягання та високою врожайністю. Однак такі сорти вимагають невеликої глибини загортання насіння – не більше 2 см [7, 8], через що їх не можна вирощувати у всіх зонах.

Іншою причиною істотних втрат зерна є неоднорідність дозрівання зернівок в колосі. Так, на момент збирання найпершими дозрівають і втрачають зв'язок з колосом найбільш крупні і найцінніші зернівки, які розміщені в верхній його частині. Як наслідок під час ударів планок мотовила по стеблах ці зернівки вибиваються з колоса і падають на землю. Прості розрахунки показують, якщо з кожного колоса вибивається по 2 зернини, а на момент збирання на 1 $м^2$ поля в середньому знаходиться 500…600 стебел [3], то на кожному гектарі вибивається по 6…8 ц зерна. Практично ці втрати є незворотними, оскільки сучасний технічний стан зернозбиральних комбайнів не дозволяє їх усунути.

Проведений нами структурно-біологічний аналіз хлібостою зернових колосових культур показує, що 70% повноцінного зерна знаходиться в 30-ти сантиметровому колосовому шарі, а решта – в низькорослих стеблах, так званих підгонах, в яких зерно за своїми властивостями є дрібним, щуплим і придатним лише для фуражу [2]. Очевидно, що саме ці біологічні особливості зернових колосових культур повинні лягти в основу розробки нового принципу їх збирання, а саме – зменшення об'єму біологічної маси, що подається як на обмолот, так і на очистку.

Тому виникає потреба у розробці нових робочих органів, які б могли в повній мірі забезпечити ефективне збирання не тільки прямостоячого і полеглого стеблостою, але й уловлювати зерно вибите планками мотовила та створювали б передумови для різкого підвищення продуктивності зернозбиральних комбайнів.

МАТЕРІАЛ І МЕТОДИКА

На нашу думку найбільш ефективним способом усунення цих недоліків є застосування двох'ярусного зрізу хлібної маси з роздільним обмолотом колосової частини верхнього і нижнього ярусів та пневмопідйому полеглого стеблостою і пневмовловлювання зерна вибитого планками мотовила, який ґрунтується на створенні розрідження в зоні мотовила. Технологічна схема пневматичного вловлювача зерна, що вибивається планками мотовила комбайна, наведена на рис.1.

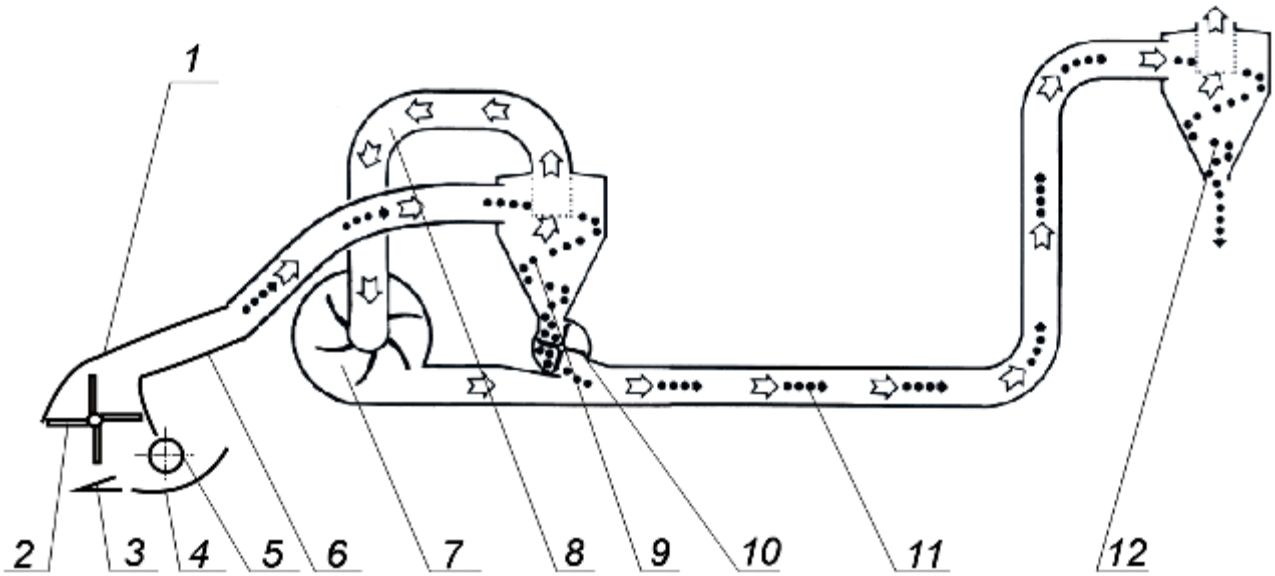

Fig. 1 - Process scheme of grain pneumatic collector which is knocked out by pickup reel pallets

:

1 – pneumatic collector; 2 – pickup reel ; 3 – cutter bar; 4 – gutter ; 5 – auger; 6 – pneumatic pipeline; 7 – extractor-type fan; 8 – suction pipe; 9 – suction cyclone; 10 – rotor valve ; 11 – transport line ; 12 – offloading cyclone.

The technological process of grain collecting is as follows. When driving a combine harvester in the field the extractor-type fan *7* through the pipe *8* sucks an air from the suction cyclone *9* and creates a vacuum in it, which through flexible pneumatic pipeline *6* extends through confuser to pneumatic collector *1*. Due to vacuum the lodged grain rise, become drown and enter the zone of the reel, which leads it to the cutter bar *3*.

After cutting the spikes part of grain placed on the header gutter *4* upper tier and then by header auger *5* is supplied in inclined camera. This grain that falls out of the spikes during the lifting of stems and by the reel palletes *2* impacts sucked by the flow of air into the cyclone *9* where the grains and air are shared. Extractor-type fan accelerate the air to the speed of $v \approx 25$ m/s while the rotor valve *10* provide a uniform grain supply into the transport line *11* and it is transported to the offloading cyclone *12*. There, the exhaust air with light mixture removed through the top hole of the cyclone in the atmosphere, and the grain is emptied into a special tank for its accumulation.

Expediency of pneumatic collector using will depend primarily on the ratio of the additional cost of diesel oil necessary to drive the fan and the market value of collected grain. Consumption of diesel fuel depends on the pressure losses in the suction path of pneumatic collector. To determine these losses must first make a pneumatic scheme of pneumatic collector that shown in Fig. 2.

Технологічний процес вловлювання зерна відбувається наступним чином. Під час руху комбайна в загінці вентилятор *7* через контур *8* відсмоктує з циклона *9* повітря і в ньому створюється розрідження, яке по гнучкому пневмопроводу *6* поширюється через конфузор до пневмовловлювача *1*. Завдяки розрідженню полеглі стебла піднімаються, витягуються по висоті і входять в зону дії мотовила, яке їх підводить до різального апарата *3*.

Після зрізування колосова частина хлібної маси вкладається на платформу *4* жниварки верхнього ярусу і далі шнеком *5* подається в похилу камеру. При цьому зерно, яке випадає з колосків під час підйому стебел та внаслідок ударів планок мотовила *2*, потоком повітря засмоктується в циклон *9*, де відбувається розподіл зерна і повітря. Вентилятор високого тиску розганяє повітря до швидкості $V \approx 25$ м/с в той час, як роторний клапан *10* проводить рівномірну порційну подачу зерна в транпортувальний контур *11* і воно транспортується до розвантажувального циклону *12*. Тут відпрацьоване повітря з легкими домішками видаляється через верхній отвір циклону в атмосферу, а зерно висипається в спеціальний бункер для його накопичення.

Доцільність застосування пневмовловлювача буде залежати насамперед від співвідношення додаткових затрат на дизпальне необхідне для приводу вентилятора та ринкової вартості вловленого зерна. Витрата дизпального залежить від втрат тиску у всмоктувальному тракті пневмовловлювача. Щоб визначити ці втрати спочатку необхідно скласти пневматичну схему пневмовловлювача, яка наведена на рис. 2.

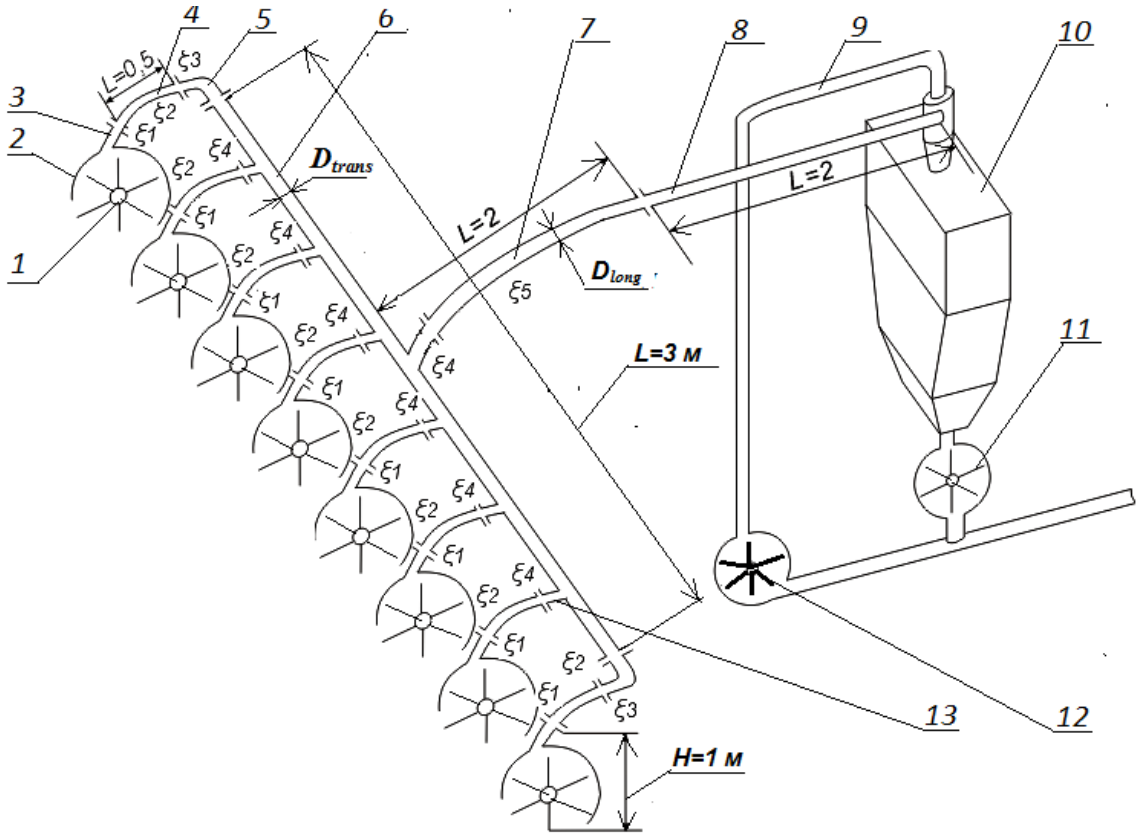

Fig. 2 – Pneumatic pipeline layout scheme and placement of design elements, in which the local resistances results:
1 – reel ; 2 – confuser ; 3 – confuser branch pipe ; 4 – connecting branch pipe; 5 – knee; 6 - transverse pipeline; 7 – flexible pipeline; 8 - horizontal pipeline; 9 - suction pipeline; 10 – cyclone; 11 - rotor valve; 12 – fan; 13 – branch tube

Cutter bar does not effect virtually on the process of grain knocking out. Therefore, it is not considered in researches and not included in the scheme. On this scheme all confusers and pipelines and branch pipes that connect them are shown. It also noted all the local resistances where pressure losses occurring (knees and narrowing of the pipeline, unloaders, etc.). The above scheme shows that the static pressure is spent to overcome friction in the pipeline, local resistances (knee, deflectors, discharger, flexible pipeline) and to lift the grain. That is, the total pressure losses $\sum h$ in suction path can be defined by the relation 1.

Різальний апарат практично не впливає на процес вибивання зерна. Тому в дослідженнях він не враховується і в склад схеми не включається. На цій схемі показано всі конфузори і магістральні трубопроводи та патрубки, які їх з'єднують. Тут також зазначено всі місцеві опори, в яких відбуваються втрати тиску (коліна, звуження трубопроводу, розвантажувачі і т.д.). З наведеної схеми видно, що статичний напір витрачається на подолання тертя в трубопроводі, місцевих опорів (коліна, дефлектори, розвантажувач, гнучкий трубопровід) і на підйом зерна. Тобто, сумарні втрати тиску $\sum h$ у всмоктувальному тракті пневмовловлювача можна визначити за формулою:

$$\sum h = h_1 + h_2 + h_3 + h_4 + h_5 \text{, [Pa]} \quad (1)$$

where h_1 is pressure loss from friction when clean air moving along the pipeline;

h_2 - pressure loss from friction when the mixture of air and grain moving through the pipeline;

h_3 - pressure loss in local resistances (knees and narrowing of the pipeline, unloaders, etc.);

h_4 - pressure loss in confuser to lift the grain; h_5 - pressure loss in the unloaders (cyclone).

To check the accepted hypothesis authenticity can be conducted an experimental research. The main material that was studied in this paper was the wheat density and its grain. Research conducted in the field in the three replications in according to developed methods using the experimental device.

Experimental device for pneumatic collecting of the grain which is knocked out by reel palletes during its movement over the standing crop of spiked cereals is shown in Fig. 3.

де h_1 – втрати тиску від тертя під час переміщення чистого повітря вздовж трубопроводу;

h_2 – втрати тиску від тертя під час переміщення по трубопроводах суміші повітря і зерна;

h_3 – втрати тиску в місцевих опорах (в колінах, при звуженні трубопроводу, розвантажувачі і т.д.);

h_4 – втрати тиску в конфузорі на підйом зерна;

h_5 – втрати тиску в розвантажувачі (циклоні).

Достовірність прийнятої гіпотези можна перевірити експериментальним шляхом. Основним матеріалом, який досліджувався в даній роботі, був стеблостій пшениці та її зерно. Дослідження роводились в польових умовах в трикратній повторності відповідно до розробленої методики з використанням експериментальної установки.

Експериментальна установка для пневмовловлювання зерна, що вибивається планками мотовила під час її переміщення над стеблостоєм зернових колосових культур, наведена на рис. 3.

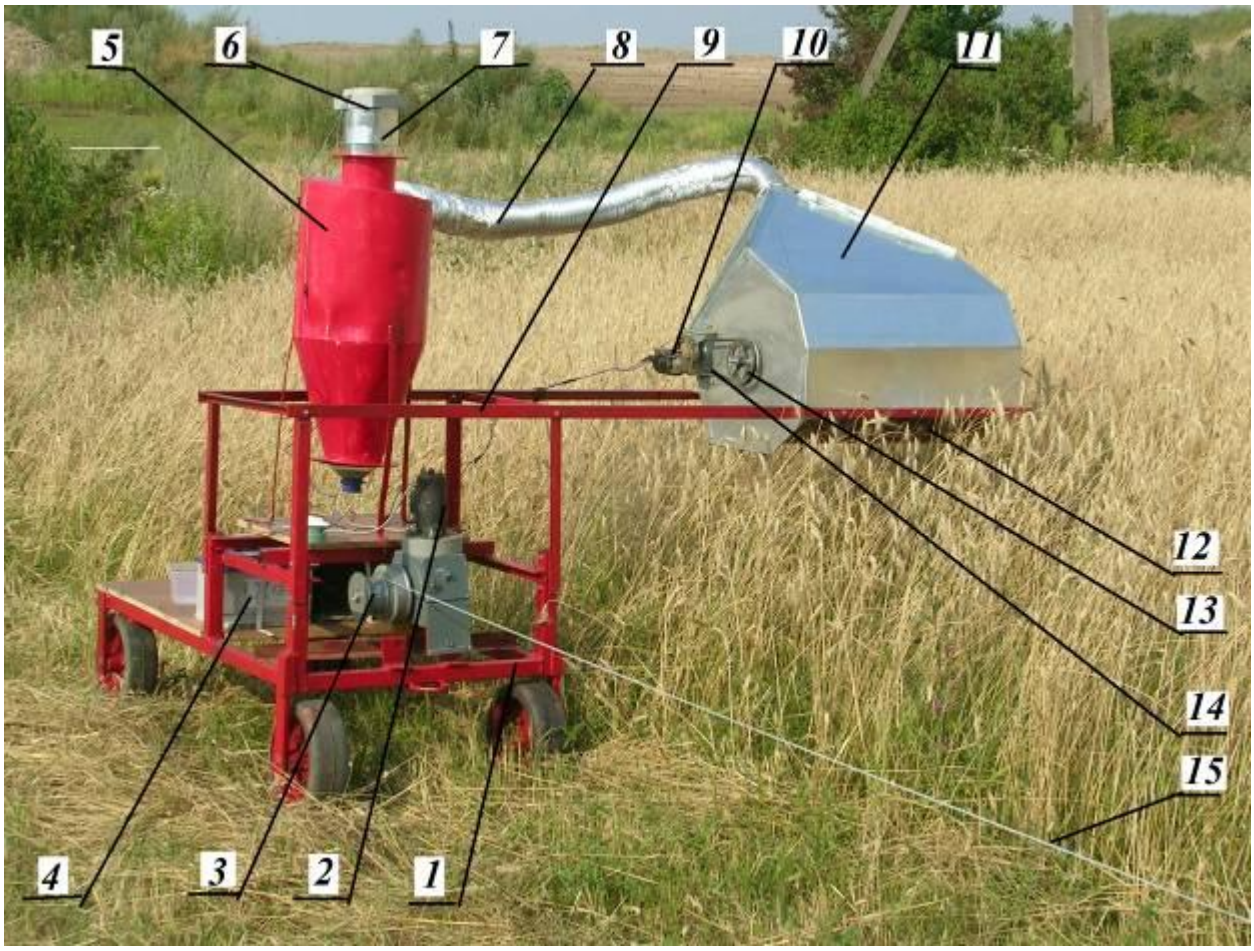

Fig. 3 - Experimental device for collectiing of the grain which is knocked out by reel palletes**:**
1 – self-propelled chassis*;* 2 – electric motor; 3 – winch*;* 4 – batteries*;* 5 – cyclone*;* 6 – fan*;* 7 – support*;* 8 – pneumatic pipeline*;* 9 – console*;* 10 – electric motor*;* 11 – pneumatic collector*;* 12 – reel*;* 13 – pulley*;* 14 – belt*;* 15 – rope

The device consists of pneumatic collector *11* and the cyclone *5*, which are installed on the self-propelled chassis *1* and connected to each other by flexible pneumatic pipeline *8*. This pneumatic collector is installed on the side of the self-propelled chassis on the rectangular frame (console) which is attached to adjustable risers which is installed on the frame and the cyclone is installed directly on three pillars. To the cyclones upper flange is attached the branch pipe with a hole that is cut off by the support *7*, and at the end of the branch pipe the fan *6* is installed. To lower cyclones flange is attached the transparent cone which is closed at the bottom by the cover.

Devices movement is carried out by using of winch *3*, which is driven by the electric motor *2*, which is powered by a battery 4.

Установка складається з пнемовловлювача *11* і циклона *5*, які встановлені на самохідному візку *1* і між собою з'єднані гнучким пневмопроводом *8*. При цьому пнемовловлювач установлено збоку самохідного візка на прямокутній рамці (консолі), яка приєднана до розсувних стояків, встановлених на рамі, а циклон встановлений безпосередньо на трьох опорах. До верхнього фланця циклона приєднано патрубок з отвором, що перекривається манжетою *7*, а на кінці патрубка встановлено вентилятор *6*. До нижнього фланця циклона приєднано прозорий конус, що закривається знизу кришкою.

Переміщення установки здійснюється за допомогою лебідки *3*, яка приводиться від електродвигуна *2*, що живиться від акумулятора *4*.

Для цього канат *15* розмотується з барабана лебідки і вільним кінцем з гаком кріпиться за металевий стержень, що забивається в землю.

For this the rope *15* unwound from the winches drum and by the free end with the hook is attached to a metal rod that is rammed into the ground.

The drive of the reel *12* is carried out by the V-belt drive *14* from the electric motor *10* through a worm reducer and the cyclones *5* fan *6* is driven by its own electric motor. All DC motors are powered by batteries with a voltage of 12 V.

Given that the reels and fans electric motor is powered by one battery and the chassis electric motor - by the other. Start the electric motors by using of individual switches.

The process pass as follows. At first turns on the fan *6* of the cyclone *5* and make the vacuum in it, the depth of which is regulated by the change of the size of the inlet hole on branch pipe by moving of the support *7*. Then turns on the electric motor *10* of the reels *12* drive and then the electric motor *2* of the winch *3*. When reeling the rope *15* on the winches drum the wagon *1* moves along the standing crop on the edge of fields or stubble and the pneumatic collector *11* moves over the spikes layer of the standing crop. Given that the reel palletes separate the portion of the stems from the main standing crop and incline it inside the pneumatic collector reproducing the same work process of the combine harvesters header. Because of the vacuum from the cyclone *5* through the pneumatic pipeline *8* extends inside the pneumatic collector *11*, the grain knocked out from the spikes by the reel palletes is sucked and transported by air flow in the cyclone. Here the air is separated from the grain and through the top branch pipe by the fan *6* is threw out into the atmosphere, and the grain falls to the bottom of the cyclone and collected in a transparent cone.

After passing by self-propelled chassis of a test length equal to 12.5 m the electric drives of winches, reel and fan turned off and at the bottom of the cyclone the box placed, then the cover unscrewed and the grain by gravity emptied from the cone into the box. Then this grain from the box emptied into a plastic bag, putted in it the label prepared beforehand, in which indicated a sort, experiment # and replication #, then closed it tightly and emptied into a separate box for further processing in steady state conditions.

On the pneumatic collector was installed the reel with five palletes of the diameter of 0.5 m and the length of 0.75 m. The width *a* and the length *b* of the inlet port at the bottom of pneumatic collector is equal accordingly to 0.8 m and 0.5 m.

Since the test length of the standing crops field in each experiment was similar of 12.5 m, so the spikes layer area, which is processed by reel pallets also was similar of 10 m^2.

RESULTS

Components of pressure losses in the suction path of pneumatic collector can be defined as follows.

1. Pressure losses *h* of friction when moving clean air along the pipeline can be defined by the Darcy relation 2. [4]

Привод мотовила *12* здійснюється клинопасовою передачею *14* від електродвигуна *10* через черв'ячний редуктор, а вентилятор *6* циклона *5* приводиться в дію від власного електродвигуна. Всі електродвигуни постійного струму і живляться від акумуляторних батарей з напругою 12 В.

При цьому електродвигун мотовила і вентилятора живиться від одного акумулятора, а електродвигун візка – від іншого. Пуск двигунів здійснюється за допомогою окремих вимикачів.

Технологічний процес протікає наступним чином. Спочатку включають вентилятор *6* циклона *5* і створюють в ньому розрідження, глибину якого регулюють зміною величини вхідного отвору на патрубку шляхом переміщення манжети *7*. Після цього включають електродвигун *10* приводу мотовила *12*, а потім електродвигун *2* лебідки *3*. Під час змотування каната *15* на барабан лебідки візок *1* переміщується вздовж хлібостою по краю поля або стерні, а пневмовловлювач *11* рухається над колосоносним шаром хлібостою. При цьому планки мотовила відокремлюють порцію стебел від основного хлібостою і відхиляють їх всередину пневмовловлювача, відтворюючи тим самим робочий процес жниварки комбайна. Оскільки розрідження з циклона *5* по трубопроводу *8* поширюється всередину пневмовловлювача *11*, то зерно, вибите з колосків планками мотовила, засмоктується і повітряним потоком транспортуються в циклон. Тут повітря відокремлюється від зерна і через верхній патрубок вентилятором *6* викидається в атмосферу, а зерно опускається в нижню частину циклона і накопичується в прозорому конусі.

Після проходження візком залікової довжини рівної 12,5 м електродвигуни приводу лебідки, мотовила і вентилятора відключали, а під нижню частину циклона підставляли лоток, відкручували кришку і зерно самопливом висипалось з конуса в лоток. Потім це зерно з лотка пересипали в поліетиленовий мішечок, вкладали в нього заздалегідь заготовлену бірку, на якій зазначали сорт, № досліду, № повторності, щільно закривали його і перекладали в окремий лоток для їх подальшої обробки в стаціонарних умовах.

На пневмовловлювачі було встановлено п'ятилопатеве мотовило, діаметр якого становив 0,5 м, а довжина 0,75 м. Ширина *a* і довжина *b* вхідного вікна в нижній частині пневмовловлювача рівна відповідно 0,8 м і 0,5 м.

Оскільки залікова довжина ділянки зі стеблостоєм в кожному досліді була однаковою і становила 12,5 м, то площа колосоносного шару, що піддавалась обробці планками мотовила, також була однаковою і становилa 10 м^2.

РЕЗУЛЬТАТИ

Складові втрати тиску у всмоктувальному тракті пневмовловлювача можна визначити в такій послідовності.

1. Втрати тиску *h* від тертя під час переміщення чистого повітря вздовж трубопроводу можна визначити за формулою Дарсі [4]:

$$h = \lambda \frac{L \rho v^2}{2gD}, \text{[Pa]} \qquad (2)$$

where λ is friction resistance coefficient;
L - length of pipeline, m;
ρ - air density, kg/m^3;
v - air speed, m/s;
g - gravitational acceleration, m/s^2;
D – diameter of pipeline, m.

Friction resistance coefficient can be defined by the Brazius relation 3. [5]

де λ - коефіцієнт опору тертю;
L - довжина трубопроводу, м;
ρ - щільність повітря, кг/м^3;
V - швидкість повітря, м/с;
g – прискорення вільного падіння, м/с^2;
D - діаметр трубопроводу, м.

Коефіцієнт опору тертю можна визначити за формулою Бразіуса [5]:

$$\lambda = \frac{0.3164}{R_e^{0.25}}, \quad (3)$$

where R_e is Reynolds number, which is defined as relation 4. [4]

тут R_e - число Рейнольдса, яке визначається так [4]:

$$R_e = \frac{v \cdot D}{\upsilon}, \quad (4)$$

where υ is air kinematic density, m^2/s.

By the air temperature of $t = 30°$ C, which mainly corresponds to actual conditions of harvesting υ = 16.6·10^6 m^2/s.

Effective calculated length of the pipeline can be determined taking into account its piping layout, Fig. 1. The scheme is shown that the total length of the suction pipeline consists of two parts. To the first part $\sum L_{p1}$ belong the branch pipes that connect the confusers with transverse pipeline with diameter D_{trans}, i.e.:

тут υ – кінематична густота повітря, м^2/с.

При температурі повітря $t = 30°$ С, яка в основному відповідає реальним умовам збирання зернових, υ = 16,6·10^6 м^2/с.

Розрахункову приведену довжину трубопроводу визначаємо з врахуванням схеми його прокладки, рис. 1. З схеми видно, що загальна довжина всмоктувального трубопроводу складається з двох частин. До першої частини $\sum L_{p1}$ відносяться патрубки, що сполучають конфузори з поперечним трубопроводом діаметром D_{trans}, тобто:

$$\sum L_{p1} = 8 \sum L_{conf} + \sum L_{bp} + \sum L_{kn}, \text{ [m]} \quad (5)$$

and to the second part $\sum L_{p2}$ belongs the transverse pipeline and two areas of longitudinal pipelines with diameter D_{long}, i.e.:

а до другої частини $\sum L_{p2}$ відносяться поперечний трубопровід та дві ділянки поздовжніх трубопроводів, що мають діаметр D_{long}, тобто:

$$\sum L_{p2} = 8 \sum L_{tc} + \sum L_{fp} + \sum L_{hp}, \text{ [m]} \quad (6)$$

where L_{conf} is confuser length (vertical part of pipeline);
L_{bp} - length of the connecting branch pipes;
L_{kn} - knee length; L_{tc} - length of transverse collector;
L_{fp} - length of flexible pipeline;
L_{hp} - length of horizontal pipeline.

Now by the formulas (3) and (4) can be defined the Reynolds number and friction resistance coefficient for each of the pipelines part.

Using the formula (1) can be defined the pressure loss h_{trans} of air friction during its movement in area of transverse pipeline with diameter D_{trans} having a total length $\sum L_{trans}$ and h_{long} for longitudinal pipeline with diameter D_{long} having a total length L_{long}. Therefore

де L_{conf} - довжина конфузора (вертикальна частина трубопроводу), м;
L_{bp} - довжина з'єднувальних патрубків, м;
L_{kn} - довжина коліна, м;
L_{tc} - довжина поперечного колектора, м;
L_{fp} - довжина гнучкого трубопроводу, м;
L_{hp} - довжина горизонтального трубопроводу, м.

Тепер за формулами (3) і (4) можна визначити для кожної частини трубопроводу число Рейнольдса і коефіцієнт опору тертю.

Користуючись формулою (1) визначимо втрати тиску h_{trans} від тертя повітря під час його переміщення на ділянці поперечного трубопроводу з діаметром D_{trans}, що має сумарну довжину $\sum L_{trans}$ та h_{long} для поздовжнього трубопроводу з діаметром D_{long}, що має сумарну довжину L_{long}. Отже

$$h_1 = h_{trans} + h_{long}, \text{ [m]} \quad (7)$$

2. Pressure loss h_2 of friction when moving through pipelines of mixture of air and grain can be defined by the relation 8.[5]

2. Втрати тиску h_2 від тертя під час переміщення по трубопроводах суміші повітря і зерна визначимо за формулою [5]:

$$h_2 = h_1 (1 + c \cdot \mu), \text{ [m]} \quad (8)$$

where c is coefficient that depends on the concentration of the mixture, speed and physical and mechanical properties of grain. When v_p = 13...26 m/s the value of the coefficient is in the range of c = 0.83...0.31; μ - coefficient of weight concentration of the mixture.

3. Pressure losses h_3 in local bearings (knees, by narrowing of the pipeline, unloaders, etc.) can be determined by the relation 9. [4]

де c - коефіцієнт, який залежить від концентрації суміші, швидкості і фізико-механічних властивостей зерна. При V_P = 13…26 м/с значення коефіцієнта знаходиться в межах C = 0,83…0,31; μ - коефіцієнт вагової концентрації суміші.

3. Втрати тиску h_3 в місцевих опорах (в колінах, при звуженні трубопроводу, розвантажувачі і т.д.) визначають за формулою [4]:

$$h_3 = \sum \xi \frac{\rho v^2}{2g}, \text{ [m]} \quad (9)$$

where ρ is air density, kg/m^3;
v - air speed, m/s;
g - gravitational acceleration, m/s^2;
ξ - the sum of the coefficients of local resistance.

According to the pneumatic diagram of the grain pneumatic collector the coefficient $\sum \xi$ is defined by, relation 10.

де ρ - щільність повітря, кг/м^3;
V- швидкість повітря, м/с;
g – прискорення вільного падіння, м/с^2;
ξ - сума коефіцієнтів місцевих опорів.

Відповідно до пневматичної схеми пневмовловлювача зерна коефіцієнт $\sum \xi$ визначається так:

$$\sum \xi = 8\xi_1 + 8\xi_2 + 2\xi_3 + 3\xi_4 + \xi_5, \quad (10)$$

where ξ_1 is coefficient of local resistance of unexpected narrowing that occurs in confuser. The value of this coefficient can be determined by the relation 11. [5]

тут ξ_1 - коефіцієнт місцевого опору від несподіваного звуження, яке виникає в конфузорі. Значення цього коефіцієнта можна визначити за формулою [5]:

$$\xi_1 = 0,5\left(1 - \frac{F_{ap}}{F_{ac}}\right), \quad (11)$$

where F_{ap} is area of the pipeline, m^2:

$$F_{ap} = \frac{\pi D^2}{4};$$

F_{ac} – area of open hole of confuser, m^2:

$F_{ac} = a \cdot b$; a and b - width and length of confuser hole, m^2;

$\xi_2 \ldots \xi_5$ - coefficient of local resistance that occurs accordingly in connecting branch pipe, connected knees, branches and flexible pipeline and is determined by the relation 12. [6]

тут F_{ap} - площа трубопроводу, м^2:

$$F_{ap} = \frac{\pi D^2}{4};$$

F_{ac} - площа відкритого вікна конфузора, м^2; $F_{ac} = a \cdot b$; a і b - відповідно ширина і довжина вікна конфузора, м^2;

$\xi_2 \ldots \xi_5$ - коефіцієнт місцевого опору, що виникає відповідно у з'єднувальному патрубку, в з'єднувальних колінах, у відводах та у в гнучкому трубопроводі і визначається за формулою [6]:

$$\xi_2 = \sqrt{\frac{\delta}{90^\circ}}, \quad (12)$$

where δ is angle of branch pipe, knee, branch of flexible pipeline, deg. For pneumatic collector these angles are accordingly 60°, 90°, 90°, 45°;

ξ_3 - coefficient of local resistance that occurs in connection knees with angle of knee 90°. Its value can be determined by the formula (12);

ξ_4 - coefficient of local resistance that occurs in branches. As branches are mounted on the pipe at the angle 90°, its value is also can be determined by the relation 12;

ξ_5 - coefficient of local resistance that occurs in the flexible pipeline with the angle 45°.

4. Loss of pressure h_4 in confuser for to lift the grain can be determined by the relation 13. [5]

тут δ - кут повороту патрубка, коліна, відводу і гнучкого трубопроводу, град. Для пневмовловлювача ці кути відповідно становлять: 60°, 90°, 90°, 45°;

ξ_3 - коефіцієнт місцевого опору, що виникає в з'єднувальних колінах з кутом повороту коліна 90°. Його значення може бути визначено за формулою (12);

ξ_4 - коефіцієнт місцевого опору, що виникає у відводах. Оскільки відводи змонтовані на трубі під кутом 90° то його значення також можна визчаити за формулою (12);

ξ_5 - коефіцієнт місцевого опору, що виникає в гнучкому трубопроводі з кутом повороту 45°.

4. Втрати тиску h_4 в конфузорі на підйом зерна можна визначити за формулою [5]:

$$h_4 = g \cdot \mu \cdot \rho \cdot H, \text{ [Pa]} \quad (13)$$

where g is gravitational acceleration, m/s^2;
μ - concentration factor of air mixture; ρ - air density, kg/m^3;
H - height of grain lifting, m.

It is determined by the size of pneumatic collector (Fig. 2) and is 1 m.

5. Pressure loss h_5 in unloader (cyclone) can be determined by the relation 14. [4]

де g – прискорення вільного падіння, м/с^2;
μ - коефіцієнт концентрації аеросуміші; ρ - щільність повітря, кг/м^3;
H - висота підйому зерна, м. Вона визначається з конструктивних розмірів пневмовловлювача (рис. 2) і становить 1 м.

5. Втрати тиску h_5 в розвантажувачі (циклоні) можна визначити за формулою [4]:

$$h_5 = \xi \frac{\rho v^2}{2g}, \text{ [Pa]} \quad (14)$$

where ξ = 2.5 is coefficient of local resistance that occurs

де ξ = 2,5 - коефіцієнт місцевого опору, що виникає

when the air-grain mixture inlet in the cyclone;

ρ - air density, kg/m^3;

v - air speed, m/s;

g - gravitational acceleration, m/s^2.

For example is taken a 4-meter harvester-threshers header and by the present methods can be determined the total pressure losses Σh in the suction path of pneumatic collector consists of eight confusers. Height of grain lifting in each confuser is H = 1.0 m and the width and the length of its inlet hole are a = 0.7 m and b = 0.5 m. The total length of pipelines in accordance with the scheme (Fig. 2) are ΣL_{trans} = 13.0 m and L_{long} =7.0 m.

For calculations is taken the transverse pipeline diameter D_{trans} = 0.078 m and longitudinal pipeline diameter D_{long} = 0.150 m [2]. Can be accepted also v = 25.0 m/s, μ = 3...5, c = 0.31...0.35 [5]. Thus, under these conditions the total pressure losses Σh in the suction path according to calculations from the formula (1) can vary from 0.6 kPa to 1.2 kPa.

6. After determining of the air total losses can be determined the inputs of air power N to drive the fan, which creates a vacuum in confuser needed for collecting (suctioning) of grain knocked out by reel palletes and its supplying to the cyclone by the relation 15. [5]

при вході повітряно-зернової суміші в циклон. ρ - щільність повітря, кг/м^3; V - швидкість повітря, м/с; g - прискорення вільного падіння, м/с^2.

Для прикладу візьмемо 4-х метрову жниварку зернозбирального комбайна і за наведеною методикою можна визначити сумарні втрати тиску Σh у всмоктувальному тракті пневмовловлювача, що складається з восьми конфузорів. Висота підйому зерна в кожному конфузорі становить H = 1,0 м, а ширина і довжина його вхідного вікна рівна відповідно a = 0,7 м і $в$ = 0,5 м. Сумарні довжини трубопроводів відповідно до схеми (рис.2) становлять ΣL_{trans} = 13,0 м і ΣL_{long} = 7,0 м.

Для розрахунків приймаємо, що діаметр поперечного трубопроводу $D_{ПОП}$ = 0,0. Також приймаємо V = 25,0 м/с, μ = 3…5, c = 0,31…0,35. Отже, за таких умов сумарні втрати тиску Σh у всмоктувальному тракті відповідно з розрахунками з формули (1) можуть змінюватись від 0,6 кПа до 1,2 кПа.

6. Після визначення сумарних втрат повітря можна визначити затрати потужності N для приводу вентилятора, який створює в конфузорах розрідження необхідне для вловлювання (засмоктування) вибитого планками мотовила зерна і його подачі в циклон за формулою [5]:

$$N = \frac{\sum h \cdot v}{3600 \cdot \eta_{be} \cdot \eta_{te} \cdot \eta_{fe}}, [\text{ kW }] \qquad (15)$$

where v is air velocity, m/s;

η_{be} - bearing efficiency;

η_{te} - transmission efficiency;

η_{fe} - fan efficiency.

After applying in the formula (15) the data v = 25.0 m/s, η_{be} = 0.97, η_{te} = 0.99 і η_{fe} = 0.8 the power losses required to drive the fan, which creates a vacuum in pneumatic collectors confusers (total pressure losses Σh in the suction path defined by the formula (1) and are 0.6 kPa and 1.2 kPa) are accordingly N_1 = 5.42 kW і N_2 = 10.84 kW.

The experimental research results by using of pneumatic collector device (Fig. 3) showed that by reel speed increasing from 50 rpm to 75 rpm when the self-propelled chassis moving with the speed of 1.5 m/s which corresponds to the combine harvesters operating regime the knocked out grain mass increased from 277 g to 330 g, and while moving the self-propelled chassis with the speed of 2.5 m/s the knocked out grain mass increased from 293 g to 365 g. These losses show that in real conditions of work of combine harvesters on each fields hectare it can be knocked out by the reel palletes from 460 kg to 600 kg of grain. The nature of grain (1000 pcs. of grains) on discount area was 60 g. Analysis of the research results showed that analytically determined by the formula (1) the total pressure losses Σh in the suction path ranges from 0.6 kPa to 1.2 kPa and coincide with the experimental data. In accordance with the vacuum gauge readings the vacuum in the confuser in the first case was 0.75 kPa and in the second - 1.32 kPa. Thus, given in the article the analytical dependencies make it possible to determine with sufficient precision the pressure losses in the suction path of pneumatic collector and the power necessary to drive its fan. The research results will be useful in the development and design of pneumatic collector, which will be installed on production combine harvesters.

де V - швидкість повітря, м/с;

η_{be} - коефіцієнт корисної дії підшипників;

η_{te} - коефіцієнт корисної дії передачі.

η_{fe} - коефіцієнт корисної дії вентилятора.

Після підстановки у формулу (15) даних V = 25,0 м/с, η_{be} = 0,97, η_{te} = 0,99 і η_{fe} = 0,8 затрати потужності необхідної для приводу вентилятора, який створює розрідження в конфузорах пневмовловлювача (сумарні втрати тиску Σh у всмоктувальному тракті визначені за формулою (1) і складають 0,6 кПа і 1,2 кПа), становлять відповідно N_1 = 5,42 kW і N_2 = 10,84 kW.

Результати експериментальних досліджень з використанням установки пневмовловлювача (рис.3) показують, що із збільшенням частоти обертання мотовила з 50 об/хв. до 75 об/хв. і при переміщенні візка з швидкістю 1,5 м/с, що відповідає режиму роботи зернозбиральних комбайнів, маса вибитого зерна зростала з 277 г до 330 г, а при переміщення візка з швидкістю 2,5 м/с маса вибитого зерна зростала з 293 г до 365 г. Такі втрати показують, що в реальних умовах роботи зернозбиральних комбайнів планками мотовила на кожному гектарі поля вибивається від 460 до 600 кг зерна. Натура зерна (1000 шт. зерен) на облікових ділянках становила 60 г. Аналіз отриманих результатів досліджень показує, що визначені аналітичним шляхом сумарні втрати тиску Σh у всмоктувальному тракті за формулою (1) змінюються в межах від 0,6 кПа до 1,2 кПа і практично співпадають з експериментальними даними. Відповідно до показів вакуумметра, розрідження в конфузові в першому випадку становила 0,75 кПа, а в другому – 1,32 кПа. Отже, наведені в статті аналітичні залежності дають можливість з достатньою точністю визначити втрати тиску у всмоктувальному тракті пневмовловлювача та потужність необхідну для приводу його вентилятора. Отримані результати досліджень будуть корисними під час розробки і проектування пневмовловлювача, який встановлюватиметься на серійних зернозбиральних комбайнах.

CONCLUSIONS

By reel speed increasing from 50 rpm to 75 rpm when the self-propelled chassis moving with the speed of 1.5 m/s which corresponds to the combine harvesters operating regime the knocked out grain mass from spikes layer on each area of 10 m^2 increased from 277 g to 330 g and by the self-propelled chassis moving with the speed of 2.5 m/s – increased from 293 g to 365 g.

In real conditions of work of combine harvesters on each fields hectare it can knocked out by the reel palletes from 460 kg to 600 kg of grain.

In order to provide 100% of grain collecting which is knocked out by reel palletes when the combine harvester moving at a speed of 1.5 m/s and 2.5 m/s in confuser must create the vacuum accordingly 0.75 kPa and 1.32 kPa. The power is needed to drive the fan can range from 5.42 kW to 10.84 kW.

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ВИСНОВКИ

Із збільшенням частоти обертання мотовила з 50 об/хв. до 75 об/хв. і переміщення візка з швидкістю 1,5 м/с, що відповідає режиму роботи зернозбиральних комбайнів, маса вибитого зерна з колосоносного шару на кожній ділянці площею 10 $м^2$ зростає з 277 г до 330 г, а при переміщенні з швидкістю 2,5 м/с - з 293 г до 365 г.

В реальних умовах роботи зернозбиральних комбайнів на кожному гектарі поля планками мотовила може вибиватись від 460 кг до 600 кг зерна.

метою забезпечення 100% вловлювання зерна, що вибивається планками мотовила, при переміщенні комбайна з швидкістю 1,5 м/с і 2,5 м/с в конфузорах необхідно створювати розрідження відповідно 0,75 кПа і 1,32 кПа. Потужність необхідна для приводу вентилятора може змінюватись в межах від 5,42 кВт до 10,84 кВт.

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EXPERIMENTAL RESEARCHES ON THE PROCESS OF SORTING HYSSOP HERB (*Hyssopus officinalis L.*)
/
CERCETĂRI EXPERIMENTALE PRIVIND PROCESUL DE SORTARE LA HERBA DE ISOP (Hyssopus officinalis L.)

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Abstract: *Plants are considered real live streams of useful products: food, textile fibers, medicines, wood, perfumes, colorants, animal feed, etc., some known for thousands of years, others still waiting to be discovered. Medicinal plants are rich in bioactive substances with phyto-therapeutic value. Growing and valorizing these plants for obtaining some quality phyto-therapeutic products is possible only by using technical equipment adapted to the specific requirements of each plant. The paper presents experimental researches on the hyssop herb concerning the process of sorting fragments of dried and chopped plant. Experiments were conducted within INMA Bucharest, on a sorter for chopped medicinal plants, by adjusting: the oscillation frequency of the sieves and adjusted flow, in the view of the optimal regime. Results are important for processors of medicinal plants (hyssop) in Romania, in order that such as herbal products, dietary supplements, nutritional products, cosmetics etc.*

Keywords: *sorting process, planar sieves, medicinal plants, herb, hyssop.*

Rezumat: *Plantele sunt considerate adevarate izvoare vii de produse utile: alimente, fibre textile, medicamente, lemn, parfumuri, coloranti, furaje, unele stiute de mii de ani, altele inca asteptand sa fie descoperite. Plantele medicinale sunt bogate in substante bioactive cu valoare fitoterapeutica. Cultivarea si valorificarea acestor plante pentru obtinerea unor produse fitoterapeutice de calitate este posibila numai prin folosirea unor echipamente tehnice adaptate la cerintele specifice fiecarei plante. Lucrarea prezinta cercetari experimentale la herba de isop cu privire la procesul de sortare a fragmentelor de planta uscata si tocata. Experimentele s-au efectuat in cadrul INMA Bucuresti, pe un sortator de plante medicinale tocate, prin reglarea parametrilor: frecventa de oscilatie a sitelor si debitul de alimentare al sitelor, in vederea stabilirii regimului optim. Rezultatele sunt importante pentru procesatorii de plante medicinale (isop) din Romania, in vederea valorificarii acestora ca produse fitoterapeutice, suplimente alimentare, produselor nutritionale, cosmetice etc.*

Cuvinte cheie: *proces de sortare, site plane, plante medicinale, herba, isop*

INTRODUCTION

Medicinal plants are a category of plant species that accumulate in some parts of the plant (flowers, leaves, stems, herb, seeds, etc.) various active substances useful in treating various diseases [7]. For growing medicinal plants is important to establish organic or even biological crops [2,8].

Hyssop (*good thyme, garden thyme, herb hyssop*) is a medicinal plant known since the oldest times and used frequently for treating bronchitis, asthma, having expectorant, antiseptic and cicatrizing properties [6]. Hyssop is important as medicinal, aromatic and spicy herb [9].

Hyssop can be grown all over the country, on average, light, sunny, limestone terrains and does not bear shaded, cold, heavy and very humid terrains, but crops in the southern areas of our country and richer in active principles and ethereal oil [9].

Hyssop (*Hyssopus officinalis L.****)*** – fig. 1 is part of the *Lamiaceae* family, is a perennial species, a shrub with erect stem, emerging from a single rhizome, 20-50 cm tall, ramified and lignified at the base. Leaves are linear-lanceolate, leathery, shiny, hairless, almost sessile, with a whole edge, opposed, 2-4 cm long, narrow. The spike shaped inflorescence, one sided, formed of short pedunculate clusters, with 7-9 blue-violet, red or white flowers. It has dry, woody, truncated, smooth fruits, grouped by four. It blooms in July – September [1].

In order to obtain extracts [10], the non lignified aerial

INTRODUCERE

Plantele medicinale sunt o categorie de specii vegetale care acumulează în anumite părți din planta (flori, frunze, tulpina herba, seminte, etc) diverse substante active utile în tratarea diferitelor afecțiuni [7]. Pentru cultivarea plantelor medicinale este importantă infiintarea de culturi ecologice sau chiar biologice [2, 8].

Isopul (*cimbru cel bun, cimbru de grădină, culecel bun*) este o planta medicinala cunoscuta din cele mai vechi timpuri si utilizata frecvent in tratarea bronsitelor, astmului, cu proprietati expectorante, antiseptice si cicatrizante [6]. Isopul este important ca planta medicinala, aromatica si condimentara [9].

Isopul poate fi cultivat în toată țara, pe terenurile mijlocii, uşoare, însorite, calcaroase şi nu suportă terenurile umbrite, reci, grele şi cu prea multă umiditate, insa culturile de isop din zonele de sud ale tarii noastre sunt mai bogate în pricipii active şi ulei eteric [9].

Isopul (*Hyssopus officinalis L.****)*** - fig.1, face parte din familia *Lamiaceae,* este o specie perenă, un subarbust, cu tulpină erectă, pornită dintr-un singur rizom, înaltă de 20-50 cm, ramificată şi lignificată la bază. Frunzele sunt liniar-lanceolate, pieloase, lucioase, glabre, aproape sesile, cu marginea intreaga, opuse, lungi de 2-4 cm, înguste. Inflorescență spiciformă, unilaterală, formată din dihazii scurt pedunculate, cu 7-9 flori albastre-violacee, roşietice sau albe. Fructe nucule, obovoidale, trunchiate, netede, grupate câte patru. Înfloreşte în iulie – septembrie [1].

organs and the inflorescences reaching maturity are used, which contain volatile oils with bicycle monoterpenes. The richest organs in volatile oil are the flowers, followed by the leaves and then the stems [1, 4, 6, 8].

The analysis of volatile oils extracted from hyssop leaves allowed identifying 28 compounds. In a larger quantity were determined: pinocamphone (42.70%), β-pinene (12.7%), camphor (11.80%), hedicariol (5.8%), β-phellandrene (3.5%) and germacrene D (2.40%) [9].

Pentru obținerea de extracte [10] se utilizează organele aeriene nelignificate şi inflorescențele ajunse la maturitate, care conțin uleiuri volatile cu monoterpene biciclice. Cele mai bogate organe în ulei volatil sunt florile, urmate de frunze şi apoi de tulpini [1,4, 6, 8].

Analiza uleiurilor volatile extrase din frunzele de isop a permis identificarea a 28 componenți. În cantitate mai mare s-a determinat: pinocamfen (42,70 %), β-pinen (12,70 %), camfor (11,80 %), hedicariol (5,80 %), β-felandren (3,50 %) şi germacren D (2,40 %) [9].

Fig. 1 – Hyssop *(Hyssopus officinalis L.)* [1]

Obtaining quality products with phyto-therapeutic value is possible only through a correct and adequate processing for each species of plant [5]. The technological processing operation comprises the totality of interrelated operations and phases necessary for preparing, passing the plant material harvested or acquired into a state adequate for storage, packaging or further processing [3].

Primary and advanced processing of medical plants can be used for obtaining volatile oils, teas (pouches, bags), macerates, plant extracts, tinctures, syrups, tablets, food colorings, cosmetic products, natural fertilizers, bio-insecticides, etc. [7].

Given the importance of adequate processing in the view of using the medicinal plants as raw material for obtaining high quality phyto-therapeutic products and not only, in this paper are presented the results of experimental researches on the process of sorting hyssop, by adjusting some working parameters of a dimensional sorter, in order to identify an optimal working regime.

MATERIAL AND METHOD

The hyssop plants used for experimental determinations were acquired in dry state from the market. Experiments were conducted within INMA Bucharest and consisted in chopping the dry plants with the machine for chopping medicinal plants adjusted to the 5 mm size, then the fragments resulted were separated on the sorter for chopped plants (fig. 2).

The sorter for chopped plants is a mechanical used for separating plant products through the method of refusals, actuated by 2 vibrating electric motors, with the help of which, can adjust the frequency and amplitude of oscillations for the sieves and three angles of inclination for the sieves that can vary between 12-15° depending on the type of plant. The equipment is fitted with 9 frames with sieves, used in sets of three with meshes of different dimensions, manufactured from wire braiding, having square shaped meshes.

For separating chopped hyssop were used the sieves with mesh sizes of 5 mm and 8 mm. The angle of inclination of the framing was of 13,33^{0}, the angle of inclination of the electro-vibrating motors to the horizontal was 57^{0}, and the time of conducting one experiment was 30 seconds.

Obtinerea unor produse de calitate cu valoare fitoterapeutica este posibila numai printr-o prelucrare corecta si adecvata pentru fiecare specie de planta [5]. Procesul tehnologic de prelucrare cuprinde totalitatea operatiilor si fazelor intercorelate necesare pentru pregatirea, trecerea materialului vegetal recoltat sau achizitionat, intr-o stare corespunzatoare depozitarii, ambalarii sau prelucrarii ulterioare [3].

Prelucrarea primara si avansata a plantele medicinale se poate utiliza pentru obtinerea de uleiuri volatile, ceaiuri (pliculete, pungi), macerate, extracte vegetale, tincturi, siropuri, comprimate, coloranti alimentari, produse cosmetice, fertilizanti naturali, bioinsecticide etc [7].

Dată fiind importanța prelucrarii corespunzatoare in vederea utilizarii plantelor medicinale ca materie prima pentru obtinerea de produse fitoterapeutice si nu numai, de calitate superioara, în această lucrare se prezintă rezultatele unor cercetări experimentale ale procesului de sortare a isopului, prin reglarea unor parametri de lucru ai unui sortator dimensional, in vederea identificarii unui regim optim de lucru.

MATERIAL ŞI METODĂ

Plantele de isop utilizate la determinările experimentale au fost achizitionate in stare uscata de pe piata. Experimentele s-au realizat în cadrul INMA Bucuresti si au constat in tocarea plantelor uscate la masina de tocat plante medicinale reglata la dimensiunea de 5 mm, apoi fragmentele rezultate au fost separate pe sortatorul de plante tocate (fig. 2).

Sortatorul de plante tocate este un echipament mecanic folosit pentru separarea produselor vegetale prin metoda refuzurilor, actionat de 2 motoare electrice vibratoare, cu ajutorul carora se poate regla frecventa si amplitudinea oscilatiilor sitelor si trei unghiuri de inclinare ale sitelor ce pot varia între 12-15^{0} functie de tipul plantei. Echipamentul este prevăzut cu 9 rame cu site, utilizate în seturi de câte trei cu ochiuri de dimensiuni diferite, confectionate din impletitura de sarma avand forma orificiilor patrata.

Pentru separarea tocaturii de isop s-au folosit sitele cu dimensiunile orificiilor de 5 mm si 8 mm. Unghiul de inclinare al batiului cu site a fost de 13,33^{0}, unghiul de inclinare al motoarelor electrovibratoare fata de planul orizontal 57^{0}, iar timpul de desfasurare al unui experiment a fost de 30 secunde.

Fig. 2 – Aspects during experimental researches

Three plant sorts were determined experimentally on the sorting equipment, varying 3 feeding flows: 90 kg/h, 60 kg/h and 30 kg/h adjusted using an inclined band transporter and three frequencies of the electric current: 50 Hz, 45 Hz and 40 Hz adjustment by means of a frequency converter.

Adequate growing and processing of medicinal plants for obtaining therapeutic valuable products is important, that is why this paper shows experimental results regarding the process of sorting hyssop herb, on 3 dimensional sorts.

RESULTS

In the case of the fragments of hyssop analyzed, were experimentally determined five samples for each of the adjusted parametres, which characterizes the process of separating on sieves. Table 1 presents the average values of measurements.

Au fost determinate experimental trei sorturi vegetale pe echipamentul de sortat variindu-se 3 debite de alimentare: 90 kg/h, 60 kg/h si 30 kg/h reglate prin intermediul unui transportor inclinat cu banda si trei frecvente ale curentului electric: 50 Hz, 45 Hz si 40 Hz reglate cu un convertizor de frecventa.

Cultivarea si procesarea adecvata a plantelor medicinale pentru obtinerea de produse terapeutice valoroase este importanta, de aceea aceasta lucrare prezinta rezultatele experimentale privind procesul de sortare a herbei de isop, pe 3 sorturi dimensionale.

REZULTATE

In cazul fragmentelor de isop analizate, au fost determinate experimental cate cinci probe pentru fiecare parametru reglat, ce caracterizeaza procesul de separare pe site. In tabelul 1 sunt redate valorile medii ale acestora.

Table 1

Experimental results regarding the screening of hyssop fragments

Adjusted flow [kg/h]	**Frequency** [Hz]	**Mass Variety 1** [kg]	**Mass Variety 2** [kg]	**Mass Variety 3** [kg]	**Total mass** [kg]	**Experimental flow** [kg/h]
90	**50**	0.472	0.035	0.033	0.540	*64.80*
	45	0.588	0.06	0.045	0.693	*83.16*
	40	0.411	0.021	0.011	0.443	*53.16*
60	**50**	0.402	0.026	0.022	0.450	*54.00*
	45	0.412	0.033	0.028	0.473	*56.76*
	40	0.371	0.018	0.015	0.404	*48.48*
30	**50**	0.189	0.009	0.010	0.208	*24.96*
	45	0.212	0.011	0.014	0.237	*28.44*
	40	0.143	0.005	0.005	0.153	*18.36*

Figure 3 shows the compared variation of the experimental flow of sieves for three feeding flows adjusted differently and for three different frequencies of the electric current.

În figura 3 se prezinta comparativ variatia debitului experimental al sitelor pentru trei debite de alimentare reglate diferit si pentru trei frecvente diferite a curentului electric.

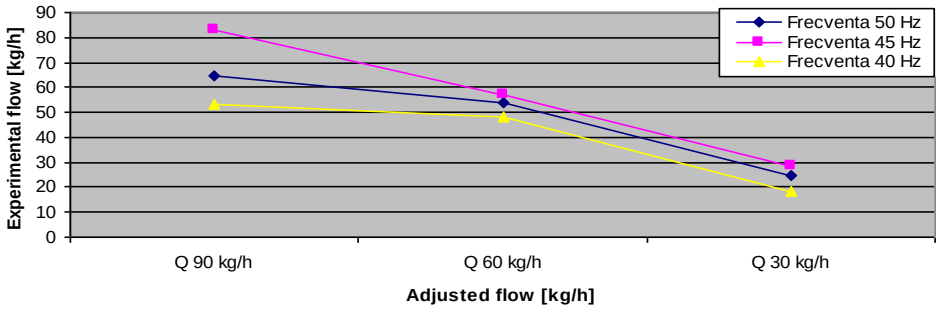

Fig. 3 – Variation of the experimental flow of sieves for different flows and frequencies

The meaning and dimensions of the mass of sorts presented in table 1 are the following ones:

- the mass of sort 1 represents the sifted material from the inferior sieve of the sorter with sizes between 0.1…5 mm;
- the mass of sort 2 is formed by the sifted material from the upper sieve and the refusal from the inferior sieve

Semnificatia si dimensiunile masei sorturilor prezentate in tabelul 1 sunt urmatoarele:

- masa sortului 1 reprezinta cernutul sitei inferioare a sortatorului cu dimensiunile cuprinse intre 0,1...5 mm;
- masa sortului 2 este formata din cernutul sitei superioare si refuzul sitei inferioare si cuprinde

and has plant fragments between 5.1…8 mm;
- the mass of sort 3 represents the refusal of the large sieve with the size of plant fragments bigger than 8 mm.

CONCLUSIONS

From the analysis and interpretation of the data obtained for the 3 sorts, was found that sort 1 is the major one and contains many inflorescences, being destined mainly for the extraction of volatile oils and sorts 2 and 3 contain leaves and stems, which can be used for packaging in paper bags or in tea bags.

From the analysis of values obtained for sort 1 of hyssop it is considered optimal the choosing of a 45 Hz the oscillation frequency sieves for each of the three feeding flows (83.16 kg/h, 56.76 kg/h or 28.44 kg/h), material losses being very low, approximately 5%.

The processes of separation was hampered when using the lowest frequency of 40 Hz and the maximum feeding flow of 90 kg/h, because the plant material began to stratify and the meshes started clogging, resulting in a low productivity.

From the analysis of results obtained it is found that the dimensional sorter with oscillating planar sieves can be used successfully for sorting chopped medicinal plants if the parameters of the working regime are chosen adequately for the purpose pursued in valorizing the plant material.

The data presented are important for all specialist and workers in the field of processing medicinal plants referring, mainly, to the sorting operation of the technological process.

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fragmente vegetale cuprinse intre 5,1...8 mm;
- masa sortului 3 reprezinta refuzul sitei mari cu dimensiunile fragmentelor vegetale mai mari de 8 mm.

CONCLUZII

Din analiza şi interpretarea datelor obținute pentru cele 3 sorturi, s-a constat că sortul 1 este majoritar si contine multe inflorescente fiind destinat, in principal, extractiei de uleiuri volatile si sorturile 2 si 3 contin frunze si tulpini, ce pot fi folosite la ambalarea in pungi de hartie sau pliculete pentru ceaiuri.

Din analiza valorilor obtinute pentru sortul 1 la isop se considera optima alegerea frecventei de oscilatie a sitelor de 45 Hz pentru fiecare din cele trei debite de alimentare (83,16 kg/h, 56,76 kg/h sau 28,44 kg/h), pierderile de material fiind foarte mici, aproximativ 5 %.

Procesul de separare a fost ingreunat la utilizarea frecventei minime de 40 Hz si a debitului maxim de alimentare de 90 kg/h, deoarece s-a produs stratificarea materialului vegetal si infundarea orificiilor sitei, de unde a rezultat si o productivitate scazuta.

Din analiza rezultatelor obtinute se constata ca sortatorul dimensional cu site plane oscilante poate fi utilizat cu succes pentru sortarea plantelor medicinale tocate dacă parametrii regimului de lucru sunt aleşi corespunzător pentru scopul urmarit in valorificarea materialului vegetal.

Datele prezentate sunt importante pentru toți specialiştii şi lucrătorii în domeniul procesarii plantelor medicinale, cu referire, în primul rând, la operatia de sortare a procesului tehnologic.

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DETERMINATION OF THE RELAXATION TIME AT STATIC COMPRESSION OF IDARED APPLES VARIETY
/
DETERMINAREA DURATEI DE RELAXARE LA SOLICITARI STATICE DE COMPRESIUNE A MERELOR DIN SOIUL IDARED

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Abstract: *Paper presents an experimental method of determining the static compression relaxation time of Idared apples variety, by preserving their integrity. Using the yield test by taking into account the viscous and elastic behaviour of the bodies described by physical rheological model of Burgers body made of elastic and viscous linear elements, the method theoretical groundwork was emphasized. A mathematical model and the suitable rheological equation describing the apples behaviour at steady static strain, has been found. Theoretical relations and experimental data are useful for evaluating (predicting) the storing time in packages which height is known.*

Keywords: *apples, compression stress*

INTRODUCTION

During the technological flow storing, the apple commercial value and quality are affected because of mechanical damage by crushing (contusion) of pulp tissue and also by apparition of deformations and deviations from characteristic shape.

Apple cellular tissue damage by contusion and remaining deformations visible through the geometrical shape modification, represent major causes of quality decrease and, consequently, of reduction of value and trading of fresh apples [7,8,12].

Value of losses represent10 – 12% out of the quantity stored [5,7], and for diminishing it, a suitable package should be chosen. Therefore, researches on finding the best solution between the package height, apple variety stored, ripening degree, time and conservation conditions, were performed.

Apple arranging height in packages has to be chosen so that any damage of fruits from lower rows do not produce, thus being detrimental to apples quality and class. Height limits depend on apple variety and ripening stage, characterized by a mechanical feature that can be a measure of rigidity (,,firmness") of fruit pulp [7,8,12].

MATERIAL AND METHOD

Theoretical aspects

As rheological material, fruits do not react to mechanical stress in terms of elasticity, their reaction combining an elastic component to a viscoelastic one [1,4].

When they are stored in bulk or arranged as a high pile for a longer period of time, the fruits are subject to a static load and, therefore deformation and damage may appear when pressure values are much smaller than those determined during the usual compression tests. For getting detailed data on apples deformation, a new technique allowing the automated time registering of continuous deformation under static load, has been

Rezumat: *Lucrare prezintă o metodă de determinare experimentală a duratei de relaxare la solicitări statice de compresiune a merelor din soiul Idared, cu menținerea integrității lor. Utilizând testul de fluaj prin considerarea comportării liniar vâscoelastice a corpurilor descrise de modelul fizic reologic al corpului Burgers format din elementele elastice şi vâscoase liniare s-au evidențiat bazele teoretice ale metodei. S-a găsit un model matematic şi ecuația reologica corespunzătoare care să descrie comportarea merelor la solicitări statice constante. Relațiile teoretice şi datele experimentale sunt utile la evaluarea (predicția) duratei de depozitare în ambalaje de înălțime cunoscută.*

Cuvinte cheie: *mere, solicitare la compresiune*

INTRODUCERE

Pe fluxul tehnologic de depozitare de lungă durată, valoarea comercială şi calitatea merelor sunt afectate datorită vătămărilor mecanice prin strivirea (contuzia) țesutului pulpei cât şi prin apariția deformațiilor şi abaterilor de la forma geometrică caracteristică.

Vătămarea prin contuzia țesutului celular la mere şi deformațiile remanente vizibile cu modificarea formei geometrice constituie cauzele majore a pierderilor de calitate şi în consecință a reducerii valorii şi a gradului de comercializare în stare proaspătă a merelor [7,8,12].

Valoarea pierderilor reprezintă 10 – 12% din cantitatea depozitată [5,7], iar pentru reducerea acesteia este necesară alegerea adecvată a ambalajului utilizat. In acest sens s-au realizat cercetări privind obținerea corelației între înălțimea ambalajului, soiul de măr depozitat, gradul de coacere, durata şi condițiile de păstrare.

Înălțimea de aranjare a fructelor în ambalaje, trebuie astfel aleasă, încât să nu se producă defecte fructelor din rândurile inferioare şi să afecteze calitatea şi clasa merelor. Limitele de înălțime sunt funcție de soiul de mere şi de stadiul de coacere caracterizat printr-o proprietate mecanică ce poate fi o măsură a însuşirilor de rigiditate (fermitate ,,firmness") a pulpei fructelor [7,8,12].

MATERIAL ŞI METODĂ

Aspecte teoretice

Ca materiale biologice fructele nu reacționează la tensiuni mecanice, într-o manieră pur elastică, reacția lor combinând o componentă elastică şi una vâscoelastică [1,4].

La depozitarea în vrac sau în stivă înaltă pentru o durată mare de timp fructele sunt supuse unei sarcini statice şi în acest caz deformarea şi vătămarea pot apare la valori ale presiunii, cu mult sub cele determinate la testele obişnuite de compresie. Pentru a obține date detaliate despre fluajul (deformarea) merelor, s-a elaborat o tehnică care permite înregistrarea automată în

drawn up.

Tests on Idared variety apple behaviour during compression strain have emphasized, by deformation-time curves, the effect of time of application of deformation force and speed, demonstrating that the time effect is of practical importance in case of fruit deformation under static load. [1,4,7].

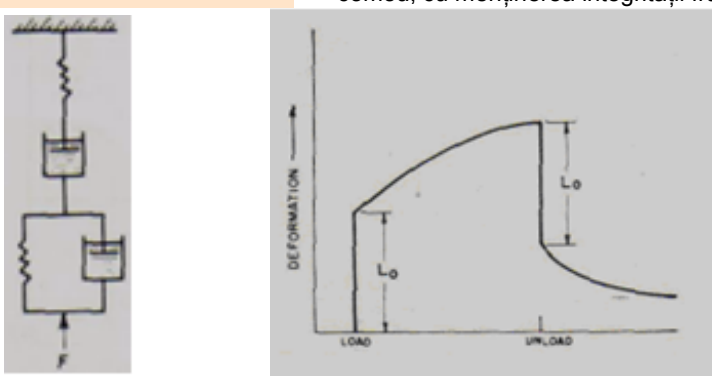
It has been tried to find out a mechanical model and its appropriate rheological equation which be suitable to experimental flow curve, similar to that from fig. 1.(through Burgers model (fig. 1a), where deformation-time curves obtained with this model are overlapping. Consequently, this curve simulates apple behaviour under static load. Following the compression tests made on whole apples located between two plane plates, the deformation-time curves have had the same profile as the curve from fig. 1 b, concluding that this curve might be described through a Burges model type, fig. 2, [2,8]. This new model type has been obtained from the classical model, by replacing: $\varepsilon \rightarrow \delta$, $\sigma \rightarrow F$, $E \rightarrow K$, $\eta \rightarrow \eta^*$, as one can see in fig.2. Appropriate experimental tests have the advantage of being performed more easily along with preserving the fruit integrity [9,11,12].

timp a deformației continue sub sarcină statică.

Testele privind comportarea la solicitarea de compresiune a merelor din soiul Idared au evidențiat, prin curbele forță-deformație efectul timpului de aplicare a forței şi a vitezei de deformare, dovedindu-se că efectul timpului este de importanță practică pentru cazul de fluaj al fructelor sub sarcină statică [1,4,7].

S-a încercat să se găsească un model mecanic şi ecuația reologica corespunzătoare care să se potrivească curbei de fluaj experimentală, similară celei din fig.1.(b) prin considerarea modelului Burgers (fig.1a), în care curbele deformație – timp obținute cu acest model se suprapun. In consecință, această curbă simulează comportamentul fructelor de măr sub sarcină statică.

Din testele de compresiune realizate pe merele întregi amplasate între două plăci plane s-au obținut curbe de deformație – timp cu acelaşi profil cu curba din fig. 1 b, fapt ce a permis ipoteza că se poate descrie această curbă printr-un model tip Burgers, fig. 2, [2,8]. Acest nou tip de model s-a obținut din modelul clasic prin înlocuirile: $\varepsilon \rightarrow \delta$, $\sigma \rightarrow F$, $E \rightarrow K$, $\eta \rightarrow \eta^*$, aşa cum se poate urmări în fig.2. Testele experimentale corespunzătoare au avantajul că se pot efectua mai comod, cu menținerea integrității fructului [9,11,12].



a) b)

Fig. 1 - Burgers physical model(a) and its deformation-time curve (b)

Establishing the rheological equation suitable to fruit behaviour at static compression was performed by taking into account the physical model of Burgers type and also the fact that equations appropriate to ideal elements state are:

- for the ideal elastic element, Hooke:

Stabilirea ecuației reologice corespunzătoare comportării fructului la solicitarea de compresiune statică, s-a făcut ținând cont de modelul fizic tip Burgers şi s-a avut în vedere că ecuațiile de stare corespunzătoare elementelor ideale sunt:

- pentru elementul ideal elastic, Hooke:

$$F = K \cdot \delta \tag{1}$$

- for ideal viscous element, Newton:

- pentru elementul ideal vâscos, Newton:

$$F = \eta^* \cdot \dot{\delta} \tag{2}$$

where

δ is deformation;

K-rigidity of elastic element [N/m];

η^*- size similar to viscosity of ideal viscous element [Ns/m].

unde

δ este deformația;

K-rigiditatea elementului elastic [N/m];

η^*- mărime similară vâscozității elementului ideal vâscos [Ns/m].

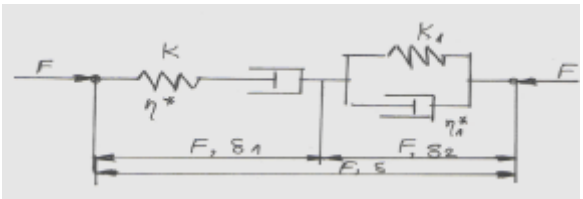


Fig. 2 - Burgers type physical model for describing the compression behavior of the whole apple

Body represented by Burgers model, subject to a constant compression force, $F = F_0$ = const. will have a

Corpul reprezentat prin modelul tip Burgers, supus acțiunii unei forțe de compresiune constante, $F = F_0$ =

time deformation given by equation:

const. va avea o deformație în timp dată de ecuația:

$$\delta = \frac{F_0}{K} + \frac{F_0}{\eta^*}t + \frac{F_0}{K_1}\left(1 - e^{-\frac{t}{T_i}}\right) \quad (3)$$

Working method

For performing the experiments, The Idared apple variety, coming from Institute of Research-Development for Tree Growing Piteşti - Mărăcineni Argeş, was chosen, the harvesting being manually made when fruits were completely ripen.

Apple samples chosen were of different sizes, randomly selected, but though, trying to find samples with apples closer of spherical shape. Up to tests performing, apples were kept in refrigerating cells at 3-4^0 C temperature and 80 – 85% relative humidity.

Before performing the tests, the apples were taking out from the cells and kept in laboratory at ambient temperature during, at least 4 – 5 hours, for reaching environment temperature.

In order to perform the deformation tests for finding out the elasticity module relaxation to apple static compression strain and relaxation time, the apparatus whose scheme is shown in fig 3a), has been designed and manufactured. In fig. 3(b,c) are presented images of apparatus aimed to perform the measurements. According to testing procedure, the apple is subject to static compression by pressing down, with a steady load, either with a rigid plane plate, fig.3(c), or another half of apple fig. 3(b) and deformation is measured by means of a comparing clock, at differenttime moments, at the beginning of feeding.

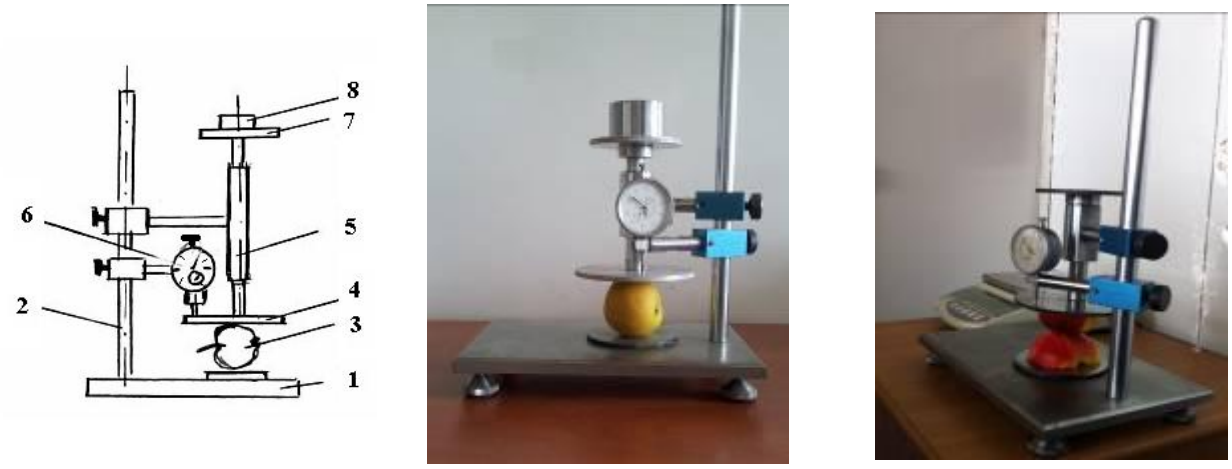
Metoda de lucru

Pentru efectuarea experimentărilor s-a ales soiul de măr Idared, provenit de la Institutul de Cercetare – Dezvoltare pentru Pomicultură Piteşti - Mărăcineni Argeş, recoltarea s-a făcut manual când fructele s-au aflat în stadiul deplinei maturități.

Probele de mere au fost de diferite dimensiuni, selectate în mod aleatoriu, căutându-se totuşi probele cu o formă apropiată de cea sferică. Până la efectuarea experimentărilor merele au fost păstrate în celule frigorifice la o temperatură de 3-4^0 C şi o umiditate relativă de 80 – 85%.

Inainte de efectuarea experimentărilor, fructele au fost scoase din celule şi ținute în laborator la temperatura camerei o durată de cel puțin 4 – 5 ore pentru a avea temperatura mediului.

In scopul efectuării testelor de fluaj în vederea determinării relaxării modulului de elasticitate şi a duratei de relaxare la solicitări statice de compresiune a merelor a fost conceput, proiectat şi realizat aparatul a cărui schemă este prezentată în fig. 3a. In fig. 3(b,c) sunt prezentate vederi ale aparatului pregătit pentru efectuarea măsurătorilor. In conformitate cu procedura de testare, mărul este supus la solicitarea de compresiune statică prin apăsarea, cu o sarcină constantă, fie a unei plăci plane rigide fig.3(c) fie a unei alte jumătăți de măr fig. 3(b) iar deformația este măsurată cu ajutorul unui ceas comparator, la diferite momente de timp la începutul încărcării.



a) b) c)

Fig. 3 – Scheme of apple compression deformation testing apparatus

1- main plate; 2-support; 3-apple 4- rigid pressing plate; 5- guidance; 6- comparing clock; 7-pan 8-load

Tests were performed in two variants, namely with the whole fruit (fig.3 b) and with halves of fruit (fig.3c). The apple was divided by a sharp knife with rigid blade and one apple half was laid on fixed surface of apparatus. The upper cup was charged with the mass appropriate to a constant pressing force F=15 N. The rigid plate was brought into contact with apple surface and cup rod was released for compression performing.

Deformation δ(t) at different moments of time was measured in seconds, starting from the beginning of strain, from 15 seconds to 15 seconds for 10 readings, from 30 seconds to 30 seconds for 5 readings, at 1 minute for 5 readings, from 5 to 5 minutes for 5 readings,

Experimentările au fost efectuate în două variante cu fructul întreg (fig.3 b) şi cu jumătăți de fruct (fig.3c). S-a secționat mărul într-un plan axial cu ajutorul unui cuțit bine ascuțit cu lama rigidă şi una din jumătăți s-a aşezat pe suprafața fixă a aparatului. S-a încărcat platanul superior cu masa de încărcare corespunzătoare unei forțe constante de apăsare F=15 N. S-a adus placa rigidă în contact cu suprafața mărului şi s-a eliberat tija platanului pentru realizarea solicitării la compresiune.

S-a măsurat deformația δ(t) la diferite momente de timp măsurate în secunde, de la începutul solicitării din 15 în 15 secunde pentru 10 citiri, din 30 în 30 secunde pentru 5 citiri, la 1 minut pentru 5 citiri, din 5 în 5 minute

from 10 minutes to 10 minutes for 5 readings and from 15 minutes to 15 minutes for 5 readings, which required a period of 2.5 hours for each experiment for which 35 values have been measured.

The elasticity module E was calculated in each point..

RESULTS AND DISCUTIONS

Compression deformation experiments have been performed at pressing loads of 12.5 N; 15 N; 17.5 N for the two variants. Deformations δ for different times have been measured and values o Young elasticity modules have been calculated.

Data obtained are shown in Tab.1.

pentru 5 citiri, din 10 în 10 minute pentru 5 citiri şi din 15 în 15 minute pentru 5 citiri, ceea ce a necesitat o durată de 2,5 ore pentru fiecare experiment pentru care s-au măsurat 35 de valori.

S-a calculat în fiecare punct modulul de elasticitate E.

REZULTATE SI DISCUTII

Experimentările de fluaj la compresiune au fost efectuate la sarcini de apăsare de 12,5 N; 15 N; 17,5 N pentru cele două variante. Au fost măsurate deformațiile δ pentru diferiți timpi şi calculate valorile modulelor de elasticitate Young.

Datele obținute sunt prezentate în Tab.1.

Table 1

Data of deformation test at constant force compression, deformation δ(t) at different time intervals t and elasticity longitudinal module – selective data

Timel [s]	F= 12,5 N				F= 15 N				F= 17,5 N			
	apple between plates		apple/apple		apple between plates		apple/apple		applebetween plates		apple/apple	
	δ [mm]	$E*10^6$ [Pa]	δ [mm]	$E*10^6$ [Pa]	δ [mm]	$E*10^6$ [Pa]	δ [mm]	$E*10^6$ [Pa]	δ [mm]	$E*10^6$ [Pa]	δ [mm]	$E*10^6$ [Pa]
15	0.48	4.07	0.66	8.62	0.60	3.81	0.77	7.82	0.64	4.12	0.74	8.61
45	0.51	3.69	0.73	7.45	0.66	3.30	0.83	6.95	0.66	3.89	0.83	7.34
75	0.53	3.51	0.77	6.91	0.68	3.14	0.86	6.56	0.69	3.68	0.87	6.84
105	0.54	3.37	0.79	6.56	0.70	3.03	0.88	6.34	0.71	3.51	0.89	6.58
135	0.56	3.25	0.81	6.39	0.71	2.95	0.90	6.15	0.73	3.39	0.91	6.35
180	0.57	3.17	0.83	6.17	0.74	2.80	0.92	5.93	0.75	3.22	0.93	6.11
240	0.58	3.06	0.85	5.97	0.76	2.65	0.94	5.75	0.77	3.14	0.96	5.88
300	0.59	2.99	0.86	5.85	0.78	2.54	0.96	5.58	0.78	3.08	0.98	5.71
420	0.6	2.89	0.87	5.68	0.81	2.40	0.98	5.41	0.82	2.90	1.00	5.52
540	0.61	2.81	0.89	5.50	0.84	2.30	1.00	5.26	0.83	2.77	1.02	5.36
900	0.64	2.64	0.92	5.28	0.88	2.15	1.01	5.16	0.87	2.60	1.06	5.07
1500	0.67	2.46	0.93	5.18	0.92	2.01	1.02	5.10	0.90	2.49	1.09	4.86
2100	0.69	2.35	0.94	5.12	0.94	1.95	1.03	5.05	0.92	2.40	1.11	4.72
3300	0.72	2.21	0.95	4.99	0.96	1.87	1.04	4.95	0.94	2.30	1.14	4.52
4500	0.74	2.12	0.98	4.80	0.99	1.80	1.06	4.81	0.97	2.21	1.16	4.42
6000	0.76	2.03	1.01	4.58	1.01	1.74	1.09	4.61	0.99	2.11	1.18	4.29
7800	0.79	1.89	1.05	4.32	1.03	1.69	1.10	4.53	1.04	2.00	1.20	4.19
9600	0.80	1.88	1.08	4.11	1.06	1.62	1.11	4.47	1.07	1.90	1.22	4.10

Based on the data obtained following the experiments, deformation δ depending on time (t) was represented by points, in fig.4 – fig.6 for stress scheme apple between plates and in fig.7 – fig.9 for apple/apple stress scheme..

By means of Microcal Origin program, experiments data were processed, testing the equation (4) for module relaxation through non-linear regression with experimental data and appropriate curves were represented comparing to experimental data in the same graphics – fig.4 – fig.9.

Pe baza datelor obținute din experimente s-au reprezentat prin puncte deformația δ în funtie de timp (t) în fig. 4 – fig.6 pentru schema de solicitare măr între plăci şi în fig.7 – fig.9 pentru schema de solicitare măr/măr .

Cu ajutorul programului Microcal Origin s-au prelucrat datele obținute din experimentări, testându-se ec.(4) pentru relaxarea modulului prin regresie neliniară cu datele experimentale şi curbele corespunzătoare au fost reprezentate, comparativ cu datele experimentale, pe aceleaşi grafice – fig.4 – fig.9.

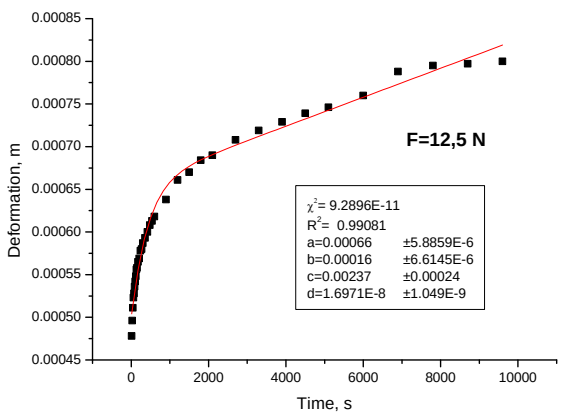


Fig.4 – Deformation curve δ(t) depending on time, for Idared apples at F=12,5 N

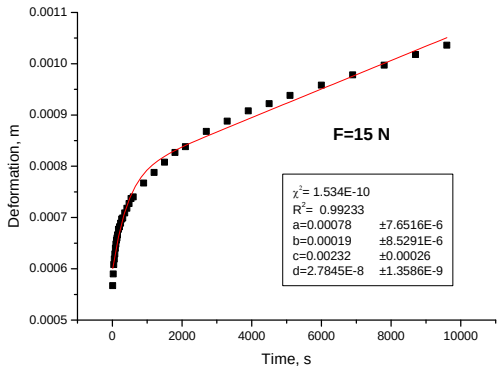


Fig.5 - Deformation curve δ(t) depending on time, for Idared apples at F=15 N

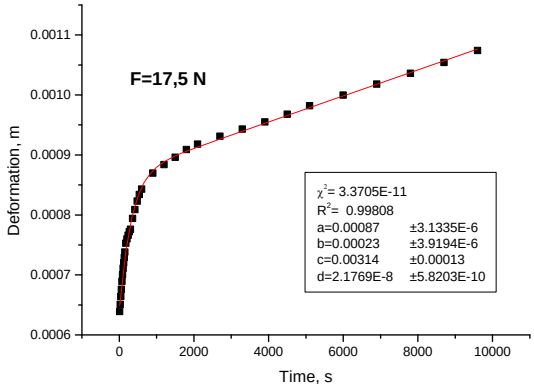


Fig.6 - Deformation curve δ(t) depending on time, for Idared apples at F=17,5 N

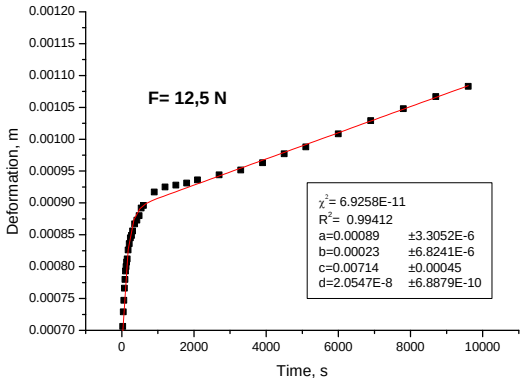


Fig.7 – Curve of deformation δ(t) depending on time for Idared apples at F=12.5 N

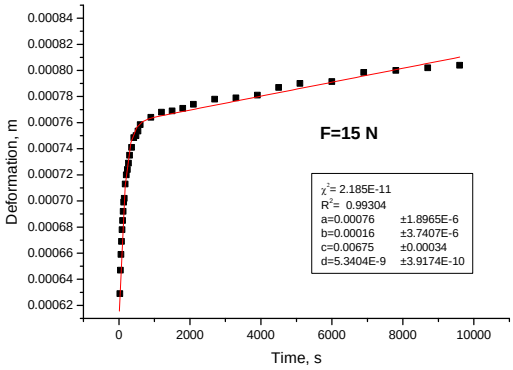


Fig.8 - Curve of deformation δ(t) depending on time for Idared apples at F=15 N

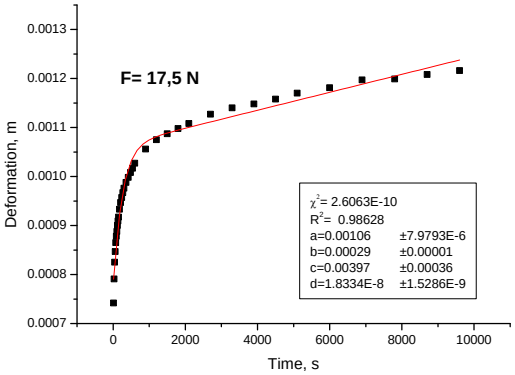


Fig.9 - Curve of deformation δ(t) depending on time for Idared apples at F=17,5 N

CONCLUSIONS

In technological flow, from harvesting to market, including the log time storing, operations which fruits are subject may produce mechanical damages (harvesting, sorting, storage, etc.) that affect their quality [6]. Damages are produced when strains surpass the elastic limit of fruit pulp, reaching its breaking resistance, fact manifested by crushing the fruit pulp tissue or apparition of deformations and deviations from characteristic geometrical shape.

Considering the linear viscoelastic behaviour of bodies described by physical rheological model of Burgers body,

CONCLUZII

In lanțul tehnologic de la recoltare la comercializare, inclusiv cu păstrare de lungă durată, operațiile la care sunt supuse fructele (recoltare, sortare, depozitare, etc.) pot produce vătămări mecanice ce le afectează calitatea [6]. Vătămările se produc când tensiunile depăşesc limita elastică a pulpei fructului, atingând rezistența la rupere a acesteia, fapt manifestat prin strivirea țesutului pulpei fructului sau apariția unor deformații şi abateri de la forma geometrică caracteristică.

Considerând pentru fruct, comportarea liniar vâscoelastică a corpurilor descrise de modelul fizic

the paper substantiates an experimental determination method of relaxation time at static compression strains. At the same time, using the deformation test, a mathematical model describing the static compression behaviour of apples is presented; it is necessary to prognosis of fruit package height, so that mechanical damages during the storing-conservation period be avoided and allow the prediction of storing time in certain packages.

A mechanical model and its appropriate rheological equation were found in order to match to experimental deformation curve, similar to that from fig. 1.b, by considering the Burgers model (fig.1a), where the deformation time curves, obtained with this model are overlapped. Consequently, this curve simulates the apple behavior subject to static load [3,10,13].

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reologic a corpului Burgers, în lucrare se fundamentează o metodă de determinare experimentală a duratei de relaxare la solicitări statice de compresiune. Totodată utilizând testul de fluaj se prezintă un model matematic pentru descrierea comportării la compresiune statică a merelor necesar la prognozarea înălțimii de aranjare a fructelor în ambalaje, astfel încât să evite apariția vătămărilor mecanice pe durate de depozitare – păstrare, şi a predicției duratei de depozitare în anumite ambalaje.

S-a găsit un model mecanic şi ecuația reologica corespunzătoare care să se potrivească curbei de fluaj experimentală, similară celei din fig. 1.(b) prin considerarea modelului Burgers (fig.1 a), în care curbele deformație – timp obținute cu acest model se suprapun. In consecință, această curbă simulează comportamentul fructelor de măr sub sarcină statică [3,10,13].

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EFFECT OF SPRAYING GIBBERELLIC ACID AND CALCIUM CHLORIDE ON STORAGE ABILITY OF JUJUBE FRUITS (Z. *mauritiana* Lam. cv. Tufahi)

تأثير الرش بحامض الجبرليك وكلوريد الكالسيوم في الصفات النوعية والقابلية الخزنية لثمار السدر صنف تفاحي *Z. mauritiana* Lam cv. Tufahi

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Abstract: *The present study was conducted on jujube trees "Ziziphus mauritiana Lam.", cv. Tufahi during the growing season 2013 -2014. The aim of the study will to investigate effects of spraying gibberellic acid at the concentrations of* (0 mg/l , 25 mg/l , 50 mg/l) *and calcium chloride at the concentrations of* (0 % , 1% , 2%) *on storage ability of jujube fruits cv.Tufahi . Fruits were packed in corky boxes (1 kg fruits for each of them) and stored at (0 °C ± 1) for five weeks. Results showed that treatment with (2%) calcium chloride was the best in reducing the percentage of physiological disorders, the percentage of fungal decay and loss in weight of fruits with no significant differences with (1%) calcium chloride, 50 mg/l gibberellic acid and 25 mg/l gibberellic acid treatments. The lowest percentage of physiological disorders was in fruits treated wit (2%) calcium chloride after five weeks of storage. The untreated fruits retained the highest percentage of totale soluble solids, total and reducing sugars with the lowest percentage of sucrose. The results also indicated to the increment of totale soluble solids, total and reducing sugars of fruits with the continuation of the storage periods.*

Keywords: *jujube, storage period, gibberellic acid, calcium chloride, physiological disorders*

الملخص

اجريت هذه الدراسة على اشجار السدر *Ziziphus mauritiana* Lam. صنف تفاحي اثناء موسم النمو 2013 -2014 وذلك لمعرفة تاثير الرش بحامض الجبرليك بالتراكيز (0 ، 25 ،50) ملغم/لتر وكلوريد الكالسيوم بالتراكيز (0 ، 1 ،2) % والتداخل بينهما في الصفات النوعية والقابلية الخزنية لثمار السدر صنف تفاحي. تم تعبئة الثمار بعبوات من الفلين تتسع ل 1 كغم وخزنت على درجة حرارة 0 °م ± 1 في حاضنة مبردة لمدة خمسة أسابيع. وأظهرت نتائج الدراسة تفوق معاملة الرش بكلوريد الكالسيوم تركيز 2% في تقليل نسبة اصابة الثمار بالاضرار الفسلجية والتلف الفطري وتقليل الفقد في الوزن الطري للثمار وبفارق غير معنوي عن المعاملة بكلوريد الكالسيوم تركيز 1% والمعاملة بحامض الجبرليك بتركيزي 50 ملغم/لتر و25 ملغم/لتر . كانت أقل نسبة مئوية للأضرار الفسلجية هي في الثمار المعاملة بكلوريد الكالسيوم 2% بعد خمسة أسابيع من الخزن . احتفظت ثمار معاملة المقارنة بأعلى نسبة مئوية للمواد الصلبة الذائبة الكلية والسكريات الكلية والمختزلة وأقل نسبة مئوية للسكروز. تشير النتائج الى ان المواد الصلبة الذائبة الكلية والسكريات الكلية والمختزلة ازدادت مع زيادة مدة الخزن .

الكلمات المفتاحية: السدر، مدة الخزن ، حامض الجبرليك، كلوريد الكالسيوم ، الأضرار الفسلجية

INTRODUCTION

Jujube fruits have highly nutritious value due to their constituents of sugars, proteins and amino acids, vitamins, fats, fiber and minerals .Every 100 grams of pulp contains 20.9 calories (Bowe. 2006). In Iraq, there are four main species of jujube which are *Z. nummularia* L. and *Z. jujuba* Lam. in addition to *Z. mauritiana* Lam. and *Z.spina-christi* that considered the two most important and economic species (Al-Rubaai, 1998).

Gibberellic acid is one of the plant growth regulators used to improve and increase the quality of fruits (Al-Ani, 1985) while calcium used to increase membrane stability and cell wall strength.Thus, the main benefits of calcium in the postharvest physiology of fruits are the organization of fruit ripening process by reducing the respiration rate and ethylene production and elongation the shelf life of fruits, in additions, controlling the physiological diorders during storage (Sams and Conway, 1984).

Cold storage cosidered one of important methods used to increase the shelf life of fruits and reduce the vital processes taken place in fruits especially respiratory and ethylene production in addition to control the growth of pathogens during storage (Shirokov, 1988).

In a study conducted by Taain (2011) refered to the reduction of physiological disorders of Tufahi jujube fruits soaked in 4% Calcium chloride + 4% calcium nitrate solutions and stored for 5 weeks at 0 °C and 5 ° C..The results of the study reported that physiological disorders significantly increased in fruits with the elongation of storage periods.

The present study aims to improve the storage ability of the jujube fruits cv.Tufahi by pre-harvest treating them with the

المقدمـــة

تمتاز ثمار السدر بأنها ذات قيمة غذائية عالية وهذا يعود الى احتوائها على السكريات والبروتينات والأحماض الأمينية والفيتامينات والدهون والألياف والمواد المعدنية.ويحتوي كل 100 غم من لب الثمار على 20.9 سعرة .(Bowe. 2006).يوجد في العراق أربعة أنواع رئيسية من السدر هي *Z. nummularia* L. and *Z. jujuba* Lam. بالاضافة الى النوعين *Z. mauritiana* Lam. and *Z.spina-christi* وهما يعدان أهم نوعين من الناحية الاقتصادية (الربيعي ، 1998) .

. يعد حامض الجبرليك من منظمات النمو التي استعملت لتحسين نوعية الثمار (العاني ،1985). بينما يستخدم عنصر الكالسيوم لزيادة نفاذية الأغشية وزيادة متانة جدران الخلايا. وعليه فأن الأهمية الرئيسية للكالسيوم في فسلجة الثمار بعد الجني هو تنظيم عملية نضج الثمار من خلال تقليل سرعة التنفس وانتاج الأثيلين واطالة العمر الخزني للثمار فضلا عن السيطرة على الأضرار الفسلجية خلال عملية الخزن (Sams and Conway, 1984).

يعد الخزن المبرد أحد أهم الطرق التي تستخدم لاطالة العمر الخزني للثمار من خلال تقليل العمليات الحيوية التي تحدث في الثمار خاصة التنفس وانتاج الأثيلين فضلا عن مقاومة المسببات المرضية أثناء الخزن (Shirokov, 1988).

في دراسة أجراها Taain (2011) لاحظ انخفاض نسبة الأضرار الفسلجية لثمار السدر صنف التفاحي التي غطست في المحاليل المائية لكلوريد الكالسيوم بتركيز 4% + نترات الكالسيوم بتركيز 4% وخزنت لمدة خمسة أسابيع بدرجتي 0°م و5°م .كما أشارت الدراسة الى ان الأضرار الفسلجية للثمار ازدادت مع تقدم مدة الخزن.

تهدف الدراسة الحالية الى تحسين القابلية الخزنية لثمار السدر صنف تفلحي من

solutions of gibberellic acid and calcium chloride and to improve the qualitative characteristics and marketing value of fruits.

MATERIAL AND METHODS

Experiment was carried out during the growing season of 2013-2014 on 12-years old jujube trees "*Ziziphus mauritiana* Lam.", cv. Tufahi grown in a private orchard situated at AL- Sedea District, Basrah Governorate, Iraq.

Solutions of gibberellic acid at the concentrations of (0 mg/l, 25 mg/l, 50 mg/l) and calcium chloride at the concentrations of (0 %, 1%, 2%) were prepared and the solutions spryed on the selected trees twice for every concentration by using hand pump .The sprying dates of gibberellic acid were 23/10/2013 and 23/11/2013 while the sprying dates of calcium chloride where 23/12/2013 and 23/1/ 2014.

Fruits of each treatment were harvested at maturation stage of growth and divided into three replicates and packed in corky boxes (1 kg fruits for each of them) and stored at (0 °C ± 1) in refrigerated incubator for five weeks. The following parameters were determined weekly during storage.

Physiological disorders and fungal decay were measured as a percentage during storage while the percentage of fruits weight loss was calculated by observed the changes in fruits weight during the storage period using weight balance (Polegaev, 1988) .Total titratable acidity (%) determined according to A.O.A.C. (1990). Total soluble solids (T.S.S.) of fruit pulps were determined by using hand refractometer (°Brix) and the results were corrected to 20 º C. Total and reducing sugars (%) of fruits were determined according to Lane and Eynon method outlined in A.O.A.C. (1990) .

Complete Randomized Design was used with three replicates. The results were analyzed by the analysis of variance and mean values were compared using the Revised Least Significant Difference Test at 0.05 probability level. (Al-Rawi and Khalf Allah, 1980).

RESULTS AND DISCUSSION

1. Physiological disorders (%):

Results presented in table (1) referred to significantly decrease in physiological disorders percentage of treated fruits with calcium chloride and gibberellic acid as compared to those of control treatment. Table (1) showed that the percentage of physiological disorders increased with the increment of storage period reached to the highest percentage 0.5% after five weeks of storage.

The interaction between sprying treatments with calcium chloride and gibberellic acid and storaqge periods was significant for its impact on the character. Fruits treated with 2% calcium chloride gave the lowest percentage of physiological disorders 0.25% after one week of storage.

Results in agreement with those obtained by Martin *et al*. (1976) who reported that the spraying of the calcium on Merton apple cultivar reduced the incidence of internal spots in stored fruits for 4 months.

2. Fungal decay(%):-

As showen in table (2) fruit treated with calcium chloride at the concentration of 2% gave the lowest percentage of fungal decay reached to 0.32% with no significant differences with 1% calcium chloride, 50 mg/l gibberellic acid and 25 mg/l gibberellic acid while untreated fruits gave the highest percentage of fungal decay 1.46%. The percentage of fungal decay increased with the increment of storage period reached to the highest percentage 0.76% after five weeks of storage. Reslts also showed that the interaction between sprying treatments with calcium chloride and gibberellic acid and storaqge periods was no significant for its impact on the character.

خلال معاملة الثمار قبل الجني بحامض الجبرليك وكلوريد الكالسيوم وتحسين الصفات النوعية والقيمة التسويقية للثمار.

المواد وطرائق العمل

نفذت التجربة خلال موسم النمو 2013-2014 على أشجار سدر صنف تفاحي "*Ziziphus mauritiana* Lam." , cv. Tufahi بعمر 12 سنة نامية في أحد البساتين الأهلية في منطقة السيدية ، محافظة البصرة جنوب العراق.

حضرت المحاليل المائية لحامض الجبرليك بالتراكيز (0 ، 25، 50) ملغم/لتر ولكلوريد الكالسيوم بالتراكيز (0 ،1،2)% ورشت المحاليل على الأشجار المنتخبة باستخدام مضخة يدوية وكانت مواعيد الرش لحامض الجبرليك هي 2013/10/23 و 2013/11/23 بينما كانت مواعيد الرش لكلوريد الكالسيوم 2013/12/23 و 2014/1/23.

تم جني ثمار كل معاملة في مرحلة اكتمال التكوين وقسمت الى ثلاثة مكررات وعبأت في عبوات فلينية تتسع ل 1 كغم لكل منها ثم خزنت بدرجة حرارة 0°م± 1 في حاضنة مبردة لمدة خمسة أسابيع وقدرت الصفات التالية اسبوعيا.

الأضرار الفسلجية والتلف الفطري تم تقديره كنسبة مئوية خلال الخزن بينما النسبة المئوية للفقد بالوزن فقد تم تقديرها من خلال ملاحظة التغيرات التي تحصل في الوزن الطري للثمار خلال الخزن(Polegaev, 1988) . الحموضة الكلية القابلة للتعادل (%) تم تقديرهما طبقا لما جاء في A.O.A.C. (1990). المواد الصلبة الذائبة الكلية (%) قدرت باستخدام الرفراكتوميتر اليدوي وصححت القراءة على درجة حرارة 20°م. أما السكريات الكلية والمختزلة فقد تم تقديرها حسب طريقة Lane and Eynon والموصوفة في A.O.A.C. (1990).

صممت تجربة عامليه بأستخدم التصميم العشوائي الكامل Complete Randomized Design وبثلاث مكررات للمعاملة الواحدة. وجرى اختبار الفرق بين المتوسطات حسب اختبار اقل فرق معنوي معدل R.L.S.D عند مستوى احتمال 0.05 (الراوي وخلف الله،1980).

النتائج والمناقشة

1.الأضرار الفسلجية (%) :

تشير النتائج الواردة في الجدول (1) الى انخفاض معنوي في النسبة المئوية للأضرار الفسلجية لثمار السدر صنف تفاحي المعاملة بكلوريد الكالسيوم وحامض الجبرليك عند المقارنة مع الثمار غير المعاملة بهما.النتائج الواردة في الجدول (1) تشير الى ان الأضرار الفسلجية للثمار تزداد كلما ازدادت مدة الخزن ووصلت الى 0.5% بعد خمسة أسابيع من الخزن.

أما التداخل الثنائي بين معاملات الرش بكلوريد الكالسيوم وحامض الجبرليك ومدة الخزن فقد كان معنوي في تأثيره على الصفة. اذ أعطت الثمار المعاملة بكلوريد الكالسيوم 2% أقل نسبة للأضرار الفسلجية لثمار السدر صنف تفاحي 0.25% بعد اسبوع واحد من الخزن.

تتفق النتائج مع Martin *et al*. (1976) والذين أوضحوا ان رش التفاح صنف Merton بالكالسيوم أدى الى تقليل الاصابة بالبقع المرة عند خزن الثمار لمدة أربعة أشهر.

2. التلف الفطري (%) :-

كما يلاحظ من الجدول (2) فان الثمار المعاملة بكلوريد الكالسيوم تركيز 2% أعطت أقل نسبة مئوية للتلف الفطري 0.32% وبفارق غير معنوي عن المعاملة بكلوريد الكالسيوم 1% والمعاملة بحامض الجبرليك بالتركيزين 25% و 50% ، بينما أعطت الثمار غير المعاملة أعلى نسبة مئوية للتلف الفطري 1.46%. النسبة المئوية للتلف الفطري ازدادت بزيادة مدة الخزن الى ان وصلت الى 0.76% بعد خمسة أسابيع من الخزن.وتشير النتائج الى عدم معنوية التداخل بين معاملات الرش بحامض الجبرليك وكلوريد الكالسيوم ومدة الخزن في تأثيرها على النسبة المئوية للتلف الفطري للثمار.

During handling and storage, fruits expose to damage that can take some forms depending on its causes. It may be the result of mechanical injuries resulting from pressure of fruits each other inside the package or the damage caused by pathogens infactions like bacteria, fungi and yeasts (Dementeva and Vegonski, 1988; Desouki *et al*., 1998). Results are in agreement with Taain (2011) who reported that fungal decay percentage decreased when jujube fruts cv.Tufahi treated with calcium salts and stored for 5 weeks at 0°C.

تتعرض الثمار أثناء تداولها وخزنها الى التلف الذي يتخذ عدة صور اعتمادا على مسبباته . فقد يكون ناتجا عن الأضرار الميكانيكية والناتجة عن ضغط الثمار بعضها البعض داخل العبوة أو ناتجا عن الاصابة بالمسببات المرضية مثل البكتريا والفطريات والخمائر (Dementeva and Vegonski, 1988; دسوقي وآخرون، 2001) .

تتفق نتائج هذه الدراسة مع Taain(2011) والذي بين ان النسبة المئوية للتلف الفطري لثمار السدر صنف تفاحي تنخفض عند المعاملة بأملاح الكالسيوم والخزن بدرجة 0°م لمدة خمسة أسابيع.

Table 1

The effect of gibberellic acid and calcium chloride treatments, storage period and the interaction between them on physiological disorders (%) of jujube fruits stored at (0± 1 °C)

Treatments	Storage period (week)					Means of treatments
	1	2	3	4	5	
control	0.36	0.38	0.42	0.55	0.78	0.49
gibberellic acid (25 mg/l)	0.33	0.38	0.39	0.42	0.65	0.41
gibberellic acid (50 mg/l)	0.35	0.37	0.39	0.40	0.46	0.39
calcium chloride (1%)	0.37	0.36	0.37	0.37	0.4	0.37
calcium chloride (2%)	0.25	0.32	0.32	0.32	0.34	0.31
Means of storage periods	0.33	0.36	0.37	0.41	0.5	

RLSD 0.05

treatments period	storage period	treatments x storage
0.15	0.17	0.19

Table 2

The effect of gibberellic acid and calcium chloride treatments, storage period and the interaction between them on fungal decay (%) of jujube fruits stored at (0± 1 °C)

Treatments	Storage period (week)					Means of treatments
	1	2	3	4	5	
control	1.4	1.4	1.46	1.51	1.57	1.46
gibberellic acid (25 mg/l)	0.32	0.4	0.42	0.57	0.61	0.46
gibberellic acid (50 mg/l)	0.32	0.32	0.4	0.40	0.51	0.39
calcium chloride (1%)	0.17	0.30	0.30	0.42	0.64	0.36
calcium chloride (2%)	0.15	0.23	0.35	0.39	0.51	0.32
Means of storage periods	0.47	0.53	0.58	0.65	0.76	

RLSD 0.05

treatments period	storage period	treatments x storage
1.11	0.30	N.S

3- Weight loss (%) :-

Results presented in table (3) indicated that the loss in weight of treated fruits with calcium chloride and gibberellic acid significantly decrease as compared to those of control treatment that gave the highest percentage of weight loss 0.96%, The percentage of weight loss increased with the continuation of storage period reached to 1.5 % after five weeks of storage.

3- الفقد بالوزن (%):-

تشير النتائج الواردة في الجدول (3) الى ان النسبة المئوية للفقد بالوزن لثمار السدر صنف تفاحي انخفضت في الثمار المعاملة بكلوريد الكالسيوم وحامض الجبرليك مقارنة مع الثمار غير المعاملة بهما والتي سجلت أعلى نسبة مئوية للفقد بالوزن 0.96% . كما يلاحظ ان الفقد في وزن الثمار ازداد مع تقدم مدة الخزن الى ان وصل الى 1.5% بعد خمسة أسابيع من الخزن.

Untreated fruits gave the highest percentage of weight loss 2.61% after five weeks of storage with no siginificant differences with the same fruits after four weeks of storage.

Weight loss of fruits takes place as a result of the loss of stored food in the vital process especially respiration or as a result of the loss of water content through evaporation from the skin of the fruit (Al-Ani, 1985; Shirokov, 1988). Results are in constant with Taain (2011) who noted that the loss of weight of Tufahi jujube fruits increased with the increament of storage periods and the lowest percentage of fruit weight loss was in fruits treated with calcium salts as compered with untreated fruits. Results are in accordance with the observation previously reported by Shear (1975) who indicated that calcium plays an important role in reducing the rate of loss in weight in many kinds of fruits and vegetables.

أعطت ثمار معاملة المقارنة أعلى نسبة مئوية للفقد بالوزن بعد خمسة أسابيع من الخزن 2.61% وبفارق غير معنوي مع ثمار المعاملة نفسها بعد أربعة أسابيع من الخزن.

يحصل فقد الوزن في الثمار كنتيجة للفقد بالمخزون الغذائي بسبب العمليات الحيوية وخاصة عملية التنفس أو نتيجة لفقد الماء عن طريق التبخر من سطح الثمرة (Shirokov, 1988 ; العاني، 1985). تتفق النتائج مع Taain (2011) والذي وجد ان الفقد في الوزن لثمار السدر صنف تفاحي يزداد مع زيادة مدة الخزن وان أقل نسبة مئوية للفقد بالوزن هي في الثمار المعاملة بأملاح الكالسيوم مقارنة مع الثمار غير المعاملة. وتتفق نتائج الدراسة مع الملاحظة التي أشار لها Shear (1975) من ان الكالسيوم يلعب دور مهم في تقليل الفقد بالوزن لأنواع مختلفة من الفاكهة والخضر

Table 3

The effect of gibberellic acid and calcium chloride treatments, storage period and the interaction between them on Weight loss (%) of jujube fruits stored at (0± 1 °C)

Treatments	Storage period (week)					Means of treatments
	1	2	3	4	5	
control	0	0	0.66	1.56	2.61	0.96
gibberellic acid (25 mg/l)	0	0	0.31	1.22	1.33	0.57
gibberellic acid (50 mg/l)	0	0	0	0.67	1.19	0.37
calcium chloride (1%)	0	0	0.27	0.78	1.22	0.45
calcium chloride (2%)	0	0	0	0.61	1.15	0.35
Means of storage periods	0	0	0.24	0.66	1.5	

RLSD 0.05

treatments period	storage period	treatments x storage
0.57	1.11	1.04

4. Total soluble solids (%):-

As is clear in table (4), the percentage of total soluble solids of fruits increased with the increment of storage period reached to the highest percentage 21.24% after five weeks of storage, while the control fruits gave the higest percentage of total soluble solids 21.94% as compered with the rest treatments.

Untreated fruits recorded the highest percentage of total soluble solids after five weeks of storage with no siginificant differences with the same fruits after four weeks of storage.

The accumulation of total soluble solids with the increament of storage periods may be due to the progress of jujube fruits which cosidered as climacteric fruits towards ripening stage (Desouki *et al*., 2001) in addition to decrease the water content of fruits with the increament of storage periodswhich led to increment the total soluble solids (Burton, 1982). The reason for the reduction of total soluble solids of fruits treated with calcium salts may be due to calcium's role in the delay fruits ripening (Al-Ani, 1985).

4. المواد الصلبة الذائبة الكلية (%):-

كما هو واضح في الجدول (4) النسبة المئوية للمواد الصلبة الذائبة الكلية للثمار ازدادت مع زيادة مدة الخزن الى ان وصلت الى أعلى قيمة لها بعد خمسة أسابيع من الخزن 21.24% . وأعطت ثمار معاملة المقارنة أعلى نسبة مئوية للمواد الصلبة الذائبة الكلية 21.94% مقارنة مع بقية المعاملات.

الثمار غير المعاملة وبعد خمسة أسابيع من الخزن سجلت أعلى نسبة مئوية للمواد الصلبة الذائبة الكلية وبفارق غير معنوي عن ثمار نفس المعاملة بعد أربعة أسابيع من الخزن.

ان تجمع المواد الصلبة الذائبة مع زيادة مدة الخزن ربما يعود الى تقدم ثمار السدر صنف تفاحي والتي تعد من الثمار الكلايمكتيرية بالنضج (دسوقي وآخرون،2001) بالاضافة الى نقص المحتوى المائي للثمار مع تقدم مدة الخزن والذي يعمل على زيادة محتوى الثمار من المواد الصلبة الذائبة الكلية (Burton, 1982). ان السبب في انخفاض النسبة المئوية للمواد الصلبة الذائبة الكلية عند معاملتها بكلوريد الكالسيوم ربما يعود الى دور الكالسيوم في تأخير نضج الثمار(العاني، 1985).

Obtained results are in the same line with those obtained by Hayat *et al*. (2003) who indicated that the percentage of total soluble solids of apple fruits treated with calcium chloride in the concentration of 2% was 14%, while it was 16.46% in control fruits at the end of storage.

5. Sugars and total titratable acidity (%):-

Table (1) showed that untreated fruits were superior to the other treatments in giving the highest percentage of total and reducing sugars at the end of storage period (18.32%, 17.33%) in arrangement, while the lowest percentage of sucrose was in untreated fruits with significant differences with the rest treatments.Statistical analysis indicated that treatments had no significant differences in their effect on total acidity at the end of storage.

The reason for the reduction of total and reducing fruit sugars treated with calcium chloride may be due to calcium's role in delaying fruits ripening (Al-Ani, 1985). The content of jujube fruits of acidity varies depending on cultivars and the stages of growth (Bal, 1980). The acidity considered as one of the flavor components in fruits and fruit reachs to the highest level of flavor when it gets the balance between sugars and organic acids during the ripening stage. Results of studies showed that changes of organic acids content varies depending on the stages of growth and development of the fruits but generlly in the most of fruit kinds, the acidity reduced as fruits inter ripening due to either the consumption of organic acids in respiration process or they maybe change into sugars (Hulme,1970). According to Pareek (1983) the total acidity of the jujube caltivars Gola, Kaithli, Banarsi-Karaka and Umran at ripening stage ranged between (0.37-0.75) %, (0.16-0.51)%, (0.13-0.48)% and (0.19-0.35%) for the four cultivars respectively.

تتفق النتائج مع النتائج المستحصل عليها من قبل Hayat *et al*. (2003) والذين أشاروا الى ان النسبة المئوية للمواد الصلبة الذائبة الكلية لثمار التفاح المعاملة

5- السكريات والحموضة الكلية القابلة للتعادل (%) :-

يبين الجدول (1) ان الثمار غير المعاملة تفوقت على بقية المعاملات في اعطاء أعلى نسبة مئوية للسكريات الكلية والمختزلة نهاية مدة الخزن (18.32%و17.33%) على الترتيب ، بينما كانت أقل نسبة مئوية للسكروز عي في الثمار غير المعاملة . وتشير نتائج التحليل الاحصائي الى عدم معنوية التداخل بين المعاملات في التأثير على النسبة المئوية للحموضة الكلية القابلة للتعادل للثمار.

ان السبب في انخفاض نسبة السكريات الكلية والمختزلة في الثمار المعاملة بكلوريد الكالسيوم ربما يعود الى دور الكالسيوم في تأخير عملية نضج الثمار (العاني ،1985). يعتمد محتوى ثمار السدر من الأحماض العضوية على الصنف ومراحل النمو(Bal, 1980). وتعد الحموضة أحد مكونات النكهة في الثمار وتصل الثمرة الى أقصى درجات النكهة عندما يكون هنالك توازن بين محتواها من الاحماض العضوية والسكريات.وأظهرت النتائج ان التغير في الأحماض العضوية يعتمد على مراحل نمو وتطور الثمار وبشكل عام في معظم الثمار فان الاحماض العضوية تقل كلما تقدمت الثمار نحو النضج لاستعلاكها بعملية التنفس أو تحولها الى سكريات (Hulme,1970). طبقا ل(Pareek (1983 فان الحموضة الكلية للأصناف Gola , Kaithli , Banarsi-Karaka and Umran تراوحت عند النضج بين (0.37–0.75) % و (0.16–0.51) % و (0.13–0.48) % و (0.19–0.35) % للأصناف الأربعة على التوالي.

Table 4

The effect of gibberellic acid and calcium chloride treatments, storage period and the interaction between them on total soluble solids (%) of jujube fruits stored at (0± 1 °C)

Treatments	Storage period (week)					Means of treatments
	1	2	3	4	5	
control	20	21	21.7	23	24	21.94
gibberellic acid (25 mg/l)	19	19.5	20	20.5	21	20.02
gibberellic acid (50 mg/l)	18.5	19	19.4	19.7	20	19.32
calcium chloride (1%)	19	19.5	20.3	20.7	21	20.1
calcium chloride (2%)	18.5	19	19.5	19.8	20.2	19.4
Means of storage periods	19	19.6	20.18	20.76	21.24	

RLSD 0.05

treatments period	storage period	treatments x storage
1.75	1.15	2.41

Table 5

The effect of gibberellic acid and calcium chloride treatments on total and reducing sugars,sucrose and total titratable acidity (%) of jujube fruits at the end of storage at (0± 1 °C)

Treatments	Total sugars	Reducing sugars	Sucrose	Acidity
control	18.32	17.33	0.99	0.43
gibberellic acid (25 mg/l)	15.55	14.44	1.11	0.45
gibberellic acid (50 mg/l)	13.04	11.85	1.19	0.5
calcium chloride (1%)	15.68	14.57	1.11	0.41

calcium chloride (2%)	13.45	12.32	1.15	0.5
RLSD 0.05	2.62	2.71	0.1	N.S.

CONCLUSIONS

In conclusion, the results obtained in the present work clearly indicated to the role of pretharvest application of gibberellic acid and calcium chloride in improving qualititive characteristics of jujube fruits cv.Tufahi after five weeks of storage.

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الاستنتاجات

تشير النتائج بوضوح الى ان معاملة ثمار السدر صنف تفاحي قبل الجني بحامض الجبرليك وكلوريد الكالسيوم أدى الى المحافظة على الصفات النوعية للثمار بعد خمسة أسابيع من الخزن.

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EMPLOYEES' ASSESSMENT OF KAIZEN IMPLEMENTATION IN INDUSTRIAL ENTERPRISE – RESULTS OF EMPIRICAL RESEARCH
/
OCENA WDROŻENIA PROGRAMU KAIZEN W OPINII PRACOWNIKÓW ZAKŁADU PRZEMYSŁOWEGO - REZULTATY BADAŃ EMPIRYCZNYCH

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ABSTRACT: *The aim of this article is to present the philosophy of kaizen, which may support the strategy for implementation of innovative changes, and thereby increase the innovativeness of Polish enterprises. The paper developed a theoretical and an empirical parts. The first part generally describes the core philosophy of kaizen and the second part shows the results of empirical studies conducted in the Polish enterprise which concern the state of employees' readiness and commitment to the implementation of kaizen.*
Keywords: innovation, kaizen, employees, process of changes, polish enterprise.

INTRODUCTION

Contemporary there are many concepts and management methods which allow the search for new and better direction for the development of enterprises and contribute to improve their competitiveness and innovation. The system solutions in the field of innovation become an important point, they are implemented in order to improve the functioning of the enterprise and its better adaptation to rapidly changing environmental conditions. The source of these changes are usually the natural human desire to improve the status quo and are the essence of streamlining the organization [12, 6]. This principle is the main message for Japanese management concepts such as Total Quality Management, Lean Management and kaizen. As part of these there are a number of methods and instruments to improve, used with varying results by enterprises around the world, including Poland.

This article describes the philosophy of kaizen in theory, and presents the results of empirical studies conducted in the Polish enterprise on the state of readiness of employees to the implementation of kaizen.

MATERIAL AND METHOD

The theoretical part of article was developed on a base of polish and foreign literature and Internet sites. The empirical part was developed from performed research. The study was conducted in 2014 in the Polish manufacturing plant operating in the metal industry in Lower Silesia. The study used a questionnaire, the fulfillment of which was supervised by a competent person dealing with the issues of implementation of kaizen. The questionnaires were addressed to the production employees working on the assembly line. The results of research were analyzed and graphically presented in the second part of paper.

THEORETICAL APPROACH OF KAIZEN VS INNOVATIONS

The term "kaizen" is a combination of two Japanese words: kai - "change" and zen - "good." The literal translation means "change for the better." In the literature there are many definitions of the term. In the Polish publication: "Handbook of Quality" kaizen is interpreted as "gradual, ordered and continuous improvement, increasing the value, perfecting, advancement" [17]. According to another definition it is: "The concept of management based on the constant search for and application of even the smallest

ABSTRACT: *Celem artykułu jest zaprezentowanie filozofii kaizen, która może wspierać strategię wdrażania zmian, a tym samym zwiększać innowacyjność polskich przedsiębiorstw. W artykule opracowano część teoretyczną oraz empiryczną. W pierwszej części ogólnie opisano podstawowe założenia filozofii kaizen, w drugiej części przedstawiono wyniki badań empirycznych przeprowadzonych w polskim przedsiębiorstwie dotyczących stanu przygotowania pracowników do procesu wdrażania kaizen.*
Słowa kluczowe: innowacje, kaizen, pracownicy, proces zmian, polskie przedsiębiorstwo.

WSTĘP

Współcześnie pojawia się wiele koncepcji i metod zarządzania, które umożliwiają poszukiwanie nowych, lepszych kierunków rozwoju dla przedsiębiorstw i przyczyniają się do poprawy ich konkurencyjności i innowacyjności. Istotnym punktem stają się systemowe rozwiązania w zakresie innowacji, które są wdrażane w celu usprawniania funkcjonowania przedsiębiorstwa i lepszego jego dopasowania do szybko zmieniających się warunków otoczenia. Źródłem innowacji są naturalne ludzkie dążenia do poprawy stanu istniejącego i stanowią one istotę usprawniania organizacji [12, 6]. Zasada ta jest głównym przesłaniem dla japońskich koncepcji zarządzania takich jak: TQM, Lean Management czy kaizen. W ramach nich pojawia się szereg metod i instrumentów doskonalenia, stosowanych z różnym skutkiem przez przedsiębiorstwa na całym świecie, w tym również w Polsce.

W artykule opisano filozofię kaizen w ujęciu teoretycznym oraz przedstawiono wyniki badań empirycznych przeprowadzonych w polskim zakładzie dotyczących stanu przygotowania pracowników do procesu wdrażania kaizen.

MATERIAŁY I METODY

Część teoretyczna w artykule została opracowana na podstawie polskiej i zagranicznej literatury przedmiotu oraz informacji dostępnych w sieci internetowej. Część empiryczna zawiera wyniki badań. Badania zostały przeprowadzone w 2014 roku w polskim zakładzie produkcyjnym działającym w branży metalowej w województwie dolnośląskim. W badaniu wykorzystano kwestionariusz ankietowy, którego wypełnienie było nadzorowane przez osobę zajmującą się problematyką wdrożeń z zakresu kaizen. Ankiety były adresowane do pracowników pracujących na linii montażowej. Wyniki badań zaprezentowano w drugiej części.

UJĘCIE TEORETYCZNE KAIZEN VS INNOWACJE

Termin: „kaizen" jest połączeniem dwóch japońskich słów: kai – „zmiana" oraz zen – „dobry". W dosłownym tłumaczeniu oznacza „zmianę na lepsze". W literaturze przedmiotu występuje wiele definicji tego pojęcia. W polskiej publikacji: „Vademecum jakości" kaizen interpretowane jest jako „stopniowe i uporządkowane oraz ciągłe ulepszenie, podnoszenie wartości, poprawa, doskonalenie" [17]. Według innej definicji jest to: „Koncepcja zarządzania oparta na nieustannym poszukiwaniu i stosowaniu najdrobniejszych nawet usprawnień we wszystkich dziedzinach działalności, na każdym stanowisku pracy. Jej celem jest osiągnięcie

improvements in all areas of activity at each workplace. Its aim is to achieve significant success through small steps" [2]. However, the most important interpretation of this concept refers to the human factor and it is: "the desire of all employees and executive-level to the continuous improvement of all aspects of enterprise" [13]. Such an approach is consistent with the original meaning of the concept, which was promoted by Japanese scientists: "Kaizen means improvement. In addition, means continuous improvement in your personal life, your home, in social and work. In the enterprise kaizen is continuous improvement of all - managers and employees" [5, 6].

For the development of this philosophy the great importance have the extension of the concept of TQM, which was originally part of kaizen improvement of Japanese quality management techniques, such as: zero defects, E. Deming cycle, quality circles, prevention system, just-in-time. This approach meant that you can do all better than before, that small steps can achieve the desired results. Perfecting everything, and the advancement should be done every day, by everyone, from small incremental improvements to major strategic changes [10, 12, 15]. Kaizen in its assumption should encourage employees to improve workplace, contribute to greater self-reliance and self-control. The basic objectives of kaizen is to improve the three parameters: quality, costs and delivery time. This means improving the quality of products and services, processes, striving to reduce costs at every stage of the business organization and shortening delivery times.

In the world of business innovations are regarded as one of the key factors of the development of each enterprise [3, 19]. In the literature, innovation generally is interpreted as: "the first use of certain ideas or inventions with adequate economic criteria in order to profit" [1]. Some authors refer innovation to all areas of enterprise's activities whilst others have in mind something new that works on the market [1, 4]. Thus, innovation is a significant improvement on the existing situation especially in the field of technology and management (this applies to: tools, techniques and processes). All these activities are expected to bring the enterprise changes in the form of improvements, which in turn are translated into concrete benefits [18].General comparison of innovation and kaizen are presented in Tab. 1.

znacznych sukcesów za pomocą drobnych kroków" [2]. Jednak najważniejsza interpretacja tego pojęcia odnosi się do ludzi, i jest to: „dążenie wszystkich pracowników szczebla decyzyjnego i wykonawczego do ciągłego doskonalenia wszystkich aspektów działalności firmy" [13]. Takie ujęcie jest zgodne z pierwotnym znaczeniem koncepcji, które było propagowane przez japońskich naukowców: „Kaizen ozn. doskonalenie. Ponadto ozn. ciągłe doskonalenie w życiu osobistym, domowym, na płaszczyźnie społecznej i w pracy. W przedsiębiorstwie kaizen to ciągłe doskonalenie się wszystkich – menedżerów i pracowników" [5, 6].

Dla rozwoju tej filozofii ogromne znaczenie miało rozszerzenie koncepcji TQM, w której kaizen pierwotnie było elementem usprawniania charakterystycznym dla japońskich technik zarządzania jakością, na przykład takich jak: zero defektów, cykl E. Deminga, koła jakości, system prewencji, just in time. Podejście to oznaczało, że wszystko można robić lepiej niż dotychczas, że małymi kroczkami można osiągnąć zamierzone efekty. Doskonalić należy wszystko, a samo doskonalenie powinno się odbywać każdego dnia, przez wszystkich, od małych stopniowych udoskonaleń do wielkich strategicznych zmian [10, 12, 15]. Kaizen w swoim założeniu powinien skłaniać pracowników do poprawy stanowiska pracy, przyczyniać się do większej ich samodzielności i samokontroli. Podstawowymi celami kaizen jest poprawa trzech parametrów: jakości, kosztów i czasu dostaw. Ozn. to poprawę jakości wyrobów, procesów, dążenie do obniżenia kosztów na każdym etapie działalności organizacji oraz skracanie czasu realizacji zamówień.

W świecie gospodarczym innowacje traktowane są jako jeden z zasadniczych czynników rozwoju każdego przedsiębiorstwa [3, 19]. W literaturze przedmiotu ogólnie innowacje interpretuje się jako „pierwsze wykorzystanie pewnych pomysłów lub wynalazków przy zachowaniu odpowiednich kryteriów gospodarczych w celu osiągnięcia korzyści" [1]. Niektórzy autorzy odnoszą innowacje do wszelkich dziedzin działalności przedsiębiorstwa, a inni mają na myśli jakąś nowość, która sprawdza się na rynku [1, 4]. Innowacje zatem to znaczące udoskonalenie stanu istniejącego przede wszystkim w zakresie technologii i sposobu zarządzania (dotyczy to: narzędzi, technik, procesów). Wszystkie te działania mają przynieść przedsiębiorstwu zmiany w postaci usprawnień, co w efekcie daje konkretne korzyści [18]. Porównanie innowacji i kaizen zaprezentowano w tab.1.

Table 1

Characteristics of kaizen and innovation [6]

Criteria	Kaizen	Innovation
Effect	The long-term effect, but not breakthrough	Short-term, breakthrough
Steps	Small steps	Big steps
Time frame	Continuous operation of gradually increasing effects	Action incidental effect of a sudden
Change	The gradual and continuous	Sudden and disposable
Involvement	Everybody	Selected leaders
Approach	Team effort, a systematic approach	Individual ideas and action
Method of work	Maintenance and improvement	"Fire fighting" and reconstruction
Ideas	Conventional know-how and traditional technology	The use of technological breakthroughs, new theories
Practical requirements	Requires a small investment, but a huge effort to maintain	Requires large investments, but little effort to maintain
Orientation	On the people	On technology
Criteria	Processes and commitment to achieving better results	Results directly affecting the profits
Utilization	Works well in a stable growing economy	Works better in a rapidly growing economy

The classic approach to innovation differs from kaizen in many aspects: the pace and scope of change, working methods and the essential - in the philosophy of kaizen human factor plays a key role in the improvement. Kaizen is a kind of innovation, in which improvement "is a state of mind inherently connected to maintaining and improving standards" [5, 6]. Important elements of the concept of kaizen are: ensuring standardization and creating system

Klasyczne podejście do innowacji różni się od kaizen w wielu aspektach: tempo i zakres zmian, stosowane metody pracy oraz w zasadniczym – w filozofii kaizen czynnik ludzki odgrywa kluczową rolę w procesie usprawnień. Kaizen jest rodzajem innowacji, w której doskonalenie „jest stanem umysłu związanym z utrzymywaniem i ulepszaniem standardów" [5,6]. Ważnymi elementami kaizen jest zapewnienie standaryzacji i systemu wspomagającego utrzymanie

maintain the level of change. In practice, defining standards means their continuous raising, only that way you can aim to improve the status quo, as a result of continuous kaizen activities. However, should be aware that the application of this philosophy does not exclude the introduction of radical improvements, they can be supported and fixed by using kaizen. Such actions affect both the measurable economic effects, as well as the behavior of employees, their knowledge, skills and attitude of openness and commitment. Therefore, an additional value of the implementation of kaizen is increasing awareness of workers for further improvement of the organization [7, 8]. In this context, the combining of kaizen and innovation can be very rational, as: "kaizen is understood as maintaining and improving standards by means of small, incremental steps, and innovation is regarded as a radical change related to major investments in technology and/or equipment" [6].

The result of kaizen activities is usually new organizational culture, focused on process improvements, resulting primarily with a positive message among employees. They should take the initiative in submitting new ideas. Acquiring even the slightest improvement suggestions from employees becomes essential. The new approach requires the development of an motivation system that takes into account the training and evaluation of employees, the verification of improvements, the definition of rules for employee teams responsible for each task. New motivation system must be adequate to the changes associated with the implementation of kaizen. It becomes essential to evaluate employees not only because of the results obtained, but you should appreciate their attitude and effort they put in to achieve results. Regardless of the stage of implementation of kaizen the main aim should be to ensure for employees the share in the benefits of their better work and more efficiently, using appropriate incentives that encourage employees to become more involved in the process of permanent change. A major role is played by the motivation of the material through the proper and fair remuneration of workers and immaterial motivation, which in many cases may be even more effective. Immaterial instruments may be to increase self-esteem and belonging, satisfaction with the work itself or participation in the success of the organization [4, 11]. The additional result of such activities in the area of management may be an increase of the knowledge and skills of employees, awareness of the requirement for improvement and problem solving using new techniques and methods. Those methods in consequence, not only allow for recognition and elimination of negative elements in the enterprise, but also develop the ability to learn from mistakes and creating favorable conditions for the implementation of innovations, exploring new opportunities. Appropriate use of these capabilities give the enterprise "*the ability to dynamically integrate, build and reconfigure internal and external competencies to be able to adapt to a rapidly changing surrounding*" [20]. Regardless of the state of preparation of participants and the conditions which induce the enterprise to make changes, kaizen is generally considered to be very cost effective and efficient.

EMPIRICAL APPROACH - THE RESULTS OF RESEARCH ON THE STATE OF READINESS OF EMPLOYEES FOR THE IMPLEMENTATION OF KAIZEN IN POLISH MANUFACTURING ENTERPRISE

In this part of the article are presented the results of research on the assessment of the attitudes of employees in the Polish enterprise, which is in the process of implemen-

poziomu zmian. W praktyce określenie standardów musi sprowadzać się do nieustannego ich podwyższania, tylko w taki sposób można dążyć do udoskonalenia stanu istniejącego, będącego rezultatem ciągłych działań kaizen. Niemniej jednak należy pamiętać, że stosowanie tej filozofii nie wyklucza wprowadzania usprawnień o charakterze innowacji radykalnych, mogą one być wspierane i utrwalane za pomocą kaizen. Takie działania wpływają zarówno na wymierne efekty ekonomiczne, jak i na zachowania pracowników, ich wiedzę, umiejętności, postawę otwartości i zaangażowania. Zatem dodatkową wartością wdrożenia kaizen jest zwiększona świadomość pracowników, co do potrzeb doskonalenia dla organizacji [7, 8]. W takim kontekście połączenie kaizen i innowacji może być bardzo racjonalne, bowiem: „kaizen rozumiany jest jako utrzymywanie i udoskonalanie standardów za pomocą małych, stopniowych kroków, a innowacje traktuje się jako radykalną zmianę związaną z dużymi inwestycjami w technologię i/lub wyposażenie" [6].

Rezultatem działań kaizen jest zazwyczaj nowa kultura organizacyjna ukierunkowana na proces usprawnień, wynikająca przede wszystkim z pozytywnego przesłania wśród pracowników. Oni powinni przejmować inicjatywę w zgłaszaniu nowych pomysłów. Istotą staje się więc pozyskiwanie propozycji najdrobniejszych nawet usprawnień od pracowników. Nowe podejście wymaga opracowania systemu motywacyjnego, który uwzględniałby program szkoleń i oceny pracowników, system weryfikacji usprawnień, określenie reguł dla zespołów pracowniczych odpowiedzialnych za realizację poszczególnych zadań. Nowy system motywacyjny musi być adekwatny do zmian związanych z wdrażaniem działań kaizen. Istotnym staje się ocenianie pracowników nie tylko ze względu na uzyskiwane przez nich wyniki, ale należy doceniać ich postawy oraz wysiłek, jaki włożyli w osiągnięcie rezultatów. Niezależnie od stopnia zaawansowania wdrażania kaizen głównym założeniem powinno być zagwarantowanie zatrudnionym udziału w korzyściach płynących z ich lepszej i wydajniejszej pracy, zastosowanie odpowiednich bodźców motywacyjnych, które skłaniałyby pracowników do większego zaangażowania się w proces permanentnych zmian. Dużą rolę odgrywa tu motywacja materialna i niematerialna. Instrumentami niematerialnymi mogą być zwiększanie poczucie własnej wartości i przynależności, satysfakcja z wykonywanej pracy czy też sam współudział w sukcesie organizacji [4, 11]. Wymiernym dodatkowym rezultatem tak podjętych działań w obszarze zarządzania może być wzrost szeroko rozumianej wiedzy i kwalifikacji pracowników, kształtowanie świadomości o potrzebie udoskonaleń dla organizacji i rozwiązywanie problemów przy wykorzystaniu nowych technik i metod, które w konsekwencji nie tylko pozwalają na eliminowanie niekorzystnych elementów w firmie, ale i na odkrywanie nowych możliwości. Właściwe ich wykorzystanie daje firmie „zdolności do dynamicznej integracji, budowy, rekonfiguracji wewnętrznych i zewnętrznych kompetencji, by móc dostosować się do szybko zmieniającego się otoczenia" [20]. Niezależnie od stopnia przygotowania uczestników i przesłanek, jakie skłaniają przedsiębiorstwa do zmian, kaizen ogólnie jest uznawane za bardzo opłacalne i skuteczne.

UJĘCIE EMPIRYCZNE – WYNIKI BADAŃ DOTYCZĄCYCH STANU PRZYGOTOWANIA PRACOWNIKÓW DO PROCESU WDRAŻANIA KAIZEN W POLSKIM ZAKŁADZIE PRODUKCYJNYM.

W tej części artykułu zostały zaprezentowane wyniki badań dotyczące oceny postaw pracowników w polskim

tation of organizational changes. The key element is to implement kaizen program in order to minimize manufacturing costs while improving productivity. The study was conducted in 2014 in the Polish manufacturing plant operating in the metal industry in Lower Silesia. The study used a questionnaire, the fulfillment of which was supervised by a competent person dealing with the issues of implementation of kaizen. The questionnaires were addressed to the production employees working on the assembly line. The enterprise selected for testing has undergone restructuring in recent years and has some experience in implementing modern management methods and tools. Changes to improve the functioning of the enterprise concerned are currently applying to Lean Management with improvement based on the philosophy of kaizen. As part of the recovery program general principles of kaizen are used, and one of the recently implemented measures is employee suggestion system named as "*I have an idea.*" The aim of the study was to analyze the level of awareness and involvement of employees in the implementation of "*I have an idea*" kaizen program. Survey was anonymous and conducted on a group of 22 people (2 women and 20 men) working at various positions in the enterprise, they were: electricians, locksmiths, logisticians, warehouse, fitters, machine operators, and one quality controller. Characteristics of the study group are presented in Tab. 2.

przedsiębiorstwie, które jest na etapie wdrażania zmian organizacyjnych. Kluczowym elementem poprawy jest zaimplementowanie programu kaizen w celu zminimalizowania kosztów wytwarzania przy jednoczesnej poprawie produktywności. Badania zostały przeprowadzone w 2014 roku w polskim zakładzie działającym w branży metalowej w województwie dolnośląskim. W badaniu wykorzystano kwestionariusz ankietowy, którego wypełnienie było nadzorowane przez kompetentną osobę zajmującą się problematyką wdrożeń z zakresu kaizen. Ankiety były adresowane do pracowników pracujących na linii montażowej. Wybrane do badania przedsiębiorstwo w ostatnich latach przeszło proces restrukturyzacji i ma pewne doświadczenie we wdrażaniu nowoczesnych metod zarządzania. Zmiany usprawniające dotyczą obecnie stosowania koncepcji Lean Management opartym na filozofii kaizen. W ramach programu naprawczego stosowane są ogólne zasady kaizen, a jednym z realizowanych w ostatnim okresie działań jest system sugestii pracowniczych określony nazwą „mam pomysł". Celem badania była analiza świadomości i poziomu zaangażowania pracowników w proces wdrażania programu kaizen „mam pomysł". Ankieta była anonimowa i przeprowadzona w grupie 22 osób (2 kobiety i 20 mężczyzn) zajmujących różne stanowiska w firmie, byli to: elektromonterzy, ślusarze, logistycy, magazynierzy, montażyści, operatorzy maszyn oraz jedna osoba będąca kontrolerem jakości. Dane grupy badawczej są zaprezentowana w tab.2.

Table 2

Characteristics of the study group

Age	No. of people	Seniority in the enterprise	No. of people	Education	No. of people
20-29	2	1-9	14	Vocational	6
30-39	12	10-19	4	Secondary	13
40-49	4	20-29	0	Higher	3
50+	4	30+	4		

RESULTS AND DISCUSSION

The study was conducted in 2014 in the Polish manufacturing enterprise. The results represent the opinion of employees on kaizen program implemented at the plant. In the opinion of the workers for the main objectives of the kaizen program were considered elements such as (Fig. 1):

- Improving performance.
- Improvement of the quality.
- Improvement of working conditions.
- Creation of a structured management system.
- Reducing costs.
- Improving employee motivation.

REZULTATY I ANALIZA

Badania zostały przeprowadzone w 2014 w polskim przedsiębiorstwie produkcyjnym. Wyniki prezentują opinię pracowników na temat oceny wdrożonego programu kaizen w zakładzie. W opinii pracowników za najważniejsze cele programu kaizen uznano takie elementy jak (rys. 1):

- Poprawa efektywności działania.
- Podniesienie jakości.
- Poprawa warunków pracy.
- Stworzenie uporządkowanego systemu zarządzania.
- Redukcja kosztów.
- Poprawa motywacji pracowników.

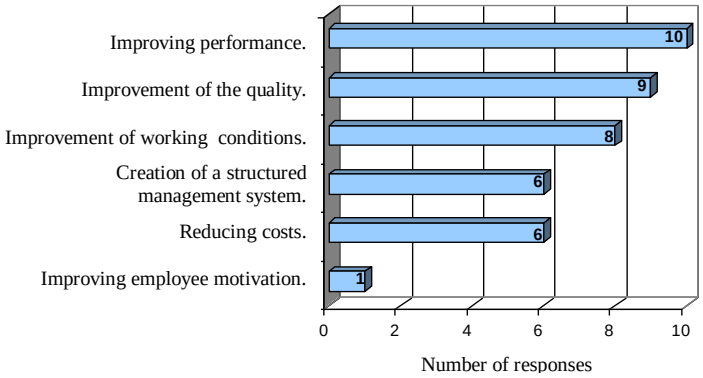

Fig. 1 - The objectives of the program's implementation in the opinion of kaizen plant employees

Improving performance of the plant is the main goal resulting from the need to implement a new philosophy; it is

Poprawa efektywności działania zakładu jest zatem głównym celem wynikającym z konieczności wdrożenia

a characteristic to the most of Polish companies. However, not all employees are properly motivated to implement process of kaizen activities. Generally, all employees are aware of the presence of organizational changes; however, only 8 respondents (36%) believe that the "*I have an idea*" program has significant impact on the functioning of the enterprise. Only 13 workers (60%) know the applicable rules and regulations of "*I have an idea*" program.

Most of workers report its improvements at least once a year, that are ideas involving not only the work they perform, but the overall operation of the enterprise. The structure of the responses is shown in Tab. 3.

nowej filozofii, jest to charakterystyczne dla większości polskich przedsiębiorstw. Jednak nie wszyscy pracownicy są odpowiednio zmotywowani do procesu wdrożenia działań z zakresu kaizen. Ogólnie wszyscy pracownicy maja świadomość występowania zmian organizacyjnych, jednak tylko 8 respondentów (36%) jest przekonanych, że program „mam pomysł" w istotny sposób wpłynie na funkcjonowanie firmy. Tylko 13 osób (60 %) zna obecnie obowiązujący regulamin dotyczący programu „mam pomysł".

Większość osób zgłasza swoje usprawnienia co najmniej raz w roku, są to pomysły, które dotyczą nie tyko wykonywanej pracy, ale i ogólnego funkcjonowania zakładu. Strukturę uzyskanych odpowiedzi prezentuje tab.3.

Table 3

Number of reported improvements during the year by the employees of the plant

Number of reported improvements in the year	None	1	2-5	6-10	More than 10
In the operation of the plant	3	15	3	0	1
In terms of work	7	9	5	0	1

Workers report their improvements because they have the opportunity to win a prize or they expect to facility in their work. Unfortunately, most employees thinks that the reward system does not meet their expectations (55% of negative responses), and waiting for a response to proposed improvements is too long, in 70% of cases it ranges from 1 to 3 months. About the implementation of the proposed improvements workers are usually informed from their supervisor or at a meeting of the staff.

In the opinion of workers implementation of the kaizen program should be transferred into specific benefits. A list and order of priority of the benefits to be achieved following the introduction of kaizen as indicated by the workers is presented in Tab. 4.

The structure of Table 4 shows that in the opinion of workers the most important benefits of the implemented program were: better organization of work, improving quality, reducing losses and wastage, saving the enterprise's financial resources; as the second in the order important benefits were indicated: the involvement of the entire staff in problem solving, improving and maintaining new standards of work, the opportunity to ask questions about new ways to solve problems.

Pracownicy zgłaszają swoje usprawnienia, bo mają możliwość zdobycia nagrody lub oczekują, że w ten sposób wprowadzone zostaną ułatwienia w wykonywanej przez nich pracy. Niestety większość pracowników uważa, że system nagród nie spełnia oczekiwań pracowników (uzyskano 55% odpowiedzi negatywnych), a oczekiwanie na odpowiedź zgłoszonego wniosku usprawnień jest zbyt długi - w 70% przypadków wynosi on od 1 do 3 miesięcy. O wdrożeniu zaproponowanego usprawnienia pracownicy dowiadują się zazwyczaj od swojego przełożonego lub na zebraniu pracowniczym.

W opinii pracowników realizacja programu kaizen powinna przełożyć się na określone korzyści. Wskazaną przez pracowników listę i hierarchię ważności korzyści, które powinny być osiągnięte po wprowadzeniu programu kaizen zaprezentowano w tab.4.

Ze struktury tabeli nr 4 wynika ze w opinii pracowników za najważniejsze korzyści wynikające z wdrożonego programu uznano: lepszą organizację pracy, poprawę jakości, ograniczenie strat i marnotrawstwa, oszczędność zasobów finansowych firmy; jako drugie w kolejności ważne korzyści wskazano: zaangażowanie całej załogi w rozwiązywanie problemów, poprawa i utrzymanie nowych standardów pracy, możliwość zadawania pytań dotyczących nowych sposobów rozwiązywania problemów.

Table 4

The validity of the various benefits of kaizen program implemented by the number of employees indicated.

Advantage:	Very important	Important	Not important
Reduce losses and waste	11	11	0
Better organization of work	12	8	2
The involvement of the whole staff in troubleshooting	3	18	1
Changing the awareness of employees	6	12	4
Opportunity to ask questions	1	18	3
Better communication among workers	7	13	2
Improving the quality of	12	10	0
Improvement and maintenance of the new labor standards	4	18	0
Saving the enterprise's financial resources	10	10	2
Shorter lead-times	9	13	0

The survey also asked to identify the barriers that exist in the implementation of kaizen program. The responses received in the form of a hierarchy of importance for individual barriers shows Table 5.

W badaniu proszono również o określenie barier, jakie występują w procesie wdrażania programu kaizen. Otrzymane odpowiedzi w postaci hierarchii ważności dla poszczególnych barier przedstawiono w tabeli 5.

Table 5

The importance of different barriers that exist in the implementation of the program by the number of indications kaizen employees.

Barrier:	Very important	Important	Less important	Not important	No opinion
Too high expectations of employees	1	7	2	11	1
Strained relations between employees	1	7	0	10	2
Competition for ideas	1	2	2	15	2
Inadequate reward for ideas submitted	2	5	1	12	2
Mutual criticism of ideas	3	12	4	2	1
General reluctance of workers to change	4	15	1	0	2
Fear of difficulties and additional responsibilities	3	8	2	8	1
Bureaucracy	11	3	3	2	3
Lack of time on implementation	10	8	2	0	2
The high cost of new system requirements	2	9	3	4	4

The employees recognized bureaucracy and lack of time for implementation for very important barriers, for the second in order of importance were listed barriers of: the general reluctance of workers to change and concerns about the mutual criticism of ideas.

In order to reduce barriers, resistance and reluctance towards the implementation of the "*I have an idea*" employees detailed the activities that they believe could assist in the process of innovative change in the plant (the order is given by the number of responses), they are:

- Regular rewarding of employees for reporting ideas (64%).
- Systematic training for employees (33%).
- Support from the kaizen team advisors (1%).
- Support from top management (1%).
- Support from co-workers (1%).

The worst assessed by the employees area was training, half of surveyed workers do not understand the reason for change and do not have complete information on the planned kaizen activities. Among the respondents there were only 7 employees trained (31%), although workers themselves recognize the systematic training of employees as a very important factor facilitating the implementation of the kaizen (was listed as the second most important factor to minimize resistance and a reluctance of employees).

It is worrying that in surveyed enterprise none of the respondents were involved in the work of the kaizen team. For the question: "*Are you a member of the »I have an idea« kaizen team?*" nobody gave affirmative answer. Unfortunately, in the enterprise direct production workers are not involved in team. This is a serious fault of the management. Numerous publications emphasize that teamwork and group problem solving have great importance for achieving positive results in the implementation of any organizational changes. Teams of employees increased ease in the implementation of innovation through the creating the opportunity to learn new solutions, the use of integrated knowledge or information exchange. Unfortunately, this has not been taken into account by the enterprise and created a real threat that in the long term kaizen would not fulfill its role.

The final evaluation of workers indicates that the *"I have an idea"* kaizen program has been assessed generally positive, the results are presented in Fig. 2.

Za bardzo ważną barierę pracownicy uznali biurokrację oraz brak czasu na działania wdrożeniowe, za drugie w kolejności ważne bariery wymieniono: ogólną niechęć pracowników do zmian i obawy związane z wzajemną krytyką pomysłów. W celu zmniejszania barier, a także oporu i niechęci wobec wdrażania programu „mam pomysł" pracownicy wyszczególnili działania, które mogłyby w ich opinii wspomagać proces zmian innowacyjnych w zakładzie (kolejność podana jest według ilości uzyskanych odpowiedzi), są to:

- Systematyczne nagradzanie pracowników za zgłaszanie pomysłów (64%).
- Systematyczne szkolenia dla pracowników (33%).
- Wsparcie ze strony doradców z zespołu kaizen (1%).
- Wsparcie ze strony naczelnego kierownictwa (1%).
- Wsparcie ze strony współpracowników (1%).

Najgorzej oceniony przez pracowników obszar dotyczył szkoleń, połowa z badanych osób nie rozumie do końca przesłanek wprowadzenia zmian i nie mają pełnej informacji na temat zaplanowanych w zakładzie działań kaizen. Wśród respondentów znalazło się tylko 7 przeszkolonych osób (31%), chociaż sami pracownicy uznali systematyczne szkolenia za bardzo ważny czynnik ułatwiający wdrożenie programu kaizen (był on wymieniany jako drugi ważny czynnik minimalizujący opór i niechęć ze strony pracowników).

Niepokoi fakt, że w badanym zakładzie nikt z respondentów nie jest zaangażowany w pracę zespołu kaizen. Na pytanie: „Czy jest Pan/Pani członkiem powołanego w zakładzie zespołu kaizen "mam pomysł"? nikt nie udzielił twierdzącej odpowiedzi. Niestety w zakładzie nie są angażowane w tym obszarze osoby bezpośrednio związane z produkcją. Jest to poważny błąd ze strony kierownictwa. W wielu publikacjach podkreśla się, że praca zespołowa, grupowe rozwiązywanie problemów ma ogromne znaczenie dla osiągnięcia pozytywnych rezultatów w procesie wdrażania wszelkich zmian organizacyjnych. Zespoły pracownicze zwiększają łatwość we wdrażaniu innowacji poprzez stwarzaną możliwość nauki nowych rozwiązań, wykorzystanie zintegrowanej wiedzy czy też wymianę informacji. Niestety nie zostało to uwzględnione przez kierownictwo zakładu i stwarza to realne zagrożenie, że w długim okresie czasu kaizen nie będzie spełniał swej roli.

Ostateczna ocena w opinii pracowników wskazuje, że programu kaizen „mam pomysł" został oceniony raczej pozytywnie, wyniki zostały zaprezentowane na rys. 2.

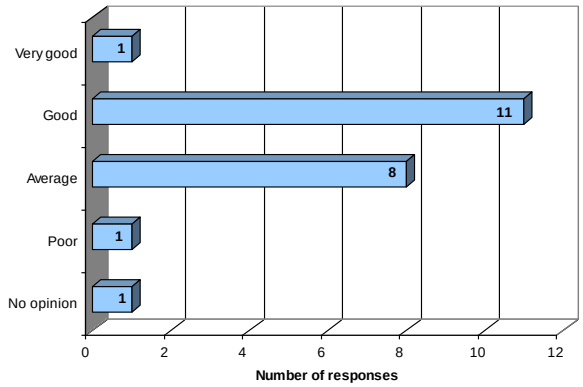

Fig. 2 - Evaluation of the implementation of the kaizen program in the opinion of employees

The results, however, are not a complete success, in the study appeared a number of negative opinions, and this means that the enterprise's management has yet to work out a strategy of change. There are basic faults in the implementation of the kaizen philosophy and not all employees understand the essence of the new approach and are not prepared to create improvements for the needs of the surveyed enterprise.

CONCULSIONS

Based on the survey some basic irregularities and faults which may occur in the process of implementing the philosophy of kaizen in Polish enterprises can be pointed out. Among them the most common causes of failures include: lack of training, ignorance and wrong approach of employees, lack of commitment, lack of teamwork in delivering results, too high or too poorly defined expectations of management. Improvement actions require a fundamental change in the functioning of the entire enterprise, especially for training in order to improve the skills and knowledge among employees and for appropriate communication. Effective implementation should be combined with an indication of the best ideas (publicizing and rewarding), and measurable results will be the basis for further action here. The employees are specifically required to have a broad knowledge of the variety of tasks and functions in enterprise and were able at any time to meet the demands of the changing situation.

Generally, the faster the enterprise has reached a sufficient level of employee involvement in the process of continuous improvement, the more effectively employees would realize it. The philosophy of kaizen is an appropriate way to increase innovation of enterprises and achieve their long-term competitiveness.

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Rezultat nie jest jednak pełnym sukcesem, w badaniu pojawiło się szereg opinii negatywnych, a to oznacza, że w zakładzie kadra kierownicza musi jeszcze dopracować strategię wprowadzania zmian. Występują podstawowe błędy w procesie wdrażania filozofii kaizen i nie wszyscy pracownicy rozumieją istotę założeń nowego podejścia i nie są przygotowani do kreowania usprawnień dla potrzeb badanego przedsiębiorstwa.

ZAKOŃCZENIE

Na podstawie przeprowadzonych badań można wskazać na nieprawidłowości i błędy jakie mogą wystąpić w procesie wdrażania filozofii kaizen w polskich przedsiębiorstwach. Wśród najczęstszych przyczyn niepowodzeń wymienia się brak szkoleń z tego zakresu, nieświadomość i niewłaściwe podejście pracowników, brak zaangażowania, brak wspólnej pracy zespołowej w osiąganiu wyników czy zbyt wysokie lub też słabo sprecyzowane oczekiwania ze strony kadry kierowniczej. Działania usprawniające wymagają gruntownej zmiany sposobu funkcjonowania całego przedsiębiorstwa, szczególnie w zakresie szkoleń w celu podniesienia kompetencji i wiedzy wśród pracowników oraz odpowiedniej komunikacji. Skuteczne wdrożenie powinno łączyć się ze wskazaniem najlepszych pomysłów (nagłaśnianie i nagradzanie). W stosunku do pracowników szczególnie wymaga się, aby mieli oni szeroką wiedzę w zakresie realizowanych w przedsiębiorstwie zadań i mogli w każdej chwili sprostać wymaganiom zmieniającej się sytuacji.

Generalnie, im szybciej przedsiębiorstwo osiągnie odpowiedni poziom zaangażowania pracowników w proces ciągłego doskonalenia, tym skutecznej będą oni realizowali poczynione ustalenia. Filozofia kaizen jest odpowiednią drogą do zwiększania innowacyjności przedsiębiorstw i osiągania przez nie długofalowej konkurencyjności.

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APPLYING CRITICAL PATH METHOD (CPM) IN PLANNING OF TRACTOR ENGINES REPAIRING
/
APLICAREA METODEI DRUMULUI CRITIC (MDC) ÎN PLANIFICAREA REPARĂRII MOTOARELOR DE TRACTOR

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Abstract: *In the manufacturing technological processes or repair of installations and equipment from any field of activity there are operations with defining character which require proper planning in time.*
Management of repair processes activities of tractors and agricultural machines can be treated as a conducting process of the ensemble of characteristic activities, which are used for planning in time of them, aiming how resources are consumed over time.
The paper presents the technological process of repairing some low-power tractor engines, with the main characteristic activities, the ordering in time and the manner of managing them, by applying the critical path method (CPM). It were determined the activities duration, the starting and ending times, time margins and reserves calculated on the basis of mathematical model characteristic of the method, the activities graph and the time grading, so that there are no major risks in the running process. The data presented in this paper can be of real use for the specialists in this field dealing with the time planning problem of such activities, in order to detect and prevent possible risks in conducting the events.

Keywords: *engines, corrective maintenance, critical path, planning, minimal time, maximum time, parts resurce*

Rezumat: *În procesele tehnologice de fabricație sau de reparare a instalațiilor şi echipamentelor din orice domeniu de activitate există operații cu caracter definitioriu care necesită planificarea corespunzătoare în timp.*
Managementul activităților proceselor de reparare a tractoarelor şi maşinilor agricole poate fi tratat ca un proces de dirijare a ansamblului de activități caracteristice, care sunt utilizate pentru planificarea în timp a acestora, urmărind modul cum sunt consumate în timp resursele.
În lucrare se prezintă procesul tehnologic de reparare a unor motoare de tractor de putere mică, cu activitățile principale caracteristice, ordonarea în timp şi modul de dirijare a acestora, aplicând metoda drumului critic (MDC). Au fost determinate duratele activităților, timpii de început şi sfârşit, marjele şi rezervele de timp calculate pe baza modelului matematic caracteristic metodei, graful activităților şi eşalonarea în timp, astfel încât să nu existe riscuri majore în derularea procesului. Datele prezentate în lucrare pot fi de un real folos specialiştilor în domeniu care abordează problema planificării în timp a unor astfel de activități, pentru a depista şi preveni eventualele riscuri în derularea evenimentelor.

Cuvinte cheie: *motoare, mentenanță corectivă, drum critic, planificare, timp minim, timp maxim, resursa piesei*

INTRODUCTION

Graphs are used in management projects as a help in the planning of complex technological processes which consist of several activities. If the duration of each activity is known, the Critical Path Method (CPM) can be used to determine the duration needed to achieve the process. CPM can also be used in determining the duration wherewith each activity can be delayed without delay achievement of the process.

The Critical Path Method calculates deterministic values for the minimum and maximum starting period and for the minimum and maximum ending period for each activity, taking into account the logic of network activities.

The process is modeled using a graph and allows pursuing the fulfilment of final term planned of the process as well as the intermediate terms.

From the managerial point of view through complex process is meant the process with a well-defined objective for whose achievement is developing a lot of activities that consume resources, time and which are made by many executants, [1,13,14].

Managers control the conducting process so that it is carried out in an optimum period of time, with an optimal resource consumption and ensuring the correlation of the process with other objectives beyond.

The Critical Path Method can be used in planning a wide range of processes that are time-dependent, such as technological processes for mechanical engineering or from other important branches of industry. Thus, the technological processes of maintenance and service can be very well planned by this method.

INTRODUCERE

Grafurile sunt utilizate în proiectele de management ca ajutor în planificarea proceselor tehnologice complexe care constau din mai multe activități. Dacă durata fiecărei activități se cunoaşte, metoda drumului critic (MDC) se poate utiliza la determinarea duratei necesare realizării procesului. MDC se poate utiliza şi la determinarea duratei cu care fiecare activitate poate fi întârziată fără a se întârzia realizarea procesului.

Metoda drumului critic calculează valori deterministe pentru termenul minim de începere, termenul maxim de începere, termenul minim de terminare şi termenul maxim de terminare pentru fiecare activitate, ținând seama de logica rețelei de activități.

Procesul se modelează prin intermediul unui graf şi permite urmărirea îndeplinirii termenului final planificat al procesului, precum şi a termenelor intermediare.

Din punct de vedere managerial prin proces complex se înțelege procesul cu un obiectiv bine definit pentru a cărui realizare se dezvoltă o mulțime de activități care consumă resurse, timp şi care sunt realizate de o mulțime de executanți, [1,13,14].

Managerii controlează desfăşurarea procesului astfel încât acesta să fie realizat într-o durată optimă, cu un consum optim de resurse şi cu asigurarea corelării procesului cu alte obiective din afara acestuia.

Metoda drumului critic poate fi utilizată în planificarea unei game largi de procese care sunt dependente de timp, aşa cum sunt procesele tehnologice de inginerie mecanică sau din alte ramuri importante ale industriei. Astfel, procesele tehnologice de mentenanță şi

However, it should be known the duration for achieving activities that form the technological process, in order to determine the critical activities whose term unrealized might disturb the whole process, [1,6].

The method has been used by Rana and Purohit [9] for reducing the maintenance time and increasing productivity through properly allocating the maintenance activities of vehicles in a auto service station. Based on CPM was calculated the optimum maintenance time, and this is used in the allocation of tasks inside this optimum time for maintenance.

Ming and Heng [8] approaches the problem of long-term programming by taking into account the resources and availability in CPM, proposing an improved method called resource-activity critical path method (RACPM). In this new development, the resource dimension is taken into account in addition to any other activities and its length in the planning of any construction. RACPM is applied to several kinds of resources (teams of specialists or workers with different skills or different types of equipment, as well as material resources, such as disposable resources) who participate in the activities once.

Optimizing the project construction programming by various methods and algorithms, including CPM, is also presented in the paper [15], which can be classified into three categories: mathematics, heuristics and metaheuristics. For implementing CPM is essential the creation of a model project that involves the following elements: a list of all the activities, the length of each activity and the priority relationship between activities [15].

The problem of organizing the repairs in specialized units has been approached in several scientific papers, [3,4,5].

By the method for organizing the repairs is meant a rational way of ordering and selection processes and technological areas, of equipments and working regime, of the workers qualification and establishing the working rules, in order to restore the functional capacity of machinery and equipment which are to be repaired. Depending on their complexity, can be applied one of the following methods: universal brigades, specialized teams, specialized workstations, industrial repair method and the aggregates replacement method.

Each of these methods has its own specific.

MATERIAL AND METHOD

In the CPM, an event is characterized by two terms, [1,7,13,14]:

- ✓ t_i^0 – the minimum term at which the event is reached achieved;
- ✓ t_i^1 – the maximum term at which the event is achieved;

For the calculation of the minimum term t_j^0 the graph is passing from left to right provided that the the minimum term of the initial event to be zero ($t_i^0 = 0$), after that it goes from node to node, of nearby, respecting the following condition:

$$t_j^0 = \max_i (t_i^0 + d_{i,j}), \text{ unde } i > j \; ; \qquad 1 < j \le m$$

where: I is the event code which marks the beginning of the activity (i–j); j - the event code which marks the end of the activity A or (i–j); A or (i–j) – activity; $d_{i,j}$ –activity length (i–j); m – number of events for technological process.

For the calculation of the maximum term t_i^1 the graph is passing from right to left, provided that the the minimum term of the final node to be equal to the maximum term of the final node ($t_m^1 = t_m^0$), going from node to node, of nearby respecting the following condition:

service pot fi foarte bine planificate prin aceasta metodă. Trebuie cunoscute, însă, duratele de realizare a activităților care alcătuiesc procesul tehnologic, astfel încât să se determine activitățile critice a căror nerealizare la termen ar putea deregla întregul proces, [1,6].

Metoda a fost utilizată de Rana şi Purohit în [9] pentru reducerea timpului de întreținere şi mărire a productivității prin alocarea în mod corespunzător a activităților de întreținere a vehiculelor într-o stație service auto. Pe baza MDC a fost calculat timpul optim de întreținere, iar acesta este folosit în alocarea sarcinilor în interiorul (cadrul) acestui timp optim de întreținere.

Ming şi Heng [8] abordează problema programării pe termen lung cu luarea în considerare a resurselor şi a disponibilității în CPM, propunând o metodă îmbunătățită denumită metoda drumului critic prin activități resursă (MDCAR). În această nouă dezvoltare dimensiunea resurselor este luată în considerare în plus față de orice activitate şi durata acesteia în planificarea unei construcții. RACPM se aplică mai multor tipuri de resurse (echipe de specialişti sau muncitori cu abilități diferite sau diferite tipuri de echipamente, precum şi resurse materiale, cum sunt resursele de unică folosință) care participă în cadrul activităților o singură dată.

Optimizarea programării proiectelor de construcții prin diverse metode şi algoritmi, printre care şi CPM, este prezentată şi în lucrarea [15], ce pot fi clasificate în trei categorii: matematice, euristice şi metaheuristice. Esențial pentru punerea în aplicare MDC este construirea unui model al proiectului care implică următoarele elemente: o listă a tuturor activităților, durata fiecărei activități şi relația de prioritate dintre activități, [15].

Problema organizării reparațiilor în unitățile de profil a fost abordată în mai multe lucrări ştiințifice, [3,4,5].

Prin metodă de organizare a reparațiilor se înțelege modul rațional de ordonare şi alegere a procedeelor şi spațiilor tehnologice, a utilajelor şi regimului de lucru, a calificării muncitorilor şi stabilirea normelor de lucru, în vederea refacerii capacității funcționale a maşinilor şi echipamentelor care urmează a fi reparate. În funcție de complexitatea acestora, se poate aplica una din următoarele metode: brigăzi universale, echipe specializate, posturi de lucru specializate, metoda industrială de reparații şi metoda agregatelor de schimb. Fiecare din aceste metode are un specific propriu.

MATERIAL ŞI METODĂ

În MDC, un eveniment este caracterizat prin două termene, [1,7,13,14]:

- ✓ t_i^0 – termenul minim la care evenimentul este atins;
- ✓ t_i^1 – termenul maxim la care evenimentul este realizat.

Pentru calculul termenului minim t_j^0 se parcurge graful de la stânga la dreapta, punând condiția ca termenul minim al evenimentului inițial să fie zero ($t_i^0 = 0$), după care se merge din nod în nod, din aproape în aproape, respectând următoarea condiție:

unde: i este codul evenimentului care marchează începutul activității (i–j); j – codul evenimentului care marchează sfârşitul activității A sau (i–j); A sau (i–j) – activitatea; $d_{i,j}$ – durata activității (i–j); m – numărul evenimentelor procesului tehnologic.

Pentru calculul termenului maxim t_i^1 se parcurge graful de la dreapta la stânga, punându-se condiția ca termenul minim al nodului final să fie egal cu termenul maxim al nodului final ($t_m^1 = t_m^0$), mergând din nod în nod, din aproape în aproape respectând următoarea condiție:

$$t_i^1 = \min_j (t_j^1 - d_{i,j}), \text{ unde } i < j \; ; \qquad 0 < i \le n$$

n being the number of operations of the technological process. Activities are defined by four terms:

$t_{i,j}^{0,s}$ - the earlier start term of the activity;

$t_{i,j}^{0,e}$ - the earlier end term of the activity;

$t_{i,j}^{1,s}$ - the later start term of the activity;

$t_{i,j}^{1,e}$ - the later end term of the activity.

There are the following relationships between activities and events:

$$t_{i,j}^{0,s} = t_i^0 \; ; \qquad t_{i,j}^{0,e} = t_i^0 + d_{i,j} \; ;$$

Is defined the total reserve of time ($R_{Ti,j}$) as being:

n fiind numărul de operații ale procesului tehnologic.

Activitățile sunt definite prin patru termene:

$t_{i,j}^{0,s}$ - termenul cel mai devreme de început al activității;

$t_{i,j}^{0,e}$ - termenul cel mai devreme de sfârşit al activității;

$t_{i,j}^{1,s}$ - termenul cel mai târziu de început al activității;

$t_{i,j}^{1,e}$ - termenul cel mai târziu de sfârşit al activității.

Există următoarele relații între activități şi evenimente:

$$t_{i,j}^{1,s} = t_j^1 - d_{i,j} \; ; \qquad t_{i,j}^{1,e} = t_j^1$$

Se defineşte rezerva totală de timp ($R_{Ti,j}$) ca fiind:

$$R_{T\,i,j} = t_j^1 - t_i^0 - d_{i,j}$$

the events margins can be calculated with relations:

$$M_i = t_i^1 - t_i^0 \; ;$$

iar marjele evenimentelor pot fi calculate cu relațiile:

$$M_j = t_j^1 - t_j^0$$

Engines repairing in dedicated workshops requires the following operations: reception and general observation, storage in the cold park, partial demounting in subassemblies, coarse prewash, washing and degreasing, drying, checking - observation – sorting, reconditioning the engine block, axle reconditioning, cylinder head reconditioning, flywheel reconditioning, general assembly, motor running, dyeing, delivery.

In order to apply critical path method for planning the repair activities, was developed the succession and coordination chart of operations from the workshop repairing small-medium power engines which is shown in Table 1, for the D-115 engine.

Repararea motoarelor în ateliere specializate necesită următoarele operații: primire şi constatare generală, depozitare în parcul rece, demontare parțială în subansambluri, prespălare grosieră, spălare şi degresare, uscare, verificare – constatare – triere, recondiționare bloc motor, recondiționare arbori, recondiționare chiulasă, recondiționare volant, montaj general, rodaj motor, vopsire, predare.

În vederea aplicării metodei drumului critic pentru planificarea activităților de reparație a fost elaborat graficul de succesiune şi coordonare a operațiilor din atelierul de reparat motoare de putere mică–medie care este prezentat în tabelul 1, pentru motorul D-115.

Table 1

Activities and events list that compose the repair process of D-115 engine

Nr. crt.	Activity code i	Activity code j	Activity name	Length (hour·person/ore·om)
1	0	1	Engine receiving, observation, receipt documentation preparation	0.5
2	1	2	Exterior wash, partial demounting, inside wash	2.44
3	2	3	Demounting in subassemblies and pieces	4.29
4	3	4	Degreasing, rinsing and drying the demounted parts	3.6
5	4	5	Observation, sorting, completing with new pieces	2
6	5	6	Launching the repair process	1
7	6	7	Checking and restoration the cylinder block	8.7
8	6	8	Crankshaft reconditioning	3.5
9	6	9	Reconditioning and installation of flywheel	1.1
10	6	10	Repairing and assembling the tiller – piston sub-assemblies	1
11	6	11	Repairing, assembly, oil pump and filter checking	1
12	6	12	Cylinder head reconditioning and assembly	2.35
13	6	13	Repairing and installation of water pump and fan	0,75
14	6	14	Cutting processing	4
15	6	15	Metallization	1.5
16	6	16	Welding operations	3,5
17	7	17	Engine general assembly	8,69
18	17	18	Engine running	4
19	18	19	Engine degreasing and dyeing	1
20	19	20	Storage and delivery	0,3

The deadlines events, time margins, start and end periods of activity, as well as their time reserves were calculated based on the above relationships. These are shown in Table 2.

Termenele evenimentelor, marjele de timp, termenele de început şi sfârşit de activitate, precum şi rezervele de timp ale acestora au fost calculate pe baza relațiilor prezentate anterior. Acestea sunt prezentate în tabelul 2.

It is found that the critical path is given by the activity 6-7, which imposes restrictions in the conducting process by activities that have as a starting point the 6th event (activities 6-8 up to 6-16), as well as those which have as

Se constată că drumul critic este dat de activitatea 6-7, care impune restricții în desfăşurarea procesului prin activitățile care au ca punct de plecare evenimentul 6 (activitățile 6-8, până la 6-16), precum şi a celor care au

ending point the 7 event (activities from 8 - 7 up to 16-7), these having the default duration zero.

The network graph of critical path is shown in Fig. 1, on this being specified also the activities lengths, as well as the minimum term of activities start (left box) and the maximum term of activities end (right box).

The resource of a part is available time for which the wear reaches a limit value above which it can no longer function normally.

ca punct de finalizare evenimentul 7 (activităţile de la 8-7 până la 16-7), acestea având durata implicită zero.

Graful reţea al drumului critic este prezentat în fig.1, pe acesta fiind specificate şi duratele activităţilor, precum şi termenul minim de începere a activităţilor (căsuţa din stânga) şi termenul maxim de terminare a acestora (căsuţa din dreapta).

Resursa unei piese reprezintă timpul disponibil al acesteia pentru care uzarea ajunge la o valoare limităpeste care ea nu mai poate funcţiona normal.

Table 2

Values of characteristics events and activities for the technological process for engines repairing

	Activity code		Activity length $d_{i,j}$ (hours)	Events terms				Event range		Activities terms				Activity reserve	
No.	i	j		t_i^0	t_j^0	t_i^1	t_j^1	M_i	M_j	$t_{i,j}^{0,s}=t_i^0$	$t_{i,j}^{0,e}=t_i^0+d_{i,j}$	$t_{i,j}^{1,s}=t_j^1-d_{i,j}$	$t_{i,j}^{1,e}=t_j^1$	$R_{ti,j}$	$R_{li,j}$
1	0	1	0.5	0	0.5	0	0.5	0	0	0	0.5	0	0.5	0	0
2	1	2	2.44	0.5	2.94	0.5	2.94	0	0	0.5	2.94	0.5	2.94	0	0
3	2	3	4.29	2.94	7.23	2.94	7.23	0	0	2.94	7.23	2.94	7.23	0	0
4	3	4	3.6	7.23	10.83	7.23	10.83	0	0	7.23	10.83	7.23	10.83	0	0
5	4	5	2	10.83	12.83	10.83	12.83	0	0	10.83	12.83	10.83	12.83	0	0
6	5	6	1	12.83	13.83	12.83	13.83	0	0	12.83	13.83	12.83	13.83	0	0
7	6	7	8.7	13.83	22.53	13.83	22.53	0	0	13.83	22.53	13.83	22.53	0	0
8	6	8	3.5	13.83	17.33	13.83	22.53	0	5.2	13.83	17.33	19.03	22.53	5.2	0
9	6	9	1.1	13.83	14.93	13.83	22.53	0	7.6	13.83	14.93	21.43	22.53	7.6	0
10	6	10	1	13.83	14.83	13.83	22.53	0	7.7	13.83	14.83	21.53	22.53	7.7	0
11	6	11	1	13.83	14.83	13.83	22.53	0	7.7	13.83	14.83	21.53	22.53	7.7	0
12	6	12	2.35	13.83	16.18	13.83	22.53	0	6.35	13.83	16.18	20.18	22.53	6.35	0
13	6	13	0.75	13.83	14.58	13.83	22.53	0	7.95	13.83	14.58	21.78	22.53	7.95	0
14	6	14	4	13.83	17.83	13.83	22.53	0	4.7	13.83	17.83	18.53	22.53	4.7	0
15	6	15	1.5	13.83	15.33	13.83	22.53	0	7.2	13.83	15.33	21.03	22.53	7.2	0
16	6	16	3.5	13.83	17.33	13.83	22.53	0	5.2	13.83	17.33	19.03	22.53	5.2	0
17	8	7	0	17.33	22.53	22.53	22.53	5.2	0	17.33	17.33	22.53	22.53	-	-
18	9	7	0	14.93	22.53	22.53	22.53	7.6	0	14.93	14.93	22.53	22.53	-	-
19	10	7	0	14.83	22.53	22.53	22.53	7.7	0	14.83	14.83	22.53	22.53	-	-
20	11	7	0	14.83	22.53	22.53	22.53	7.7	0	14.83	14.83	22.53	22.53	-	-
21	12	7	0	16.18	22.53	22.53	22.53	6.35	0	16.18	16.18	22.53	22.53	-	-
22	13	7	0	14.58	22.53	22.53	22.53	7.95	0	14.58	14.58	22.53	22.53	-	-
23	14	7	0	17.83	22.53	22.53	22.53	4.7	0	17.83	17.83	22.53	22.53	-	-
24	15	7	0	15.33	22.53	22.53	22.53	7.2	0	15.33	15.33	22.53	22.53	-	-
25	16	7	0	17.33	22.53	22.53	22.53	5.2	0	17.33	17.33	22.53	22.53	-	-
26	7	17	8.69	22.53	31.22	22.53	31.22	0	0	22.53	31.22	22.53	31.22	0	0
27	17	18	4	31.22	35.22	31.22	35.22	0	0	31.22	35.22	31.22	35.22	0	0
28	18	19	1	35.22	36.22	35.22	36.22	0	0	35.22	36.22	35.22	36.22	0	0
29	19	20	0.3	36.22	36.52	36.22	36.52	0	0	36.22	36.52	36.22	36.52	0	0

Based on the data presented in Table 2 was prepared the events and activities scheduling in time, these being shown in Fig. 2.

Pe baza datelor prezentate în tabelul 2 a fost elaborată eşalonarea în timp a evenimentelor şi activităţilor, acestea fiind prezentate în fig. 2.

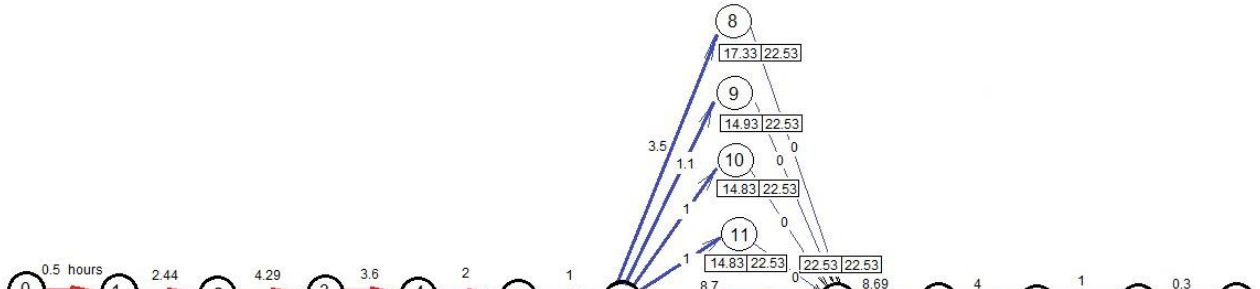

Fig. 1. Critical path network graph at the engine repair workshop/Graful rețea drum critic la atelierul de reparații motoare

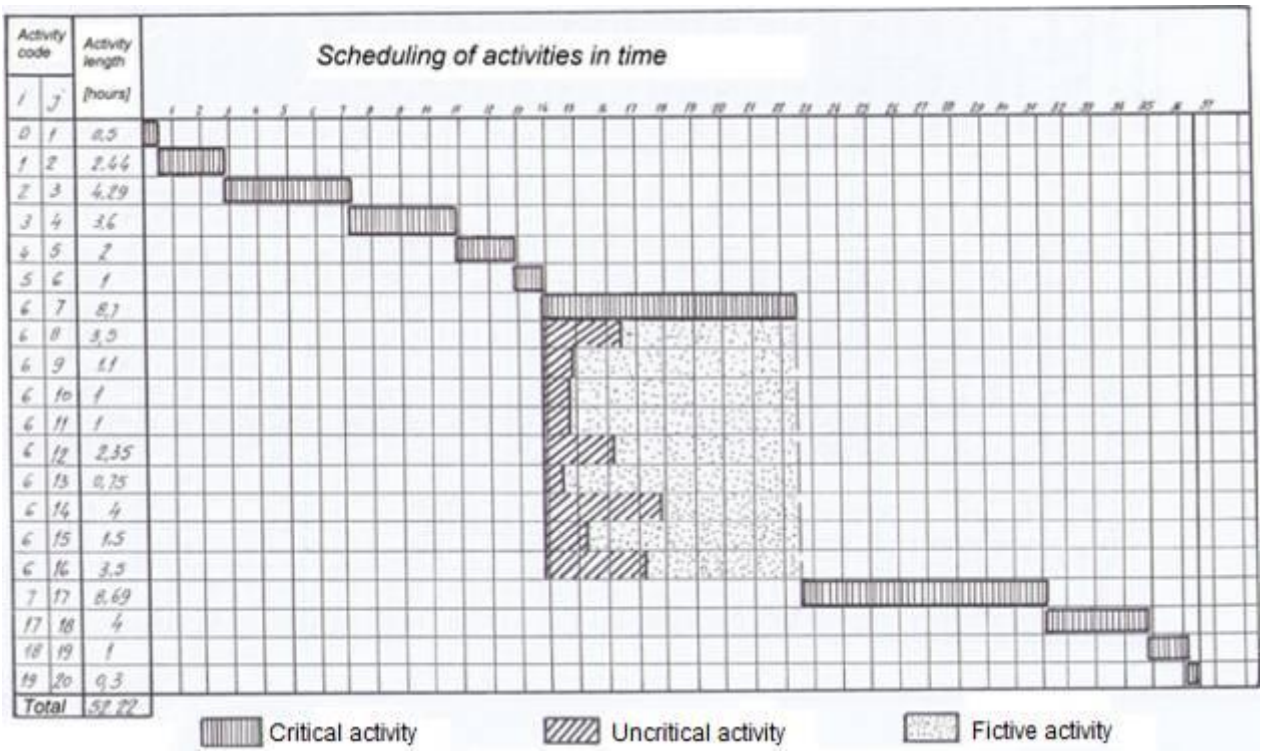

Fig. 2. Resource-activity critical-path method (RACPM) schedule highlighting resources, time and activity

CONCLUSIONS

Critical Path Method is a time planning method of a project activities or of a technological process so that to avoid risks arising from the improper scheduling of events.

For repairing engines of small and medium power tractors, the critical activity in repair planning in a specialized workshop is given by checking and reconditioning of cylinder block because this subassembly is one which will be assemble and mount the remaining pieces and engine subassemblies. When planning events has not been taken into account the assembly and mounting of the injection pump which although is a basic subassembly of engine can follow another technological path.

For the D-115 romanian engine, the activities of technological process of repair, the activities lengths, the time margins and the reserves events can have values presented in this paper, technical norming of work being

CONCLUZII

Metoda drumului critic este o metodă de planificare în timp a activităților unui proiect sau ale unui proces tehnologic astfel încât să fie evitate riscurile apărute din eşalonarea necorespunzătoare a evenimentelor.

Pentru repararea motoarelor tractoarelor de putere mică şi medie, activitatea critică în planificarea reparației într-un atelier specializat este dată de verificarea şi recondiționarea blocului cilindrilor, deoarece acest subansamblu este cel pe care se vor asambla şi monta restul pieselor şi subansamblurilor motorului. În planificarea evenimentelor nu s-a ținut seama de asamblarea şi montarea pompei de injecție care, deşi este un subansamblu de bază al motorului, poate urma un alt traseu tehnologic.

Pentru motorul românesc D-115, activitățile procesului tehnologic de reparație, duratele activităților, marjele de timp şi rezervele evenimentelor pot avea valorile

taken after existing standards in older workshops for enginer repairing, [2,10,11,12].

If some events change their terms or are excluded from the technological process, then the critical path of planning activities changes accordingly.

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prezentate în această lucrare, normarea tehnică a lucrărilor fiind preluată după normativele existente în atelierele mai vechi de reparat motoare, [2,10,11,12].

Dacă unele evenimente îşi modifică termenele sau sunt excluse din procesul tehnologc, atunci drumul critic al planificării activităților se modifică corespunzător.

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EVALUATION OF THE DEGREE OF SOIL COMPACTION BY PENETROMETER TESTS
/
EVALUAREA GRADULUI DE COMPACTARE A SOLULUI PRIN TESTE DE PENETROMETRIE

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Abstract: *Penetration resistance is a valuable and easily determined indicator of the degree of compaction of agricultural soils. In this paper are presented the results of some experimental research on penetration resistance of three types of soil, at different moistures and having different agricultural destinations, in order to assess, from an qualitative point of view, their degree of compaction.*

Keywords: *agricultural soil, compaction, penetration resistance*

INTRODUCTION

Worldwide, soil compaction became a subject of great concern, being recognized as one of the major problems facing modern agriculture.

Compaction is one of the most dangerous forms of degradation of agricultural soil, that alters soil structure, reduces water and air infiltration in the soil, increases the risk of surface runoff and flood, and also increases soil strenght and limits root penetration in the soil, thus leading to yield reduction of most agricultural crops.

Penetration resistance and bulk density are the most common measures of the degree of soil compaction [3, 5, 6, 8, 11]. Penetrometry, or soil strength, measures the resistance opposed by the surface of soil to a vertical force produced by pushing a rod or a penetrometer into the soil [6]. Measurement of the mechanical resistance of soil by the penetrometer test is known as a conventional method for estimating the level of soil compaction.

Penetration resistance has a dynamic nature, varies spatially and temporally and is influenced by soil properties, such as: moisture, bulk density, compressibility, texture and the content of organic matter [4, 12]. Soil resistance is highly influenced by its moisture and varies significantly during a year, with each wetting-drying cycle [11]. Usually, soil resistance increases with the increase of bulk density and the decrease of soil moisture [4, 11], with the exception of low compacted soils, whose resistance decreases as the soil dries [4]. The increase of clay content of soil leads to the decrease of soil resistance as the soil dries up to the point of wilting. By increasing the content of organic matter, soil penetration resistance increases, especially if the bulk density of soil has high values [4].

Surfaces of soil with high mechanical resistance may occur naturally, by artificial compaction produced by agricultural vehicles, or by the formation of thick layers under the plowpan. In compacted soils, high mechanical resistance reduces the development of roots and limits the absorbtion of water and nutrients by the plants. Thus,

Rezumat: *Rezistenţa la penetrare este un indicator valoros şi uşor de determinat al gradului de compactare al solurilor agricole. În lucrare sunt prezentate rezultatele unor cercetări experimentale privind rezistenţa la penetrare a trei tipuri de sol, aflate la diferite umidităţi şi având diferite destinaţii agricole, în vederea estimării, din punct de vedere calitativ, a gradului de compactare al acestora.*

Cuvinte cheie: *sol agricol, compactare, rezistenţă la penetrare*

INTRODUCERE

La nivel mondial, compactarea solului a devenit un subiect de mare interes, fiind recunoscută ca una dintre problemele majore cu care se confruntă agricultura modernă.

Compactarea este una dintre cele mai periculoase forme de degradare a solului agricol, care alterează structura solului, reduce infiltrarea apei şi a aerului în sol, creşte riscul scurgerilor de suprafaţă şi de inundaţii şi, de asemenea, creşte rezistenţa solului şi limitează penetrarea rădăcinilor în sol, conducând astfel la reducerea productivităţii majorităţii culturilor agricole.

Rezistenţa la penetrare şi densitatea aparentă sunt cele mai uzuale măsuri ale gradului de compactare al solului [3, 5, 6, 8, 11]. Penetrometria, sau rezistenţa solului, măsoară rezistenţa opusă de suprafaţa solului la o forţă verticală produsă prin împingerea unei tije sau a unui penetrometru în sol [6]. Măsurarea rezistenţei mecanice a solului prin teste de penetrometrie este recunoscută ca fiind o metodă convenţională de estimare a nivelului de compactare a solului.

Rezistenţa la penetrare are natură dinamică, variază spaţial şi temporal şi este influenţată de proprietăţile solului, precum: umiditatea, densitatea aparentă, compresibilitatea, textura şi conţinutul de materie organică [4, 12]. Rezistenţa solului este puternic influenţată de umiditatea acestuia şi variază semnificativ pe durata unui an, cu fiecare ciclu umezire-uscare [11]. Uzual, rezistenţa solului creşte cu creşterea densităţii aparente şi cu scăderea umidităţii [4, 11], excepţie făcând solurile cu grad redus de compactare, a căror rezistenţă scade pe măsură ce solul se usucă [4]. Creşterea conţinutului de argilă din sol duce la scăderea rezistenţei solului pe măsura uscării acestuia până la punctul de ofilire. Prin creşterea conţinutului de materie organică din sol, rezistenţa la penetrare creşte, în special dacă densitatea aparentă a solului are valori ridicate [4].

Suprafeţele de sol cu rezistenţă mecanică ridicată pot apărea natural, prin compactarea artificială produsă de vehiculele agricole, sau prin formarea straturilor dense sub talpa plugului. În solurile compactate, rezistenţa mecanică mare reduce dezvoltarea rădăcinilor şi

the agricultural production is affected and agricultural works are required to reduce the compaction of soil [1].

It is considered that values of penetration resistance larger than 2000 kPa will produce a significant reduction of root growth [10]. Also, it was found that penetration resistance measured with the penetrometer is usually 2 to 8 times higher than that actually undergone by the root tips, due to the different way in which the roots and the probes of the penetrometer penetrate the soil [5].

Experimental determination of soil penetration resistance by penetrometer tests is achieved under optimal conditions when the soil is not dry or very wet, the most appropriate being that such tests be carried out in winter. Studies conducted by Collins (1971) and Voorhees and Walker (1977) showed that soils with high moisture content have low penetration resistance [9]. In paper [7] it is recommended that, if a layer of precipitation as rain with a height of 15 mm is settled on the soil, one should wait two days for the redistribution of the water in the soil, before assessing soil resistance by penetrometer tests. From the experiments carried out by Ayers (1980) it was observed that clay soils require 24 hours to complete distribution of the water content, while coarse soils require less time [9]. A generally accepted method is to measure penetration resistance at or near field moisture capacity [4].

The depth at which is located the compacted layer of soil is indicated by the sudden increase of penetration resistance [7]. It is believed that a soil is compacted if its penetration resistance is between 2000 – 3000 kPa in the top layer of 10 - 15 cm depth.

MATERIAL AND METHOD

Experimental research presented in this paper aimed to determine soil penetration resistance and were carried out in November 2014, on three experimental plots within INMA Bucharest, namely: a plot of energy willow (Salix Viminalis) in the first year of cultivation, a cherry orchard and a plot of clover (stubble). At the time when the experiments were carried out, the plot of energy willow was in vegetation break; planting of willow cuttings was conducted in April 2014, and the soil was prepared for planting, by plowing works performed at 25-28 cm deep, followed by a phytosanitary treatment 10 days before planting.

The tested soil has the following characteristics [13]:

a) the layer at soil surface, between 0-20 cm deep, is made of loamy clay with glomerular rugged structure, medium and fine texture, is moderately plastic and adhesive, having a density of 2,49 g/cm^3, bulk density of 1,22 g/cm^3 and total porosity of 51 %;

b) the layer of soil between 20-35 cm is clayey loam, with high angular glomerular structure and fine texture, is moderately compact, plastic and adhesive, having total porosity of 46 %;

c) the layer of soil between 35-80 cm is clayey loam, with medium prismatic structure and fine texture, is compact, plastic and adhesive, dry, having a density of 2,69 g/cm^3, bulk density 1,75 g/cm^3 and total porosity of 36 %.

When conducting the experimental research presented in this paper, were use [13]:

- FieldScout SC 900 digital electronic cone

limitează absorbţia apei şi a nutrienţilor de către plante. Astfel, este afectată producţia agricolă şi sunt necesare lucrări agricole pentru reducerea compactării solului [1].

Se consideră că valori ale rezistenţei la penetrare mai mari de 2000 kPa produc o reducere semnificativă a creşterii rădăcinilor [10]. De asemenea, s-a constatat că rezistenţa la penetrare măsurată cu penetrometrul este de obicei de 2 - 8 ori mai mare decât cea efectiv suferită de vârfurile rădăcinilor, datorită modului diferit în care rădăcinile şi sondele penetrometrului pătrund în sol [5].

Determinarea experimentală a rezistenţei la penetrare a solului prin teste de penetrometrie se realizează în condiţii optime atunci când solul nu este uscat sau foarte umed, cel mai indicat fiind ca aceste teste să se realizeze în sezonul de iarnă. Studiile realizate de către Collins (1971) şi Voorhees şi Walker (1977) au arătat că solurile cu umiditate crescută au rezistenţă mică la penetrare [9]. În [7] se recomandă ca în cazul depunerii unui strat de precipitaţii sub formă de ploaie cu înălţimea de 15 mm, să se aştepte două zile pentru redistribuirea apei în sol, înainte de a evalua rezistenţa solului prin penetrometrie. Din experimentele realizate de Ayers (1980) s-a observat că solurile argiloase necesită 24 ore pentru distribuirea completă a conţinutului de umiditate, iar solurile cu granulometrie grosieră necesită mai puţin timp [9]. O metodă general acceptată este măsurarea rezistenţei la penetrare la capacitatea de câmp sau aproape de aceasta [4].

Adâncimea la care este localizat stratul de sol compactat este indicată prin creşterea bruscă a rezistenţei la penetrare [7]. Un sol este compactat dacă rezistenţa la penetrare are valori cuprinse între 2000 – 3000 kPa în stratul superior de adâncime 10 – 15 cm.

MATERIAL ŞI METODĂ

Cercetările experimentale prezentate în această lucrare au urmărit determinarea rezistenţei la penetrare şi au fost efectuate în luna noiembrie 2014, pe trei terenuri experimentale din cadrul INMA Bucureşti, şi anume: o parcelă de salcie energetică (Salix Viminalis) aflată în primul an de cultură, o livadă de vişini şi o parcelă de trifoi (mirişte). La momentul realizării experimentelor, parcela de salcie energetică se afla în pauză vegetală; plantarea butaşilor de salcie s-a realizat în luna aprilie 2014, iar terenul a fost pregătit în vederea plantării, prin lucrări de arat la 25-28 cm, după care s-a aplicat un tratament fitosanitar cu 10 zile înaintea plantării.

Solul testat are următoarele caracteristici [13]:

a) stratul de sol de la suprafaţă, cuprins între 0-20 cm adâncime, este format din lut argilos cu structură glomerulară colţuroasă, mijlocie şi mică şi textură fină, este moderat plastic şi moderat adeziv, având densitatea de 2,49 g/cm^3, densitatea aparentă 1,22 g/cm^3 şi porozitatea totală 51 %;

b) stratul de sol cuprins între 20-35 cm este de tip argilo-lutos, are structură glomerulară colţuroasă mare şi textură fină, este moderat compact, plastic şi adeziv, având porozitatea totală 46 %;

c) stratul de sol cuprins între 35-80 cm este de tip argilo-lutos, are structură prismatică mijlocie şi textură fină, este compact, plastic şi adeziv, uscat, cu densitatea de 2,69 g/cm^3, densitatea aparentă 1,75 g/cm^3 şi porozitatea totală 36 %.

La efectuarea cercetărilor experimentale din această lucrare s-au utilizat [13]:

- penetrometrul electronic digital cu con FieldScout SC

penetrometer (figure 1), which measures the force of resistance to cone penetration and the depth of cone penetration into the soil.

- FieldScout TDR 300 capacitive portable moisture analyzer (figure 2), which can monitor and record soil moisture at four depths: 3,8; 7,5; 12 and 20 cm. It can show on the electronic display, the volumetric water content and the relative water content, as well as the moisture deficit (the amount of water needed to bring the soil moisture at the top level of reference).

900 (figura 1), care măsoară forţa de rezistenţă la penetrarea conului şi adâncimea de pătrundere a conului în sol.

- umidometrul portabil capacitiv FieldScout TDR 300 (figura 2), care poate monitoriza şi înregistra umiditatea solului la patru adâncimi: 3,8; 7,5; 12 şi 20 cm. Poate afişa pe display-ul electronic conţinutul de apă volumetric şi conţinutul de apă relativ, precum şi deficitul de umiditate (cantitatea de apă necesară pentru a aduce conţinutul de apă al solului la nivelul superior de referinţă).

Fig. 1 - FieldScout SC 900 penetrometer [13]

Fig. 2 - FieldScout TDR 300 moisture analyzer [13]

On the diagonal of each of the three plots were marked three points, found at 10 m distance from each other. Penetration resistance (P_r) was measured in each of the three points, from 2,5 to 2,5 cm, for a total depth of 45 cm, by means of FieldScout TDR 300 penetrometer. To determine soil moisture (w), the FieldScout TDR 300 moisture analyzer was introduced at 3,8 cm depth into the soil and at a distance of 10 cm from the points in which penetration resistance was measured.

Thus, for each experimental plot were obtained three sets of values of the penetration resistance, coresponging to the three moistures determined in the three points marked on each plot. The, for each plot, were calculated the average value of peentration resistance and the average value of soil moisture. On the basis of these values was estimated, in qualitative terms, the degree of soil compaction.

In literature are presented the limits within which is estimated qualitatively the state of soil compaction, depending on the range in which the penetration resistance is found (table 1).

Pe diagonala fiecăruia dintre cele trei terenuri s-au marcat trei puncte, aflate la distanţă de 10 m unul faţă de celălalt. Rezistenţa la penetrare (P_r) s-a determinat în fiecare dintre cele trei puncte, din 2,5 în 2,5 cm, pe o adâncime totală de 45 cm, cu penetrometrul FieldScout SC 900. Pentru determinarea umidităţii solului (w), s-a introdus umidometrul FieldScout TDR 300 la adâncimea de 3,8 cm în sol şi la distanţa de 10 cm faţă de punctele în care s-a măsurat rezistenţa la penetrare.

Astfel, pentru fiecare teren experimental s-au obţinut câte trei seturi de valori ale rezistenţei la penetrare, corespunzătoare celor trei umidităţi determinate în cele trei puncte marcate pe fiecare teren. Apoi, pentru fiecare teren, s-au calculat valoarea medie a rezistenţei la penetrare şi valoarea medie a umidităţii solului. Pe baza acestor valori s-a estimat, din punct de vedere calitativ, gradul de compactare al solului.

În literatură sunt prezentate limitele între care se estimează calitativ starea de compactare a solului, în funcţie de intervalul valoric în care se încadrează rezistenţa la penetrare (tabelul 1).

Table 1

Qualitative estimation of soil compaction depending on penetration resistance [2]

Qualitative degree of soil compaction	Penetration resistance [kPa]
Low	< 1000
Average	1000 - 2000
Severe	2000 - 3000

RESULTS

High values of soil moisture, which were determined experimentally on the three tested plots, are due to the weather conditions, given that in the days before the experiments, poor rains fell and the water ponded in certain areas.

On *the plot of energy willow*, soil moisture measured in the three marked points were: w_1 = 22,9 %, w_2 = 33,15 %, respectively w_3 = 35,25 %, thus resulting the averge value of moisture w_{med} = 30,43 %.

In *the cherry orchard*, measured values of soil moisture were: w_1 = 33,5 %, w_2 = 38,5 %, respectively w_3 = 44,8 %,

REZULTATE

Valorile ridicate ale umidităţii solului, determinate experimental pe cele trei parcele testate, se datorează condiţiilor meteo, având în vedere faptul că în zilele precedente desfăşurării experimentelor au căzut ploi slabe şi apa a băltit pe anumite zone.

Pe *parcela de salcie energetică*, valorile măsurate ale umidităţii solului în cele trei puncte au fost: w_1 = 22,9 %, w_2 = 33,15 %, respectiv w_3 = 35,25 %, rezultând deci valoarea medie a umidităţii w_{med} = 30,43 %.

În *livada de vişini*, valorile măsurate ale umidităţii solului au fost: w_1 = 33,5 %, w_2 = 38,5 %, respectiv w_3 =

with the average value of moisture w_{med} = 38,9 %.

Regarding the experimental measurements carried out on *the plot of clover*, the values of soil moisture were: w_1 = 29 %, w_2 = 37,7 %, repectively w_3 = 36 %, and the average value of soil moisture was w_{med} = 34,23 %.

Average values of penetration resistance, at 0-45 cm depth, determined on the three experimental plots, are presented in table 2. On the basis of the recorded data it was plotted the variation of penetration resistance with soil depth, corresponding to the three experimental plots (figures 3, 4 and 5).

44,8 %, valoarea medie a umidităţii fiind w_{med} = 38,9 %.

În ceea ce priveşte determinările experimentale realizate pe *parcela de trifoi*, valorile umidităţii solului au fost: w_1 = 29 %, w_2 = 37,7 %, respectiv w_3 = 36 %, iar valoarea medie calculată a umidităţii a fost w_{med} = 34,23 %.

Valorile medii ale rezistenţei la penetrare, pe adâncimea 0–45 cm, determinate pe cele trei terenuri experimentale, sunt prezentate în tabelul 2. Pe baza datelor înregistrate s-a reprezentat grafic variaţia rezistenţei la penetrare în funcţie de adâncimea solului, corespunzătoare celor trei terenuri experimentale (figurile 3, 4 şi 5).

Table 2

Penetration resistance on the experimental plots

Soil depth [cm]	Penetration resistance [kPa]		
	Energy willow plot (w_{med} = 30,43 %)	Cherry orchard plot (w_{med} = 38,9 %)	Clover plot (w_{med} = 34,23 %)
0	338.83	541.33	336.17
2,5	462	1088	590.67
5	639.17	1123	666.83
7,5	877.33	1095	719.17
10	935.83	1251.67	988.5
12,5	1088	1216.67	1123.17
15	1152.33	1415	1292.67
17,5	1287	1617.33	1316.33
20	1509.17	1928	1176
22,5	1462.5	1924.67	1298.83
25	1386.33	1816.67	1515.17
27,5	1562	1928	1937.5
30	1913.17	2162.67	2042
32,5	1924.83	2372.67	2129.67
35	2281.83	2138.67	2123.67
37,5	2234.83	2145	2305.17
40	2301.5	2305.33	2177.5
42,5	2253.17	2378.67	2339
45	2616.83	2516	2392

Figure 3 presents the variation of penetration resistance with the depth of soil on the plot of energy willow. By the regression analysis performed in Microsoft Office Excel program was obtained the curve of linear regression, whose equation is useful to estimate the average penetration resistance of the soil to a certain depth. Regression analysis shows a high correlation of experimental data with the law of linear variation, expressed by the correlation coefficient R^2 = 0,974.

By comparing the values of penetration resistance obtained experimentally on the plot of energy willow (figure 3) with the data from table 1, the following were observed: to a depth of 10 cm, the soil is low compacted; between 12,5 and 32,5 cm deep, the soil has an average degree of compaction; at depths between 35 and 45 cm (normal plowing), the soil is severely compacted.

High values of penetration resistance, measured under

În figura 3 este prezentată variaţia rezistenţei la penetrare cu adâncimea solului de pe parcela de salcie energetică. Prin analiza de regresie realizată în programul Microsoft Office Excel s-a obţinut dreapta de regresie liniară, a cărei ecuaţie este utilă pentru a estima rezistenţa medie la penetrare a solului pe o anumită adâncime. Analiza de regresie indică o corelaţie ridicată a datelor experimentale cu legea de variaţie liniară, exprimată prin coeficientul de corelaţie R^2 = 0,974.

Comparând valorile rezistenţei la penetrare obţinute experimental pe parcela de salcie energetică (figura 3) cu datele prezentate în tabelul 1, se constată următoarele: până la adâncimea de 10 cm, solul prezintă un grad slab de compactare; la adâncimi cuprinse între 12,5 şi 32,5 cm, solul prezintă un grad mediu de compactare; la adâncimi cuprinse între 35 şi 45 cm (arătură normală), solul este sever compactat.

Valorile ridicate ale rezistenţei la penetrare, înregistrate

the arable layer of the plot of energy willow, at depths of 45 cm, indicate that the wet soil is compacted, which explains that the water could not percolate down to greater depths and stagnated at soil surface.

Variation of penetration resistance with the depth of soil in the cherry orchard is presented in figure 4. In this case, by regression analysis was obtained a good correlation of experimental data with a law of linear variation, and the correlation coefficient has the value R^2=0.925. By comparing the experimental data with the ones presented in table 1, it was found that: at surface, to a depth of 2,5 cm, the soil has a low degree of compaction; sudden increase in penetration resistance at a depth of 2,5 cm can be explained by the possibility that the penetrometer tip have met a stone or a hard body during penetration; at depths between 5 and 27,5 cm, the soil has an average degree of compaction, and at depths between 30 and 45 cm (shallow plowing), the soil is severely compacted.

Regarding the measurements carried out on *the plot of clover* (figure 5), the variation of penetration resistace with soil depth is also described by a linear law (with R^2=0.959). Following the same principle of data interpretation as in the first two cases, the following can be found: to a depth of 10 cm, the soil has a low degree of compaction; at depths between 12,5 and 27,5 cm, the soil has an average degree of compaction; between 30 and 45 cm deep, the soil is severely compacted.

în orizontul subarabil al parcelei de salcie energetică, la adâncimea de 45 cm, indică faptul că solul umed este compactat, ceea ce explică faptul că apa nu a putut percola până la adâncimi mari şi a stagnat la suprafaţa solului.

Variaţia resistenţei la penetrare cu adâncimea solului din livada de vişini este prezentată în figura 4. Şi în acest caz, prin analiza de regresie s-a obţinut o bună corelaţie a datelor experimentale cu o lege de variaţie liniară, coeficientul de corelaţie având valoarea R^2=0.925. Comparând datele experimentale cu cele din tabelul 1, s-a putut constata că: la suprafaţă, până la adâncimea de 2,5 cm, solul este slab compactat; creşterea bruscă a rezistenţei la penetrare la adâncimea de 2,5 cm poate fi explicată prin posibilitatea ca vârful penetrometrului să fi întâlnit o piatră sau un corp dur în timpul penetrării solului; la adâncimi cuprinse între 5 şi 27,5 cm, solul prezintă un grad mediu de compactare; la adâncimi cuprinse între 30 şi 45 cm (arătură superficială), solul este sever compactat.

Referitor la măsurătorile realizate pe *parcela de trifoi* (figura 5), variaţia rezistenţei la penetrare cu adâncimea solului este descrisă tot printr-o lege liniară (cu R^2=0.959). Urmând acelaşi principiu de interpretare a datelor ca şi în primele două cazuri, se pot constata următoarele: până la adâncimea de 10 cm, solul are un grad slab de compactare; la adâncimi cuprinse între 12,5 şi 27,5 cm, solul are un grad mediu de compactare; la adâncimi cuprinse între 30 şi 45 cm, solul este sever compactat.

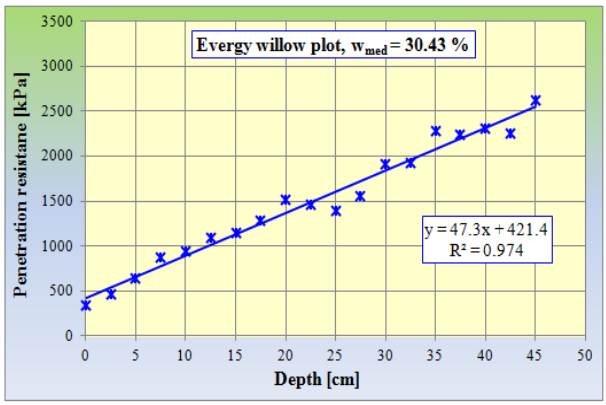

Fig. 3 – Penetration resistance on the plot of energy willow

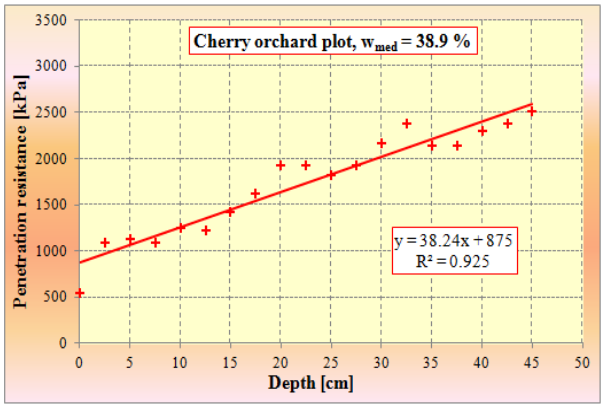

Fig. 4 – Penetration resistance on the plot of cherry orchard

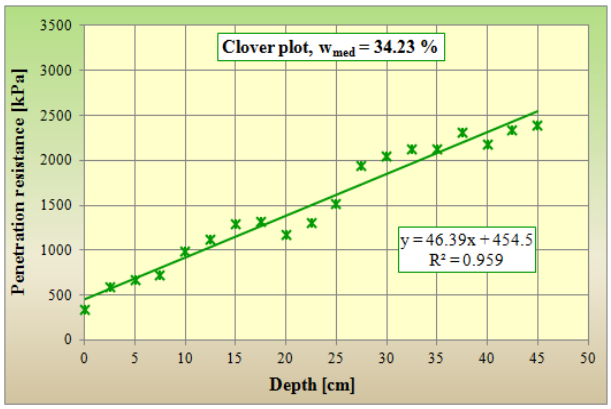

Fig. 5 – Penetration resistance on the plot of clover

CONCLUSIONS

Penetration resistance is dependent on the agricultural works apllied to the soil. The hardpan is found at depths of 20-25 cm, depending on the agricultural works carried out in previous years, being mandatory to perform deep plowing or deep loosening of

CONCLUZII

Rezistenţa la penetrare este dependentă de lucrările agricole aplicate solului. Se constată existenţa hardpanului la adâncimi de 20-25 cm, în funcţie de lucrările agricole efectuate în anii anteriori, fiind obligatorie arătura adâncă sau afânarea adâncă a solului odată la 2-

soil every 2-3 years. Sometimes, this depth increases up to values of 30-35 cm, where is observed a severe compaction, so that we can say that plowing was performed under better conditions, but the weight of agricultural machinery has led to deep soil compaction.

Penetration resistance has linear variation with soil depth. Between 0-20 cm deep, peentration resistance has relatively small values, which however increase beyond this depth.

On the plot of energy willow, the average penetration resistance varied between 338-2616 kPa, on the soil in the cherry orchard the average penetration resistance varied between 541-2516 kPa, and on the plot of clover was recorded average penetration resistances between 336-2392 kPa.

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3 ani. Uneori, această adâncime creşte la valori de 30-35 cm, unde se constată o compactare severă, astfel că putem afirma că arătura s-a făcut în condiţii mai bune, dar greutatea utilajelor agricole a condus la compactarea profundă a solului.

Rezistenţa la penetrare are variaţie liniară pe adâncimea solului. Pe adâncimea 0-20 cm, rezistenţa la penetrare are valori relativ mici, care însă cresc dincolo de această adâncime.

Pe parcela de salcie energetică, rezistenţa medie la penetrare a variat între 338-2616 kPa, pe terenul din livada de vişini, rezistenţa medie la penetrare a variat între 541-2516 kPa, iar pe parcela de trifoi s-au înregistrat rezistenţe medii la penetrare cuprinse între 336-2392 kPa.

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INTELLIGENT HOEING EQUIPMENT BASED ON THE METHOD OF IMAGES RECOGNITION / *METODA DE RECUNOASTERE A IMAGINILOR IN AGRICULTURA PENTRU CONTROLUL UNUI ECHIPAMENT INTELIGENT DE PRASIT*

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Abstract: *Agricultural works by their effects on physical, chemical and biological properties of soil represent one of the main methods of increasing the production. Maintenance works are an important category of agricultural works which have to be performed for obtaining high productivity crops. The paper presents the components and operating system of an experimental model of such intelligent equipment aiming to hoe between and in hoeing crops rows, using a software method of recognizing the images in agriculture.*

Keywords: *intelligent, hoeing, images recognizing method*

Rezumat: *Lucrările agricole prin efectele lor asupra proprietatilor fizice, chimice şi biologice ale solului reprezinta una dintre cele mai importante modalitati de crestere a producției. O categorie importanta a lucrarilor agricole care trebuie efectuate in scopul obtinerii unor culturi optime cu productivitati tot mai mari il reprezinta lucrarile de intretinere a acestora. In lucrare se prezinta componenta si principiul de functionare al unui model experimental de echipament inteligent pentru realizarea lucrarii de prasire intre si pe randuri pentru culturile de prasitoare, folosind o metoda software de recunoastere a imaginilor in agricultura.*

Cuvinte cheie: *inteligent, prasire, metoda recunoastere imagini*

INTRODUCTION

In the context of practising a precision agriculture, that according to European Union program 2020 has to comprise the SMART concept meaning, most researchers are being concerned of implementation of the recent technological achievements related to machinery.

Among the new farming technologies, we must remember the GPS automated guide, fields mapping, aiming to obtain maps with soil features (such as, soil electro-conductivity, PH, nutrients quantity, etc) which should be used by specialists to obtain a high-performance management of cultures, utilization of intelligent algorithms of recognizing the images with crops weed percentage level [1], for evaluating the crops health degree [3], aiming to identify possible pests attack, ensuring a sustainable management of sprinkling [4], etc. At the same time, a series of researches related to implementation of certain technologies similar to those regarding soil works, have been achieved.

Through soil works, is obtained the soil loosening, so that the plants root system find the best growing conditions. Roots better develop and easily penetrate into a loosened soil, especially during the growing starting period. Therefore, the respective operations should ensure a balanced ratio between soil solid phase and porosity, namely of 1/1 [2].

Through soil works, favourable conditions to accumulate and stock the humidity in the soil, in drought areas, are created, and in wetter areas they ensure deep down water gathering and draining, so that the humidity excess in soil productive layer be avoided.

Soil works also influence soil chemical features by intensifying the mechanisms of mineral alteration and organic matter decay. In a loosened soil, the nitrification process is more intense. Nitrification determines the enhancement of favourable chemical processes through which macro-nutrients turn from poorly soluble forms to

INTRODUCERE

In contextul practicarii unei agriculturi de precizie, care conform programului Uniunii Europene Horizon 2020 trebuie sa incorporeze semnificatia conceptului de SMART, tot mai multi cercetatori isi indreapta atentia catre implementarea ultimelor realizari tehnologice in cadrul masinilor agricole pe care le realizeaza.

Printre tehnologiile noi care au inceput sa fie folosite in agricultura amintim ghidarea automata prin GPS, cartarea terenurilor in scopul realizarii unor harti cu proprietati ale solului (cum ar fi electroconductivitatea acestuia, PH-ul, cantitatea de nutrienti, etc) care sa fie folosite de catre specialisti in scopul realizarii unui management performant al culturilor, folosirea de algoritmi inteligenti de recunoastere a imaginilor pentru caracterizarea gradului de imburuienare al culturilor [1], pentru evaluarea gradului de sanatate al culturilor [3], pentru identificarea unor eventuale atacuri ale daunatorilor, pentru realizarea unui management durabil al operatiei de stropire [4], etc. De asemenea s-au realizat o serie de cercetari in ceea ce priveste implementarea unor tehnologii asemanatoare in gama reprezentata de lucrarile solului.

Prin lucrările solului trebuie să se realizeze afanarea acestuia, astfel incat sistemul radicular al plantelor să găsească condiții optime creşterii şi dezvoltării. Rădăcinile se dezvoltă mai bine şi pătrund mai uşor într-un sol afânat, mai ales în perioada incipienta a vegetației. În acest scop trebuie ca prin lucrări să se realizeze un raport echilibrat între faza solidă a solului şi porozitate , raport care trebuie să fie de 1/1[2].

Prin lucrările solului se crează condiții favorabile pentru acumularea şi reținerea umiditatii în sol în zonele secetoase, iar în zonele mai umede acumularea şi drenarea apei în adâncime, astfel încât se evită excesul de umiditate în stratul productiv al solului.

Lucrările solului influențează şi proprietatile chimice ale acestuia prin intensificarea mecanismelor de alterare minerală şi de descompunere a materiei organice. Într-un sol afânat, procesul de nitrificare este mai intens. Nitrificarea atrage după sine accentuarea unor procese chimice favorabile prin care macronutrientii trec din forme greu solubile în forme accesibile plantelor. Îmbunătățirea

plants accessible forms. Soil chemical features improvement is greatly due to micro-organisms in the soil, that optimally develop within a loosened and well aerated soil.

Therefore, the maintenance works of agricultural crops represent an efficient method of increasing soil productivity by improving soil physical and chemical characteristics.

Maintenance operations may differ depending on plant variety, distance between rows, weed level of respective crop, soil compaction and humidity, etc.

For hoeing crops, according to climate conditions and plant requirements, the following operations can be performed: harrowing, gaps filling, thinning, ridging, mulching, hoeing, etc.

By hoeing, we aim, first, to destroy weeds and perform a loosened layer of soil at soil surface, that contribute to maintain water in soil, aerate it, etc. During the growing period, between2-5 hoeing operations can be performed depending on weeds level, soil features, rainfalls and plant variety.

Between the plants row, the hoeing is mechanically performed with cultivators equipped with different active parts according to plant and hoeing aim, and in the row, the hoeing is manually performed or by chemical control, with high expenses and soil infestation. This last operation, namely the row hoeing is mostly important for plants to grow harmoniously and in order to obtain high productivity. Therefore, specialized equipment will be manufactured to achieve this operation automatically, without human intervention and chemical substances applying.

At world level, the researches on hoeing technology in row began since 2001, being conducted by Garford Farm Machinery under the name of –Robocrop MK2 – using the electronic part from Robydome [5]. This technology uses board computers for identifying and locating the crop plants in real time by video digital images broken in culture scenes. Another example is given by the robot produced by Nanne Kooiman [6]. Robot is equipped with a special camera which detects the plant, located on each frame of working section. It has a mechanical instrument that is operated by hydraulic system. Hydraulic components are very robust, being conceived for long-term life and high speed operation.

In the paper is presented an experimental model of intelligent equipment designed to hoe the hoeing crops, endowed with a real-time intelligent control system, that incorporates the software method of recognizing images, method used to identify and control the weeds.

MATERIAL AND METHOD

Intelligent hoeing equipment - EIP – aims to mechanically maintain the agricultural crops, by hoeing between the rows of plants and between plants in row. It comprises two main components: technical multifunctional equipment designed to mechanically maintain the agricultural crops in rows and between the row plants and an intelligent control system.

Equipment can work in aggregate with 45 HP tractors, being carried in front of the tractor, on the three-point suspension mechanism, I-st category, either during work or transport.

Technical mechanical maintenance equipment in row

caracteristicilor chimice ale solului se datoreaza în mare măsură şi microorganismelor din sol, care se dezvolta optim intr-un sol afânat şi bine aerat.

In acest sens lucrarile de intretinere a culturilor agricole reprezinta o modalitate eficienta de crestere a productivitatii prin ameliorarea caracteristicilor fizico-chimice ale solului.

Lucrările de întretinere sunt diferite, în funcție de tipul plantei, de distanța dintre rânduri, de gradul de îmburuienare a culturii, de compactarea solului si a umiditatii acestuia, etc.

Pentru culturile de prăşitoare, în funcție de condițiile climatice şi de cerințele plantelor se pot executa: grăpatul, completarea golurilor, răritul, muşuroitul, mulcitul, prasitul etc.

Prăşitul, urmăreşte în primul rând distrugerea buruienilor şi realizarea unui strat de sol afânat la suprafața solului, care să contribuie la păstrarea apei în sol, aerarea acestuia etc. În funcție de gradul de îmburuienare, de însuşirile solului, de regimul precipitațiilor şi de felul plantei în cursul perioadei de vegetație se pot executa intre 2- 5 praşile.

Printre rândurile de plante prăşitul se execută mecanic cu cultivatoare echipate cu piese active diferite în funcție de planta de cultură şi scopul praşilei, iar pe rând prăşitul se execută manual sau prin combatere chimică, cu cheltuieli ridicate şi cu infestarea solului. Aceasta ultima lucrare, prasitul pe rand este deosebit de importanta pentru dezvotarea armonioasa a plantelor de cultura si realizarea unor productivitati ridicate. In acest sens se urmareste dezvoltarea unor echipamente specializate care sa realizeze aceasta operatie automat, fara interventie umana si fara utilizarea unor substante chimice.

Cercetările privind tehnologia de prasit mecanizat pe rand au început, pe plan mondial, din anul 2001 de catre Garford Farm Machinery sub denumirea –Robocrop MK2 - folosind partea electronica de la Robydome [5]. Această tehnologie foloseşte calculatoare de bord pentru a identifica şi a localiza plantele de cultură în timp real cu imagini video digitale pe scene de cultură. Alt exemplu este reprezentat de robotul produs de Nanne Kooiman [6]. Robotul este echipat cu o cameră de detectare a plantei speciala, plasatata pe cadrul fiecărei secti de lucru. Aceasta are un instrument mecanic care este operat de sistemul hidraulic. Componentele hidraulice sunt foarte robuste şi concepute pentru funcționarea la viteză mare si durata lungă de viață.

In lucrare se prezinta un model experimental de echipament inteligent de prasit al culturilor de prasitoare, echipat cu un sistem inteligent de control in timp real care incorporeaza o metoda software de recunoastere a imaginilor in agricultura folosita pentru identificarea si combaterea buruienilor.

MATERIAL ŞI METODĂ

Echipamentul inteligent de prăşit - EIP - este destinat întreținerii mecanice a culturilor agricole, prin efectuarea operației de prăşire între rândurile de plante şi între plante pe rând. Acesta este format din doua componente principale: un echipament tehnic multifuncțional de intreținere mecanică pe rând şi între plante a culturilor agricole si un sistem inteligent de control.

Echipamentul poate lucra în agregat cu tractoarele de 45 CP, fiind purtat în fața tractorului, pe mecanismul de suspendare în trei puncte categoria I, atât în lucru cât şi în transport.

Echipamentul tehnic multifuncțional de intreținere mecanică pe rând şi între plante a culturilor (fig. 1), ansamblu EIP-0, este alcătuit dintr-un cadru (poz. 1) pe care se montează două secții de prăşit (poz. 2), două roți

and between crop plants (fig. 1), assembly EIP-0, is made of a frame (pos. 1) on which are mounted two hoeing sections (pos. 2), two wheels (pos. 3) of displacement and adjusting the working depth, two supports, (pos. 4) for cameras seizing the images and a parking foot (pos. 5). Hoeing sections are equipped with a classic knife, that destroys weeds between rows and two mobile knives, driven by two electric actuators aiming to destroy the weeds in the row.

(poz. 3) de deplasare şi reglare a adâncimii de lucru, doi suporți (poz. 4) pentru camerele de achizitie a imaginilor şi un picior de parcare (poz. 5). Sectiile de prasit sunt fiecare echipate cu cate un cutit clasic de distrugere a buruienilor intre randuri si cu cate doua cutite mobile, actionate de cate doi actuatori electrici, pentru distrugerea buruienilor pe rand.

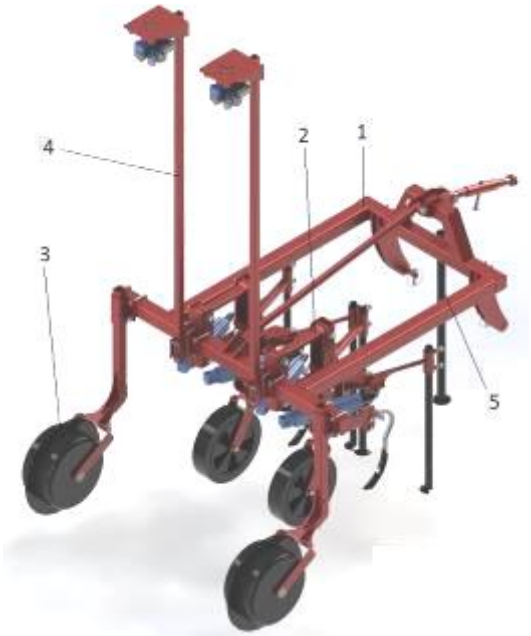


Fig. 1 – Technical multifunctional equipment designed to mechanical maintenance in row and between crop plants

The intelligent control system is a software-hardware system that achieves a differentiation of crop plants from the weeds and the latter destruction. It is based on two intelligent cameras, endowed with internal memory card able to store the software steps and have integrated controller aiming to achieve images processing operations. Each camera surveys two rows of culture and digitally transmits the commands obtained after the images processing, to a logical programmable controller (PLC). PLC achieves the synchronization of cameras with moving speed of tractor and with the state of the four electric linear actuators, driving the equipment knives. PLC also commands the opening and closing of actuators in weed areas, by transmitting digital signals to controllers. Interface between technical equipment, intelligent control system and the operator is made by an operation terminal with touch-screen. By means of this one, the operator can obtain the start-stop functioning commands of TE, monitor the actuators, number the crop plants and assess the weed level.. At the same time, it can guide the technical equipment by means of a GPS, so that it achieves the optimum crop maintenance, without surpassing the distance between rows and destroying the plants. Cameras are designed by National Instruments company aiming the industrial screening installations and use algorithms for images detection.

The main feature of these cameras is the fact that they are compacted, have the same chassis with the following components: fixed focal length lenses, camera with image sensor CCD and image processing system. Cameras shall be installed above the crop rows and will perform in

Sistemul inteligent de control este un sistem software-hardware care realizeaza o discriminare a plantelor de cultura de restul buruienilor si realizeaza distrugerea mecanica a celor din urma. Sistemul inteligent de control are la baza doua camere inteligente care dispun de memorie interna reinscriptibila care poate stoca pasi de program software si au controller integrat care poate realiza operatii de prelucrare imagini. Fiecare camera supravegheaza doua randuri de cultura si transmite pe cale digitala unui controller logic programabil (PLC) comenzile obtinute in urma prelucrarii imaginilor. PLC-ul realizeaza sincronizarea camerelor cu viteza de inaintare a tractorului, si cu starea celor patru actuatori electrici liniari care actioneaza cutitele echipamentului. Tot PLC-ul comanda actionarea in sensul deschiderii si inchiderii actuatorilor in zonele imburuienate, prin transmiterea unor semnale digitale catre controller-ele acestora. Interfata intre echipamentul tehnic, sistemul inteligent de control si operator este realizata prin intermediul unui terminal de operare cu touch-screen. Prin intermediul acestuia, operatorul poate realiza comenzile de start-stop functionare ET, monitorizare actuatori, numar plante cultura, grad de imburuienare. Deasemenea acesta poate ghida echipamentul tehnic prin intermediul unui GPS astfel incat sa se realizeze o operatie de intretinere a culturilor optima, fara depasirea distantei dintre randuri si a distrugerii plantelor de cultura.

Camerele sunt special concepute de catre firma National Instruments pentru sortatoare industriale si utilizeaza algoritmi de detectare a imaginilor.

Caracteristic acestui tip de camera este faptul ca sunt compacte, in acelasi sasiu avand incorporate urmatoarele componente: obiectiv cu lentile cu distanta focala fixa, camera cu senzor de imagine CCD si sistemul de procesare a imaginilor. Camerele vor fi instalate deasupra randurilor de cultura si vor efectua in timp real sarcinile

real time the tasks programmed. These tasks will implement the method of recognition of developed agriculture images.

Cameras were set to monitor the hoeing plant rows and programmed so that, when a plant is in camera's sight, it sends a digital signal to PLC commanding the electric actuators and that, at the moment dictated by camera, will be moved again in the row. When the crop plant passed, the instrument would be moved again in the row.

In figure 2, we present the whole scheme of intelligent control system.

programate de utilizator. Acestea sarcini vor implementa metoda de recunoastere a imaginilor in agricultura dezvoltata.

Camerele au fost setate pentru realizarea operatiei de monitorizare a randurilor de plante prasitoare si programate astfel incat in momentul în care trece o planta prin raza camerei de luat vedere, acesta va trimite un semnal digital catre PLC-ul de comanda a actuatorilor electrici care la timpul specificat de camera va fi mutat din rand.Cand planta de cultura a trecut instrumentul va fi mutat in rand din nou.

In figura 2 prezentam schema bloc a sistemului inteligent de control.

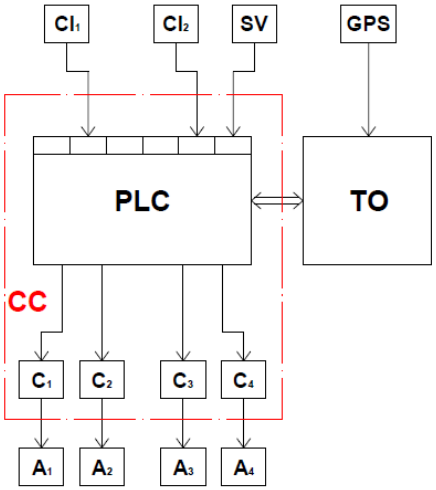


Fig. 2 – Block scheme of intelligent control system EIP 5.0(CI1÷2 – intelligent cameras, SV-speed sensor, GPS-global positionning system, PLC- programable logical controller, TO-operation terminal, C1÷4 – controller of electric actuator, A1÷4 – linear electric actuator, CC – control box)/

In figure 3, the intelligent experimental model of hoeing - EIP, achieved by INMA Bucharest, is shown.

In figura 3 se prezinta Modelul experimental de Echipament inteligent de prasit - EIP, realizat de INMA Bucuresti.

Fig. 3 – Experimental model EIP
(1–frame, 2 – hoeing section, 3 – wheels of displacement and working depth adjusting, 4 – cameras supports, 5 – cameras, 6– parking foot)

RESULTS

We present the innovative method of recognizing the images in agriculture, developed in order to implement it to multifunctional technical equipment designed to mechanical maintenance in row and between plants, by means of intelligent control system.

Method of recognizing the images proposed consists in performing the following operations:

- sequences of images, in real time, taken directly from the field. This operation will be continuously performed by

REZULTATE

In continuare prezentam metoda inovativa de recunoastere a imaginilor in agricultura, dezvoltata in scopul implementarii acesteia in echipamentul tehnic multifuncțional de intreținere mecanică pe rând şi între plante a culturilor agricole, prin intermediul sistemului inteligent de control.

Metoda de recunoastere a imaginilor propusa consta in realizarea urmatoarei secvente de operatii:

- esantionarea de imagini, in timp real, preluate direct din teren. Aceasta operatie se va realiza continuu de catre

intelligent camera, with acquisition frequency adjusted by the user, each image being subsequently analyzed by performing the operations below. Images are in black and white, screen size of 307200 digitized pixels, identification of objects and their contours being made by differentiating the pixels grey tones.

-storing images for a subsequent analysis. This operation is optional, allowing to user to estimate the crop weeds level and after that, necessary maintenance works.

- dividing the image in interest areas. The final aim of this operation is that to use a sole intelligent camera for monitoring two rows of crop simultaneously or to perform maintenance works of several crop types with plants of different growing stages. This classification will be made by the operator, so that the delimited areas mark the limits of crop rows, generally, and plants, principally.

- identifying the distinct objects from images (soil, stones, plants, etc). This operation will be made by numbering the pixels suitable to each different object, depending on the grey tone intensity of each pixel, taking from reference a scale introduced by the user.

- identifying the space between crop plants. This will be made for recognizing the area between plants suited to mechanical maintenance. The space between plants will be obtained by extracting it from initial image of distinct objects.

- PLC gives the command according to existence/non existence of crop plants. In this stage, the digital command will be given within the range of 0-24Vcc to digital input of PLC, in order to drive the arm of mobile knife of multifunctional technical equipment designed to mechanical maintenance in row and between plants of agricultural crops.

Operations described above are performed by making the following steps, (described in software of Vision Builder AI):

Step 1

Images are taken in sequences, with 640x480 pixels resolution. Images acquired are stored in internal memory of the camera. Images (frames) number with which the acquisition is made may be adjustable, according to exposure time, light and sensor amplifying.

camera inteligenta, cu frecventa de achizitie reglabila de catre utilizator, fiecare imagine fiind analizata ulterior prin efectuarea operatiilor de mai jos. Imaginile preluate sunt alb-negru, digitizate sub forma a 307200 pixeli, identificarea obiectelor si a contururilor acestora facandu-se pe principiul discriminarii tonurilor de gri ai pixelilor.

- stocarea de imagini in vederea unei analize ulterioare. Aceasta operatie este optionala permitand utilizatorului sa estimeze gradul de imburuienare al culturii, ulterior realizarii lucrarii de intretinere a acesteia.

- impartirea imaginii in zone de interes. Scopul final al acestei operatii este folosirea unei singure camere inteligente pentru monitorizarea a doua randuri de cultura simultan sau a realizarii operatiei de intretinere a mai multor tipuri de cultura cu plante cu grade de dezvoltare diferite. Aceasta impartire se va realiza de catre operator astfel incat zonele delimitate sa contureze randurile de cultura in general si plantele in particular.

- identificarea obiectelor distincte din imagine (sol, pietre, plante, etc). Aceasta operatie se va realiza prin numararea pixelilor corespunzatori fiecarui obiect diferit, in functie de intensitatea tonului de gri al fiecarui pixel, avand ca referinta o scala introdusa de utilizator.

- identificarea spatiului dintre plantele de cultura. Se va face in scopul identificarii zonei dintre plante care se preteaza operatiei de intretinere mecanica. Spatiul dintre plante se va obtine prin extragerea din imaginea initiala a obiectelor distincte.

- emiterea comenzii catre PLC, in functie de existenta/inexistenta plantelor de cultura. Aceasta etapa va realiza emiterea comenzii digitale in domeniul 0-24Vcc catre intrarile digitale ale PLC-ului, in scopul actionarii bratului cutitului mobil al echipamentului tehnic multifuncțional de intreținere mecanică pe rand si între plante a culturilor agricole.

Operatiile descrise mai sus se efectueaza prin parcurgerea secventiala a urmatorilor pasi, descrisi in softul de configurare Vision Builder AI:

Pasul 1

Achizitia de imagini se realizeaza secvential, cu o rezolutie de 640x480 pixeli. Numarul de imagini achizitionate se stocheaza in memoria interna a camerei. Numarul de imagini (frame-uri) cu care este realizata achizitia este reglabil, in functie de timpul de expunere, luminozitate si amplificarea senzorului.

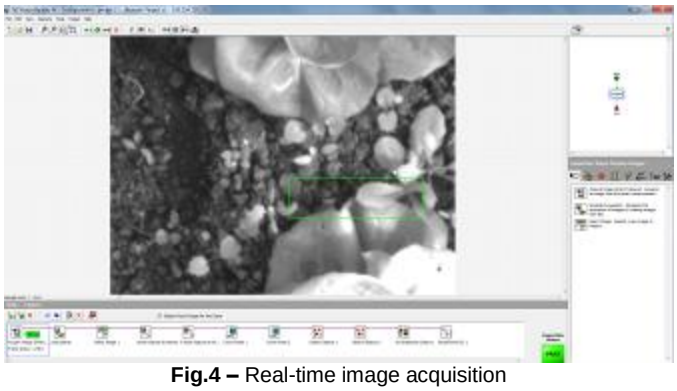


Fig.4 – Real-time image acquisition

Step 2 (optional)

Images can be stored in a previously defined folder to be subsequently analyzed.

Step 3 (optional)

Software is able to analyze both the images in real time, and saved images in a defined folder.

Step 4

Two interest areas, of fixed surface, represented by the

Pasul 2 (optional)

Imaginile pot fi stocate intr-un folder predefinit pentru a putea fi analizate ulterior.

Pasul 3 (optional)

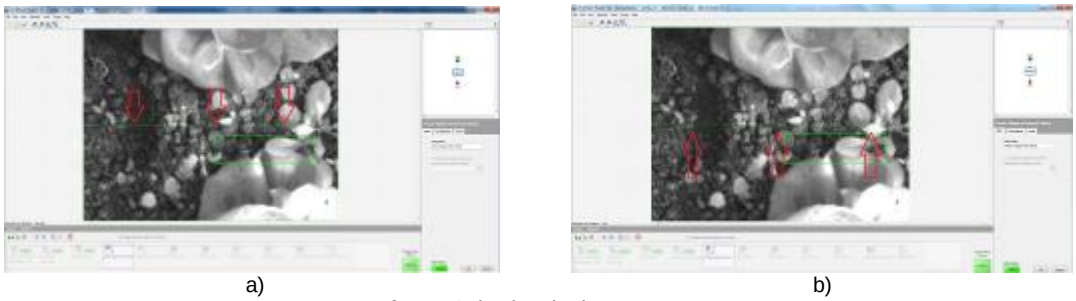
Software-ul ofera posibilitatea analizei imaginilor atat in timp real cat si a celor salvate intr-un folder predefinit.

Pasul 4

Se selecteaza doua zone de interes, cu suprafata fixa,

green frame from figure 5 – a, that frames the lower half of the image and figure 5 – b , framing the image upper half, are selected.

reprezentata de chenarul verde din figura 5 – a, care incadreaza jumatatea inferioara a imaginii si figura 5 – b , care incadreaza jumatatea superioara a imaginii



a) b)

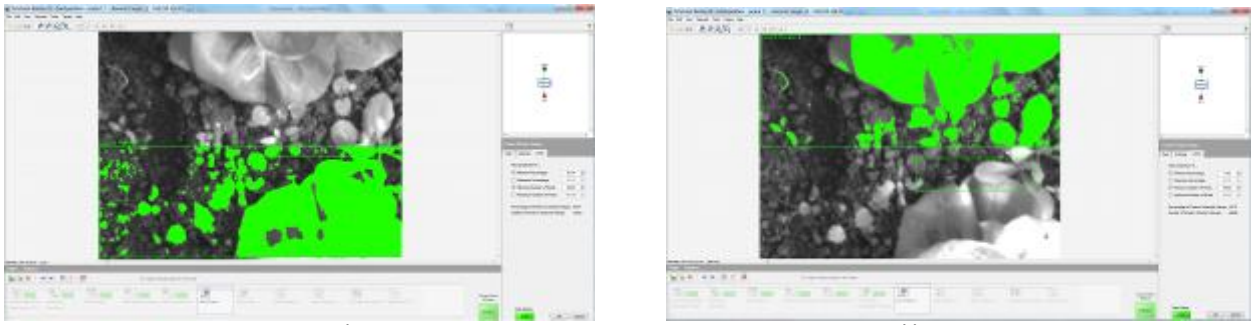
Fig.5 – Selecting the interest area
a) Image lower half; b)Image upper half

Step 5

There are identified the interest objects from image lower part, by numbering the pixels of a certain intensity, appropriate to respective object (crop plant, weed, stone, etc).

Pasul 5

Se identifica obiectele de interes din partea inferioara a imaginii analizate, prin numararea pixelilor de o anumita intensitate, corespunzatoare obiectului respectiv (planta de cultura, buruiana, piatra, etc).



a) b)

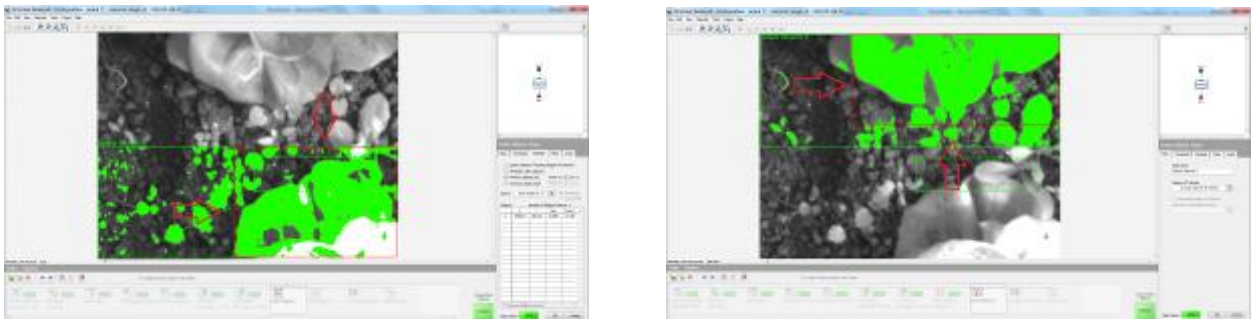
Fig.6 – Identification of interest objects(plants and weeds marked in light green)
a) Image lower half b)Image upper half /

Step 6

Area of objects surpassing 10000 squared pixels is identified (this number can vary according to crop plant and its average surface at the plant growing level suitable to crop maintenance performing), for image lower part (area framed in red).

Pasul 6

Se identifica zona obiectelor cu un numar mai mare de 10000 de pixeli patrati (acest numar este variabil in functie de planta de cultura si de suprafata medie a acesteia la nivelul de dezvoltare al plantei corespunzator realizarii operatiei de intretinere a culturii) pentru partea inferioara a imaginii analizate, zona incadrata in chenarul rosu.



a) b)

Fig.7 – Identification of interest object (crop plant marked in light green in red frame)
a) Image lower half; b) Image upper half

Step 7

After analyzing the previous steps, step 7 quantifies the previous answers of method proposed, necessary for sending the command signal to the end of analysis sequency. The area of plants location is framed in red, the gap between them representing the field that requires to

Pasul 7

Dupa analiza pasilor anteriori, la pasul 7 se realizeaza o cuantificare a raspunsurilor secventelor anterioare ale metodei propuse, necesara pentru a trimite semnalul de comanda la finalul secventei de analiza. In chenarele rosii este identificata zona de amplasare a plantelor, spatiul

be worked.

liber dintre acestea reprezentand terenul care necesita prelucrare.

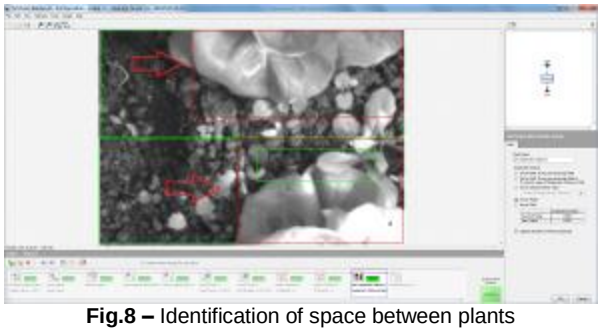


Fig.8 – Identification of space between plants

Step 8

During step 8, the output channel by means of which the signal is sent to PLC, is set, as well as the conditions of transmitting it.

By implementing the method of recognizing the crop plants and the space between them, in the row, the equipment performed by INMA can achieve the hoeing of hoeing plants in row.

CONCLUSIONS

In Romania, soil work between plants in row is manually performed or by chemical control, with high costs and soil infestation. Experience of West-European countries have demonstrated that the efficiency of maintenance works designed to hoeing plants by achieving state-of-the art mechanizing technologies with specialized technical equipment of high precision, can become profitable both for manufacturer/provider of equipment and user. Therefore, it is necessary to achieve researches able to promote a technology and high performance equipment adapted to Romania's soil and climate conditions.

The advantages of manufacturer are the following:

- completing the machinery range with marketable equipment;
- maintaining the people's jobs;
- obtaining incomes by selling.

The advantages of user are the following:

- enhancing agricultural works;
- performing the works during the optimum period;
- ensuring safety of works in planned period.

Main users of mechanizing technology and technical equipment for hoeing crop maintenance are owners of fields in vegetable and cereal crops, where non-qualified manpower is reduced.

Acknowledgement

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Pasul 8

La pasul 8 se seteaza canalul de iesire prin intermediul caruia este trimis un semnal catre PLC, precum si conditiile in care aceste este trimis.

In urma implementarii metodei de recunostere a plantelor de cultura si a spatiilor dintre ele, pe rand, echipamentul produs de INMA poate realiza operatia de prasire pe rand a culturilor de plante prasitoare.

CONCLUZII

In ţara noastră operaţiunea de lucrare a solului dintre plante pe rând se efectuează numai manual sau prin combatere chimică, cu cheltuieli ridicate şi cu un procent de infestare a solului. Experienţa ţărilor vest-europene demonstrează că eficientizarea lucrărilor agricole de întreţinere a culturilor prăşitoare prin realizarea de tehnologii avansate de mecanizare cu echipamente tehnice de intretinere, cu precizie ridicată, a culturilor poate deveni profitabilă atât pentru producătorul/ furnizorul de echipamente tehnice, cât şi pentru utilizator. In acest contest se impune necesitatea de a realiza o asemenea cercetare pentru a promova o tehnologie şi un utilaj performant adaptat condiţiilor de sol şi climă specifice ţării noastre.

Pentru producător se pot identifica următoarele avantaje:

- completarea gamei de maşini cu utilaje vandabile;
- menţinerea locurilor de muncă;
- obţinerea de venituri prin vânzare.

Pentru utilizator pot fi menţionate următoarele avantaje:

- eficientizarea lucrărilor agricole;
- efectuarea lucrărilor în perioada optimă;
- siguranţa efectuării lucrărilor în perioada planificată.

Principalii utilizatori în exploatare ai tehnologiei de mecanizare şi a echipamentelor tehnice de întreţinere a culturilor prăşitoare sunt proprietarii de terenuri din ferme legumicole şi cultura mare unde forţa de muncă necalificată este redusă.

Recunoastere

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THE ELASTICITY INFLUENCE OF SUSPENDING RODS ON CIRCULAR MOTION OF A PLANSIFTER FOR SIFTING MILL PRODUCTS
/
INFLUENȚA ELASTICITĂȚII TIJELOR DE SUSPENDARE ASUPRA MIŞCĂRII CIRCULARE A SITEI PLANE PENTRU CERNEREA PRODUSELOR DE MĂCINIŞ

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Abstract:
In this paper is studied, based on the calculation model of plansifter SPP 618 A, the influence of the elastic suspending rods on the circular movement described by the plansifter. The operating regime of the plansifter must transmit to the material an adequate relative motion that meet the requirements of a good separation. Thus, each grid point of the plansifter must describe a circle of radius equal to the eccentricity between the vertical long axis of the plansifter and the short axis of the counterweights. For usual construction of plansifters, the radius of the described circle has the value of r = 45 mm. Based on the calculation model, we determined the own pulsations, the stiffness of the suspending system and thus the radius of the circle described by the movement of the plansifter. This study was conducted in order to establish dependencies between dimensions of elastic rods and materials they are made of and the radius of the circle described by the movement of the plansifter.
Keywords: *plansifter, circular plan motion, eccentricity, suspension rods, elastic elements.*

Rezumat:
În această lucrare este studiată, pe baza modelului de calcul al sitei plane SPP 618 A, influența tijelor elastice de suspendare asupra mişcării circulare descrise de sita plană. Regimul de funcționare al sitei trebuie să asigure materialului o mişcare relativă corespunzătoare care să îndeplinească cerințele unei bune separări. Astfel, fiecare punct al sitei plane trebuie să descrie un cerc de rază egală cu excentricitatea dintre axul lung vertical al sitei plane şi axul scurt al contragreutăților. Pentru construcții uzuale de sită plană raza cercului descris are valoarea r = 45 mm. Pe baza modelului de calcul au fost determinate pulsațiile proprii, rigiditatea sitemului de suspendare şi, implicit, raza cercului descris de mişcarea plan circulară a sitei. Acest studiu a fost realizat în vederea stabilirii unei dependențe între dimensiunile şi materialele din care sunt confecționate tijele elastice şi raza cercului descris de mişcarea sitei plane.

Cuvinte cheie: *sita plană, mişcare plan circulară, excentricitate, tije de suspendare, elemente elastice.*

INTRODUCTION

The use of plansifters for sifting intermediate products, resulted in the milling process is known for over a century, during which time they have undergone many changes to improve product quality, production capacity, specific charging and reducing energy consumption. The principle of sifting was preserved regardless the type of construction of the plansifters. The plansifter assembly consists of several overlapped sieves, which are simultaneously put in motion by an oscillating mechanism, printing to the sifting surfaces a circular plan motion. The plansifter offers the possibility of sorting a mixture of milled products into several fractions of the same particle size or appropriate granulations. The relative movement of the material on plansifter is ensured by printing to the sieve a circular motion by using a crank type mechanism. The operating regime of the plansifter must transmit to the material an adequate relative movement that meet the requirements of a good separation.

The efficiency of the sifting process on sieve is ensured by a relative movement in both ways without the detachment of the material. At the same time, the material on the sieve must have a forward movement to the opposite end of feeding, to allow the discharge of the material. In order to achieve quality in sifting, the plansifter vibration parameters (amplitude and frequency) must be correlated with the others parameters so as to be, simultaneously, achieved the required values for the height and the length of the material grain jumps on the sieve [2].

INTRODUCERE

Folosirea sitelor plane pentru cernerea produselor intermediare, rezultate în procesul de măcinare este cunoscută de peste un secol, timp în care acestea au suferit numeroase modificări pentru a îmbunătății calitatea produselor, capacitatea de producție, încărcarea specifică şi reducerea consumului de energie. Principiul de cernere a fost păstrat indiferent de tipul constructiv al sitei. Ansamblul sită plană este formată din mai multe site aşezate suprapus, care sunt acționate simultan de un mecanism liber oscilant, imprimând suprafețelor de cernere, o mişcare plan circulară. Sita plană oferă posibilitatea sortării unui amestec de produse măcinate în mai multe fracțiuni de aceeaşi granulație sau de granulații apropiate. Deplasarea relativă a materialului pe sita plană se asigură imprimând sitei o mişcare circulară cu ajutorul unui mecanism de tip bielă-manivelă (cel mai des întâlnit). Regimul de funcționare al sitei trebuie să imprime materialului o mişcare relativă corespunzătoare care să îndeplinească cerințele unei bune separări.

Mişcarea relativă care asigură desfăşurarea eficientă a procesului de separare pe sită este cel de deplasare relativă în ambele sensuri fără desprindere. Totodată materialul de pe sită trebuie să aibă o mişcare de înaintare către capătul opus alimentării, pentru a permite evacuarea refuzului. Pentru a realiza o cernere de calitate, trebuie ca parametrii vibrațiilor sitei (amplitudine şi frecvență) să fie corelați cu ceilalți parametri, astfel încât să se realizeze simultan valorile necesare pentru înălțimea şi lungimea saltului granulelor de material pe sită [2].

Most often, the vibration generator is composed of an electric motor with flange and a driving sheave. The motor assembly is fitted in the interior of the central frame through a metal plate which allows the displacement of the entire system through of V-belts, which ensures transmission of the motion from the drive shaft to the axis of the central mechanism for generating the rotational movement of the sieve, [1]. To achieve circular vibration and thus a circular movement, it takes only one vibration generator placed at the bottom of the plansifter.

Each grid point of the plansifter must describe a circle of radius equal to the eccentricity between the vertical long axis of the plansifter and the short axis of the counterweights in order to achieve a good separation of the product in question, [4]. For usual construction of plansifters, the radius of the described circle, r = 45 mm, [4]. The sieves block are suspended by a frame mounted on the ceiling by means of suspending rods that are made from different materials (e.g. elastic reed, bamboo, boiled beech, glass fiber ..)

MATERIAL AND METHOD

The plansifter SPP 618 A have 24 elastic suspension rods, divided by 6 in 4 attachment points that are supporting the sieves block with a weight of approximately 3935 kg and is shown in Figure 1. The suspending rods were made of fiber glass and had a length of about 1585 mm.

The plansifter SPP 618 A is equipped with a vibration generator having a mass m_0 = 345 kg. Its revolution speed is n = 220 [rev/min] and eccentricity e = 260 mm. The plansifter SPP 618 A with square frames has 6 compartments. It sums up a large number of overlapping screening surfaces (18 pcs.) that are put into motion simultaneously with a weight of M = 3935 kg.

Cel mai adesea, generatorul de vibrații se compune dintr-un motor electric cu flanşă şi şaibă de antrenare. Ansamblul motor este fixat în interiorul cadrului central prin interiorul unei plăci metalice care permite deplasarea întregului sistem prin intermediul curelelor trapezoidale, ce asigură transmiterea mişcării de la arborele motor la axul mecanismului central de generare a mişcării de rotație a sitei, [1]. Pentru realizarea unor vibrații circulare şi, implicit, a unei mişcări circulare, este nevoie de un singur generator de vibrații amplasat la partea inferioară a cadrului sitei.

Fiecare punct al sitei plane trebuie să descrie un cerc de rază egală cu excentricitatea dintre axul lung vertical al sitei plane şi axul scurt al contragreutăților pentru a obține o bună separare pentru produsul în cauză, [4]. Pentru construcții uzuale de sită plană raza cercului descris, r = 45 mm, [4]. Blocul cu site este suspendat de un schelet montat pe tavan cu ajutorul tijelor de suspendare elastice care pot fi confecționate din diferite materiale (ex. trestie, bambus, fag fiert, fibra de sticlă, ...).

MATERIAL ŞI METODĂ

Sita plană SPP 618 A prezintă 24 de tije elastice de suspendare, repartizate câte 6 în 4 puncte de prindere care susțin blocul de site cu o greutatea de aproximativ 3935 kg şi este prezentată în Figura 1. Tijele de suspendare au fost confecționate din fibră de sticlă şi au o lungime de aproximativ 1585 mm.

Sita plană SPP 618 A, este echipată cu un generator de vibrații cu o masă m_0 = 345 kg. Turația acestuia este de n = 220 rot/min, iar ecentricitatea e = 260 mm. Sita plană cu rame pătrate SPP 618 face parte din grupa sitelor plane cu 6 compartimente. Ea însumează un număr mare de suprafețe de cernere suprapuse (18 buc.) puse în mişcare simultan şi au o greutate M = 3935 kg.

Figure 1. The plansifter SPP 618 A with square frames, [5]

The method used is based on the calculation model of the plansifter and graphical representation of motion described by the plansifter according to Figure 2. For the application of the calculation model (see Figure 2-b) it was based on the following considerations:

- The location of the center of mass C_M of the sieves block and the center of mass C_{m0} of vibration generator is symmetrical about the position of the center of mass of the whole system, C (see Figure 2-a);
- The two centers of mass are moving on concentric circles centered in C, equilibrating the sifting system (see Figure 2-a);
- It is neglected the effect of elastic elements

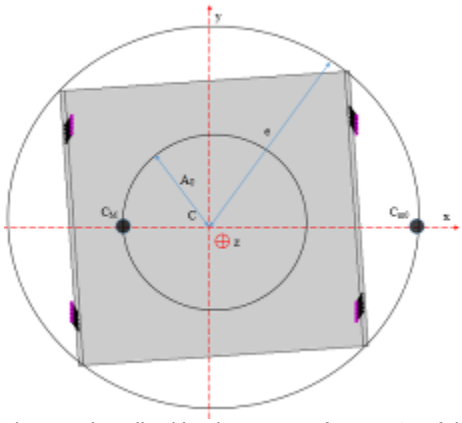
Metoda utilizată are la bază modelul de calcul al sitei plane, precum şi reprezentarea grafică a mişcării descrise de sita plană în conformitate cu Figura 2. Pentru aplicarea modelului de calcul (v. Figura 2-b) s-a pornit de la următoarele considerente:

- poziția centrului de masa al blocului de site C_M şi centrul de masa al generatorului de vibrații C_{m0} se află în poziție simetrică cu poziția centrului de masa al întregului sistem, C (v. Figura 2-a);
- cele două centre de masă se deplasează pe cercuri concentrice cu centrul în C, echilibrând sistemul de cernere (v. Figura 2-a);
- este neglijat efectul de masă a elementelor elastice şi efectele lor neliniare;

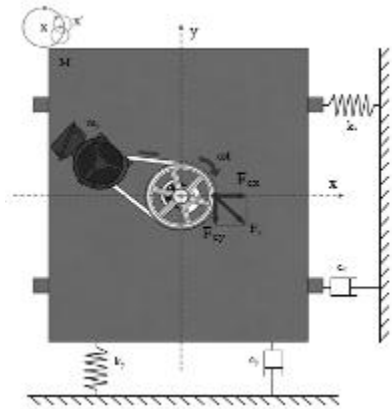
mass and their nonlinear effects;

- The amplitude of the plansifter vibrations is approximated as the radius of the circle described by its own circular motion.

- amplitudinea vibrațiilor sitei plane este aproximată ca fiind raza cercului descris de mişcarea circulară a sitei plane.



a) The trajectory described by the center of mass C_M of the sieves block and the center of mass C_{m0} of vibration generator



b) The calculation model of the plansifter SPP 618 A

Figure 2. The 3D calculation model of the plansifter SPP 618 A, [4]

The differential equations of motion for the model in Figure 2 were determined in paper [4], where was shown that each point of the plansifter describes a circle of radius equal to the amplitude of vibration A_0 (calculated with relation (1)).

Ecuațiile diferențiale ale mişcării pentru modelul din Figura 2 au fost determinate în lucrarea [4], unde s-a demonstrat faptul că fiecare punct al sitei plane descrie un cerc de rază egală cu amplitudinea vibrațiilor A_0 (calculată cu relatia (1)).

$$A_0 = \frac{\frac{F_0}{k}}{\left|1-\left(\frac{\omega}{\omega_0}\right)^2\right|} \qquad (1)$$

where, $F_0 = m_0 \cdot e \cdot \omega^2$ is the inertia force of the vibration generator, [N], m_0 is the mass of the vibration generator, [kg], e eccentricity of the vibration generator, [mm], $\omega = \frac{\pi \cdot n}{30}$ is the angular velocity of the vibration generator, [rad/s], n is the revolution speed of the vibration generator, [rot/min], $k = z \cdot \frac{12 \cdot E \cdot I}{l^3}$ is the stiffness of the suspending system, [N/m], z is the number of the elastic suspending rods, E is the elasticity modulus, [N/mm^2], $I = \frac{\pi \cdot d^4}{64}$ is the axial inertia moment of the rod, [mm^4], d represent the diameter of the elastic rod, [mm], l is the length of the elastic rod, [mm], $\omega_0^2 = \frac{k}{M + m_0}$ is the own pulsation of the system, [rad/s] and M is the mass of the sieves block, [kg].

în care, $F_0 = m_0 \cdot e \cdot \omega^2$ este forța de inerție a generatorului de vibrații, [N], m_0 este masa generatorului de vibrații, [kg], e este excentricitatea generatorului de vibrații, [mm], $\omega = \frac{\pi \cdot n}{30}$ este viteza unghiulară a generatorului de vibrații, [rad/s], n este turația generatorului de vibrații [rot/min], $k = z \cdot \frac{12 \cdot E \cdot I}{l^3}$ este rigiditatea sitemului de suspendare, [N/m], z este numărul de tije elastice de suspendare, E este modulul de elasticitate [N/mm^2], $I = \frac{\pi \cdot d^4}{64}$ este momentul de inerție axial al tijei de suspendare, [mm^4], d reprezintă diametrul tijei elastice [mm], l este lungimea tijelor de suspendare, [mm], $\omega_0^2 = \frac{k}{M + m_0}$ este pulsația proprie a sistemului, [rad/s] iar M este greutatea blocului de site [kg].

RESULTS

It is noted that the stiffness of the suspending system might influence the radius of the circle described by the movement of the plansifter. To determine this influence we calculated the amplitude of vibration of SPP 618 A

REZULTATE

Se observă faptul că rigiditatea sistemului de suspendare ar putea influenţa raza cercului descris de mişcarea sitei plane. Pentru a determina această influenţă am calculat amplitudinea vibraţiilor sitei plane

plansifter for elastic suspension rods made of different materials and different sizes. The materials used in the simulation for the elastic suspension rods are shown in Table 1.

SPP 618 A, pentru tijele elastice de suspendare confecţionate din diferite materiale şi de diferite dimensiuni. Materialele folosite în studiu, sunt prezentate în Tabelul 1.

Table 1

Characteristics of the materials used in study

Material	Density [kg/m^3]	Poisson ratio	Elastic Modulus [MPa]	Damping
Boiled beech	760	0,2...0,394	10000	0.194
Fiber glass	2550	0,21...0,23	80000	0.02
Bamboo	600	0,22...0,31	16170	0.2

For these, we calculated the stiffness of the suspending system, *k* and amplitude of vibration, A_0 using relation (1). The results have been listed in Table 2 and Table 3.

Pentru aceasta s-a calculat rigiditatea sistemului de suspendare *k* şi amplitudinea vibraţiilor A_0 cu ajutorul relaţiei (1). Rezultatele obţinute sunt prezentate in Tabelul 2 şi Tabelul 3.

Table 2

The stiffness and the vibration amplitude for rods with Φ 12 and Φ 14 diameter

Material	Elastic rod length [mm]	The diameter of elastic rods [mm]							
		d = 12 I = 1018 mm^4				d = 14 I = 1885,74 mm^4			
		Suspending stiffness k [N/m]	Own pulsation ω [rad/s]	Pulsation ratio ω/ω_0	Vibration amplitude A_0 [mm]	Suspending stiffness k [N/m]	Own pulsation ω [rad/s]	Pulsation ratio ω/ω_0	Vibration amplitude A_0 [mm]
Boiled Beech	1285	1381.754	0.568	40.550	20.970	2559.558	0.773	29.794	20.981
	1385	1103.547	0.508	45.374	20.968	2044.208	0.691	33.338	20.977
	1485	895.284	0.457	50.376	20.966	1658.422	0.622	37.013	20.973
	1585	736.296	0.415	55.549	20.965	1363.912	0.565	40.814	20.970
	1685	612.831	0.378	60.888	20.963	1135.206	0.515	44.737	20.968
	1785	515.496	0.347	66.388	20.962	954.904	0.472	48.778	20.967
	1885	437.730	0.320	72.045	20.962	810.849	0.435	52.934	20.965
	1985	374.851	0.296	77.853	20.961	694.373	0.403	57.202	20.964
Fiber glass	1285	11054.036	1.607	14.337	21.060	20476.461	2.187	10.534	21.148
	1385	8828.378	1.436	16.042	21.039	16353.660	1.955	11.787	21.110
	1485	7162.273	1.294	17.811	21.024	13267.373	1.761	13.086	21.081
	1585	5890.368	1.173	19.640	21.012	10911.300	1.597	14.430	21.059
	1685	4902.646	1.070	21.527	21.003	9081.646	1.457	15.817	21.042
	1785	4123.971	0.982	23.472	20.996	7639.231	1.336	17.246	21.028
	1885	3501.839	0.905	25.472	20.990	6486.796	1.231	18.715	21.018
	1985	2998.808	0.837	27.525	20.985	5554.983	1.139	20.224	21.009
Bamboo	1285	2234.297	0.723	31.888	20.978	4138.805	0.983	23.430	20.996
	1385	1784.436	0.646	35.682	20.974	3305.484	0.879	26.217	20.988
	1485	1447.675	0.582	39.616	20.971	2681.668	0.792	29.107	20.982
	1585	1190.591	0.527	43.684	20.969	2205.446	0.718	32.096	20.978
	1685	990.947	0.481	47.883	20.967	1835.628	0.655	35.181	20.975
	1785	833.558	0.441	52.208	20.965	1544.080	0.601	38.359	20.972
	1885	707.809	0.407	56.656	20.964	1311.144	0.553	41.627	20.970
	1985	606.134	0.376	61.224	20.963	1122.801	0.512	44.983	20.968

Table 3

The stiffness and the vibration amplitude for rods with d 16 and d 18 diameter

Material	Elastic	The diameter of elastic rods

	rod length [mm]	[mm]							
		d =16 I = 3217 mm^4				d = 18 I = 5153 mm^4			
		Suspending stiffness k [N/m]	Own pulsation ω [rad/s]	Pulsation ratio ω/ω_0	Vibration amplitude A_0 [mm]	Suspending stiffness k [N/m]	Own pulsation ω [rad/s]	Pulsation ratio ω/ω_0	Vibration amplitude A_0 [mm]
Boiled Beech	1285	4366.507	1.010	22.811	20.998	6994.284	1.278	18.023	21.022
	1385	3487.339	0.903	25.525	20.990	5586.031	1.142	20.168	21.009
	1485	2829.204	0.813	28.338	20.984	4531.826	1.029	22.391	21.000
	1585	2326.782	0.737	31.248	20.979	3727.047	0.933	24.690	20.992
	1685	1936.617	0.673	34.252	20.976	3102.079	0.851	27.063	20.986
	1785	1629.029	0.617	37.346	20.973	2609.384	0.781	29.508	20.982
	1885	1383.278	0.569	40.527	20.970	2215.739	0.720	32.022	20.978
	1985	1184.574	0.526	43.795	20.969	1897.453	0.666	34.603	20.975
Fiber glass	1285	34932.056	2.857	8.065	21.285	55954.270	3.616	6.372	21.487
	1385	27898.716	2.553	9.024	21.218	44688.245	3.231	7.130	21.378
	1485	22633.628	2.300	10.019	21.169	36254.612	2.910	7.916	21.298
	1585	18614.258	2.085	11.048	21.131	29816.373	2.639	8.729	21.236
	1685	15492.939	1.903	12.110	21.102	24816.635	2.408	9.568	21.189
	1785	13032.234	1.745	13.204	21.079	20875.071	2.208	10.433	21.152
	1885	11066.224	1.608	14.329	21.060	17725.911	2.035	11.321	21.123
	1985	9476.588	1.488	15.484	21.046	15179.626	1.883	12.234	21.099
Bamboo	1285	7060.642	1.284	17.938	21.023	11309.757	1.626	14.174	21.063
	1385	5639.028	1.148	20.073	21.010	9032.611	1.453	15.860	21.041
	1485	4574.822	1.034	22.285	21.000	7327.963	1.308	17.608	21.026
	1585	3762.407	0.938	24.574	20.992	6026.634	1.187	19.416	21.013
	1685	3131.510	0.855	26.936	20.987	5016.062	1.083	21.283	21.004
	1785	2634.140	0.785	29.369	20.982	4219.374	0.993	23.205	20.997
	1885	2236.761	0.723	31.871	20.978	3582.850	0.915	25.182	20.991
	1985	1915.455	0.669	34.440	20.975	3068.182	0.847	27.212	20.986

In addition, we notice that the stiffness of the suspending system decreases proportionally with increasing length of elastic rods. In Figure 3 is represented graphically the variation of vibration amplitude with diameter of elastic rod made of beech boiled for its length values.

De asemenea, observăm că rigiditatea sistemului de suspendare scade direct proporțional cu creşterea lungimii tijelor elastice. În Figura 3 este reprezentată grafic variația amplitudinii vibrației cu diametrul tijei elastice confecționată din fag fiert pentru valorile lungimii acesteia.

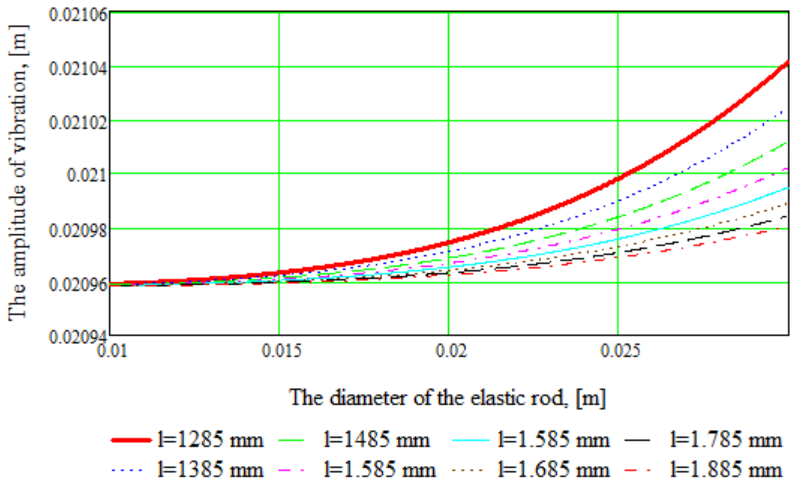


Figure 3. The variation of vibration amplitude with the diameter of elastic rod made of boiled beech for its length values

The final relation that describes the amplitude dependence of the system parameters is represented by:

Relația finală care descrie dependența amplitudinii funcție de parametrii sistemului este reprezentată de:

$$A_0 = \frac{m_0 \cdot e \cdot \omega^2}{\left| \frac{12 \cdot \pi \cdot z \cdot E \cdot d^4}{64 \cdot l^3} - (M + m_0)\omega^2 \right|} \qquad (2)$$

In Figure 4 is shown the variation of the amplitude of vibration with the length and the diameter of the elastic rod made of beech boil. The step along the length of the rod is

În figura 4 este reprezentată variația amplitudinii sitei cu diametrul şi cu lungimea tijei confecționată din fag fiert. Pasul în lungimea tijei este de 0.1 m,

0.1 m, the length considered: between 1 and 2 m. The step in the diameter of the rod is 0.001 m, the diameter considered: between 0.01 and 0.03 m.

lungimea considerată: între 1 şi 2 m. Pasul în diametrul tijei este 0.001 m, diametrul considerat: între 0.01 şi 0.03 m.

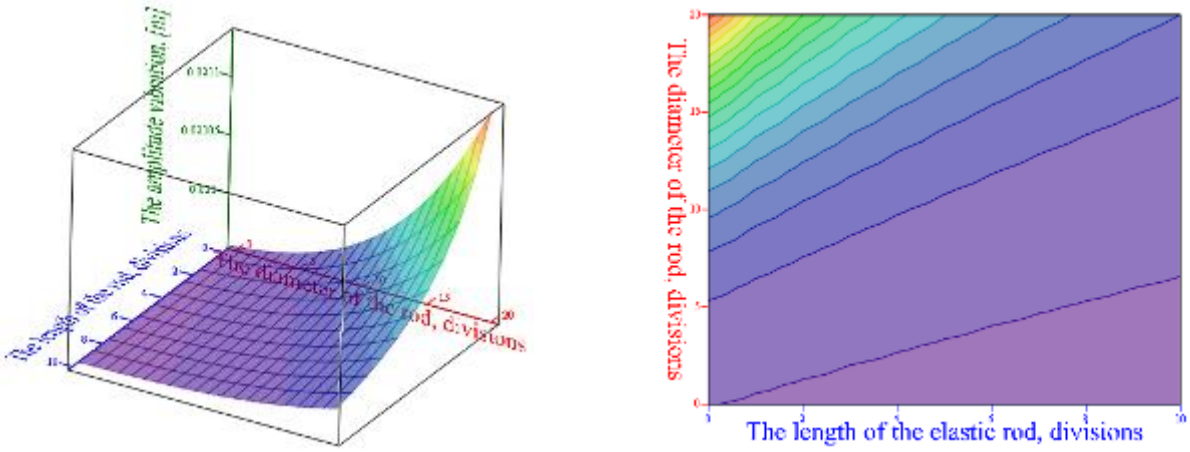


Figure 4. The variation of vibration amplitude with diameter and the length of elastic rod made of boiled beech

CONCLUSIONS

Following the results obtained it is noted that the stiffness of the elastic suspending system does not influences the radius of the circle described by the movement of the plansifter. In Figure 3 can be noted that the amplitude of vibration, remain constant around the value of 21 mm for all cases we studied. From Figure 4 is seen that the amplitude of the vibration increases with increasing the rod diameter and decreases with the length of the rod. For the model we studied is observed that each grid point of the plansifter describes a circle of radius 21 mm, which is concentric with the circle described by the movement of the vibration generator radius of 260 mm. The study establishes a dependence between the stiffness the suspending system and the circular movement described by the plansifter and provides important data on the construction of plansifter.

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CONCLUZII

În urma rezultatelor obținute se observă că rigiditatea sistemului elastic de suspendare nu influențează raza cercului descris de mişcarea circulară a sitei plane. Din Figura 3 se observă că amplitudinea vibrațiilor, rămane constantă în jurul valorii de 21 mm pentru toate cazurile studiate. Din Figura 4 se observă că amplitudinea vibrației creşte cu creşterea diametrului tijei şi scade odată cu creşterea lungimii. Pentru modelul studiat se observă ca fiecare punct al sitei plane descrie în mişcare un cerc de rază 21 mm, cerc care este concentric cu cel descris de mişcarea generatorului de vibrații cu raza de 260 mm. Studiul realizat stabileşte o dependență între rigiditatea sistemului de suspendare şi mişcarea circulară descrisă de sita plană şi furnizează date importante referitoare la construcția sitelor plane.

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CONSIDERATIONS REGARDING THE CURRENT STATE OF COUPLING DEVICES EXISTING ON THE AGRICULTURAL TRACTORS
/
CONSIDERAȚII PRIVIND STADIUL ACTUAL AL DISPOZITIVELOR DE CUPLARE EXISTENTE PE TRACTOARELE AGRICOLE

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Abstract: *Couplings are used to make the connection between self-propelled system (tirailleur) and the towed system (trailer, agricultural machine, etc.). When driving on public roads may arise clearances, frictions and forces between the hook of the coupling device and the eyelet of the towed system, due to the unevenness of the road, cornerings, level differences between the two systems, all these leading to stress and wear over time which can cause damages, deformations, and even breakage of these couplings. This paper presents current technical solutions used by the major manufacturers of tractors in the world, solutions that provide a quick coupling but mainly safety and security in transport on public roads.*

Keywords: *systems, solutions, safety, security, stress*

INTRODUCTION

The necessity to increase the transport safety and security is one of the priorities pursued at EU level and in Romania, because of the increasing number of accidents that occur annually in this domain.

the transport safety and security is one of the important directions pursued at EU level and in Romania, because of the large number of people who use the means of transportation but mainly the numerous accidents that occur annually in this domain. In this respect, Romania occupies a leading position in terms of number of accidents at 1,000 cars - almost twice the average of the EU countries [1].

In order to reduce as much as possible the injuries or death of the persons involved, besides the solutions legislative, administrative and of road traffic have been sought solutions by testing of all components that contribute to increasing the transport safety and security.

The technical and mechanical strength of the tractors, trailers and of some elements of tractors and trailers (traction devices), regarding the traffic safety on public roads in Romania and of their admission in road traffic are regulated by national and international rules such as: STAS, ISO, EEC Directives and UN ECE Regulations.

The elements of coupling between tractor and trailer are:

- the traction devices of wheeled tractors;
- the towing eyelets for biaxial or single axle trailers.

MATERIAL AND METHOD

Along the time there have been made various classifications of the coupling systems, classifications made on the basis of certain criteria considered representative of the authors in question which were based on the main technical elements which must be observed in performing a fair pairing, from the point of view of operation and compatibility, between the components of the system tractor - machine. These criteria refer mainly to the following:

- the type of trailer or machine from aggregate;

Rezumat: *Dispozitivele de cuplare sunt utilizate pentru a face legătura dintre sistemul autopropulsat (trăgător) şi sistemul tractat (remorcă, maşină agricolă, etc.). În timpul deplasării pe drumurile publice pot apărea jocuri, frecări şi forțe între cârligul dispozitivului de cuplare şi ochetul sistemului tractat, datorate denivelărilor drumurilor, virajelor, diferențelor de nivel dintre cele două sisteme, toate acestea conducând în timp la solicitări şi uzuri care pot produce deteriorări, deformări şi chiar ruperi ale acestor dispozitive de cuplare. Lucrarea de față prezintă soluții tehnice actuale utilizate de marii producători de tractoare de pe plan mondial, soluții care asigură o cuplare rapidă dar mai ales siguranța şi securitate în transport pe drumurile publice.*

Cuvinte cheie: *sisteme, soluții, siguranță, securitate, solicitări*

INTRODUCERE

Necesitatea creşterii siguranței şi securității în transport reprezintă una din prioritățile urmărite la nivelul UE şi în România, datorită numărului tot mai mare de accidente ce se produc anual în acest domeniu.

Siguranța şi securitatea în transport reprezintă una din direcțiile importante urmărite la nivelul UE cât şi în România, datorită numărului mare de persoane ce utilizează mijloacele de transport dar mai ales numeroaselor accidente ce se produc anual în acest domeniu. În acest sens, România ocupă un loc fruntaş în Europa ca număr de accidente produse la 1.000 de maşini - aproape dublul mediei țărilor din UE [1].

În vederea reducerii cât mai mult posibil a vătămările persoanelor implicate sau decesul acestora, pe lângă soluțiile de ordin legislativ, administrativ şi de circulație s-au căutat soluții, prin testarea tuturor componentelor la concură la creşterea siguranție şi securității în transport.

Condițiile tehnice şi de rezistență mecanică a tractoarelor, remorcilor şi unor elemente componente ale tractoarelor şi remorcilor (dispozitivele de tracțiune), în ceea ce priveşte siguranța circulației pe drumurile publice din România şi admiterii acestora în circulație sunt reglementate prin norme naționale şi internaționale precum: STAS, ISO, Directive CEE şi Regulamente ECE-ONU.

Elementele de cuplare dintre tractor şi remorcă sunt:

- dispozitivele de tracțiune ale tractoarelor pe roți;
- ocheții de remorcare pentru remorci biaxe sau monoaxe.

MATERIAL ŞI METODĂ

De-a lungul timpului s-au făcut diverse clasificări ale sistemelor de cuplare, clasificări efectuate pe baza anumitor criterii considerate reprezentative de autorii în cauză care au avut la bază elementele tehnice principale ce trebuie respectate la efectuarea unei cuplări corecte, din punct de vedere al funcționării şi al compatibilității, între componentele sistemului tractor –maşină. Aceste criterii se referă în principal la următoarele:

- tipul remorcii sau a maşinii din agregat;

- the type of construction and the functional dimensions of the coupling systems;
- the mounting position on tractor;
- permissible horizontal and vertical loads on the coupling systems.

RESULTS

- ***JOHN DEERE*** [1]

The tractors of *series 5* have back tie rod in three points that confers a lifting capacity of 26kN. This is achieved in two versions: category I and II allowing to the tractor to adapt to a wide variety of equipment and accessories (fig. 1).

The electronic control of the tie rod is ergonomically located The electronic control of the tie rod is ergonomically located in the front side, on the the console on the right side for quick adjustments directly on the move. The new button for fast up / down is located at the console from the right hand side.

- tipul constructiv şi dimensiunile funcționale ale sistemelor de cuplare;
- poziția de montaj pe tractor;
- sarcinile orizontală şi verticală admisibile pe sistemele de cuplare.

REZULTATE

- ***JOHN DEERE*** [1]

Tractoarele din *seria 5* au tirant spate în trei puncte ce coferă o capacitate de ridicare de 26kN. Acesta se realizează în două variante: categoria I şi II şi permite tractorului să se adapteze unei mari varietăți de utilaje şi accesorii (fig. 1).

Controlul electronic al tirantului este ergonomic situat în partea din față pe consola de pe partea dreaptă pentru ajustări rapide direct din mers. Noul buton de urcare / coborâre rapidă este localizat la consola de pe partea dreaptă.

Fig. 1 - The back coupling system at tractors John Deere Series 5

The tractors of *series 6* - have the frontal central tie rod optional with PTO, with the lifting capacity up to 4000 kg. The coupling system in three-point of these tractors offers a maximum lifting capacity of 9550 kg (fig. 2)

Characteristics of the system:

- electronic detection of the tie rod for various load situations;
- amortization of the tie rod for superior stability while driving;
- stabilizers against the balance (including hydraulic);
- iITC system for the total control of equipment;
- easy control via Command Center – the tie rod configuration withcoupling in the three points, depth, height, descent rate, sliding and dampening.

Tractoarele din *seria 6* - au tirantul central frontal, opțional cu priză de putere, cu capacitatea de ridicare de până la 4.000 kg. Sistemul de prindere în trei puncte al acestor tractoare oferă o capacitate de ridicare maximă de 9.550 kg (fig. 2)

Caracteristici ale sistemului:

- detectare electronică a tirantului pentru diferite situații de încărcare;
- amortizare a tirantului pentru o stabilitate superioară în timpul mersului;
- stabilizatori împotriva balansului (inclusiv hidraulici);
- sistem iTEC pentru controlul total al echipamentelor;
- control uşor prin CommandCenter – configurarea tirantului cu prindere în trei puncte, adâncime, înălțime, rata coborârii, alunecare şi umezire.

Fig. 2 - The back coupling system at tractors John Deere Series 6

The tractors of *series 8* (fig. 3), being high power tractors, are fitted with coupling (coupling) three-point system with a maximum lifting capacity of 12,124 kg, ideal for the works with attached equipment such as harrows, combiners, etc., completely carried.

Characteristics of the system:

- coupling systems with electronic sensors for various loading conditions;
- amortization of the coupling system to improve the travel stability;
- equilibration blocks and stabilizers of swinging for comfortable driving of the equipment;
- iTEC system technology for a total management of the attached equipment;
- the function of anticipation of load (with Auto Power).

The central tie rod of the 8R Series tractors provides a lifting capacity of up to 5200kg.

Characteristics of this system are:

- two frontal coupling devices with SCV;
- double-acting cylinders for pressure at lifting and lowering;
- switch for lifting and lowering remotely
- compatible with iTEC
- FPTO – optional front PTO.

Tractoarele din *seria 8* (fig. 3), fiind tractoare de puteri mari sunt prevăzute cu sistemu de prindere (cuplare) în trei puncte cu o capacitate de ridicare maximă de 12.124 kg, ideal pentru lucrările cu utilajele ataşate precum grape, combinatoare,e tc., complet purtate.

Caracteristici ale sistemului:

- sisteme de prindere cu senzor electronic pentru diverse condiții de încărcare;
- amortizarea sistemului de prindere pentru îmbunătățirea stabilității la deplasare;
- blocuri de echilibrare şi stabilizatori la balansare pentru ca dumneavoastră să conduceți liniştiți;
- tehnologie cu sistem iTEC pentru un management total al utilajelor ataşate;
- funcția de anticipare a Încărcăturii (numai cu AutoPower).

Tirantul central al tractoarelor din Seria 8R asigură o capacitate de ridicare de până la 5200 kg.

Caracteristicile acestui sistem:

- două dispozitive de cuplare frontale cu SCV;
- cilindri cu acțiune dublă pentru presiune la ridicare şi coborâre;
- comutator de ridicare şi coborâre de la distanță
- compatibil cu iTEC
- FPTO – priză de putere frontală opțională.

Fig. 3 - The back coupling system of tractors John Deere Series 8

Seria 9 (fig. 4) permite la alegere opțiuni multiple pentru bara de tracțiune, sistemul de prindere (cuplare) în 3 puncte şi priza de putere spate, pentru a obține forța şi versatilitatea de care este nevoie pentru a tracta sau ridica echipamente agricole grele.

Sistemul de prindere în trei puncte al acestei serii este de tip cu cuplare rapidă, având o capacitate de ridicare: 6.800 ÷ 9.070 kg.

Barele de tracțiune sunt disponibile în diferite opțiuni din categoria IV şi V, pentru a acoperi toate cerințele de bare de tracțiune: de la bare de tracțiune de capacitate mare la cele cu sau fără balansare.

PTO - priza de putere independentă (1000 rot^{-1}) este acum disponibilă opțional la toate tractoarele din Seria 9R.

Seria 9 (fig. 4) permite la alegere opțiuni multiple pentru bara de tracțiune, sistemul de prindere (cuplare) în 3 puncte şi priza de putere spate, pentru a obține forța şi versatilitatea de care este nevoie pentru a tracta sau ridica echipamente agricole grele.

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PTO - priza de putere independentă (1000 rot^{-1}) este acum disponibilă opțional la toate tractoarele din Seria 9R.

Fig. 4 - The back coupling system of tractors John Deere, seria 9 [1]

- ***CLASS*** [2]

Dispozitivele de cuplare cu care sunt echipate tractoarele din seriile AXION, XERION, ARION (fig. 5), prezintă următoarele caracteristici:

- capacitate maximă de ridicare de 11.000 kg, permițând ataşarea celor mai grele utilaje;
- tiranți laterali cu sistem de cuplare, cat. III sau IV;
- tirant central mecanic sau hidraulic, cat. III sau IV;
- stabilizatoare cu acționare manuală sau automată pentru ambii tiranți laterali;
- funcție de control al patinării roților;

comenzi externe pe ambele apărătoare de noroi.

- ***CLASS*** [2]

Dispozitivele de cuplare cu care sunt echipate tractoarele din seriile AXION, XERION, ARION (fig. 5), prezintă următoarele caracteristici:

- capacitate maximă de ridicare de 11.000 kg, permițând ataşarea celor mai grele utilaje;
- tiranți laterali cu sistem de cuplare, cat. III sau IV;
- tirant central mecanic sau hidraulic, cat. III sau IV;
- stabilizatoare cu acționare manuală sau automată pentru ambii tiranți laterali;
- funcție de control al patinării roților;
- comenzi externe pe ambele apărătoare de noroi.

Fig. 5 - The back coupling system of tractors CLAAS [2]

- ***NEW HOLLAND*** [3]

Dispozitivele de cuplare cu care sunt echipate tractoarele din seriile T5, T6, T7, T8, T9 (fig. 6), prezintă următoarele caracteristici:

- ridicator hidraulic, cat II/III;
- capacitate ridicator hidraulic la capatul tirantilor: maxim 7.864 kg;
- 2 cilindri de ridicare cu diametrul de 90 mm;
- bara tractiune;
- stabilizatoare laterale cu reglare mecanica; cupla remorcare;
- control electronic de forta si pozitie.

- ***NEW HOLLAND*** [3]

Dispozitivele de cuplare cu care sunt echipate tractoarele din seriile T5, T6, T7, T8, T9 (fig. 6), prezintă următoarele caracteristici:

- ridicator hidraulic, cat II/III;
- capacitate ridicator hidraulic la capatul tirantilor: maxim 7.864 kg;
- 2 cilindri de ridicare cu diametrul de 90 mm;
- bara tractiune;
- stabilizatoare laterale cu reglare mecanica; cupla remorcare;
- control electronic de forta si pozitie.

Fig. 6 - Sistemul de cuplare spate la tractoarele NEW HOLLAND [3]

- ***FENDT*** [4]

Dispozitivele de cuplare cu care sunt echipate tractoarele din seriile VARIO 200, VARIO 300, VARIO 500, VARIO 700, VARIO 800, VARIO 900 (fig. 7), prezintă următoarele caracteristici:

- ***FENDT*** [4]

Dispozitivele de cuplare cu care sunt echipate tractoarele din seriile VARIO 200, VARIO 300, VARIO 500, VARIO 700, VARIO 800, VARIO 900 (fig. 7), prezintă următoarele caracteristici:

- ridicător spate cu commandă EHR, sistem de prindere în trei puncte cu cuplă rapidă;
- cuplă de remorcare automată;
- bară de tracţiune;
- priză de putere 540 / 1000 [rot^{-1}].

- ridicător spate cu commandă EHR, sistem de prindere în trei puncte cu cuplă rapidă;
- cuplă de remorcare automată;
- bară de tracţiune;
- priză de putere 540 / 1000 [rot^{-1}].

Fig. 7 - The back coupling system of tractors FENDT [4]

- ***MASSEY FERGUSON*** [5]

Ca inovator al ridicătorului în trei puncte cu capabilități hidraulice şi de putere, sistemele MF îndeplinesc şi depăşesc exigențele utilajelor moderne. Fiind parte integrantă a conceptului Massey Ferguson, sistemul de ridicare în trei puncte (fig. 8) reprezintă de mai bine de 75 de ani cel mai bun exemplu de productivitate, putere şi capacitate de răspuns în slujba operatorului de pe camp.

Caracteristicile sistemului:

- ridicător spate pentru regim greu cu o capacitate între 1500 ÷ 12 000 kg. Designul ridicătorului spate şi constituția structurală a tractorului sunt concepute pentru a purta echipamente grele, cu o pereche de cilindri de ridicare externi şi o pereche de stabilizatoare telescopice cu flotație variabilă. Cuplele rapide cu sistem de decompresie sunt o dotare standard, la fel şi comenzile externe ale ridicătorului şi valvelor (sunt disponibile în total 6 valve distribuitoare.);
- în față, opțional se poate monta un ridicător frontal complet integrat cu o capacitate de până la 5 000 kg conceput pentru a fi compatibil cu suspensia față Massey Ferguson, cu două valve distribuitoare dublu direcționale şi o linie de retur liber;

cuplele de ataşare spate au o gamă la alegere de Piton-fix, dispozitiv de agățare şi ridicare, cap furcă de remorcare, bilă K80 sau bară de tracțiune, reproiectată în întregime pentru a face cuplarea mai rapidă, mai uşoară şi mai sigură. Designul ISO al cuplelor este compatibil cu o gamă largă de capete de furcă şi bare de tracțiune alternative, în funcție de piețe.

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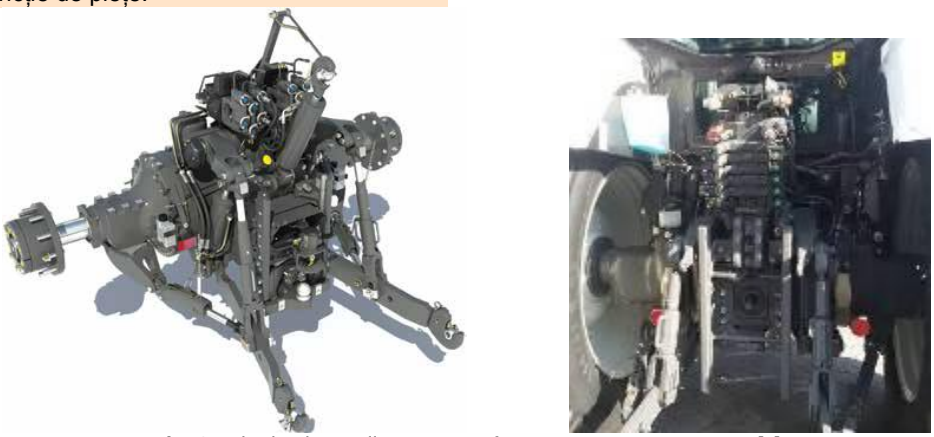

Fig. 8 - The back coupling system of tractors Massey Ferguson [5]

- ***VALTRA*** [6]

Dispozitivele de cuplare cu care sunt echipate

- ***VALTRA*** [6]

Dispozitivele de cuplare cu care sunt echipate

tractoarele din seriile seria A, N, T, S (fig. 9), prezintă următoarele caracteristici:

- cuplă de remorcare rapidă;
- triunghi de prindere cat. II cu cuplă rapidă;
- ridicător spate cu comandă mecanică;
- priză de putere frontală, priză hidraulică frontală;
- cuplă de remorcare inclusiv suport;
- bară de tracțiune;
- ridicător spate cu comandă electrică Slip Control ACD

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- cuplă de remorcare inclusiv suport;
- bară de tracțiune;
- ridicător spate cu comandă electrică Slip Control ACD.

Fig. 9 - The back coupling system of tractors VALTRA [6]

- ***DEUTZ – FAHR*** [7]

Dispozitivele de cuplare cu care sunt echipate tractoarele din seriile 5000, AGROTRON, AGROFARM (fig. 10), prezintă următoarele caracteristici:

- sistem de ridicare în trei puncte cu control electrohidraulic şi stabilizatori telescopici;
- cuplă remorcare spate categoria "C" cu reglare rapidă;
- cuplă remorcare față;
- bară de remorcare şi sistem de ridicare Sauermann;
- capacitate de ridicare între 3000 – 10000 kg.

- ***DEUTZ – FAHR*** [7]

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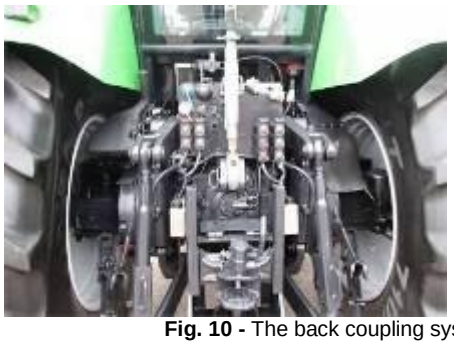

Fig. 10 - The back coupling system of tractors Deutz-Fahr [7]

- ***CASE-IH*** [8]

Dispozitivele de cuplare cu care sunt echipate tractoarele din seriile MAGNUM, PUMA, STEIGER & QUADTRAC, FARMALL, QUANTUM (fig. 11), prezintă următoarele caracteristici:

- cârlig şi bară de tracțiune pentru tractări grele
- sistem automat pentru reglare a înălțimii cârligului de de tracțiune funcție de sarcina tractată.

- ***CASE-IH*** [8]

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- sistem automat pentru reglare a înălțimii cârligului de de tracțiune funcție de sarcina tractată.

Fig. 11 - The back coupling system of tractors CASE-IH [8]

- ***ZETOR*** [9]

Dispozitivele de cuplare cu care sunt echipate tractoarele din seriile PROXIMA, MAJOR, FORTERRA, CRYSTAL (fig. 12), prezintă următoarele caracteristici:

- funcția "zăvor" hidraulic permite un transport sigur a agregatelor;
- cuplare şi asigurare rapidă a agregatelor;
- comenzi mecanice care asigura o fiabilitate şi durată de funcționare îndelungată;
- capacitate de ridicare mare; robinet de reglare a vitezei de coborâre cu functia "zăvor" hydraulic;
- terminația bratelor de cidicare de tip "cioc" permite o cuplare usoara a agregatelor.

- ***ZETOR*** [9]

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Fig. 12 - The back coupling system of tractors ZETOR [9]

- ***KUBOTA*** [10]

Dispozitivele de cuplare cu care sunt echipate tractoarele din seriile BX, B, L M (fig. 13), prezintă următoarele caracteristici:

- bară de tracțiune
- cârlig de remorcare de până la 3.300 kg
- sistem de prindere în 3 puncte cu capacitate de tracțiune de până la 3.300 kg.

- ***KUBOTA*** [10]

Dispozitivele de cuplare cu care sunt echipate tractoarele din seriile BX, B, L M (fig. 13), prezintă următoarele caracteristici:

- bară de tracțiune
- cârlig de remorcare de până la 3.300 kg
- sistem de prindere în 3 puncte cu capacitate de tracțiune de până la 3.300 kg.

Fig. 13 - The back coupling system of tractors KUBOTA [10]

- ***GOLDONI*** [11]

Dispozitivele de cuplare cu care sunt echipate tractoarele din seriile RONIN, STAR, QUASAR, ENERGY (fig. 14), prezintă următoarele caracteristici:

- ridicător posterior hidraulic cu poziție şi forță controlată (1600 kg la capătul brațelor);
- brațe ridicătoare şi tiranți stabilizatori cu cuplare în 3 puncte;

- ***GOLDONI*** [11]

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- cârlig de remorcare posterior;
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Fig. 14 - The back coupling system of tractors GOLDONI [11]

- ***STEYR*** [12]

Dispozitivele de cuplare cu care sunt echipate tractoarele din seriile KOMPAKT, PROFI, MULTI, CVT, THE NEW CVT prezintă următoarele caracterisitci:

- sistem de ridicare in trei puncte;
- bară de remorcare;
- sistem dinamic de control şi reducere a vibraţiilor.

- ***STEYR*** [12]

Dispozitivele de cuplare cu care sunt echipate tractoarele din seriile KOMPAKT, PROFI, MULTI, CVT, THE NEW CVT prezintă următoarele caracterisitci:

- sistem de ridicare in trei puncte;
- bară de remorcare;
- sistem dinamic de control şi reducere a vibraţiilor.

Fig. 15 - The back coupling system of tractors STEYR [12]

- ***MAT SA Craiova*** [13]

Dispozitivele de cuplare cu care sunt echipate tractoarele din seriile MAT 8100 şi MAT 546 DT (fig. 16), prezintă următoarele caracteristici:

- mecanism de suspendare în trei puncte acţionat hidraulic,
- cu dispozitiv inferior de tracţiune,
- cu dispozitiv inferior de cuplare remorci monoax.

- ***MAT SA Craiova*** [13]

Dispozitivele de cuplare cu care sunt echipate tractoarele din seriile MAT 8100 şi MAT 546 DT (fig. 16), prezintă următoarele caracteristici:

- mecanism de suspendare în trei puncte acţionat hidraulic,
- cu dispozitiv inferior de tracţiune,
- cu dispozitiv inferior de cuplare remorci monoax.

Fig. 16 - The back coupling system of tractors MAT SA Craiova [13]

- ***IRUM Reghin*** [14]

Dispozitivele de cuplare cu care sunt echipate tractoarele din seria TAG (fig. 17), prezintă următoarele

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- instalația hidraulică dispune de control automat de forță şi poziție.

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Fig. 16 - The back coupling system of tractors IRUM Reghin [14]

CONCLUSIONS

În momentul de față toți marii producători mondiali de tractoare agricole (surse energetice), caută soluții pentru cuplarea maşinilor agricole, remorci, etc., cât mai rapidă, uşoară şi sigură.

Legătura între agregatul format din tractor - maşină agricolă se realizează prin sisteme (dispozitive) mecanice care au o importanţă deosebită pentru siguranţa traficului pe drumurile publice. O problemă apărută la acest sistem (ruperea acestuia) poate cauza accidente de circulaţie, vehiculul remorcat rămânând fără control şi poate intra în coliziune cu alte vehicule din trafic sau cu alte obstacole întâlnite în cale.

De asemenea sistemele de cuplare de pe tractoare, remorci şi echipamente destinate să lucreze în domeniul agricol trebuie executate conform aceloraşi cerințe şi standarde, astfel încât să existe posibilitatea de cuplare a tuturor maşinilor existente pe piaţă, la diferite tractoare.

Acknowledgement

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Mulțumiri/Recunoştință

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THE STUDY OF SOME DEFINITORY CHARACTERISTICS FOR SPECIFIC PHENOMENA OF LUBRICATING PROCESS IN TRACTOR COMPRESSION IGNITION ENGINE
/
STUDIUL UNOR CARACTERISTICI DEFINITORII PENTRU FENOMENE SPECIFICE PROCESULUI DE UNGERE DIN MOTOARELE CU APRINDERE PRIN COMPRIMARE ALE TRACTOARELOR

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Abstract: *Engine lubricating system plays an important role in developing some of its operating performances. Operational economy and performances of compression ignition engines relates to the working quality of lubricating system. The present article analyses the mathematical models of important phenomena from lubricating process. Compression ignition engine lubrication has a major role in influencing all sequences of the operation cycle and the components life span. Some of the particular phenomena which characterisis the lubricating process have a significant influence upon the engine durability and indirectly on pollution. Environmental issue and products durability are significant aspects in the present days. Our life is in a specific relation with the environment and modern products. The present analyzing article shows the influence of component manufacturing quality, fuel type and other essential aspects upon the compression ignition engine lubrication process through mathematical models. It is real that there are many important factors which significantly influence the quality of the lubricating process. In this paper are presented the mathematical models and graphs of some important factors that influence the lubricating process in various situations, determined by complex analyze of available data.*
Keywords: *engine, lubrication, viscosity, durability, wearness.*

Rezumat: *Sistemul de ungere al motorului îndeplineşte un rol important în dezvoltarea unora dintre performanțele sale operaționale. Economia şi performanțele funcționale ale motoarelor cu aprindere prin comprimare depind de calitatea funcționării sistemului de ungere. Prezentul articolul analizează modelele matematice ale fenomenelor esențiale din procesul de ungere. Ungerea motorului are un rol major în influențarea tuturor etapelor ciclului de funcționare şi fiabilitatea pieselor. Unele fenomene particulare ce caracterizează procesul de lubrifiere au o influență semnificativă asupra durabilității motorului şi indirect asupra poluării. Problema mediului şi durabilitatea produselor sunt aspecte semnificative în prezent. Viața omului este într-o relație particulară cu mediul şi produsele moderne. Prezentul articol de analiză arată influența calității de manufacturare a produselor, a tipului de combustibil şi a altor aspecte esențiale asupra procesului de ungere în motorul cu aprindere prin comprimare prin modele matematice. E real că sunt mulți factori importanți care influențează semnificativ calitatea procesului de ungere. În acest articol sunt prezentate modelele matematice şi graficele unor factori importanți care marchează procesul de ungere în condiții diverse, determinate de o analiză complexă a datelor disponibile.*
Cuvinte cheie: *motor, ungere, viscositate, durabilitate, uzură.*

INTRODUCTION

Engine lubrication, lubricant and fuel type, chemical and physical effects, combustion process and residual products have a significant influence on the components durability and wearness (Fig. 1) as long as there are some mechanical efforts. Today engines are hardly exploited in various operating conditions that suppose the continous action of mechanical, chemical and tribologic efforts on the static and moving components at different temperature levels. Their wearness development speed determines the exploitaition costs and finally the business outcome.

INTRODUCERE

Lubrifierea motorului, tipul uleiului şi al combustibilului, efectele fizico-chimice, arderea şi produsele reziduale au o influență semnificativă asupra durabilității şi uzurii componentelor (Fig. 1) atât timp cât există anumite solicitări mecanice. Motoarele actuale sunt intens exploatate în condiții variate de regim care presupun acțiunea continuă a eforturilor mecanice, chimice şi tribologice asupra pieselor fixe şi mobile la diferite valori ale temperaturii. Ritmul apariției uzurii lor influențează costurile de exploatare şi apoi profitul muncii.

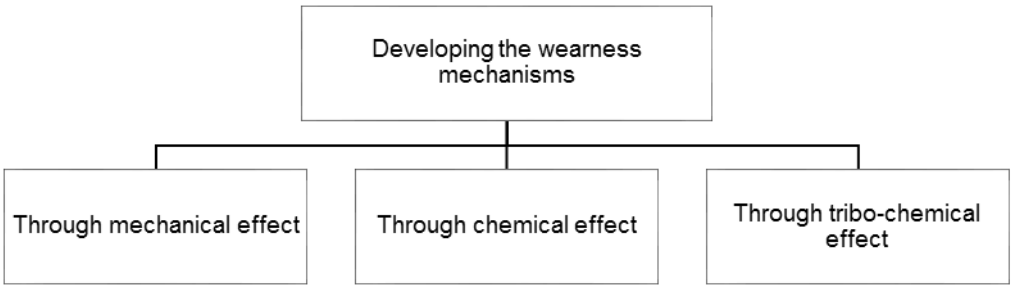

Fig. 1 – Synoptic view of wearness development

RESEARCH METHODOLOGY

Common characteristics [1][2] of various wearness mechanisms consist on one hand in the mechanical effects developed in highly tensioned separation zones, where tiredness effects and material transfer appear and on the other hand chemical and tribo-chemical effects

METODOLOGIA CERCETĂRII

Caracteristicile [1][2] comune diverselor mecanisme de uzură constau pe de o parte în efectele mecanice produse în zonele de separație puternic tensionate, unde apar efecte de oboseală, de smulgere sau transfer de material, iar pe de altă parte în efectele chimice sau tribo-chimice manifestate

materialized through consumption or material transfer due to some specific processes [3]. In general the causes for early replacement of a component are the many types of wearness, from which a single one has a capital importance. The main wearness types (Fig. 2) are related to main producing mechanism [4][6]. All mathematical models developed in the research are presented synthetically to validate the lubrication theories in the engines field.

prin consum sau transformări de material datorită unor procese specifice [3]. În general cauzele pentru înlocuirea prematură a unor piese sunt multiplele forme de uzare dintre care una este de o importanță decisivă. Principalele procese de uzură (Fig. 2) se grupează în funcție de mecanismul preponderent de producere [4][6]. Toate modelele matematice dezvoltate în cadrul cercetării sunt prezentate sintetic pentru a fundamenta teoriile lubrifierii în domeniul motoarelor.

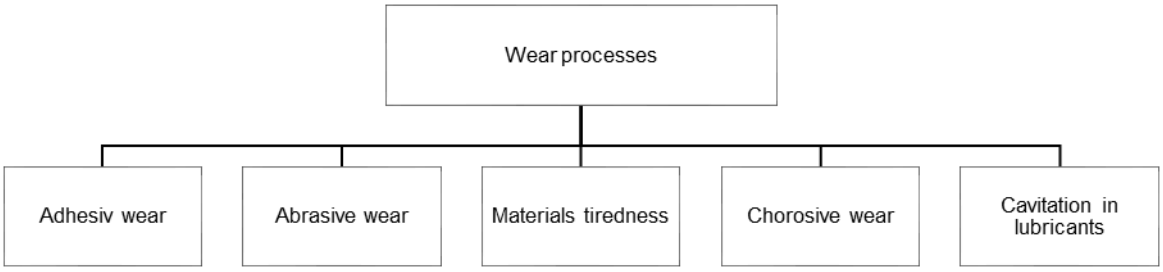

Fig. 2 - Process types of components wearness

Between the engine moving components, the wearness of cylinder-piston-piston rings assembly, bearings, valves and timing system presents the most importance. Wearing and deteriorating too much of some of these components, for exemple the cylinder-piston-piston rings assembly, influences the engine operation, meanwhile, the bearings or valves, make it imposible [3][4]. Manufacturing characteristics, operating parameters of I.C. engines and the various features their lubricants should manifest, impose the establishment of some correlations between all these parameters and oil's phisico-chemical properties and its operational properties [5].

The analytical research methodology develops on four pre-established phases of applied study (Fig. 3).

Dintre piesele în mişcare ale motorului, uzarea cuplului cilindru-piston-segmenți, a lagărelor, a supapelor şi a sistemului de distribuție prezintă cea mai mare importanță. Defectarea şi uzarea prea mare a unora dintre aceste piese, de exemplu a cuplului cilindru-piston-segmenți, înrăutățeşte funcționarea motorului, în timp ce altele, cum sunt lagărele sau supapele, o fac imposibilă [3][4]. Caracteristicile constructive, parametrii funcționali ai motoarelor termice şi diversele funcțiuni pe care trebuie să le îndeplinească lubrifianții acestora impun stabilirea unor corelații între toți aceşti parametri şi proprietățile fizico-chimice şi funcționale ale uleiurilor [5].

Metodologia cercetării analitice se dezvoltă pe patru faze prestabilite de studiu aplicat (Fig. 3).

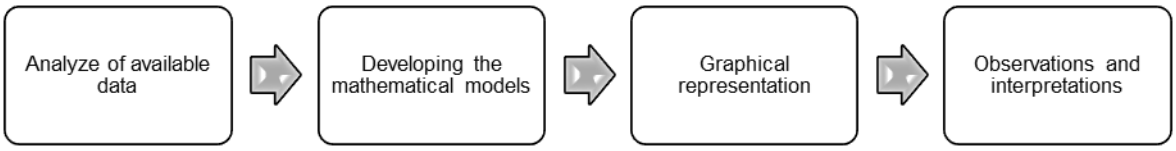

Fig. 3 - Methodology of the applied study

In the research first step there were analized the available data in order to bring up the valid information for developing the mathematical models. For this reason there were studied the specific references and available empirical data concerning the studied subject.

In the second step of the study all the analyzed data were properly related in order to develop the most accurate mathematical models that describe the variation of wearness in distinct operating situations.

Third step shows the graphic representations that can be drawn on the basis of developed mathematical models. There have been represented the wearness indicator, the lubricant impurification level, viscosity indicator, as well as cylinder wearness value.

The final step of analytic inquiry consists in developing the proper observations and final conclusions concerning the mathematical models and graphical representations.

ANALYZE OF THE MATHEMATICAL MODELS

In this section of the scientific inquiry are analized the developed mathematical models which are characteristic to the lubrification process. In table 1 are presented the empirical data concerning the lubricating system of a compression ignited engine of 4500 cm^3 volumetric capacity.

În primul pas al cercetării au fost analizate datele disponibile în vederea scoaterii în prim plan a informațiilor valide pentru dezvoltarea modelelor matematice. Pentru acest motiv au fost studiate referințele bibliografice specifice şi datele empirice disponibile privitoare la subiectul în cauză.

În al doilea pas al studiului toate datele analizate au fost corelate adecvat pentru a putea dezvolta modelele matematice cât mai exacte care să exprime variația nivelului de uzură în diferite condiții de funcționare.

Al treilea pas al cercetării arată reprezentările grafice care pot fi trasate pe baza modelelor matematice dezvoltate. Au fost reprezentate indicatorul de uzură, nivelul de impurificare a uleiului, indicatorul de viscozitate, precum şi nivelul de uzură a cilindrului.

Ultimul pas al studiului analitic constă în elaborarea observațiilor corespunzătoare şi a concluziilor finale cu privire la modelele matematice şi reprezentările grafice

ANALIZA MODELELOR MATEMATICE

În această secțiune a demersului ştiințific sunt analizate modelele matematice dezvoltate ce caracterizează procesul de lubrifiere. În tabelul 1 sunt prezentate datele empirice privitoare la sistemul de ungere al unui motor cu aprindere prin comprimare de 4500 cm^3 capacitate cilindrică.

Table 1

Empirical data concerning the analyzed lubricating system

Measure	Symbol /	U.M.	Pump operational regime									
			1	2	3	4	5	6	7	8	9	10
Rotation speed	n	rot/min	500	1000	1500	2000	2500	3000	3500	4000	4500	5000
Pump dimensions	d	mm	38,85									
	b	mm	29,5									
	h	mm	8,65									
Pump eficiency	η_p	-	0,8									
Pump mechanical eficiency	η_{mp}	-	0,8									
Intake pressure	p_i	daN/cm^2	1,1									
Output pressure	p_e	daN/cm^2	5									
Pressure diference	Δ_p	daN/cm^2	4									
Calculated lubricant flow	D_u	l/min	12,5	24,9	37,3	49,8	62,2	74,7	87,2	99,6	112	125
Power consumption of the pump	P_{pu}	W	4,1	8,3	12,4	16,6	20,7	24,9	29	33,2	37,3	41,6

The analyze through calculus of lubricating system is realised through different modeling sequences. Knowing the lubricant flow in a sleave bearing D_{ul} from the sleave bearing calculus, it may be determined the lubricant flow for operation of a specific number „f" of crank shaft bearings $D_{ua}=f \cdot D_{ul}$. Lubricant flow in all bearings is aproximately 15÷50% of lubricant flow D_{um} which pass through lubricant main rail; the upper limit is applied to the supercharged engine, with cooled pistons. Results that the lubricant flow which passes the main rail is given by:

Analiza prin calcul a sistemului de ungere se realizează prin secvențe diferite de modelare. Cunoscând debitul de ulei printr-un lagăr de alunecare D_{ul} din calculul lagărului se determină debitul de ulei pentru ungerea unui număr „f" de fusuri ale arborelui cotit $D_{ua}=f \cdot D_{ul}$. Debitul de ulei în fusuri este aproximativ de 15÷50% din debitul de ulei D_{um} care trece prin magistrala de ulei; limita superioară se aplică la motoarele supraalimentate, cu pistoane răcite. Rezultă că debitul de lubrifiant care circulă prin rampa magistrală este date de relația:

$$D_{um} = (2 \div 7) D_{ua} \tag{1}$$

and lubricant flow delivered by pump D_u is amplified because a part of it passes the safety valves, being expressed by the relation:

iar debitul livrat de pompa de ulei D_u se amplifică întrucât o parte din ulei trece prin supapele de siguranță, fiind exprimat prin relația:

$$D_u = (1{,}5 \div 2{,}5) D_{um} \tag{2}$$

Operational eficiency of lubricating system may be apreciated also through the level of heat exchange or through the thermal transfer realized by the lubricant in the engine operational interval. The cooling feature of the engine lubricating system has a crucial influence upon the engine general performances, as well as on its using limits or conditions.

With the aid of available mathematical aparatus (polynomial equation) was developed a calculus model for determining the minimum posible piston diameter which are cooled with oil from the lubrication system (rel. 3) and on the other hand has been proposed a model for estabishing the maximum posible piston diameter for non-cooled operation with lubricant (rel. 4), depending on the brake mean effective pressure.

Eficiența operațională a sistemului de ungere poate fi definită şi prin nivelul schimbului de căldură sau prin transferul termic realizat de către acesta în timpul funcționării motorului. Funcția de răcire a sistemului de ungere al unui motor are o influență determinantă asupra performanțelor generale ale motorului, precum şi asupra limitelor sau condițiilor de utilizare ale acestuia.

Cu ajutorul aparatului matematic disponibil (ecuația polinomială) s-a construit un model de calcul pentru determinarea diametrului minim posibil al pistoanelor care sunt răcite cu ulei din sistemul de ungere (rel. 3) iar pe de altă parte s-a propus un model pentru stabilirea diametrului maxim posibil al pistoanelor care pot funcționa fără a fi răcite cu lubrifiant (rel. 4), în funcție de presiunea medie efectivă din cilindru.

$$D_{racit}^{min} = 1{,}97 p_e^2 - 62{,}8 p_e + 590{,}43 \text{ [mm]}. \tag{3}$$

$$D_{neracit}^{max} = 1{,}26 p_e^2 - 46{,}1 p_e + 544{,}12 \text{ [mm]}. \tag{4}$$

In figure 4 are presented the data concerning protection level variation depending on the surface condition and in figure 5 are expressed the values of the medium level of wearness measured in micrometers depending on the biodiesel content (rape methyl ester) [3][4][5].

There may be seen that engine lubrication is better when the lubricant film is higher than 8 micrometers and also when the biodiesel content is greater than 5%.

In figura 4 sunt reprezentate datele privitoare la variația nivelului de protecție în funcție de starea suprafeței iar în figura 5 sunt exprimate valorile nivelului mediu de uzură măsurat în micrometri în funcție de conținutul de biodiesel (metil ester de rapiță) [3][4][5].

Se poate observa că sistemul de ungere al motorului este mai bun când filmul de ulei depăşeşte 8 microni şi de asemenea când conținutul de biodiesel depăşeşte 5%.

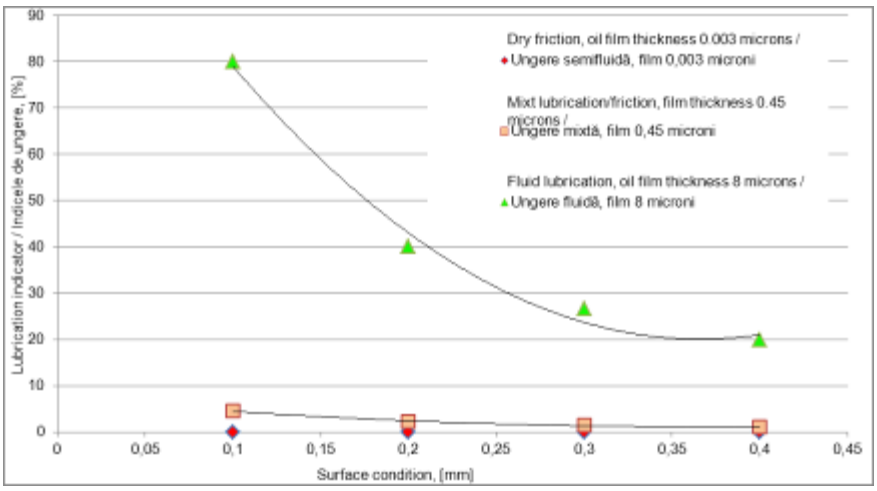

Fig. 4 - Variation of protection indicator/Variatia indicatorului de protectie

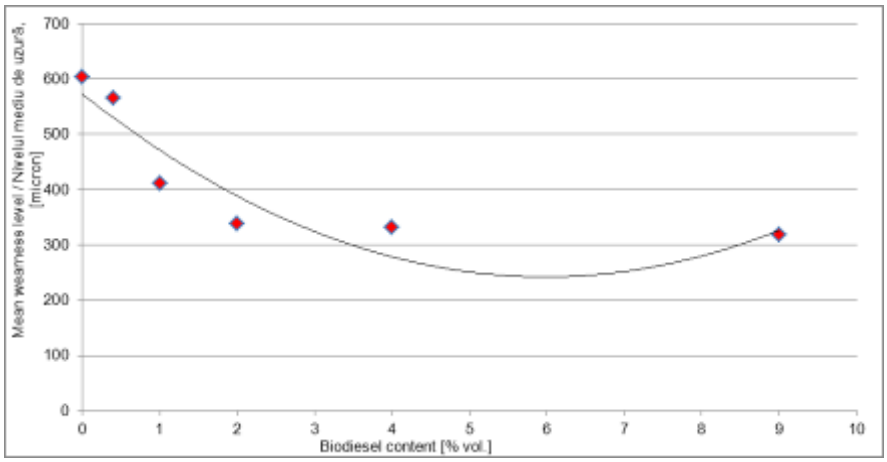

Fig. 5 – Variation of mean wearness level versus biodiesel content/Variatia nivelului mediu de uzura in functie de continutul de biodiesel

In the figure 6 are synthesized the specific values of cylinder wearness versus cylinder hight in two cases of operation after 1200 hours and 1700 hours, showing that the first interval has a greater influence on surface quality.

In the figure 7 is shown the viscosity index variation for two lubricant types produced from distinct sources.

În figura 6 sunt sintetizate valorile specifice ale uzurii cilindrului raportată la înălțimea acestuia în două cazuri funcționale după 1200 ore şi după 1700 ore, arătând că primul test are o influență mărită asupra calității suprafeței.

În figura 7 este prezentată variația indicelui de viscozitate pentru două tipuri de lubrifiant din surse diferite.

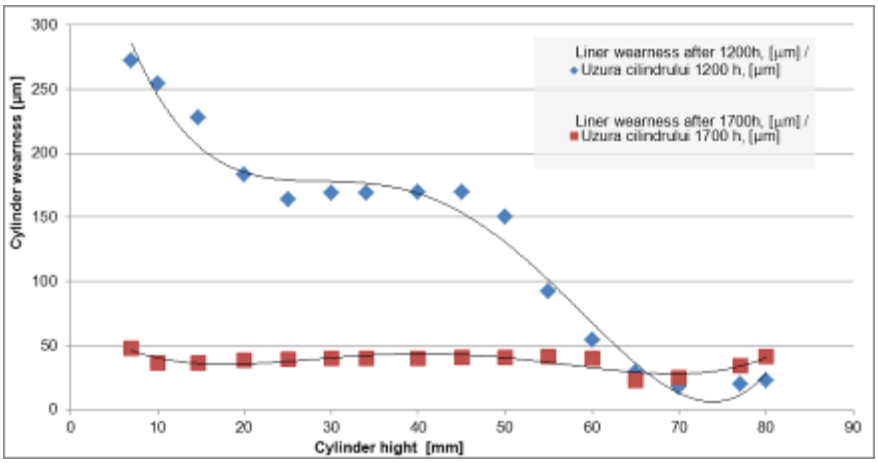

Fig. 6 - Research results synthesis of both tests /Rezultatele sintetizate pentru ambele teste

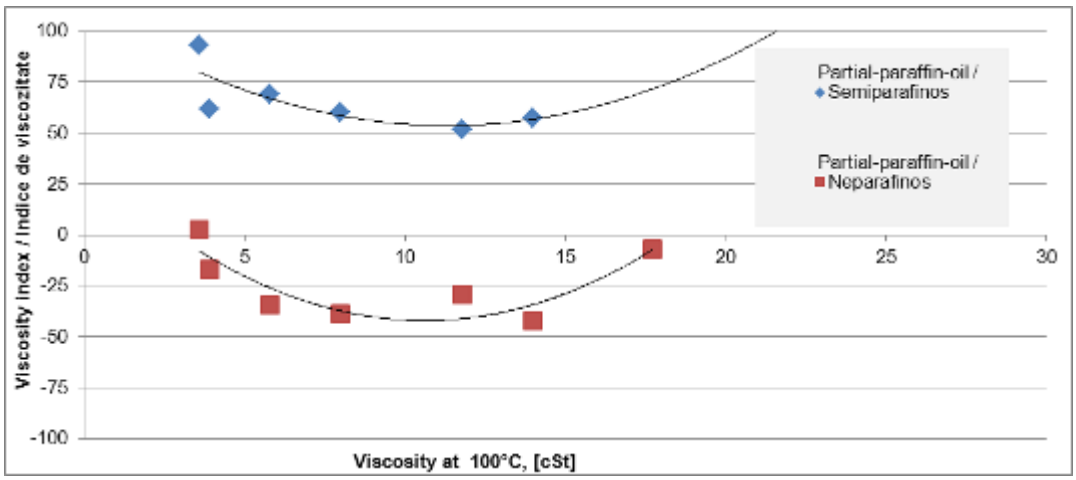

Fig. 7 – Variation of viscosity index versus the viscosity at 100°C / Variatia indicelui de viscozitate functie de viscozitatea efectiva la 100°C

Analyzing the variation curves of cylinder wearness it may be pointed out that the first operation interval is more influential then the 1700 hour period, because the in the second interval the operation time consists only in 500 hours and the wearness level is stabilized compared with the initial surface condition.

Variation of viscosity index shows that the non-paraphin lubricant has the lowest index at 10 cSt viscosity.

The mathematical aparatus developed for determining the semifluid lubricating index calculated on the basis of surface quality is given by relation (5):

Analizând variația curbelor de uzură a cilindrului poate fi arătat că primul interval de funcționare este mult mai important decât perioada după 1700 de ore, deoarece al doilea interval de lucru constă doar în 500 de ore şi nivelul de uzură este stabilizat comparative cu starea inițială a suprafeței.

Variația indicelui de viscozitate arată că lubrifiantul non parafinos are valoarea minimă la o viscozitate de 10 cSt.

Aparatul matematic dezvoltat pentru determinarea indicelui de ungere semifluidă calculat pe baza calității suprafeței este dat de relația (5):

$$I_u^s = 0{,}31 \cdot R_s^2 - 0{,}23 \cdot R_s + 0{,}05\ [\%]. \qquad (5)$$

where: I_u^s is the semifluid lubrication index;

R_s - surface rugosity.

Establishing the development tendency of protecting layer in the mixt lubrication process of engine parts through the condition perspective of their surface rugosity by the polynomial operators related with the specific phenomena is realized in the ecaution (6):

unde: I_u^s este indicele de lubrifiere semifluidă;

R_s - rugozitatea suprafeței.

Stabilirea tendinței de dezvoltare a stratului protector în procesul de lubrifiere mixtă a pieselor motorului din perspectiva stării de rugozitate a suprafețelor acestora prin intermediul operatorilor polinomiali corelați cu particularitatea fenomenului se realizează prin ecauția (6):

$$I_u^m = 46{,}9 R_s^2 - 34{,}3\, R_s + 7{,}4\ [\%]. \qquad (6)$$

where: I_u^m is the mixt lubrication index.

The tendency of fluid lubrication correlated with oil film on surface and rugosity is given by the relation (7):

unde: I_u^m este indicele de lubrifiere mixtă;

Tendința lubrifierii fluide corelată cu pelicula de ulei superficial şi rugozitatea este dată de relația (7):

$$I_u^f = 833{,}3 \cdot Rs2 - 610 \cdot R_s + 131{,}7\ \ [\%]. \qquad (7)$$

where: I_u^f is the fluid lubrication index.

The evolution of wearness mean level recorded in dependence with the biodiesel content is determined at the field limit by an equation like (8):

unde: I_u^f este indicele de lubrifiere fluidă;

Evoluția nivelului mediu de uzură înregistrat în funcție de conţinutul de biodiesel se determină la limita domeniului de variație printr-o ecuație de forma (8):

$$U_B = 9{,}25 \cdot B^2 - 110{,}69 \cdot B + 573{,}08\ [\mu m]. \qquad (8)$$

where: U_B is the wearness mean level in case of using biodiesel;

B - biodiesel content.

The wearness level in the first phase of testing follows a specific tendency described by forth degree polinomial

unde: U_B este nivelul mediu de uzură în cazul utilizării biodieselului;

B - conținutul de biodiesel.

Nivelul de uzură în prima etapă a testării variază după o tendință specifică exprimată prin ecuația polinomială de

ecuation, related with the cylinder hight (9):

gradul patru (9), în raport cu înălțimea cilindrului (I_C):

$$N_{uz}^{1200} = 10^{-4} \cdot I_C^4 - 216.10^{-4} \cdot I_C^3 + 1,25 \cdot I_C^2 - 30,38 \cdot I_C + 444,31 \text{ [µm]}. \quad (9)$$

where: N_{uz}^{1200} is the wearness level after 1200 hours of operation;
I_C - cylinder hight.

The wearness level in the second phase of testing after another 500 operating hours expressed by a forth degree polinomial ecuation (10), in conditions of a total testing interval that records 1700 hours:

unde: N_{uz}^{1200} este nivelul de uzură după 1200 ore de funcționare;
I_C - înălțimea cilindrului.

Gradul uzurii în a doua etapă a testării la un interval de încă 500 ore de funcționare exprimat printr-o ecuație polinomială de gradul patru (10), în condițiile în care durata totală de testare înregistrează 1700 ore:

$$N_{uz}^{1700} = 3 \cdot 10^{-5} \cdot I_C^4 - 40 \cdot 10^{-4} I_C^3 + 0,25 I_C^2 - 5,25 I_C + 71,99 \text{ [µm]}. \quad (10)$$

where: N_{uz}^{1700} is the wearness level after a total interval of 1700 hours of operation.

The viscosity index determined after reaching the 100°C temperature is expressed in the polinomial relation for an paraphinic lubricant:

unde: N_{uz}^{1700} este nivelul de uzură după o perioadă totală de 1700 ore de funcționare.

Indicele de viscozitate stabilit la atingerea temperaturii de 100°C este exprimat prin ecuația polinomială pentru un ulei parafinos:

$$I_V^p = 0,44 \cdot V_{100°C}^2 - 9,95 \cdot V_{100°C} + 109,91 \text{ [%]}. \quad (11)$$

where: I_V^p is the viscosity index for paraphinic lubricant;
$V_{100°C}$ - viscosity at 100°C.

The viscosity index value established at the standard temperature of 100°C is expressed in the polinomial relation for an non-paraphinic lubricant:

unde: I_V^p este indicile de viscozitate al uleiului parafinos;
$V_{100°C}$ - viscozitatea la 100°C.

Valoarea indicelui de viscozitate stabilit la temperatura standard de 100°C este exprimat în ecuația polinomială pentru un lubrifiant neparafinos:

$$I_V^{np} = 0,69 \cdot V_{100°C}^2 - 14,66 \cdot V_{100°C} + 35,81 \text{ [%]}. \quad (12)$$

where: I_V^{np} is the viscosity index for non-paraphinic lubricant.

Each relation for description of the phneomena which defines the lubrication process of compresion ignited engines is developed on the basis of some relative specific measures and of some coeficients with constant value.

The lubricants analyze, consistent greases and specific hydraulic liquids permits a rapid and precise definition of what is going on inside an engine.

unde: I_V^{np} este indicile de viscozitate al uleiului non-parafinos.

Fiecare relație pentru descrierea fenomenelor care definesc procesul de lubrifiere al motoarelor cu aprindere prin comprimare este construită în baza unor mărimi specifice relative şi a unor coeficienți de valoare constantă.

Analiza uleiurilor de lubrifiere, a unsorilor consistente şi a fluidelor hidraulice specifice permite o definire rapidă şi precisă a ceea ce se petrece în interiorul motoarelor.

INTERPRETATIONS AND CONCLUSIONS

After finalizing the analytic study of available data concerning the lubrication process in compression ignited engines with advanced methods of mathematical calculus there can be formulated some of the main important conclusive aspects:

- the elements of piston assembly in alternative-intermitent linear movement at variable speed values (as measure and direction), in situation in which difficulties apear in realizing the lubrication process for a liquid friction and elements with corrosive and abrasive action, doing the thermal transfer between gases and cylinder, suports a complex wearing regime,
- even short period action of an semifluid lubrication accelerates the wearness index of surfaces that are in contact, because the highest peaks of micro irregularities of the surface get in contact with the ones of the other surface that is in relative movement with each other.
- The wearness degree of the surfaces is outlined for a low protection index, that can be observed more clearly in the case of an dimensionally reduced lubricant film

INTERPRETĂRI ŞI CONCLUZII

După finalizarea studiului analitic a datelor disponibile privind procesul de lubrifiere în motoarele cu aprindere prin comprimare cu metode avansate de calcul mathematic pot fi formulate unele dintre principalele aspect concluzive:

- elementele ansamblului piston aflate într-o translație alternativ-intermitentă la valori variabile ale vitezei (ca mărime şi sens), în situația în care apar dificultăți în realizarea procesului de ungere pentru o frecare lichidă şi elemente cu acțiune corozivă şi abrazivă, realizând totodată transferul termic de la gaze la cilindru, suportă un regim de uzură complex,
- acțiunea chiar şi pe durate scurte a modului de ungere semifluidă accelerează indicele de uzură a suprafețelor care vin în contact, deoarece vârfurile neregularităților microscopice ale suprafeței ajung în contact cu ale celeilalte suprafețe aflate în mişcare relativă unele în raport cu altele.
- gradul de uzură al suprafețelor se accentuează pentru un indice de protecție scăzut, ceea ce se observă mai clar în cazul existenței unui film de ulei redus

of 0,003 micrometers, even at rugosities comprised between 0,1÷0,4 micrometers. Thus a semifluid lubricating process leads to a rapid development of the wearness level.

- the biodiesel fuel through its higher viscosity and through its greater lubricating properties influences the wearness producing method and especially has a positive effect concerning the deterioration level of components surfaces.
- Due to the cold start and running, of more intense grinding and of more operating hours in the frame of first testing phase (0÷1200 ore) the recorded wearness in the upper area of the cylinder, closer to the combustion chamber, is even ten times higher then the wearness level that apears in bottom dead center area of the cylinder,
- the second phase of tests is developed on the 500 hours running interval recorded after initial grinding of cylinder mirror surfaces. In this case the wearnesses are limited at the values of 50 micrometers on the entire length of cylinder hight. Values which express the degree or level of recorded wearness on the length of cylinder hight represents a measure of mean wearness determined on two orthogonal plans of which one contains the piston pin axis for assembling the piston and the connecting-rod. There were determined values for 16 different levels beginning with combustion chamber area under the wearness begin point marked by the top dead center in which reaches the first piston ring. The most significant wearnesses in the second phase are realized in the marginal point of pistonston displacement, thus to the dead centers, where even the secondary rotation movement of the piston is the most important. Also, important values are being recorded in mid area of cylinder hight, when the connecting rod (which is articulated on the excentric bearing of the crank shaft through connecting rod head) changes the rotation direction from the exterior into the interior of the engine, getting closer to its central axis, generating thus a oscilation torque in this period. In an absolute value, the wearness maximum in the second phase of testing is positioned in top dead center being determined in the most part by a deficitary lubrication, higher temperatures, higher gas pressures which compress the piston rings (especially the first one from combustion chamber) stronger on the cylinder surface.
- maximum general wearness recorded in both phases of the research is positioned in upper part of cylinder, toward top dead center, being measured in the first testing phase.

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dimensional la 0,003 microni, chiar şi la rugozități cuprinse între 0,1÷0,4. Astfel un proces de ungere semifluidă contribuie la dezvoltarea rapidă a nivelului de uzură.

- biodieselul prin viscozitatea mai ridicată şi prin proprietățile sale lubrifiante sporite influențează modul de producere a uzurii şi în special are un aport pozitiv în ceea ce priveşte diminuarea nivelului de deteriorare a suprafețelor pieselor.
- datorită pornirii şi funcționării la rece, a rodării mai accentuate şi a orelor mai multe de funcționare în cadrul primei etape de testare (0÷1200 ore) uzura înregistrată în zona superioară a cilindrului, mai aproape de camera de ardere, este şi de peste 10 ori superioară gradului de uzură care apare în zona punctului mort inferior,
- etapa a doua a testării este derulată pe intervalul a 500 de ore de funcționare înregistrate după formarea inițială a suprafețelor oglindă ale cilindrului. În acest caz uzurile sunt limitate la valoarea de 50 microni pe lungimea întregii generatoare a cămăşii de cilindru. Valorile care exprimă gradul sau nivelul de uzură înregistrat pe generatoarea cămăşii de cilindru reprezintă o mărime medie a uzurilor determinate pe două plane perpendiculare dintre care unul conține axa bolțului de asamblare a pistonului şi bielei. S-au determinat valori la 16 paliere diferite începând cu zona camerei de ardere sub pragul de uzură marcat prin punctul mort superior în care ajunge segmentul de foc. Uzurile cele mai semnificative în a doua etapă sunt realizate în extremele cursei pistonului, adică la punctele moarte, unde şi mişcarea secundară de basculare a pistonului este cea mai pregnantă. De asemenea, valori sesizabile se mai regăsesc în zona mediană a generatoarei cămăşii de cilindru, când biela articulată pe fusul maneton al arborelui cotit prin capul de bielă îşi schimbă sensul de rotație dinspre exteriorul motorului înspre interiorul acestuia, apropiindu-se de axa centrală a motorului, generând astfel un moment de oscilație a pistonului în această perioadă. În valoare absolută, valoarea maximă a uzurii în cea de-a doua etapă a încercărilor se situează în punctul mort superior fiind determinată în cea mai mare masură de o lubrifiere deficitară, temperaturi mai ridicate, presiunea mai ridicată a gazelor care comprimă segmenții (în special pe cel de foc) mai puternic pe oglinda cilindrului.
- uzura generală maximă înregistrată pe ambele etape ale cercetării este situată în partea superioară a cilindrului, spre punctul mort superior, fiind măsurată în prima etapă a testărilor.

RECUNOŞTINȚE

Acest articol a fost susținut prin activitatea desfăşurată în competiția internă de proiecte de cercetare a Universității Tehnice din Cluj-Napoca 2014-2015, C.I. 27126.

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CALORIFIC VALUE - AN IMPORTANT PROPERTY OF WOODEN BIOMASS

PUTEREA CALORICA - O PROPRIETATE IMPORTANTA A BIOMASEI LEMNOASE

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Abstract: *Woody biomass is one of the oldest combustible materials. Woody biomass is a renewable fuel material for 2 reasons: wood is a renewable material, as a product of photosynthesis and annual increases, wood products remain are inherent in the wood processing flows. The researches carried out as part of the project have shown that the biomass has a series of combustible features, which determines its competitive qualities on the energy market. Solid fuel burning is regarded as a complex process. Romania holds wide renewable energy potential, and, more specifically in biomass energy generation.*

Keywords: *calorific value, wood, biomass, sawdust, timber*

INTRODUCTION

Trees use the water and mineral salts in the soil to grow, and the carbon dioxide in the atmosphere to develop synthesis chemical reactions.

In order to grown in width and height, wood uses cambial division [1].

Cambium is a fragile layer, located underneath the bark. The growth in width and height of the trees includes three stages: the embryo stage, the expansion stage, and the differentiation stage [2].

The embryo stage occurs when meristem cells with a thin cellular wall and large lumen grow in size, increasing the protoplasm quantity. When the protoplasm quantity reaches the maximum critical value, the cell divides, and a new cell is born.

The second cambial growth and division stage is the expansion stage. Thus, the new cells no longer divide, but, instead, they grow lengthwise [3].

The third growth stage is the differentiation stage, which leads to the formation of specialized cells (for conduction, resistance, storage) [4].

The wooden biomass is made up of the total wood processing waste (timber, veneer, playwood factories).

Small-sized waste is obtained as part of the wood processing process, which can be used for burning purposes.

The production balance of a softwood timber production factory is as follows:

- timber 67% (50000 m^3);
- waste 15% (11300 m^3);
- sawdust 13% (9700 m^3);
- irrecoverable loss 5% (3700 m^3).

The mincing operation is the operation through which certain small-sized wooden materials are turned into wood chips [4].

It is recommended that only wood waste resulting pursuant to the various manufacture technologies is turned into chops (timber, furniture, veneer).

This operation is carried out with the tool holder disk chopper [5].

Rezumat: *Biomasa lemnoasă este unul dintre cele mai vechi materiale combustibile. Biomasa lemnoasă reprezintă un material regenerabil, ca produs al fotosintezei şi al creşterilor anuale, rămăşițele lemnoase sunt produse inerente ale fluxurilor de prelucrare a lemnului.Cercetările efectuate în cadrul lucrării au demonstrat faptul că biomasa prezintă o serie de caracteristici combustibile, care îi determină calitățile competitoare pe piața energetică.Arderea combustibilului solid se consideră un procedeu complex.România este o țară cu potențial mare în domeniul surselor de energie regenerabilă şi anume în producerea energiei din biomasă.*

Cuvinte cheie: *puterea calorică, lemn, biomasă, rumeguş, cherestea*

INTRODUCERE

Pentru a creşte arborii folosesc apa şi sărurile minerale din pământ şi dioxid de carbon din atmosferă, pentru a elabora reacțiile chimice de sinteză.

Pentru a creşte pe grosime şi înălțime, lemnul foloseşte diviziunea cambială [1].

Cambiul este un țesut fragil, situat sub coajă. Creşterea în grosime şi în înălțime a arborilor are trei faze: faza embrionară, faza expansionară, faza diferențierii [2].

Faza embrionară se produce când celulele meristematice cu peretele celular subțire şi lumen mare creşte în dimensiuni, crescând cantitatea de protoplasmă. Când cantitatea de protoplasmă atinge valoarea critică maximă, celula se va divide şi o nouă celulă se va naşte.

Faza a doua a creşterii şi divizării cambiale este faza expansiunii. Astfel noile celule nu se mai divid ci vor creşte în lungime [3].

Faza a treia a creşterii este faza diferențierii, astfel se formează celule specializate (pentru conducere, de rezistență, pentru depozitare) [4].

Biomasa lemnoasă este formată din totalitatea rămăşițelor lemnoase obținute de la prelucrarea lemnului (fabricile de cherestea, furnire, placaje).

În timpul prelucrării lemnului vor rezulta rămăşițe cu dimensiuni mici care pot fi folosite la ardere.

Balanța de producție a unei fabrici de cherestea de răşinoase este următoarea:

- cherestea 67% (50000 m^3);
- rămăşițe 15% (11300 m^3);
- rumeguş 13% (9700 m^3);
- pierderi nerecuperabile 5% (3700 m^3).

Operația de tocare este operația prin care unele materiale lemnoase de mici dimensiuni se transformă în tocătură lemnoasă [4].

Se recomandă să se transforme în tocătură numai rămăşițele lemnoase de la diferite tehnologii de fabricație (cherestea, mobilă, furnire).

Această operație de tocare se realizează cu tocătorul cu disc portcuțite [5].

MATERIAL AND METHOD

Before the test, the wooden fuel needs to be brought to 20°C. Generally, there are two calorific value alternatives for solid fuels, depending on the water status in the combustion products.

There is the higher calorific power (when water vapours condense, releasing evaporation heat) and lower calorific value (when water is in the burning gases under the form of vapours).

Using the calorimeter bomb equipment, the higher calorific power is determined for complete burning and a 30 bar oxygen atmosphere. The lower calorific power is deduced by calculation, pursuant to the analysis of the fuel water content. The higher calorific power is determined based on the energy balance method [4].

In this case, the calorific value of the wood is determined using the calorimeter bomb (with explosive burning).

Fig.1 illustrates the calorimeter bomb.

Calorimeter bomb is a special steel container, inert to combustion-generated acids. It is fed with 30 bar pressure oxygen.

In calibration terms, the calorimeter bomb must withstand air pressures of 50 atmospheres and hydraulic pressures of 200 atmospheres, so as to support the larger pressures generated through the combustion of the researched fuel.

Performance of experimental determinations, with the 3 main periods [4]:

The purpose of the initial period is to determine the temperature variations of the water in the calorimeter container, due to the heat exchange with the exterior, prior to combustion.

During this period, usually of 5 minutes, temperature is read and noted down every minute, using the high accuracy Bechmann thermometer.

The purpose of the main period is to determine the temperature increase of the water in the calorimeter container, due to the wooden particle combustion.

The purpose of the end period is to determine the average temperature variation of the water in the calorimeter container, due to the heat exchange with the exterior, after combustion.

MATERIAL ŞI METODĂ

Înainte de încercare combustibilul lemnos se aduce la temperatura de 20°C. În general există două puteri calorifice ale combustibililor solizi în funcție de starea apei din produsele de ardere.

Există puterea calorică superioară (atunci când vaporii de apă s-au condensat, cedând căldură de vaporizare) şi putere calorică inferioară (când apa se află în gazele de ardere sub formă de vapori).

Cu ajutorul instalației cu bombă calorimetrică se determină puterea calorică superioară în condițiile unei arderi complete şi atmosferă de oxigen la 30 bari. Puterea calorică inferioară se deduce prin calcul în urma analizei de apă pe care o conține combustibilul. Determinarea puterii calorice superioare se face prin metoda bilanțului de energie [4].

În cazul de față determinarea puterii calorice a lemnului se face cu bomba calorimetrică (cu ardere explozivă).

În fig.1 se prezintă bomba calorimetrică.

Bomba calorimetrică este un vas de oțel special, inert la acizii rezultați prin ardere. Aceasta se încarcă cu oxigen la o presiune de 30 bari.

Metrologic bomba calorimetrică trebuie să reziste la presiuni pneumatice de 50 atmosfere şi presiuni hidraulice de 200 atmosfere, astfel încât să reziste la presiunile mari ce se produc prin arderea combustibilului cercetat.

Efectuarea determinărilor experimentale cu cele 3 perioade principale [4]:

Perioada inițială are drept scop determinarea variațiilor de temperatură a apei din vasul calorimetric, datorită schimbului de căldură cu exteriorul, înainte de ardere.

În această perioadă, de obicei de 5 minute se citeşte şi se notează din minut în minut temperatura cu termometrul de precizie Bechmann.

Perioada principală are drept scop determinarea creşterii temperaturii apei din vasul calorimetric, datorită arderii particulei de lemn.

Perioada finală are drept scop determinarea variației medii de temperatură a apei din vasul calorimetric, datorită schimbului de căldură cu exteriorul după ardere.

Fig. 1 – Calorimeter bomb

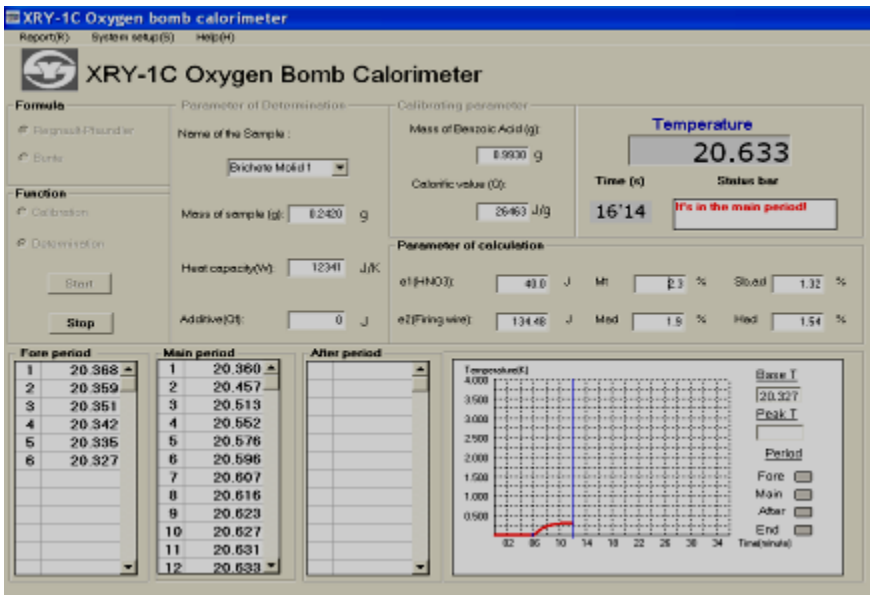

Fig. 2 – The initial stage of calorific value determining process

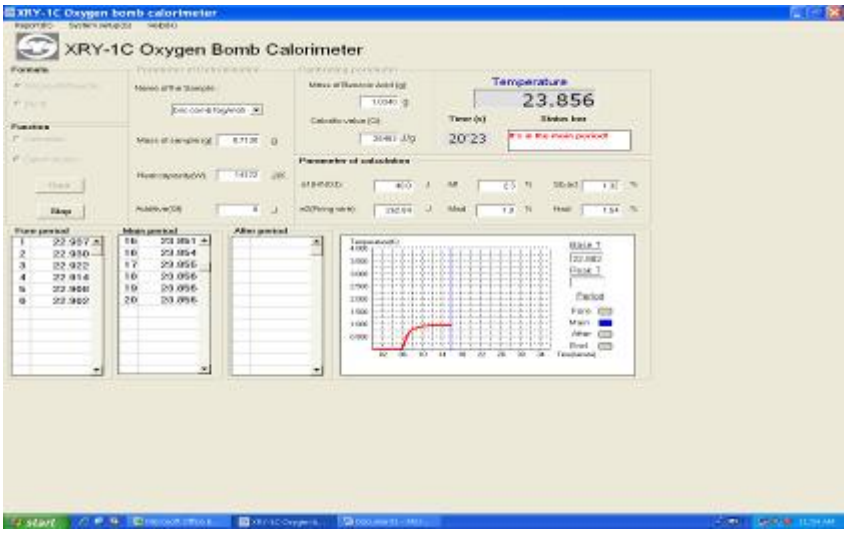

Fig. 3 – The main stage of calorific value determining process

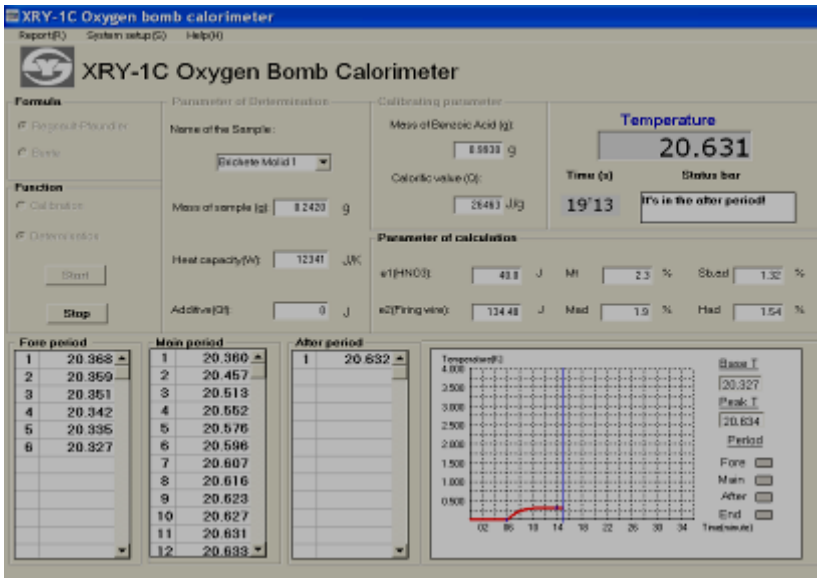

Fig. 4 – The final stage of calorific value determining process

The higher calorimeter value is determined based on the following equation:

Determinarea puterii calorice superioare se face cu relația:

$$Q_s = k(t_f - t_i) - q_s/m \text{ [Kcal/kg] [4]}, \quad (1)$$

where: k- calorific coefficient (KJ/degree);
t_f- final temperature (°C);
t_i- initial temperature (°C);
q_s- heat consumed for the burning of the wire and cotton (KJ);
m- wood particle weight (Kg).

unde: k- coeficient calorimetric (KJ/grad);
t_f- temperatura finală (°C);
t_i- temperatura inițială (°C);
q_s- căldura consumată pentru arderea firului de sârmă şi a bumbacului (KJ);
m-masa pastilei de lemn (kg).

RESULTS

It has been noted that, pursuant to the experiments performed, for 5 pellet samples, the lower calorific value for spruce pellets is of 18309 kJ/kg, and of 19006 kJ/kg for the higher calorific value.

In the first stage of the fuel (pellet) combustion process (fig.2), the heating and evaporation of fuel water occurs. In the second stage of the fuel (pellet) combustion process (fig.2), the heating and evaporation of fuel water occurs. In the second stage (fig.3), the vapours generated through the combustion process mix with the air. In the third stage (fig.4), the heating, ignition and combustion of the fuel-derived substances occurs.

REZULTATE

Se observă că în urma experimentelor efectuate, pentru 5 probe de peleți, puterea calorică inferioară pentru peleții de molid este de 18309 kJ/kg, şi de 19006 kJ/kg pentru puterea calorică superioară.

In prima fază a procesului de ardere (fig.2) a combustibilului (peleților) se produce încălzirea şi evaporarea apei din combustibil. In faza a doua (fig.3), vaporii formați prin procesul de ardere a combustibilului se amestecă cu aerul. În faza a treia (fig.4) are loc încălzirea, aprinderea şi arderea amestecului substanțelor rezultate din combustibil.

CONCLUSIONS

Biomass fuels are susteinable.

Biomass contains sun-derived energy, as trees intake sun energy during the photosynthesis process.

Briquettes and pellets are the best fuels obtained from wooden biomass, alongside the fuel gas generated during airless decay.

Quantitatively, only 15% of the biomass is used for combustion purposes, as most of it is taken over by the composites industry.

Wooden pellets and briquettes are wooden fuels used for generating hot water and steam.

CONCLUZII

Combustibilii din biomasă sunt sustenabili.

Biomasa conține energie preluată de la soare, astfel încât arborii absorb energia soarelui în procesul de fotosinteză.

Brichetele şi peleții sunt cele mai bune produse combustibile obținute din biomasa lemnoasă, alături de gazele combustibile rezultate la putrezirea fără aer.

Cantitativ, numai o parte de 15% din biomasă se foloseşte la foc, deoarece majoritatea este captată de industria compozitelor.

Peleții din lemn şi brichetele sunt produse lemnoase combustibile folosite pentru obținerea de apă caldă şi abur.

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THE ECOLOGICAL DESIGN OF A 3 IN 1 ELECTRICAL HOUSEHOLD APPLIANCES: MICROWAVE, TOASTER AND SANDWISH TOASTER
/
DESIGN ECOLOGIC AL APARATULUI ELECTROCASNIC 3 ÎN 1: CUPTOR CU MICROUNDE, PRĂJITOR DE PÂINE ŞI SANDWICH MAKER

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Abstract: *Given the large variety of the household appliances on the market, it's difficult to come up with something innovative. A thorough analysis of people's needs of such devices is leading us to develop products having increasingly strange shapes, but also increasingly more functions designed to make our work and our life easier.*
The esthetical valence is ensured by using refined high quality plastic, metal and ceramic materials and also by disposing different primary and combined geometric shapes in order to offer the status of a decorative object, so we could see the decoration of the kitchen as art. In this paper we propose the household appliance Breakfast 3in1.

Keywords: *Design, home appliances, 3in1, microwave, toaster, sandwich toaster*

INTRODUCTION

This paper is aimed to present the design of a household appliance. This project was first presented in 2010 to the "Electrolux Design Lab" contest, where the main theme of the international contest was to create household appliances designed to fit in small living spaces. The projects were supposed to show how the users would prepare and keep their food, wash their dishes and laundry in 2050 given that by then (according to United Nations) 74 percent or the world population is going to be urban.

The ideas must address to certain key users, to be "eco / green", adjust to the user's space and time and provide individualization. Besides the main feature of the products – that is, to adjust to the urban area of the year 2050 – there is another very important element: to be an eco product; and not just as energy consumption, but also as a whole, including the materials used and the possibility to recycle it when the cycle of life of the product ends.

3D GRAPHICS

Because of recent progress in sample techniques, the digital images, sounds and video are now part of our daily life. Recently, the development of 3D graphics opened the way to shaping complex objects or scenes in 3D [1], [2], [3]. An animated 3D scene is a mix of different objects, geometrically defined in tridimensional space, along with their parameters of visualization and brightness.

Finally, the present evolution of the Internet and telecommunication networking facilitates the interchange of those models. Therefore, they are used in various fields like medicine, computer aided design, augmented reality, virtual experiments, video games, animation or

Rezumat: *Diversitatea pe piață a aparatelor electrocasnice este atât de mare încât este greu să aduci ceva inovativ, însă o analiză riguroasă asupra nevoilor oamenilor în materie de electrocasnice, duce la dezvoltarea unor produse cu forme din ce în ce mai ciudate dar şi din ce în ce cu mai multe funcții menite să ne uşureze munca şi viața. Valențele estetice sunt asigurate printr-o utilizare a unor materiale plastice, metalice şi ceramice de înaltă calitate şi finisare, dar şi printr-o dispunere a diferitelor forme geometrice primare sau combinate ce conferă statutul de obiect de „decor", atunci când privim amenajarea bucătăriei ca pe o artă. În articolul de față, propunem aparatul ecologic electrocasnic Breakfast 3 în 1.*

Cuvinte cheie: *Design, aparate electrocasnice, 3 în 1, microunde, toaster, sandwich maker*

INTRODUCERE

Articolul de față îşi propune prezentarea unui design de aparat electrocasnic. Acest proiect a fost propus în cadrul concursului „Electrolux Design Lab" pentru anul 2010 unde tema propusă de acest concurs internațional a fost crearea unor aparate electrocasnice destinate spațiilor mici de locuit. Proiectele trebuia să redea cum îşi vor pregăti şi păstra mâncarea, spăla rufele şi vasele consumatorii în anul 2050, când este estimat că 74 % (Conform Națiunile Unite) din populația lumii va locui în medii urbane.

Ideile trebuie să se adreseze consumatorilor cheie, să fie „verzi" / eco, adaptabile spațiului şi timpului şi să permită individualizarea. Pe lângă principala caracteristică a produselor create, de a se adapta la mediul urban al anului 2050, se mai adaugă un element foarte important, încadrarea acestor electrocasnice în zona produselor ecologice; nu doar din prisma consumului energetic ci şi al întregului produs, incluzând materiale utilizate şi posibilitatea de reutilizare a acestora după încheierea ciclului de viață al produsului.

GRAFICA 3D

Datorită progreselor recente în tehnicile de eşantionare, imaginile, sunetul şi video-urile digitale fac parte acum din viața noastră de zi cu zi. De curând, dezvoltarea graficii 3D a deschis calea modelării obiectelor sau a scenelor complexe în 3D [1], [2], [3]. O scenă animată 3D reprezintă un ansamblu de diferite obiecte care au fost definite geometric în spațiul tridimensional, împreună cu parametrii asociați de vizualizare şi iluminare.

În cele din urmă, dezvoltarea actuală a internetului şi a rețelelor de telecomunicații facilitează schimbul acestor modele, care sunt astfel utilizate în diverse domenii cum ar fi medicina, proiectarea asistată de calculator (Computer Aided Design - CAD), realitate augmentată, experimentele

digital simulation [4], [5].

The main challenge with this type of modeling is to hide for the user the discretion of the signal that he receives continually [2].

THE PURPOSE OF OUR PRODUCT

Using it means satisfying certain physical and biological human needs according to the performance of the product concept.

This product is no exception. Just like all other household appliances, Breakfast 3 in 1 has a utility based on primary human needs – that is to prepare the food and to eat it. To supply the food is one of the main activities of man, be it directly or indirectly obtained. Therefore, the product must be easy to use and have all the necessary functions in order to provide a pleasant and efficient use.

From its use we get to its purpose. Breakfast 3in1 could have various purposes, starting with the most obvious one which is to be placed in the kitchen, where it can be used by everyone in the family.

It could also be placed in a specially designed space of a company, where employees could heat their food. One must not overlook the fact that it is a compact device that could easily integrate in dormitories, where the space is very tight.

As any new product, it must replace the old ones and for that reason the main criterion is to have a new commodity or an improved technical performance.

The first and most obvious new feature is the combination of three main functions of other household appliances that do not lack to any home – a microwave oven, a toaster and a sandwich maker.

MATERIAL AND METHOD

THE DEVELOPMENT STAGES OF THE PRODUCT

Competition is the market regulator, so everyone is following his or hers own interest – to better satisfy the manufacturing or consuming requirements and to obtain profit. Knowing the market means knowing the demand, the offering, price and competition.

The competition designates the specific relationships between economic agents – manufacturers and buyers. In such competitive conditions, the manufacturer' and consumer's economic efficiency is increasing as maximization of profit and maximization of satisfaction, respectively.

Just like any contest, the competition results in winners and losers. The winners are economic agents able to manufacture goods at low prices or of increased quality [6], [7], [8].

The ability to manufacture at low costs and to sell at low prices in order to beat the competition stimulates innovation, leads to new products, to using new manufacturing techniques, to a better level of specialization for the employees, to a better organization of the work.

Such instruments, used initially by a small number of economic agents, are gradually expanding, due to the compelling effect of lowering the price or to the better quality of the new products.

So, the old ones are risking being off the market.

virtuale, jocurile video, animațiile sau simularea digitală [4], [5].

Principala provocare atunci când se modelează în acest mod este de a ascunde utilizatorului discretizarea semnalului primit de acesta în formă continuă [2].

DESTINATIE PENTRU PRODUSUL PROPUS

Utilitatea presupune satisfacerea anumitor necesități umane fizice şi biologice la performanțele pentru care a fost conceput produsul. Produsul de față nu face excepție de la regulă, ca în cazul tuturor produselor electrocasnice, Breakfast 3 în 1 are o utilitate desprinsă din nevoile primare ale omului şi anume prepararea şi alimentația cu hrană. Procurarea hranei este una din principalele activități ale omului, fie că se face direct sau indirect; pornind de aici ajungem la concluzia că produsul trebuie să fie cât mai usor de utilizat şi să înglobeze toate funcțiile necesare, care să asigure o utilizare plăcută şi eficientă.

Pornind de la utilitatea produslui ajungem în sfera destinației acestuia. În cazul Breakfast 3 în 1 acesta poate avea diferite destinații, începând de la cea mai evidentă şi anume plasarea în bucătăriile oamenilor, unde poate fi folosit de toți membrii familiei; de asemenea poate fi destinat şi pentru firmele care au amenajat special un spațiu pentru angajați unde aceştia îşi pot încălzii mâncarea. Nu trebuie neglijat şi faptul că este un produs compact şi se poate integra cu uşurință în căminele pentru studenți, unde spațiul este foarte restrâns.

Ca orice produs dezvoltat acesta trebuie să înlocuiasca unul deja existent, iar pentru a realiza acest lucru, un criteriu esențial este acela de a introduce o nouă facilitate utilizatorului sau de a îmbunătății performanțele tehnice ale predecesorului. Prima şi cea mai evidentă noutate este îmbinarea a trei funcții principale ale unor electrocasnice ce nu lipsesc din casele oamenilor, şi aici vorbim de un cuptor cu microunde, un aparat de prăjit pâinea şi un sandwich maker.

MATERIAL ŞI METODĂ

ETAPELE PROCESULUI DE PROIECTARE

Regulatorul pieței este concurența, astfel că fiecare îşi urmăreşte propriul interes, satisfacerea cât mai avantajoasă a necesităților de producție sau de consum şi obținerea de câştig. Cunoaşterea pieței presupune cunoaşterea cererii, ofertei, prețului şi concurenței.

Concurența desemnează relațiile de competiție, de rivalitate dintre agenții economici în calitate de producători sau cumpărători, relații specifice economiei de piață. În condițiile concurenței creşte eficiența economică a producătorului (maximizarea profitului) şi a consumatorului (maximizarea satisfacției).

Ca orice competiție, concurența se soldează cu învingători şi învinşi. Învingători sunt agenții economici care produc bunuri la costuri joase, sau bunuri de calitate superioară [6], [7], [8].

Capacitatea de a produce mai ieftin şi de a vinde mai ieftin pentru a învinge concurența, stimulează inovația, conduce la realizarea de noi produse, la folosirea de noi tehnici de fabricație, la ridicarea nivelului general de calificare a personalului, la mai bună organizare a producției şi muncii.

Aceste mijloace, utilizate la început de puțini agenți, se extind treptat, datorită constrângerii materiale exercitate de prețul mai redus, sau de calitatea superioară a produselor asupra unităților rămase în urmă, care riscă astfel să iasă

Therefore, the competition transforms the progress into an existence requirement.

The competition also operates a selection of manufacturers, because of efficacy inequity between them.

As a result, the weak ones are eliminated and the remaining resources are to be concentrated to those able to administrate and use them properly.

Competition also imposed diversity – the manufacturers being forced to enter unexplored market sectors and to improve certain professions. Such household appliances could be very simple ones or could prove to be useful only to certain individuals.

THE PROJECT GRAPHICS

The product modeling and rendering was made using CATIA V5R19. See Figure 1.

This software used for modeling the elements, units and structures has multiple advantages, presented in this paper:

- Modeling in fields requiring complex geometry;
- Modeling the assemblies and subassemblies;
- Flexibility;
- Modeling based on relative large categories of materials from the software library;
- Modeling of non-linear materials;
- Modeling one-dimensional, bi-dimensional and tridimensional fields;
- Modeling the stabile and mobile links between the elements of assemblies and subassemblies;
- Modeling of basic links (stabile parts);
- Modeling of the load: focusing or spreading forces, momentum, accelerations, focusing or spreading acceleration mass, forced displacing, temperatures;
- Ability to check the right design of the device;
- Static analysis, vibration modes and frequencies, thermal analysis;

Ability to visualize the results as value fields in colors code, deformed and animated states, list of values, graphics.

chiar de pe piață. Astfel concurența transformă progresul într-o condiție de existență.

Concurența realizează de asemenea o selecție a producătorilor, având în vedere inegalitatea dintre întreprinderi în ceea ce priveşte eficacitatea. Astfel agenții economici slabi sunt eliminați. Ca urmare, resursele se vor concentra la dispoziția unităților capabile să le gospodărească şi să le utilizeze rațional. Concurența a dus de asemenea la diversitate, producătorii ar trebuit să capteze sectoare ale pieții neexplorate încă şi să aducă îmbunătățiri specifice pentru anumite meserii. Astfel, aparatele electrocasnice pot fi dintre cele mai simple sau având dotări ce se dovedesc a fi utile doar anumitor persoane.

GRAFICA PROIECTULUI DE PRODUS

Modelarea şi randarea produsului a fost realizată folosind CATIA V5R19, figura 1. Acest soft care este utilizat pentru modelarea elementelor, subansamblelor şi structurilor din prezenta lucrare cu multiple avantaje:

- Modelarea unor domenii cu geometrie complexă;
- Modelarea ansamblelor şi subansamblelor;
- Flexibilitate;
- Modelarea unor categorii relativ mari de materiale existente în biblioteca soft-ului;
- Modelarea materialelor cu comportare neliniară;
- Modelarea domeniilor unidimensionale, bidimensionale şi tridimensionale;
- Modelarea legăturilor fixe şi mobile dintre elementele componente ale ansamblelor şi subansamblelor;
- Modelarea legăturilor cu bază (partea fixă);
- Modelarea încărcărilor de tip: forte concentrate sau distribuite, momente, accelerații mase concentrate sau distribuite, deplasări impuse, accelerații, temperaturi;
- Posibilitatea verificării întocmirii corecte a modelului;
- Posibilități de analiză statică, a modurilor şi frecvențelor proprii de vibrație şi de analiză termică;
- Viteze relativ mari de analiză a modelului;

Posibiltăți de vizualizare a rezultatelor sub formă de: câmpuri de valori în codul culorilor, stări deformate şi animate, liste de valori, grafice.

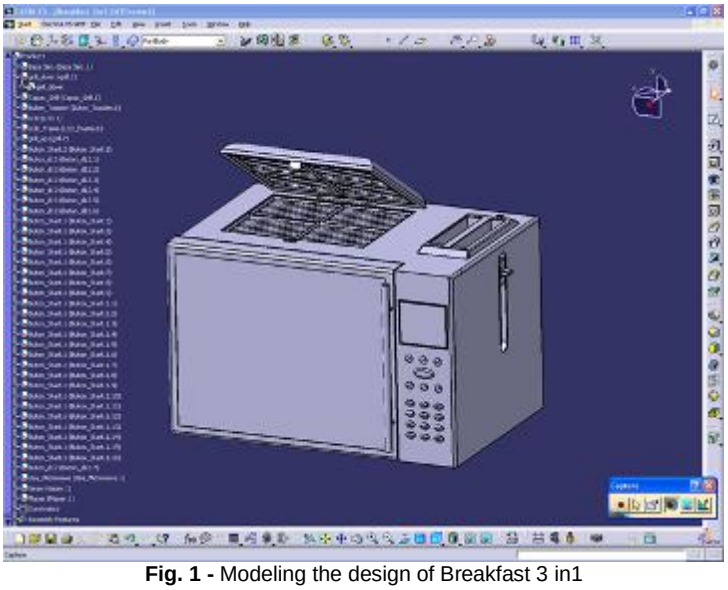

Fig. 1 - Modeling the design of Breakfast 3 in1

PRINCIPLES UPON IS BASED THE DESIGN OF OUR PRODUCT

A good product is a product that it sells, one that doesn't need an aggressive promotion. In order to create such a product we have to apply a few fundamental principles:

- The functional value principle: if the product is not functioning or is not functioning properly, then it should not be graded as functional;
- The principle of harmony between appearance and function: the functioning and the appearance of the product are acting simultaneously in order to satisfy the user; apart from its utility, the device may also have a decorative role in the kitchen;
- Ecology principle: the product must not pollute the environment and the materials used must be mostly recyclable. The materials are not the only aspect to envision when a product is designed to be "eco" or "green". The energy consumption is also important, having direct consequences on the owner;
- Economy principle: this principle is strongly associated with the latter, with focus on small costs for usage and maintenance.

RESULTS

PRODUCT PRESENTATION

The product we chose to create has the purpose to satisfy people's needs such as meal preparation in a way that is pleasant and effortless. One should not neglect the fact that people need to eat healthy, without fast-food, as much as possible. This household appliance wants to combine the functions of three products in only one, having many benefits, acting directly upon the user and also the environment.

The device we created is based on a microwave oven that, in addition to its specific function, has also the features of a toaster and those of a sandwich maker. So it is a compact product we could define as a 3 in 1 device. It has a simple name, Breakfast 3 in 1, aimed to encourage to user to use it only for breakfast. As for the rest of the meals, he or she must follow the concept of healthy food and not fast-food.

Based on a compact design, the product is also elegant and easy to fit in any kitchen.

Like any other household appliance, this one too must have a good control interface, easy to use, but also a way to inform the user about the time left until a certain cycle ends or about its functions. The best way to provide this information is by integrating a big LCD screen, easy to read, intelligently designed in order to be used by different people.

PRINCIPII CE SE REGĂSESC ÎN DESIGNUL DE PRODUSULUI

Un produs reuşit este un produs care se vinde, un produs ce nu necesită o publicitate agresivă. Pentru a obține un astfel de produs a fost nevoie de aplicarea unor principii fundamentale:

- Principiul valorii funcționale: dacă produsul nu va funcționa sau nu o va face într-un mod corect acesta nu poate fi catalogat funcțional;
- Principiul armoniei între aspect şi funcție: funcționalitatea şi estetică produsului acționează cocomitent pentru satisfacerea utilizatorului; pe lângă utilitățile principale în bucătărie produsul poate avea şi un rol decorativ în ansamblul numit bucătărie;
- Principiul ecologic: produsul nu trebuie să polueze mediul în niciun fel, materialele folosite sunt reciclabile în marea majoritatea. Însă nu doar materialele sunt singurele ce trebuie avute în vedere atunci când un produs se doreşte a fi „eco" sau mai bine zis un produs „verde", ci şi consumul de energie, în acest caz energie electrică, cu efect direct asupra cumpărătorului;
- Principiul economiei: oarecum acest principiu este în strânsă legătură cu cel anterior, accentul făcându-se pe costuri reduse de utilizare şi întreținere.

REZULTATE

PREZENTAREA PRODUSULUI

Produsul pe care am ales să îl proiectăm îsi propune să satisfacă necesitățile oamenilor în materie de preparare a hranei, într-un mod plăcut şi fără prea mult efort din partea acestora. Nu trebuie neglijat faptul că oamenii necesită o alimentație sănătoasă, lipsită pe cât posibil de prezența hranei de tip „fast-food". Aparatul electrocasnic îşi propune să îmbine utilitățile a trei produse în unul singur, aducând numeroase avantaje, atât cu răsfrângere directă asupra utilizatorului dar şi a mediului.

Aparatul electrocasnic proiectat are la bază un cuptor cu microunde, care pe lângă funcțiile specifice unui astfel de produs are înglobate şi caracteristicile unui toaster, dar şi pe cele ale unui sandwich maker. Astfel s-a obținut un produs compact, ce poate fi definit ca un aparat electrocasnic de „tipul 3 în 1". Denumirea produsului este una simplă, Breakfast 3 în 1, menită să încurajeze utilizatorul în a îl folosi doar la prepararea micului dejun, păstrând pentru restul meselor ideea de a mânca sănătos şi nu preparate rapide.

Bazat pe un design compact, produsul este în acelaşi timp elegant şi uşor de integrat în orice tip de bucătărie.

Ca orice produs electrocasnic, şi cel de față trebuie să beneficieze de o bună interfață de control, uşor de utilizat, dar şi de o modalitate de a informa utilizatorul, pe toată durata funcționării, de timpul rămas până la terminarea unui anumit ciclu sau de funcțiile de care dispune. Cea mai uşoară modalitate de a oferii astfel de informații este integrarea unui ecran LCD cu proporții generoase, uşor de citit, cu poziționarea inteligentă a informațiilor, astfel încât să poată fi utilizat de o gamă foarte largă de oameni.

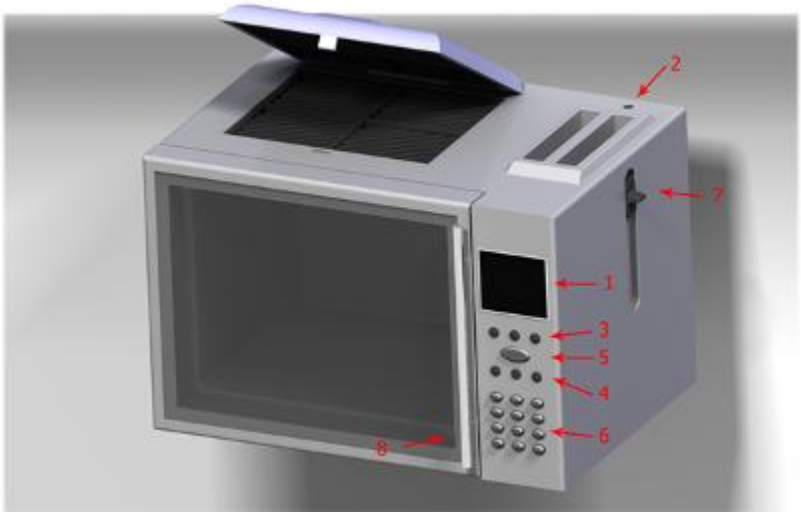

Fig. 2 – Control elements

One must not neglect the buttons. They must have a proper size in order to be easy to touch, without the risk of touching another button by mistake, figure 2. The control elements of Breakfast 3in1 are:

1. Big LCD screen, easy to read;
2. On / Off button, requiring you to press for 5 seconds – childproof;
3. Displaying functions buttons Microwave oven / Toaster / Sandwich maker;
4. Selection up / left – Selection function – Selection down/right;
5. On / Off, starting button after setting all the functions;
6. Numeric keyboard;
7. Toaster handling button;
8. Handle of the oven door.

PRODUCT PRESENTATION

Having three products integrated in one could seem an easy task, but one must take into account their position in order not to interfere with the product proper functioning as a whole. It is also necessary to integrate a unitary control system of the three household appliances in order to reduce its size. To have separate units of control and settings for each and every device will mean an increased size. The control is exclusively digitalized, the options being displayed on a LCD screen, having a generous size, easy to read and understand. See Figure 3.

Butoanele nu trebuie să fie neglijate, acestea au dimensiuni care fac atingerea lor foarte uşoară, fără a exista riscul de a acționa din greşală un alt buton, figure 2. Elementele de control ale breakfast 3 în 1 sunt:

1. Ecran LCD de mari dimensiuni, uşor de citit;
2. Buton Pornire/Oprire, ce necesită o apăsare de 5 secunde ca protecție împotriva utilizării de către copii;
3. Butoane de selecție afişare funcții Cuptor / Toaster / Sandwich Maker;
4. Selecție sus / stânga a€“ Selecție funcție a€“ Selecție jos / dreaptă;
5. START-STOP, buton pentru pornire după ce toate setările au fost realizate;
6. Tastatură numerică pentru introducere caractere;
7. Buton acționare toaster;
8. Element de apucare pentru deschiderea uşii.

PREZENTAREA PRODUSULUI

Integrarea a trei produse în unul singur poate părea usoară, însă trebuie ținut cont de poziționarea acestora astfel încât să nu influențeze funcționarea corectă a produsului. Trebuie integrat şi un sistem de control unitar al celor trei aparate electrocasnice, reducând astfel dimensiunile. Dacă am avea unități de control şi reglaj separate pentru fiecare subansamblu atunci dimensiunile întregului aparat ar fi foarte mari. Controlul se va realiza electronic, complet digital, cu opțiuni afişate pe un ecran LCD cu dimensiuni generoase uşor de citit şi interpretat, figura 3.

Fig. 3 – The LCD screen

Not all the function of this device could be digitally controlled.

For the toaster, the up and down mechanism for the

Nu toate funcțiile aparatului electrocasnic pot fi controlate prin intermediul panoului digital, pentru toaster mecanismul de coborâre şi ridicare a feliilor de pâine se realizează prin

bread slices is manual, just like for all such appliances; one must operate a button with vertical translation. See Figure 4.

intermediul unui control mecanic, întâlnit la toate aparatele de acest gen; se acționează un buton prin translatarea lui pe vertical, figura 4.

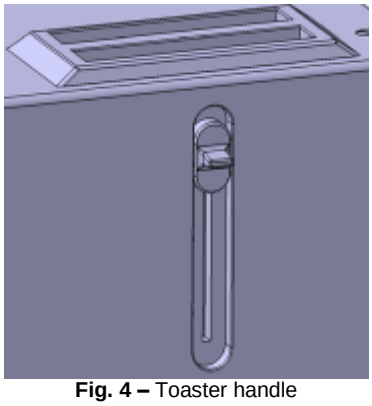

Fig. 4 – Toaster handle

The sandwich maker is also very easy to use. The cover is up simply pulling it, with no pressing flips, just an interior mechanism to keep it closed. See Figure 5. When in use, it cannot be opened thanks to its blocking system that doesn't allow accidental or on purpose opening in order to prevent injuries.

Sandwich maker-ul este de asemenea foarte uşor de utilizat. Capacul se ridică printr-o simplă tragere, neexistând clapete care se apasă, ci un singur mecanism interior care îl menține închis, figura 5. Pe toată perioada funcționării, acesta fiind imposibil de deschis datorită sistemului de blocare, ce nu permite deschiderea accidentală sau voită deoarece pot apărea accidente.

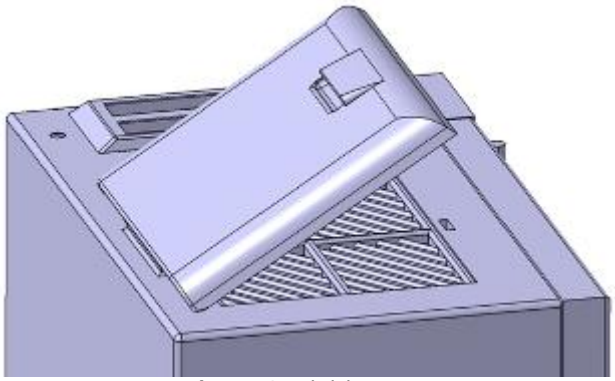

Fig. 5 – Sandwich toaster

Last but not least, the control system of the microwave oven is entirely digitalized, only the door is handled manually by pulling the handle. See Figure 6.

Nu în ultimul rând, pentru cuptorul cu microunde, sitemul de control este integral electronic, doar manevrarea uşii făcându-se manual, prin tragerea de mâner, figura 6.

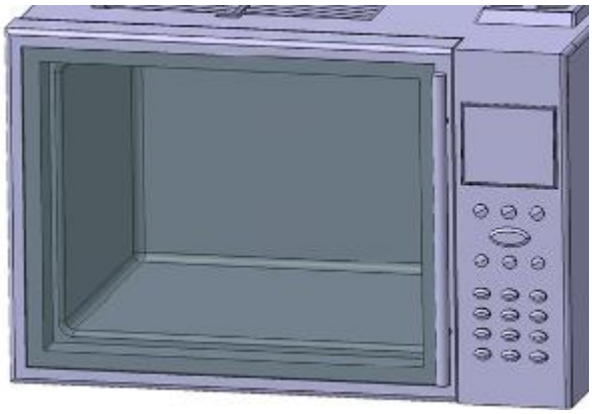

Fig. 6 – Microwave oven

Breakfast 3in1 as a whole integrates three household appliances without affecting any of their original functions. See Figure 7.

Breakfast 3 în 1 privit ca un ansamblu integrează trei aparate electrocasnice, fără însă să facă rabat de la vreo funcție a unuia dintre ele, figura 7.

Fig. 7 – The Breakfast 3 in 1

NEW PRODUCT PROPERTIES: BREAKFAST 3in1

Today, an extremely important aspect is the protection of the environment, because technological and human evolution has left their mark upon the natural environment.

In the design of new products one must always ask himself: "What is going to happen to the product when out of use?"

The answer is relatively simple: recycling. But this is the starting point for other questions: who is making the recycling?, is the owner willing to make an extra effort?

Many companies have found the answer to those questions and the solutions are very simple.

Our device too is taking into account the recycling process when out of use. Therefore, in order to compel the user to recycle, we appealed to a sales campaign with discounts for the customers who buy new products presenting an old and / or broken one from the same brand.

CONCLUSIONS

In this paper we presented a household appliance very well fit for the future, having a compact design, being user friendly and easy to fit in every kitchen.

Out main purpose is to propose the household appliance Breakfast 3 in 1 with an eco profile, low energy requirements, functions that allow it to stand by or even to shut down when is not used.

No home should lack this device, because it helps creating a safer environment, especially for the kids (childproof function).

The paper presents the industrial design concept, stressing on the interest to meet the requirements that beneficiaries of the industrial products have imposed. Today, for designing a product, it is necessary to know, understand and anticipate the customers' needs [9], [10], [11].

If working in areas that offer products that meet other needs than the basic ones then you have found innovative ways to convey information [12], [13], [14].

For William Ralph Inge, originality means an undiscovered plagiarism. In our attempt to create something original, consciously or not, we included

PROPRIETĂȚI ALE NOULUI PRODUS: BREAKFAST 3 ÎN 1

Un aspect extrem de important în ziua de azi este protecția mediului, efectele evoluției tehnologice dar şi umane au lăsat urme adânci asupra naturii. Când se vorbeşte de proiectarea unor noi produse întotdeauna trebuie pusă întrebarea: „Ce se va întâmpla cu acestea după scoaterea din uz ?".

Răspunsul este unul relativ simplu: reciclarea, însă de aici apar alte probleme precum cine va face reciclarea, dacă proprietarului va fii dispus să depună un efort suplimentar.

Multe firme au găsit răspunsul la aceste întrebări, iar soluțiile aplicate sunt foarte simple. Şi în acest caz s-a ținut cont de reciclarea produsului după scoaterea din uz, iar pentru a determina utilizatorul să facă acest lucru s-a apelat la o campanie ce oferă reduceri clienților ce prezintă la achiziționarea unui nou produs, un produs vechi şi nefuncțional al aceleiaşi firme.

CONCLUZII

Am prezentat în acest articol aparatul electrocasnic ce se încadrează foarte bine în cerințele viitorului printr-un design compact, minim de efort în utilizare, uşor de integrat în orice bucătarie. Scopul nostru principal este de a propune un aparat electrocasnic Breakfast 3 in 1 care are şi un profil eco, cu un consum redus de energie, cu funcții ce îi permit intrarea într-o stare de hibernare, sau chiar de oprire automată atunci când nu este folosit. Este un aparat electrocasnic de nelipsit din casa fiecăruia. Ajută la crearea unui mediu mai sigur pentru cei din jur, în special prin integrarea protecției pentru copii.

Articolul de față prezintă conceptul de design industrial, concentrându-se pe interesul de a acoperi cerințele beneficiarilor produsului industrial. În zilele noastre, pentru proiectarea unui nou produs industrial, este absolut necesar cunoaşterea, înțelegerea şi anticiparea nevoilor clienților dar şi a întregii societăți [9], [10], [11]. Dacă se lucrează în domenii care oferă produse ce îndeplinesc alte nevoi decât cele de bază, atunci trebuie găsite metode inovatoare pentru a transmite informația (promovare produs) [12], [13], [14].

Conform lui William Ralph Inge, originalitatea este un plagiat nedescoperit. În tentativa noastră de a creă ceva original, conştient sau nu, vom include elemente pe care

elements from the design of other objects. Therefore, our originality degree depends only on the skills and the knowledge of others.

Acknowledgement

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le-am întâlnit în designul altor obiecte, deci cât de originali vom fi depinde de numai de priceperea şi cunoştințele celorlalți.

Mulțumiri/Recunoştință

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THE SMART DESIGN OF AN ELECTRICAL HOUSEHOLD APPLIANCES – IRON / *DESIGN INTELIGENT AL APARATULUI ELECTROCASNIC – FIER DE CĂLCAT*

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Abstract: *Through designing standards and technolgical development, electrical household appliances are manufactured by respecting well defined and regulated parameters. In order to fit into our courrent environment these appliances should be manufactured using efficient technologies that imply lower costs and lower amounts of energy. The performance of the appliances is targeted through continuous development and transformation. The quality of all electrical appliances is a decisive factor in creating the features that aim to make our life better. In this article, we present the intelligent appliance named – iron.*

Keywords: *Design, home appliances, iron, innovation, project*

INTRODUCTION

This article aims to present the designing process of an electrical appliance. This project was proposed during the „Electrolux Design Lab" contest for the year 2013. Looking into the recent past, soon after the year 1989 some poor quality appliances were sold on the Romanian market. This situation was caused from carelessness but also because of the manufacturer's failure to consider highest quality standards.

If we follow the idea of continuous development in the process of designing and building appliances, we have to determine producers to be aware of the necessity for using an adequate quality standard. This way, our environment is also protected.

In order to increase the performance of appliances, producers should use modern and effcient materials and production systems [1], [2]. Nowadays, the market offers a wide range of appliances, for example the modern iron. This machine is a tool used for smoothing out clothing or fabrics by hot pressing. This ironing operation loosens the links between the long molecules of the fabric. Also, taking into account the weight of the machine, the fabric shall be smooth and cooled in the desired shape. Some fabrics like those made of cotton need some added water in the process so that the molecules can be loosened.

In the current business environment, consumers are increasingly fastidious and competitors are fiercely fighting to harness new ideas, innovative products and services [3], [4], [5], [6], [7]. Hence, this article is presenting a new product design for household iron series.

HISTORY

In China, starting with the first century, metal pots filled with charcoal were used for ironing. In Europe, triangular cast iron plates were used starting with the seventeenth century. Afterwards, charcoal filled cast iron flatiron appeared. The electrical iron was presumably inivented in 1882 by Henry W. Seeley. The first iron with thermoregulator was launched in 1920. Later, Thomas

Rezumat: *Prin proiectare şi standarde, apoi construcție şi modernizare tehnologică, aparatele electrocasnice se caracterizează prin parametrii reglementați şi necesari de îndeplinit. Pentru o ambianță cât mai confortabilă trebuie promovate tehnologii eficiente cu costuri şi consumuri energetice minime. Se urmăreşte eficiența aparatelor electrocasnice prin modernizarea continuă şi performantă a acestora. Calitatea tuturor aparatelor electrocasnice este o condiție deteminantă în realizarea unor funcții menite să ne uşureze munca şi viața. În articolul de față, propunem aparatul inteligent electrocasnic – fier de călcat.*

Cuvinte cheie: *Design, aparate electrocasnice, fier de călcat, inovație, proiect*

INTRODUCERE

Articolul de față îşi propune prezentarea unui design de aparat electrocasnic. Acest proiect a fost doar propus în anul 2013, în cadrul concursului „Electrolux Design Lab". Anii de după 1989 au fost caracterizați de apariția în Romania a multor aparate electrocasnice necorespunzătoare din punct de vedere calitativ, care degradează mediul, fie din superficialitate, neglijență sau lipsă de pregătire profesională în concepția aparatului, fie din nerespectarea, neînțelegerea sau superficialitatea profesională în materializarea proiectului de către realizatorul obiectivului. În ideea progresului în concepția şi realizarea aparatelor electrocasnice, este necesară conştientizarea celor care lucrează în acest domeniu, a necesității cunoaşterii condițiilor de calitate ale mediului de lucru şi a aplicării lor corecte.

Pentru a se mări calitatea şi performanțele aparatelor electrocasnice, trebuie utilizate materiale şi sisteme de proiectat moderne, eficiente [1], [2]. Piața de profil oferă o gamă variată de astfel de aparate electrocasnice. Un fier de călcat este o unealtă folosită la netezirea prin apăsare a materialelor textile. Operația de călcare desface legăturile dintre moleculele lungi ale fibrelor țesăturilor. Fibrele sunt îndreptate datorită greutății fierului de călcat, iar prin răcire rămân în noua formă. Unele materiale, ca bumbacul, necesită un aport de apă ca legăturile să poată fi desfăcute.

Mediul de afaceri dinamic, consumatorii pe zi ce trece mai pretențioşi şi concurența din ce în ce mai ascuțită obligă jucătorii de pe piață să vină mereu cu idei noi, cu produse şi servicii care să satisfacă nevoile consumatorilor mereu în schimbare [3], [4], [5], [6], [7]. Articolul de față îşi propune un design nou de produs pentru aparatul electrocasnic – fier de călcat.

ISTORIC

În China încă din secolul I s-au folosit pentru călcat vase metalice umplute cu mangal. În Europa s-au folosit plăci de fontă triunghiulare prevăzute cu un mâner începând cu secolul al XVII-lea. Ulterior au apărut, fiare de călcat din fontă umplute cu mangal. Se consideră că fierul încălzit electric a fost inventat în 1882 de Henry W. Seeley. Primul fier electric termostatat a apărut în 1920. Mai târziu, a apărut fierul de călcat cu aburi inventat de

Sears invented the steam iron and these products were continuously developing.

The steam iron also helped for smoothing and finishing rippled fabrics. Although the steam iron was invented somehow early, it only became popular in the 1940' [8], [9].

PRODUCT PRESENTATION – CONCEPT

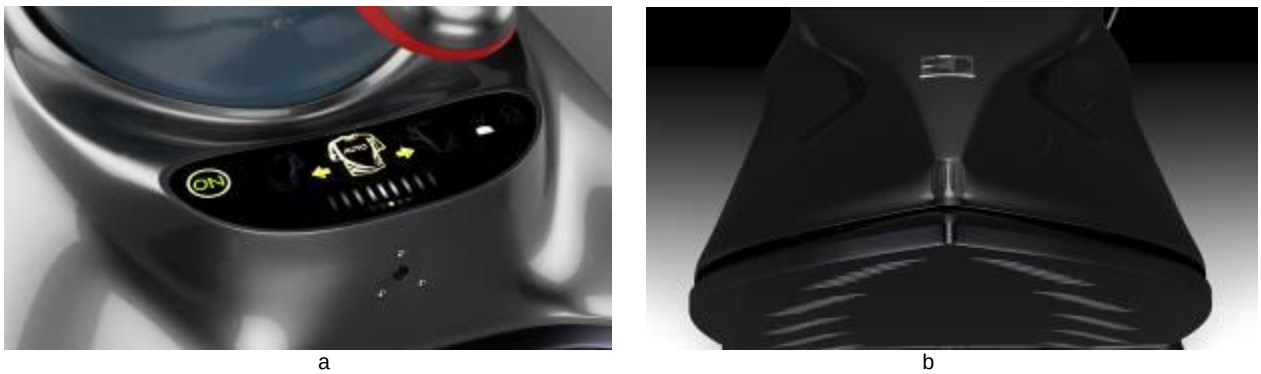
The underlying concept of this iron represents a rechargeable iron that identifies the fabric structure (using a sensor) and automatically sets the ironing temperature for the specific fabric. Aside of these features, this iron has all the functions of a modern one; images 1-a) and 1-b).

către Thomas Sears şi de atunci modelele de fier de călcat au tot evoluat.

Fierul de călcat cu abur realiza mai uşor aplatizarea şi finisarea țesăturii încrețite. Deşi fierul de călcat cu aburi a apărut destul de devreme, el a devenit popular numai în anii 1940 [8], [9].

PREZENTAREA PRODUSULUI – CONCEPT

Conceptul la baza căruia stă acest produs propus este acela al unui fier de călcat dotat cu un acumulator, un senzor ce recunoaşte structura materialului şi un sistem de reglare automată a temperaturii în funcție de materialul ce urmează a fi călcat. Pe lângă aceasta are toate celelalte funcții ale unui fier de călcat modern, fig. 1 a şi b.



a b

Fig. 1 – a) The LCD screen; b) The thermoregulatory sensor

MATERIAL AND METHOD

The 3-D Model was performed using the 3-D Studio Max sofware; image 2. In the next sequence we present the steps of the modeling process.

MATERIAL ŞI METODĂ

Modelul 3D a fost realizat în întregime cu ajutorul softului 3D Studio Max, figura 2. Urmează o prezentare a paşilor de modelare a acestuia.

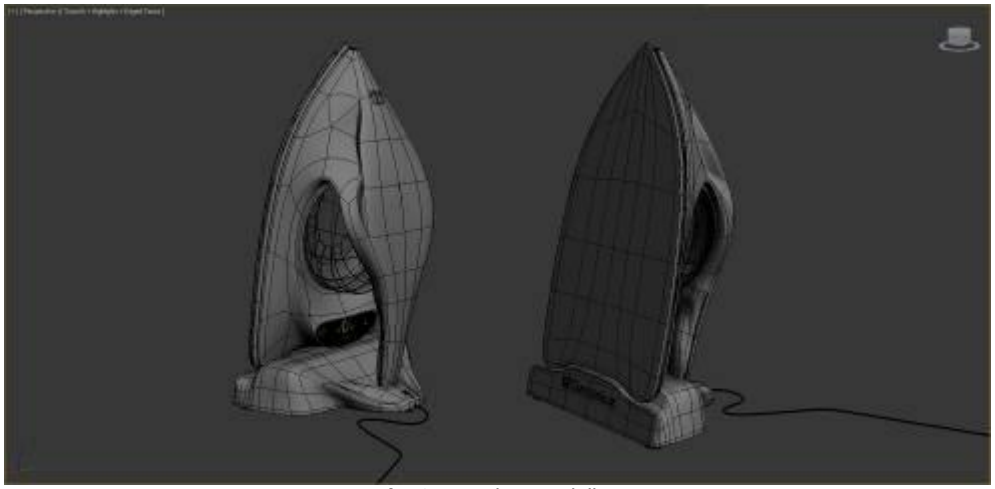
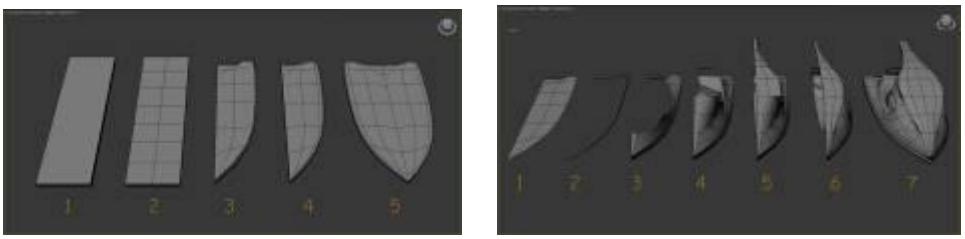


Fig. 2 – Product modeling

In order to create the model, basic geometrical forms were shaped in order to accomplish the desired result. In the image of figure 3, we can see how the soleplate was modeled starting from a box (1) and then adding parts using the ‚connect' function. In the second step, the vertex (3) is modeled alongside with other added parts. In the third step, the ‚turbo smooth' function was added (4). In the final step the ‚symmetry' function was used to complete the other half of the model and finish the entire element (5); images 3-a) and 3-b).

Pentru realizarea modelului s-a pornit de la forme geometrice de bază (box, sfera) care ulterior au fost manipulate până s-a ajuns la rezultatul dorit. În figura 3, se poate observa cum s-a modelat talpa pornind de la un box (1) la care s-au adăugat subdiviziuni cu ajutorul comenzii „connect" (2); ulterior s-a manipulat meşul vertex şi s-au adăugat subdiviziuni unde a fost cazul pâna s-a ajuns la forma (3); s-a adăugat un modifer numit „turbo smooth" ce subdivizează dând un rezultat rotunjit (4); modelul fiind simetric a fost realizat doar o jumătate apoi s-a folosit „symmetry" pentru a obține elementul final (5), figura 3 a şi b.



a b

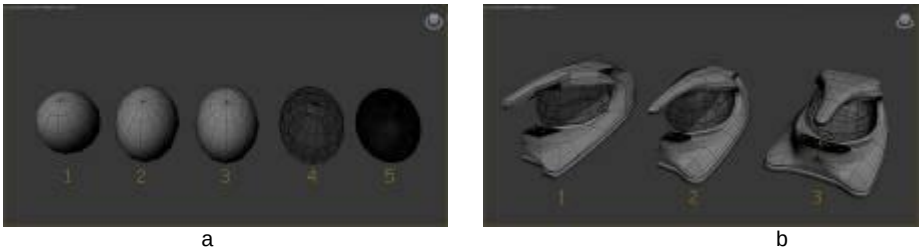
Fig. 3 – a/b) Modeling steps - 1

The next image presents the steps of creating the body structure. This element was created starting from the upper part of the soleplate that was shaped on one side of the model. Moving forward, the inner side was erased in order to start the modeling process (3),(4),(5). Also, turbo smooth and symmetry functions were applied; image 4-a).

The water tank was created starting from the basic geometrical form which is a sphere that was manipulated on the X and Y axes, (3). In the next phase, the inner quarter was cut in order to obtain a flat surface (4). Here, the turbo smooth function was added once more; image 4-b).

În următoarea imagine este prezentată realizarea corpului. Acesta a fost realizat pornind de la planul superior al tălpii (1) ce ulterior a fost extrudată pe o margine a acestuia (2) şi şters interiorul pentru a putea porni procesul de modelare (3), (4), (5). De asemenea a fost adăugat „turbo smooth” (6) şi „symmerty” (7), figura 4 a.

Bazinul de apă a fost creat pornind, de asemenea, de la forma geometrică de bază, respectiv sfera (1) ce a fost manipulată de-a lungul axelor y şi z (2), (3). În pasul următor s-a tăiat sfertul inferior al acesteia pentru a obține o suprafață plană (4) şi, de asemenea a fost adăugat modul „turbo smooth” (5), figura 4 b.



a b

Fig. 4 – a/b) Modeling steps - 2

As specified earlier, the symmetrical elements have been modeled only on one half. In the image below, the three phase model is presented as following: (1) raw model (unchanged); (2) turbo smooth added; (3) symmetry added (on elements that support the function).

Cum s-a precizat mai sus, elementele simetrice au fost modelate doar jumătate, în figura 4 fiind prezentat modelul în 3 ipostaze, respectiv: (1) modelul brut fără nicio modificare, (2) adăugat „turbo smooth”, (3) s-a adăugat „symmerty” pe elementele simetrice, figura 4 b.

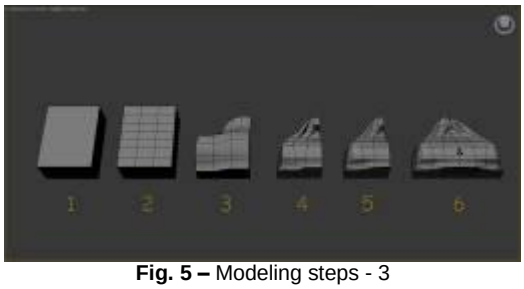


Fig. 5 – Modeling steps - 3

In the image above we can see the steps for modeling the iron charging station. This was created starting from a box form that was divided for better modeling purposes. This process is presented in the steps (3),(4). The turbo smooth and symmetry functions are added in steps (5), (6); Image 5.

TURBO SMOOTH

In this section, the turbo smooth function is explained. In the image below, two perpendicular planes are presented in three phases:

- In the upper side we have the two perpendicular planes with the turbo smooth function disabled and in the lower side we have the two perpendicular planes with the

În imaginea din figura 5 sunt prezentați paşii de modelare a bazei de alimentare. Aceasta a fost realizată pornind de la un box (1) ce a fost subdivizat (2) pentru a fi manipulat cu uşurință, În paşii (3), (4) este prezentat procesul de modelare şi subdivizare pentru a obține forma dorită. La (5) este adăugat „turbo smooth”, iar la (6) este adăugat „symmerty”, figura 5.

TURBO SMOOTH

În continuare este prezentat cum funcționează această comandă. În imaginea de mai jos sunt reprezentate două planuri perpendiculare în trei ipostaze şi efectul uneltei Turbo Smooth:

- În partea de sus a celor trei ipostaze se regăsesc cele doua planuri fără a avea activat efectul turbo smooth, iar în partea de jos cele două planuri cu

turbo smooth function enabled. When this function is enabled we can observe how the right angle becomes a curve. This curve is defined by the distance between the edge and the closest line.

- In order to better demonstrate this effect and obtain a smaller curve, a line on each plane was added between the two planes and close to the edge.
- In this phase, the lines are very close to the edge and a very small edge was obtained. Here, the curve is perceived as a sharp edge and the deformation of the two planes is much smaller.

To conclude, various phases can be used in modeling in order to obtain the desired shapes, from very sharp edges to very smooth curves, all without the deformation of the initial geometrical form.

turbo smooth activat. Se poate observa atunci când se activează această unealtă cum unghiul drept dintre cele două planuri devine o curbă ce este determinată de distanță dintre muchie şi cea mai apropiată linie.

- Pentru a demonstra mai bine acest efect şi pentru a obține o curbă mai mică s-a adăugat în apropierea muchiei dintre cele două planuri câte o linie pe fiecare plan (această curbă devine mai mică).
- În această ipostază s-au mutat liniile foarte aproape de muchie astfel încât s-a obținut o curbă foarte mică ce este sesizată ca o muchie ascuțită şi deformarea celor două planuri este mult mai mică.

Diferitele ipostaze se pot folosi în modelare pentru a obține formele dorite, de la muchi foarte ascuțite, păstrarea geometriei inițiale nedeformate, până la curbe fine.

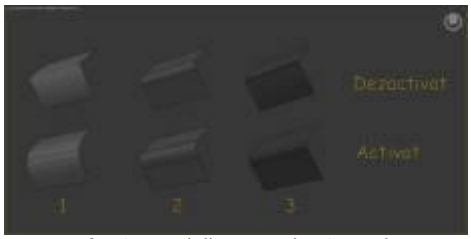


Fig. 6 - Modeling – Turbo Smooth

RESULTS

The chosen iron design is futuristic and has aerodynamic shapes, smooth curves and a quality finish that exposes the structure and features. The ultimate model was obtained by creating elements around the water tank which is the starting point of this design project. The materials used comprise glossy surface plastic and rubber for a better grip on the handle. In the rear side, a touch screen display was added for accessing and utilizing the iron functions. The following images represent 3-D rendering created in 3-D studio Max Software; Image 7.

REZULTATE

Designul ales a fost unul futurist cu forme aerodinamice, linii curbe fine ce pun în vedere forma şi funcționalitatea acestuia. Forma finală a fost obținută construind elementele în jurul rezervorului de apă sferic ce este vizibil în proporție de 60% fiind centrul de pornire şi dezvoltare al acestui design. Materialele folosite sunt plastice cu o suprafață glossy, respectiv cauciuc în zona mânerului pentru o mai bună prindere. În partea din spate a produsului propus a fost integrat un display cu touch screen prin care se pot accesa şi vizualiza toate funcțiile acestuia. Imaginile din figura 7 sunt randari 3D realizate în 3D Studio Max.

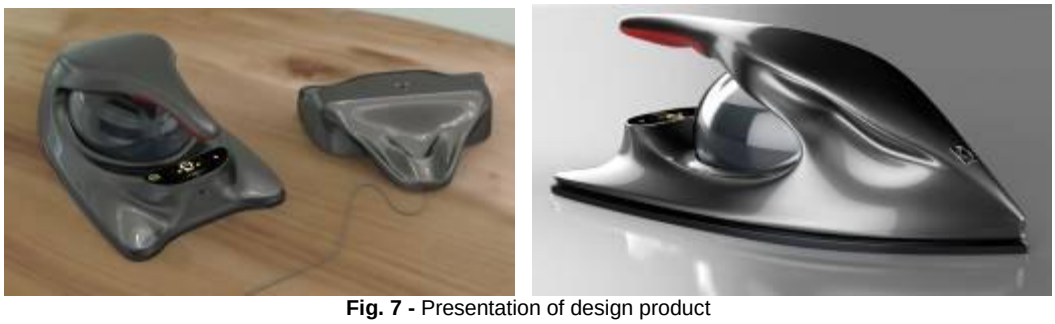


Fig. 7 - Presentation of design product

Launching new products is extremely costly and, for this reason, careful planning is essential. When a new product is released on the market, it already has a history behind it. The process starts from identifying a need or demand which should be analyzed prior to developing the product and creating packaging. Afterwards, the role of marketing and communication strategies sets the future course of development.

Considering that innovation is not an option but a prerequisite, creating new products is a very difficult task and that's why only a few ideas prove to be good enough to attain success in the market. In this case, the proposed item offers remarkable solutions, image 8.

Lansarea de produse noi este extrem de costisitoare şi din acest motiv trebuie tratată cu mare grijă. În momentul în care un produs a fost lansat pe piață, el are deja în spate o veritabilă istorie. Aceasta porneşte de la identificarea unei nevoi încă nesatisfăcute pe deplin, trece prin analiza unei poziționări relevante, continuă cu devoltarea produsului, a ambalajului şi a numelui şi se termină cu generarea unei strategii de comunicare.

Pentru că inovația nu mai este demult opțională, crearea unor produse noi este o misiune dificilă şi relativ puține idei se dovedesc a fi destul de bune pentru a înregistra un succes comercial. Produsul propus prezentat în figura 8 oferă soluții inedite.

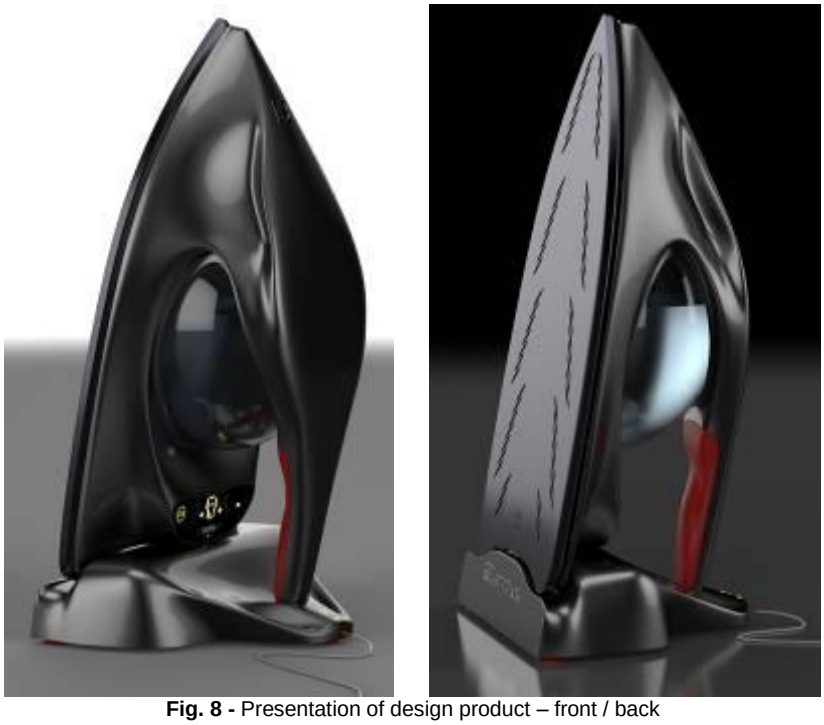


Fig. 8 - Presentation of design product – front / back

In the present time, the customers' demands for increased comfort are manifold so, to offer maximum satisfaction, the new irons are elegant in both design and functional features. The body and structure of the iron emphasizes the differentiation and makes it stand out among similar products, image 9.

Nevoile actuale ale utilizatorilor de a-şi creea un confort mai mare sunt din ce în ce mai variate. Pentru a satisface aşteptările, noile aparate de călcat propuse aduc soluții elegante şi simplu de aplicat. Construcția fierului de călcat, prin originalitatea lui, iese în evidență între produsele similare, figura 9.

Fig. 9 - Presentation of design product – front / back

CONCLUSIONS

The process of designing an iron is a complex activity that comprises multiple steps before accomplishing a state-of-the-art product, like the iron presented above. Knowing that design can be represented at various levels, this iron fits the Product Design category meaning the process was created with regard to both design

CONCLUZII

Fierul de călcat proiectat reprezintă o activitate de creație a unui produs util şi estetic în acelaşi timp. Designul poate avea diferite nivele. Nivelul la care se încadrează fierul de călcat proiectat este – design de produs – care presupune o concepție a produsului în acelaşi timp cu proiectarea tehnică, fiind rezultatul comun

standards and technical standards. The end product is the result of common efforts from mechanical engineers, designers and marketing specialists.

The product is part of durable goods that are bought infrequently and the buying decision is decisively influenced by the following ratio: price-quality-brand. This specific product is an exceptional electrical appliance that has innovative functional attributes, a state of the art iron in terms of ergonomics, quality and authenticity.

Acknowledgement

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al activității proiectanților mecanici ai tehnologiilor designerului şi specialistului în marketing.

Produsul proiectat poate fi încadrat în categoria produselor de folosință îndelungată, cumpărate mai rar în care factorii preț – calitate – marcă au o influență decizivă la achiziționare [3]. Produsul realizat este unul inedit, prezentând o inovație de senzație în domeniu. Totodată, produsul proiectat prezintă şi următoarele atributele şi anume: utilitate şi estetică precum şi ergonomicitate, originalitate, actualitate etc.

Mulțumiri/Recunoştință

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NEW TRENDS CONCERNING THE MAINTENANCE OF CROPS THROUGH UNCONVENTIONAL METHODS
/
TENDINȚE NOI PRIVIND ÎNTREȚINEREA CULTURILOR AGRICOLE PRIN METODE NECONVENTIONALE

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Abstract: *Agricultural work through their effects on the soil physical, chemical and biological properties is one of the most important ways to increase production. An important category of agricultural operations to be carried out in order to achieve optimal crops with growing productivity is the maintenance of their works. The paper presents a variety of methods for crops maintenance by various farm equipment with an different operating principle but with the same aim, namely removing weeds.*

Keywords: *weeding, intelligent, unconventional methods*

INTRODUCTION

They are called weeds wild plant species adapted to live together with the plants grown which they hamper the rise and sometimes destroys them or remove them from the chain.

Under the name of weeds in a broader sense means all foreign plants from a crop. For example rye plants in a crop of wheat are regarded as weeds. Such weeds are called conditional weeds.

In each he soil and climate area, there is a certain degree of weed and dominates a certain biological group of weeds, certain species. This is the case of ciurlan in Bărăgan, which was developed in close connection with the climatic and soil conditions and the technique applied in agriculture.

Weeds are the main calamity of agriculture and so it is necessary to use the whole complex of measures to combat them. For these measures to lead to the expected results it is necessary to give special attention to weed biology knowledge.

Weeds consumes water in large quantities. M. E. Wolny found in a field of potatoes with weed 19.68% of water in the soil, and in a neighbor field clean of weeds 22.40%. The difference of 2.82% represents a loss of 84.6 tonnes of water per hectare on 20 cm arable layer. Weeds generally extract 3 times more water than cereals. A mustard plant consumes 4 times more water than a plant of oats. Weeds are rightly considered as one of the main reasons that determine soil drought even when the weather conditions are favorable. [6]

The weeds consume from the soil large amounts of nutrients in the detriment of agricultural plants. This can be seen from the chemical composition of the weeds in comparison with wheat (Table 1).

Rezumat: *Lucrările agricole prin efectele lor asupra proprietatilor fizice, chimice şi biologice ale solului reprezinta una dintre cele mai importante modalitati de crestere a producției. O categorie importanta a lucrarilor agricole care trebuie efectuate in scopul obtinerii unor culturi optime cu productivitati tot mai mari il reprezinta lucrarile de intretinere a acestora. În lucrare se prezintă o varietate de metode de întreținere a culturilor cu diverse echipamente agricole cu un principiu de funcționare diferit dar cu acelasi scop şi anume eliminarea buruienilor.*

Cuvinte cheie: *prăşire, inteligent, metode neconvenționale*

INTRODUCERE

Se numesc buruieni speciile sălbatice de plante adaptate să trăiască împreună cu plantele cultivate pe care le stânjenesc în creştere şi uneori le distrug sau le elimină din lan.

Sub numele de buruieni în sens mai larg se înțeleg toate plantele străine dintr-o cultură. De exemplu plantele de secară dintr-o cultură de grâu sunt considerate buruieni. Asemenea buruieni se numesc buruieni condiționate.

În fiecare zonă pedoclimatică, există un anumit grad de îmburuienare, predomină o anumită grupă biologică de buruieni, anumite specii. Aşa este cazul ciurlanului în Bărăgan, care s-a dezvoltat în strânsă legătură cu condițiile de climă, de sol şi cu tehnica aplicată în agricultură.

Buruienile reprezintă calamitatea principală a agriculturii şi din această cauză este necesar să se folosească întreg complexul de măsuri pentru combaterea lor. Pentru ca aceste măsuri să ducă la rezultatele scontate este necesar să se dea o atenție deosebită cunoaşterii biologiei buruienilor.

Buruienile consumă apă în cantitate mare. M.E. Wolny a găsit într-un lan cu cartofi îmburuienat 19,68 % apă în sol, iar într-un lan vecin curat de buruieni 22,40%. Diferența de 2,82% reprezintă o pierdere de 84,6 tone apă la hectar pe stratul arabil de 20 cm. Buruienile extrag în general de 3 ori mai multă apă decât cerealele. O plantă de muştar consumă de 4 ori mai multă apă decât o plantă de ovăz. Buruienile sunt socotite pe drept cuvânt ca fiind una din cauzele principale, care determină seceta solului chiar atunci când condițiile meteorologice sunt favorabile. [6]

Buruienile consumă din sol importante cantități de substanțe hrănitoare în detrimentul plantelor agricole. Acest lucru reiese din compoziția chimică a buruienilor în comparație cu a grâului (tabelul 1).

Table 1 [6]

The chemical composition of some species of weeds and the wheat

Specia	Conținutul		
	N	K_2O	P_2O_5
Albăstrița (*Centaurea cyanus*)	2,3	2,0	1,0
Pălămida (*Cirsium arvense*)	2,6	2,0	1,2
Media la 18 specii diferite de buruieni	1,9	3,5	0,5
Grâu de toamnă	0,7	0,7	0,5

The analysis of these data shows that in comparison with the weeds, wheat extracted about 3 times less nitrogen, 5 times less potassium and about 2 times less phosphorus.

In cultures invaded by weeds, due to lack of light, the plants are grown without chlorophyll, grow in length, assimilates least, can not form strength mechanical tissues, are easily broken and the process of photosynthesis is hampered.

Because weeds, farmers are forced to use a larger volume of work, to make additional investments to purchase tools, machinery, herbicides etc.

Weeds hinder or impede the execution of works for preparing the soil for sowing, proper seeding, the works for crops maintenance and harvesting, thus reducing the work efficiency.

In the U.S. have been made calculations and it was concluded that the soil works is about 16% of the production value of arable land and almost 50% of these costs are due to weeds.

In our country the losses caused by weeds varies in limits very greatly depending on: the cultivated species, the degree of weed infestation, climatic conditions (drought year or rainy), the ratio of different weed species, potential of natural fertility of the soil and the doses of applied fertilizer. [5].

In Table 2 are played back the limits of losses registered at the main plants field.

Din analiza acestor date rezultă că în comparație cu buruienile, grâul extrage de aproape 3 ori mai puțin azot, de 5 ori mai puțin potasiu şi aproape de 2 ori mai puțin fosfor.

În culturile invadate de buruieni, din cauza lipsei de lumină, plantele cultivate se etiolează, cresc în lungime, asimilează puțin, nu-şi pot forma țesuturi mecanice de rezistență, se frâng uşor, iar procesul de fotosinteză este stânjenit.

Datorită buruienilor, agricultorii sunt nevoiți să folosească un volum mai mare de muncă, să facă investiții suplimentare pentru procurarea uneltelor, maşinilor, erbicidelor etc.

Buruienile îngreunează sau împiedică executarea lucrărilor de pregătire a solului în vederea semănatului, semănatul propriu-zis, lucrările de îngrijire a culturilor şi recoltatul, micşorând în felul acesta randamentul muncii.

S-au făcut calcule în S.U.A. şi s-a ajuns la concluzia că lucrările solului reprezintă circa 16% din valoarea producției terenurilor arabile şi că aproape 50% din aceste cheltuieli se datorează buruienilor.

În țara noastră pierderile cauzate de buruieni variază în limite foarte mari în funcție de: specia cultivată, gradul de infestare cu buruieni, condițiile climatice (an secetos sau ploios), raportul dintre diferitele specii de buruieni, potențialul de fertilitate naturală a solului şi dozele de îngrăşăminte aplicate.[5].

În tabelul 2 sunt redate limitele pierderilor înregistrate la principalele plantede câmp.

Table 2 [5]

The level of production losses caused by weeds in various plants field

Plantele	Limitele pierderilor în parcelele neplivite sau neprăşite față de cele tratate cu erbicide
Grâu de toamnă	10-70 %
Orz	10-40 %
Porumb boabe	30-95 %
Floarea-soarelui	15-55 %
Soia	40-84 %
Fasole	35-80 %
Mazăre	15-70 %
Trifoliene	40-100 %
Cartof	42-72 %
Sfeclă pentru zahăr	53-96 %
In ulei	20-68 %
Cânepă sămânță	10-52 %

MATERIAL AND METHOD

In our country tillage operation between plants on row is performed only manually or by chemical control, with high costs and a high percentage of infestation of the soil. The experience of Western countries shows that the efficiency of the agricultural maintenance of hoeing cultures by achieving advanced mechanization technologies with innovative and intelligent machinery for maintenance, with high precision, of the crops can become profitable for both the manufacturer supplier of technical equipment and for the user. In this context it is necessary to conduct such a research to promote a technology and an advanced equipment for maintenance the weeding crops, adapted to specific soil and climatic conditions of our country.

RESULTS

An example of the row crop maintenance is the equipment for weeding CPA 5.6, and for remove all weeds between plants is used JET machine researched by INMA Bucharest, represented in figures 1 and 2.

Hoeing cultivator with new types of working bodies type CPA 5.6 works in aggregate with 65 HP wheels tractors and is intended for execution the works of weeds destruction and soil shredding, breaking crust on the range of the plants and watering gutters recovery at the plants from field corn, vegetable crops, potatoes and beet.

Among the rows of plants the hoeing is running with cultivators equipped with different active parts depending on the crop or hoeing purposes, and on the raw the hoeing is executed all manual or by chemical control, with high spending and soil infestation.

MATERIAL ŞI METODĂ

In țara noastră operațiunea de lucrare a solului dintre plante pe rând se efectuează numai manual sau prin combatere chimică, cu cheltuieli ridicate şi cu un procent ridicat de infestare a solului. Experiența țărilor vest-europene demonstrează că eficientizarea lucrărilor agricole de întreținere a culturilor prăşitoare prin realizarea de tehnologii avansate de mecanizare cu echipamente tehnice inovative si inteligente de intretinere, cu precizie ridicată, a culturilor poate deveni profitabilă atât pentru producătorul furnizorul de echipamente tehnice, cât şi pentru utilizator. In acest contest se impune necesitatea de a realiza o asemenea cercetare pentru a promova o tehnologie şi un utilaj performant de întreținere a culturilor prăşitoare, adaptat condițiilor de sol şi climă specifice țării noastre.

REZULTATE

Un exemplu de întreținere a culturilor pe rând este şi echipamentul de prăşit solul CPA 5,6, iar pentru înlăturarea buruienilor pe rând între plante se foloseşte maşina JET cercetată de către INMA Bucureşti, reprezentate în figurile 1 si 2.

Cultivatorul de prăşit cu tipuri noi de organe de lucru tip CPA 5,6 lucrează în agregat cu tractoarele de 65 CP pe roți şi este destinat pentru executarea lucrărilor de distrugere a buruienilor si mărunțirea solului, spart crusta pe intervalul dintre plante şi refacerea rigolelor de udare la plantele din cultura mare, legumicultură, plante tehnice, cartofi şi sfeclă.

Printre rândurile de plante prăşitul se execută mecanic cu cultivatoare echipate cu piese active diferite în funcție de planta de cultură şi scopul praşilei, iar pe rând prăşitul se execută manual sau prin combatere chimică, cu cheltuieli ridicate şi cu infestarea solului.

Fig. 1 – Weeding equipment on row researched by INMA Bucharest CPA 5,6 [12]

The machine JET 4 (Fig. 2) is intended for execution chemical treatments to control the diseases, pests and herbicides in field crops. This can work in aggregate with 45 or 65 HP tractors and is operated from the PTO tractor. It consists in: frame; solution tank; clean water tank for primary remediation; hydraulic installation; liquid installation. The carried machine for manage herbicide spraying works by hydraulic spraying principle. The transport of drops to the culture submitted to the treatment is achieved due to the speed printed thereof from the pressure created by the pump at the passage through spray heads.

Maşina JET 4 (fig. 2) este destinată efectuării tratamentelor chimice pentru combaterea bolilor, dăunătorilor şi erbicidării în culturile de câmp. Acesta poate lucra în agregat cu tractoare de 45 sau 65CP şi este acționată de la priza de putere a tractorului. Se compune din: cadru; rezervor de soluție; rezervor de apă curată pentru depoluare primară; instalație hidraulică; instalație de lichid. Maşina purtată de administrat erbicide lucrează pe principiul pulverizării hidraulice. Transportul picăturilor spre cultura supusă tratamentului se realizează datorită vitezei imprimate acestora de presiunea creată de pompă la trecerea prin capetele de pulverizare.

Fig. 2 – The machine to destroy weeds between plants - JET 4 [12]

This last work, hoeing on row is particularly important for the harmonious development of crop plants and the achieving of high productivities. In this sense is pursuing the development of some specialized equipment to perform this task automatically, without human intervention and without the use of chemicals.

Romania benefit from transitional measures relating to the use (after the accession date) of stocks of plant protection products (PPP) containing active substances withdrawned from the EU market in accordance with European Commission no. 2024/2006 published in the Official Journal of the European Communities nr. L384 from 29.12.2006. The grace period for 12 mounths granted by Romania based on Regulation CE no. 2024/2006 for plant protection products containing substances: amitraz, atrazine, benomyl, endosulfan, kasugamycin and simazine expires on 31 December 2007. From 1 January 2008, in accordance with applicable law, the use of products containing these active substances is prohibited. [11]

An unconventional method that has been developed is the equipment The Red Dragon Vegetable Bed Flamer produced by Earth & Sky Inc wich eliminates weeds with the help of flames.

The Red Dragon Vegetable Bed Flamer offers to producers more options for weed control while reduces or eliminates the use of herbicide. Flames burn clean propane, efficient, so there is no residue or any contamination to worry. Flames burning are using 4-7 liters of propane per ½ ha, about half the cost of herbicides in a normal year. Hoeing with the help of this equipment can be done before or after sprouting and has been proven effective on a variety of crops, including corn, milo, sorghum, soybeans, cotton, carrots and more. [9]

Aceasta ultima lucrare, prasitul pe rand este deosebit de importanta pentru dezvotarea armonioasa a plantelor de cultura si realizarea unor productivitati ridicate. In acest sens se urmareste dezvoltarea unor echipamente specializate care sa realizeze aceasta operatie automat, fara interventie umana si fara utilizarea unor substante chimice.

România beneficiază de măsuri tranzitorii referitoare la utilizarea (după data aderării) a stocurilor de produse de protecție a plantelor (PPP) ce conțin substanțe active retrase de pe piața Uniunii Europene în conformitate cu Regulamentului Comisiei Europene nr. 2024/2006 publicat în Jurnalul Oficial al Comunităților Europene nr. L384 din 29.12.2006. Perioada de grație de 12 luni acordată de România în baza Regulamentului CE nr. 2024/2006 pentru produsele de protecția plantelor conținând substanțele: amitraz, atrazin, benomil, endosulfan, kasugamicin şi simazin expira la 31 decembrie 2007. Începând de la 1 ianuarie 2008, în conformitate cu legislația în vigoare, utilizarea produselor conținând aceste substanțe active este interzisă.[11]

O metoda neconventionala care a fost dezvoltata este si echipamentul The Red Dragon Vegetable Bed Flamer produs de catre Earth & Sky Inc care elimină a buruienile cu ajutorul flăcărilor.

The Red Dragon Vegetable Bed Flamer oferă producătorilor mai multe opțiuni pentru controlul buruienilor în timp ce reduce sau elimină utilizarea de erbicid. Făcările ard propan curat, eficient, astfel încât nu există nici un reziduu sau vreo contaminare de care sa ne îngrijorăm.Flacarile care ard folosesc 4 - 7 litri de propan pe ½ ha, aproximativ jumătate din costul de erbicide într-un an normal. Prasitul cu ajutorul acestui echipament se poate face înainte de răsărire sau după răsărire şi a fost dovedit eficient pe o varietate de culturi, inclusiv porumb, milo, sorg, soia, bumbac, morcovi şi altele. [9]

Fig. 3 – Echipamentul The Red Dragon Vegetable Bed Flamer [9]

Hoeing on the row is particularly important for the harmonious development of crop plants and achieving high productivity. In this sense are pursuing the

Prasitul pe rand este deosebit de important pentru dezvoltarea armonioasa a plantelor de cultura si realizarea unor productivitati ridicate. In acest sens se

development of some specialized equipments to perform this task automatically, without human intervention and without the use of chemicals.

Research on mechanical weeding technology on the row and between plants began, worldwide, in 2001 by Garford Farm Machinery named -Robocrop MK2 (fig.4) - using the electronic part from Robydome. This technology uses on-board computers to identify and locate crop plants in real time with the digital video images. Following a successful research project in collaboration with Garfords are now on market at high technology level, concerning weed control between crop plants.

Robocrop MK2 uses two technologies, one GPS type to guide the technical equipment on the cultivated rows to perform the operation of hoeing on the interval with precision and at high speeds. Technology relieves the users the need to focus the forward direction, allowing it to monitor the operations without a high level of stress. A video camera mounted on the machine sees the harveste and pass the images to a computer that processes the images and calculates the lateral position relative to the crop rows, activating a mechanism of lateral movement, so as to reduce any misalignment.

The second technology relates to hoeing on line between plants, in wich is identified each plant from the row. Then the computerised system synchronizes the rotation of a disc tillage ring between plants on the row. The result is a significant increase in the cultivated area eliminating the need for manual weeding of crops. The maximum productivity of the system Robocrop to hoeing the range of crops, and between the plant reached a rate of up to 2 plants per second.

Differences between the mechanized and manual hoeing between plants is very high after a research study done on lettuce, Robocrop MK2 machine was used for rare the culture and to remove weeds and the operation lasted 8.4 h / ha compared with the same procedure done manually which lasted 23.2 hours / ha and plant density was 62,000 plants / ha compared to only 56,000 plants / ha. The crops tracking and tracing technology was developed by the team from THTechnology research for 12 years.

The active organs for hoeing on the range of the plants are classic and the bodies for hoeing between plants on the row have a special construction. These have in comprise a particular crescent-shaped disc mounted parallel to the ground working at a low depth (typically 10 to 20 mm) on the row cultures. It is mounted on a vertical support and a flange shaft to a hydraulic motor driven by a proportional hydraulic valve controlled and synchronized with forward speed from the Robocrop computer following information taken from the camera.

The crescent profile of the disc is designed to maximize the worked surface with precision (within 10 mm from the average position of the detected plant leaves), around the plants and between plants area. [7]

urmareste dezvoltarea unor echipamente specializate care sa realizeze aceasta operatie automat, fara interventie umana si fara utilizarea unor substante chimice.

Cercetările privind tehnologia de prasit mecanizat pe rand au început, pe plan mondial, din anul 2001 de catre Garford Farm Machinery sub denumirea –Robocrop MK2 (fig.4) - folosind partea electronica de la Robydome. Această tehnologie foloseşte calculatoare de bord pentru a identifica şi a localiza plantele de cultură în timp real cu imagini video digitale pe scene de cultură. În urma unui proiect de cercetare de succes în colaborare cu Garfords sunt acum pe piață la nivel de tehnologie înaltă, privind controlul buruienilor dintre plante de cultură.

Robocrop MK2 utilizează două tehnologii, una de tip GPS pentru a ghida echipamentul tehnic pe rândurile cultivate pentru a efectua operațiunea de prăşit pe interval cu precizie şi la viteze mari. Tehnologia scuteşte mecanizatorul de necesitatea de a se concentra pe direcția de înaintare, permițându-i să monitorizeze operațiunile fără un nivel ridicat de stres. O camera video montata pe masina vede recolta înainte şi trece imagini la un calculator care proceseaza imaginile si calculează poziția laterală în raport cu rândurile de cultura, activand un mecanism de deplasare laterală , astfel încât să reducă la minimum orice nealiniere.

A doua tehnologie se referă la prăşitul pe rând, între plante, în care este identificată fiecare plantă din rând. Sistemul computerizat sincronizează apoi rotirea unui disc ciclic de prelucrare a solului între plante pe rând. Rezultatul este o creştere semnificativă în zona cultivată eliminând necesitatea plivitului manual al culturilor. Productivitatea maximă a sistemului Robocrop la prăşitului pe intervalul dintre culturi, cât şi pe rând între plante a ajuns la o rată de până la 2 plante pe secundă.

Diferentele dintre prasitul intre plante mecanizat si cel manual este foarte mare, dupa un studiu de cercetare facut pe salata verde, utilajul Robocrop MK2 a fost folosit pentru a rari cultura si pentru a indeparta buruienile şi operațiunea a durat 8,4 h/ha fata de acelaşi procedeu efectuat manual care a durat 23,2 h/ha, iar densitatea de plante a fost de 62000 plante/ha față de doar 56000 plante/ha. Tehnologia de localizare si de urmarire a culturi a fost dezvoltata de catre echipa de la THTechnology timp de 12 ani de cercetare.

Organele active de prăşit pe intervalul dintre plante sunt clasice iar cele de prăşit între plante pe rând au o construcție specială. Acestea au în componență un disc special în formă de semilună montat paralel cu solul care lucrează la o adâncime redusă (în mod obişnuit 10 până la 20 mm) pe randul culturilor. El este montat pe un suport vertical şi pe o flanşă de axul unui hidromotor acționat de o supapă hidraulică proporțională controlată şi sincronizată cu viteza de înaintare de calculatorul Robocrop după informațiile preluate de la cameră de luat vederi.

Profilul de semilună al discului este conceput pentru a maximiza suprafața lucrată cu precizie (până la 10 mm de poziția medie a frunzelor de plante detectate) în jurul plantelor şi zona între plante.[7]

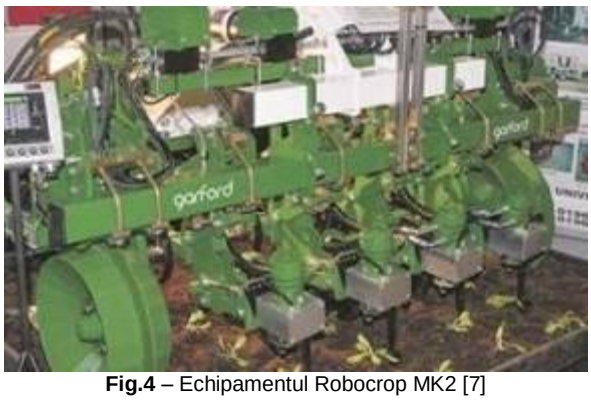

Fig.4 – Echipamentul Robocrop MK2 [7]

A developed equipment for mechanical hoeing on row and between plant, is equipment Robovator Nanne Kooiman (Figure 5).

The robot is equipped with a special camera for plant detection, placed on each work sector framework. This has a mechanical instrument which is operated by hydraulic system. Hydraulic components are very robustes and designed to operate at high speed and long life.

Cameras specially designed for detecting plants mounted on each parallelogram monitors continuously the plants. If the plant goes through a range cameras, the computer will send a signal to the hydraulic tool who at the specified time will be moved from the row. When the crop plant has passed the instrument will be moved again on the row.

If there is a gap between rows, for example one or more plants are missing, the hoeing active bodies will remain only on the row to. The side automatic control ensures you that the device remains in the exact position, even if the tractor rolls off the trajectory..

Features: side automatic control of the machine, can operate in darkness, high capacity, low energy requirement, reduced maintenance. [8]

Un echipament dezvoltat pentru prasitul mecanic pe rand si intre plante este si echipamentul Nanne Kooiman Robovator (fig.5).

Robotul este echipat cu o cameră de detectare a plantei speciala, plasatata pe cadrul fiecărei secti de lucru. Aceasta are un instrument mecanic care este operat de sistemul hidraulic. Componentele hidraulice sunt foarte robuste şi concepute pentru funcționarea la viteză mare si durata lungă de viață.

Camerele de luat vedere special concepute de detectare a plantelor montate pe fiecare paralelogram monitorizează continuu plantele. In cazul în care trece o planta prin raza camerei de luat vederei, computerul va trimite un semnal la instrumentul hidraulic care la timpul specificat de camera va fi mutat din rand. Cand planta de cultura a trecut instrumentul va fi mutat in rand din nou.

In cazul in care exista un decalaj intre randuri, de exemplu una sau mai multe plante lipsesc organele active de prăşit vor ramane doar pe rand. Controlul automat lateral vă asigură că aparatul rămane in poziția exacta, chiar daca tractorul iese de pe traiectorie.

Caracteristici: controlul automat lateral al maşinii, poate funcționa în întuneric, de mare capacitate, cerința redusă de energie, întreținere redusă. [8]

Fig.5 – Echipamentul Nanne Kooiman Robovator [8]

Another equipment for hoeing on row and between planst is Ferrari Removeed equipment which is an automatic equipment for hoeing between plants and on the row manufactured by FERRARI COSTRUZIONI MECCANICHE.

Different from standard digs available on the market, this equipment introduce innovative technological solutions. The most unique capacity is the ability to remove weeds between rows and between plants on the same row.

The device can scan and remove weeds found along the width of the frame, during the advance. The

Un alt echipament pentru prasitul pe rand si intre plante este echipamentul Ferrari Removeed care este un echipament automatic de prasit intre randuri si pe rand fabricat de FERRARI COSTRUZIONI MECCANICHE.

Diferit de sapele standard disponibile pe piata, aceasta masina introduce solutii tehnologice inovatoare. Carcateristica cea mai unica este capacitatea de a elimina buruieni intre randuri si intre plante pe acelasi rand.

Aparatul poate scana si elimina buruienile gasite de-a lungul latimii cadrului, in timpul inaintarii. Sapa automata este echipata cu un cadru de plutire capabil sa se

equipment is equipped with a floating frame able to change on both sides using hydraulic pistons.

Each unit uses an infrared optical bar to detect weeds and plants. This unit is also equipped with a pair of hydraulic arms on which are mounted two cutting blades.

The cutting blades can cut weeds until 1 cm from the plants and their work height can be adjustable. [10]

schimbe pe ambele parti prin utilizarea pistoanelor hidraulice.

Fiecare unitate utilizeaza un bar optic inflarosu pentru a detecta buruienile si plantele. Aceasta unitate este, de asemenea, echipata cu o pereche de brate hidraulice pe care sunt montate cele doua lame de taiere.

Lamele de taiere pot taia buruienile pana la 1 cm fata de plante si inaltimea lor de lucru poate fi reglata. [10]

Fig.6 – Echipamentul Ferrari Remoweed [10]

Due to the new tendencies on wedding of crops and in the context of practically a precision agriculture, which according to European Union Horizon 2020 program must incorporate the significance of the SMART concept, INMA Bucharest researched a equipment who is intended to mechanical maintenance of crops, by hoeing between the plants rows and between plants in the row. This is made from two main components: a multifunctional machinery which make a mechanical maintenance on row and between crop plants and an intelligent system for control.

The hoeing intelligent equipment will be traveling in weeding crops, which is mounted in three-point in front of the tractor. Through the light sensor intelligent camera type and the recognition methods implemented in this, the intelligent system will recognize the weeding from the plants and will command the knifes on rows of plants, via electric actuators, in purpose of destruction them. For guidance the tractor is used an agricultural GPS. The correlation of the working knives position with light senzor location will do through a speed senzor mounted on the equipment wheel. [13]

Datorita noilor tendinte de prasire a culturilor agricole si in contextul practicarii unei agriculturi de precizie, care conform programului Uniunii Europene Horizon 2020 trebuie sa incorporeze semnificatia conceptului de SMART, INMA Bucuresti a cercetat un echipament care este destinat întreținerii mecanice a culturilor agricole, prin efectuarea operației de prăşire între rândurile de plante şi între plante pe rând. Acesta este format din doua componente principale: un echipament tehnic multifuncțional de intreținere mecanică pe rând şi între plante a culturilor agricole si un sistem inteligent de control.

Echipamentul inteligent de prasit se va deplasa in culturile de plante prasitoare, acesta fiind montat in trei puncte in fata tractorului. Prin intermediul senzorilor luminosi de tip camera inteligenta si a metodei de recunoastere implementata in acestia, sistemul inteligent va recunoaste plantele prasitoare de buruieni si va comanda actionarea cutitelor pe randurile de plante, prin intermediul actuatorilor electrici, in scopul distrugerii acestora. Pentru ghidarea tractorului se foloseste un GPS agricol. Corelarea pozitiei cutitelor de lucru cu pozitia senzorilor luminosi se face prin intermediul unui senzor de viteza montat pe roata echipamentului. [13]

Fig.7 – Smart weeding equipment researched by INMA Bucharest [13]

CONCLUSIONS

Agricultural research played an important role in order to increase production and most efficient exploitation of the existing resources, in the event that the planet's population is constantly growing and exploited agricultural fund is limited and with clear trends of deterioration.

The development of precision farming is one of the main priorities for the development of crops with productivity that satisfy the market demands, in environmentally friendly conditions and with minimal resource consumption.

The experience of Western European countries show that the efficiency of agricultural works for maintenance weeding crops by making an advanced technical mechanization with an equipment for maintenance, with high precision, crops can become profitable to both for the manufacturer / supplier of technical equipment, and also to the user. In this context it is necessary to realize such a research to promote a technology and a modern equipment adapted to specific soil and climatic conditions of our country.

Acknowledgement

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CONCLUZII

Cercetările în domeniul agricol au jucat un rol deosebit de important în scopul creşterii producției şi în exploatarea cât mai rațională a resurselor existente, în situația în care populația planetei este într-o continuă creştere iar fondul agricol exploatat este limitat si cu tendințe clare de deteriorare.

Dezvoltarea agriculturii de precizie reprezinta una din prioritatile de baza pentru realizarea unor culturi cu productivitati care sa satisfaca cererea de pe piata, in conditii prietenoase mediului si cu consumuri minime de resurse.

Experiența țărilor vest-europene demonstrează că eficientizarea lucrărilor agricole de întreținere a culturilor prăşitoare prin realizarea de tehnologii avansate de mecanizare cu echipamente tehnice de intretinere, cu precizie ridicată, a culturilor poate deveni profitabilă atât pentru producătorul/ furnizorul de echipamente tehnice, cât şi pentru utilizator. In acest contest se impune necesitatea de a realiza o asemenea cercetare pentru a promova o tehnologie şi un utilaj performant adaptat condițiilor de sol şi climă specifice țării noastre.

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CONSIDERATIONS ON THE IMPORTANCE OF SOYBEAN CROP IN PEOPLE AND ANIMAL FEED

CONSIDERATII PRIVIND IMPORTANTA CULTURII DE SOIA IN HRANA OAMENILOR SI ANIMALELOR

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Abstract: *This paper aims to provide a rich and updated information as to the importance of culture soybean (Glycine max.) Feed humans and animals. The paper addresses both specialists in larger farms farmers and gardeners and growers of soybeans gardens, highlighting the most important links and measures needed to achieve quality products and favorable economic conditions.*

Keywords: *technology, soybean Rhizobium japonicum, atmospheric nitrogen.*

Rezumat: *Prezenta lucrare îşi propune să ofere o informație cât mai bogată şi actualizată asupra importanței culturii de soia (Glycine max.) în hrana oamenilor şi animalelor. Lucrarea se adresează atât specialiştilor, fermieri în exploatații mai mari, cât şi grădinarilor şi cultivatorilor de soia din grădinile familiale, evidențiind verigile cele mai importante şi măsurile ce se impun pentru obținerea unor produse de calitate şi în condiții economice avantajoase.*

Cuvinte cheie: *tehnologie, soia, Rhizobium japonicum, azot atmosferic.*

INTRODUCTION

Soybean (*Glycine max*.) (fig. 1) is a plant that comes from the Fabaceae family called legumes (*Leguminoaseae* or *Papilionaceae*), which include beans, peas, chickpeas, peanuts, etc. [2]

This plant comes from Asia, where it was cultivated 3,000 years BC. [3]

In Europe, arrived later around 1700, the first a rarity in the university botanical gardens and much later getting to be introduced in agriculture. At the end of the twentieth century became one of the most cultivated plants in the world, was declared the world's most useful plant. [5]

Within the species *Glycine max* (L.) Merrill four subspecies known in our country is cultivating subspecies *manshurica* Enk. Which is characterized by: the stem thick, flat; leaves medium-pubescent (white or light brown hairs); Medium flowers, white or purple; Middle pods, straight, slightly curved; Seed medium (MMB = 120-180 g), oval, oval-oblong, rarely spherical, yellow, green, brown or black. There are five areas of favorable soybean crop: southern and northern Romanian Plain and Dobrogea, Banat Plain and Crisana, Moldova and western Transylvania [9].

INTRODUCERE

Soia (*Glycine max*.) (fig. 1) este o plantă ce provine din familia *Fabaceae* numită şi a Leguminoaselor *(Leguminoaseae* sau *Papilionaceae)* care include fasolea, mazărea, năutul, arahidele, etc. [2]

Aceasta plantă provine din Asia, unde era cultivată cu 3000 de ani înaintea erei noastre. [3]

In Europa, a ajuns tarziu, in jurul anului 1700, fiind mai intai o raritate, in gradinile botanice ale universitatilor si mult mai tarziu ajungand sa fie introdusa in agricultura. La sfarsitul secolului XX a devenit una din cele mai cultivate plante de pe glob, fiind declarata cea mai folositoare planta din lume. [5]

În cadrul speciei *Glycine max* (L.) Merrill se cunosc patru subspecii, *în țara noastră* cultivându-se subspecia *manshurica* Enk. , care se caracterizează prin: tulpină groasă, dreaptă; frunze mijlocii, pubescente (perişori albi sau castaniu-deschis); flori mijlocii, albe sau violete; păstaie mijlocie, liniară, puțin curbată; semințe mijlocii (MMB = 120-180 g), ovale, oval-alungite, rar sferice, galbene, verzi, castanii sau negre. Există 5 zone de favorabilitate a culturii soiei: sudul si nordul Câmpiei Române, Dobrogea, Câmpia Banatului şi Crişanei, Moldova si vestul Transilvaniei [9].

Fig. 1 - Soia *(Glycine max.)* [1]

It is an excellent source of vitamin C, folate, dietary fiber, protein, thiamin, calcium, iron, magnesium, phosphorus and potassium. It is very useful in preventing breast and prostate cancer due to isoflavones in treating cardiovascular and circulatory diseases. [4]

Soy farming is one of the plants of greatest importance for human nutrition and animal nutrition industry. Soybeans tends to become one of the increasingly

Este o sursă excelentă de vitamina C, acid folic, fibre alimentare, proteine, tiamină, calciu, fier, magneziu, fosfor şi potasiu. Este foarte utila in prevenirea cancerului de sân şi de prostată datorita isoflavonoidelor, în tratarea bolilor cardiovasculare şi circulatorii. [4]

Soia este una din plantele agricole de cea mai mare importanta pentru alimentatia umana, alimentatia animalelor si industrie. Cultura de soia tinde să devină

profitable, generating a culture is extremely valuable vegetable protein.

Soy protein is several times less toxic than the animals, while unsaturated fats from this plant are a true protector of the blood vessels. [5]

MATERIAL AND METHOD

By processing of soybeans are obtained:

- soybean meal, used in the food (milk, cheese, chips, coffee, chocolate, pasta, biscuits, meat substitute);
- soybean oil, used in margarine, soaps, lecithin, etc .;
- soybean cakes resulting from the processing oil; flour, cakes, green grass (hay, silage) used in animal feed;

As planned grading of the national grading seed consumption (Manual grading), soybeans must meet the following requirements:

- 27-50% protein content
- organoleptic characteristics - specific healthy product
- 3-5% foreign bodies from which minerals max. 0.5-1%
- seeds stained max. 5-8%
- cracks on the 3,15R sieve, crushed seeds attacked by insects-total 10-15%
- Flue-hot soybean max. 2-5%

Besides the good parts of soybeans, there are certain anti-nutritional factors. These anti-nutritional factors are the obstacle that should take account of soybean processors for eliminating or at least minimizing the adverse effects thereof. Among these anti-nutritional factors are:

- chymotrypsin and trypsin inhibitors, which hampers protein digestion by inactivating trypsin and chymotrypsin;
- phytic acid - is involved in blocking the corresponding absorption of minerals;
- wishes - this enzyme is important because it gives us information about the degree of processing soybeans (urease index);
- allergens - glycine and beta conglycinin - reduce nutrient absorption affecting the integrity of the intestinal microvilli;
- lipase and lipoxilipaza - causes peroxidation;
- isoflavones - have estrogenic properties that may lead to problems for reproduction;
- antivitamins - are compounds that cause an inhibiting effect partial or total vitamin activity by decomposition, inactivation or prevent their assimilation.

The most common methods that we have at hand anyone roasting and boiling. Following these processes some of the factors are inactivated anti-nutritional and soybeans can be used in pig and poultry diets in proportions estimated 8-10%.

General aspects of diseases in soybeans:

1. Soybean mosaic (fig.2) is produced by the virus *Marmor sojae*. The first symptoms appear 6-14 days after infection, with chlorosis fleeting manifestations of secondary leaf veins. Then we can see leaf chlorosis tissues, except for some strips located along the main veins that are heavily ruffled. Alternate between healthy tissue (green) and give the appearance of mottled chlorotic areas.

Measures to prevent and combat:

- use of healthy seed;
- Destruction of plant;
- If vegetation is observed during diseased plants they are removed and destroyed. [5]

una din ce în ce mai rentabilă, fiind o cultură generatoare de proteină vegetală extrem de valoroasă.

Proteinele din soia sunt de cateva ori mai putin toxice decat cele animale, in timp ce grasimile nesaturate din aceasta planta sunt un adevarat protector al vaselor de sange. [5]

MATERIAL ŞI METODĂ

Prin prelucrarea boabelor de soia se obtin:

- faina de soia, utilizata in industria alimentara (lapte, branza, fulgi, cafea, ciocolata, macaroane, biscuiti, substituent al carnii);
- uleiul de soia, folosit la fabricarea margarinei, sapunurilor, lecitinei, etc.;
- sroturile de soia, rezultate din procesarea uleiului; făină, turte, masă verde (fân, siloz) utilizate in hrana animalelor;

Conform planului de gradare stabilit prin Sistemul National de Gradare a Semintelor de Consum (Manualul de gradare), boabele de soia trebuie sa indeplineasca urmatoarele cerinte:

- continut de proteina 27-50%
- caracteristici organoleptice - specifice produsului sanatos
- corpuri straine 3-5%, din care minerale max. 0,5-1%
- seminte patate max. 5-8 %
- sparturi pe ciurul de 3,15R, seminte strivite, atacate de insecte-total 10-15%
- seminte de soia arse-incinse max. 2-5%

Pe langa părțile bune ale boabelor de soia, exista si anumiti factori antinutriționali. Aceşti factori antinutriționali sunt obstacolul de care ar trebui să țină cont procesatorii de soia pentru eliminarea sau cel puțin minimalizarea efectelor defavorabile ale acestora. Dintre aceşti factori antinutriționali amintim:

- inhibitori de tripsină şi chimotripsină, care obstrucționează digestia proteinelor prin inactivarea tripsinei şi chimotripsinei;
- acidul fitic - este implicat în blocarea absorbției corespunzătoare a mineralelor;
- ureaza - această enzimă este importantă întrucât ne dă informații despre gradul de procesare a boabelor de soia (indicele de urează);
- factori alergenici - glicina şi beta conglicina - reduc absorbția substanțelor nutritive afectând integritatea microvililor intestinului subțire;
- lipaza şi lipoxilipaza - determină peroxidare;
- izoflavonele - au proprietăți estrogenice care pot duce la apariția de probleme de reproducție;
- antivitaminele - sunt compuşi care determină un efect de inhibare parțială sau totală a activității vitaminelor prin descompunerea, inactivarea sau împiedicarea asimilării acestora.

Metodele cele mai uzuale pe care le are la îndemână oricine sunt prăjirea şi fierberea. În urma acestor procedee unii din factorii antinutriționali sunt inactivați iar soia boabe poate fi folosită în alimentația porcilor şi a păsărilor în proporții estimative de 8-10%.

Aspecte generale privind bolile în cultura de soia:

1. Mozaicul soiei (fig.2) este produs de virusul *Marmor sojae*. Primele simptome apar la 6-14 zile de la infectie, cu manifestari de cloroza trecatoare a nervurilor secundare ale frunzei. Apoi se poate observa clorozarea tesuturilor frunzei, cu exceptia unor benzi situate in lungul nervurilor principale care sunt puternic incretite. Alternanta intre tesutul sanatos (verde) si zonele clorotice da aspectul de marmorat.

Masuri de prevenire si combatere:

- folosirea de samanta sanatoasa;
- distrugerea resturilor vegetale;

• daca in timpul vegetatiei se observa plante bolnave acestea sunt indepartate si se distrug. [5]

Fig. 2 - Mozaicul soiei [5]

2. Bacterial burn (fig. 3) produced by the bacterium *Pseudomonas glycinea*.

The cotyledons are manifested by the appearance of small spots, aqueous, which enlarge and then brunifică, causing stunting seedlings.

The attack occurs on leaves in the form of small translucent spots, yellow or brown, which then becomes black. On the bottom, in the right spots, may appear small droplets of bacterial slime that after it dries a skin forms a glossy dark gray.

Measures to prevent and combat:

- use of healthy seed.
- destruction of plant.
- chemical treatments Funguran OH 50. [5]

2. Arsura bacteriana (fig. 3) a soiei produsa de bacteria *Pseudomonas glycinea*.

Pe cotiledoane se manifesta prin aparitia de pete mici, apoase, care se maresc si apoi se brunifica, provocand piticirea plantulelor.

Atacul se manifesta pe frunze sub forma de pete mici translucide, galbene sau brune deschis, care apoi devin negricioase. Pe partea inferioara, in dreptul petelor, pot aparea picaturi mici de exudat bacterian, care dupa ce se usuca formeaza o pojghita lucioasa de culoare cenusiu inchis.

Masuri de prevenire si combatere:

- folosirea de samanta sanatoasa.
- distrugerea resturilor vegetale.
- tratamente chimice cu Funguran OH 50. [5]

Fig. 3 - Arsura bacteriana [4]

3. Bacteriosis pustular (fig. 4) produced by the bacterium *Xanthomonas sojense*.

In all phases of growth they are attacked leaves, which appear small spots open green or reddish-brown that time thickens, forming prominent or pustules.

Later, diseased tissue atrophy and irregular patches appear, which sometimes shows a yellow halo. The tissue of these spots can be drawn right.

Measures to prevent and combat:

- use of healthy seed.
- destruction of plant.
- chemical treatments Funguran OH 50. [5]

***3.* Bacterioza pustulara** (fig. 4) produsa de bacteria *Xanthomonas sojense*.

In toate fazele de crestere sunt atacate frunzele, pe care apar pete mici, verzi deschis sau brun-roscate, care cu timpul se ingroasa, formand proeminente sau pustule.

Mai tarziu, tesutul bolnav se atrofiaza si apar pete neregulate, care uneori prezinta un halou galbui. Tesutul din dreptul acestor pete se poate desprinde.

Masuri de prevenire si combatere:

- folosirea de samanta sanatoasa.
- distrugerea resturilor vegetale.
- tratamente chimice cu Funguran OH 50. [5]

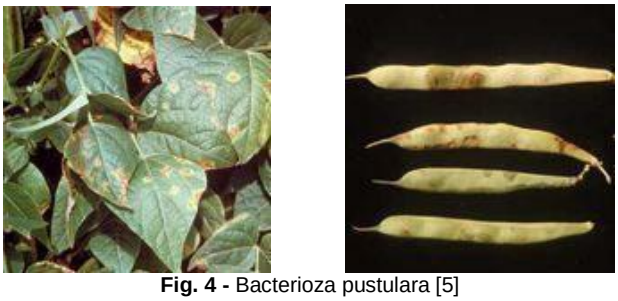

Fig. 4 - Bacterioza pustulara [5]

4. Rot fuzarian (fig. 5) of the soybean plant produced by *Fusarium fungus scirpi var. accuminatum*.

4. Putregaiul fuzarian (fig. 5) al plantutelor de soia produsa de ciuperca *Fusarium scirpi var. accuminatum*.

It is a disease that causes damage during and after the emergence of seedlings.

Part of the appeal seedlings die before sunrise. When the attack occurs in the later stages of vegetation, plants stop growing, leaves turn yellow, dry up and fall.

The attack occurs sometimes in the package region, which darkens, thins and dries plants and fall.

Measures to prevent and combat:

- crop rotation.
- use of healthy seed.
- Topsin treatments (10 g / 10 l water). [5]

Este o boala care provoaca pagube in timpul si dupa rasarirea plantutelor.

O parte din plantutele atacate mor inainte de rasarire. Cand atacul se produce in faze mai avansate de vegetatie, plantele se opresc din crestere, frunzele se ingalbenesc, se usuca si cad. Atacul se produce uneori in regiunea coletului, care se innegreste, se subtiaza si plantele se usuca si cad.

Masuri de prevenire si combatere:

- rotatia culturii.
- folosirea de samanta sanatoasa.
- tratamente cu Topsin (10 g/ 10 l apa). [5]

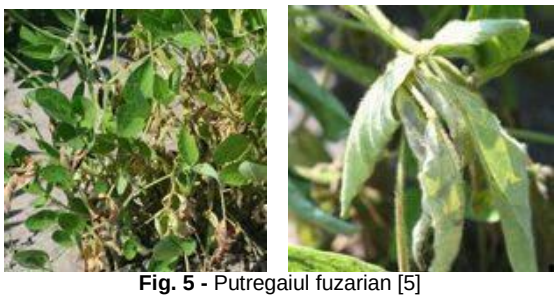

Fig. 5 - Putregaiul fuzarian [5]

5. Manna soy (fig. 6) produced by the fungus *Peronospora manshurica*.

It appears on all aerial organs. Brown spots on the upper face of the limbs, in respect of which the underside forms a fine downy gray-purple, containing spores of the fungus.

Measures to prevent and combat:

- cultivation of resistant varieties and hybrids.
- avoid excessive watering and the presence of water on plant leaves.
- chemical treatments with Dithane M45 (20 g / 10 l water), Neotec Dithane WG 75 (20 g / 10 l water). [5]

5. Mana soiei (fig. 6) produsa de ciuperca *Peronospora manshurica*.

Apare pe toate organele aeriene. Pete brune pe fata superioara a limbului, in dreptul carora pe fata inferioara se formeaza un puf fin cenusiu-violaceu, continand sporii ciupercii.

Masuri de prevenire si combatere:

- cultivarea de soiuri si hibrizi rezistenti.
- evitarea udarii excesive si prezenta apei pe frunzele plantelor.
- tratamente chimice cu Dithane M45 (20 gr/ 10 l apa), Dithane Neotec 75 WG (20 gr/ 10 l apa). [5]

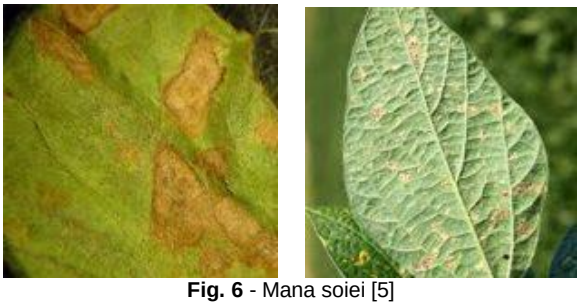

Fig. 6 - Mana soiei [5]

General aspects pests in soybeans

1. Moth pods (*Etiella zinckenella* Tr.) (fig. 7) is golden-gray body with silky. Previous wings are yellowish brown, set with a yellow-orange macula. Rear wings are colored gray with darker veins. The antennae are long and unicolor, wingspan is 20-26 mm. Leaflets forming the first generation appear in May and continue their flight by the end of June or early July. They fly only at night (nocturnal species) and day stay hidden by grasses, shrubs bushes etc. The butterflies appear in July and give birth to a second generation, which develops until August to September. In general, the first generation develop on peas, and the second soybean. [11]

Larvae of the second generation fruit beans in the pod. [7]

Measures to prevent and combat:

- chemical treatments decis 2.5 EC (0.25 l / ha) Actara, Karate Zeon. [5]

Aspecte generale privind daunatorii în cultura de soia

1. Molia pastailor (*Etiella zinckenella* Tr. **)** (fig.7) are corpul de culoare cenuşie-aurie, cu aspect mătăsos. Aripile anterioare sunt brune-gălbui, prevăzute cu cate o maculă galbenă-portocalie. Aripile posterioare au culoarea cenuşie, cu nervurile mai inchise. Antenele sunt lungi şi unicolore, Anvergura aripilor este de 20-26 mm. Fluturaşii care formează prima generaţie apar in luna mai şi zborul lor se continuă pană la sfarşitul lunii iunie sau inceputul lunii iulie. Ei zboară numai noaptea (specie nocturnă), iar ziua stau ascunşi prin ierburi, tufe de arbuşti etc. Fluturii apar in luna iulie şi dau naştere la generaţia a doua, care se dezvoltă pană in august-septembrie. In general, prima generaţie se dezvoltă pe mazăre, iar a doua pe soia. [11]

Larvele din cele doua generatii rod boabele din pastaie. [7]

Masuri de prevenire si combatere:

- tratamente chimice cu Decis 2.5 CE (0.25 l/ ha), Actara, Karate Zeon. [5]

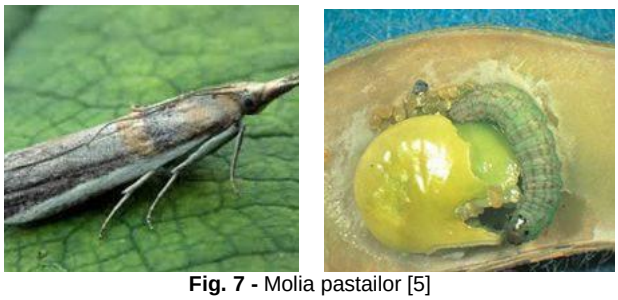

Fig. 7 - Molia pastailor [5]

2. Buha Gamma (*Autographa gamma*) (Figure 8) is a polyphagous pest and is found in all areas of the country. The adult butterfly is brown-gray wings earlier, with golden hues and shows a gamma-shaped design. The larva is green with yellow stripes. The insect has two generations per year. The first generation develops in May-July and the second in August-October, the hibernating larvae of this generation. [11]

Caterpillars of the first generation leaves from May to July rod partially or entirely, can attack and flower buds. [7]

To prevent damage to the appearance of larvae, it is necessary to execute combat chemical treatment plant, using one of the following products: Helarat 2,5EC; Sumi Alpha 5; EW decided Mega 50 or 10 EC felt lost; and so on [8]

***2.* Buha gamma** (*Autographa gamma)* (fig.8) este un dăunător polifag şi se intalneşte in toate zonele țării. Adultul este un fluture cu aripile anterioare brun-cenuşii, cu nuanțe aurii şi prezintă un desen de forma literei gamma. Larva are culoarea verde cu dungi gălbui. Insecta are două generații anuale. Prima generație se dezvoltă in perioada mai-iulie, iar cea de a doua in august-octombrie, larvele din această generație fiind hibernante. [11]

Omizile din prima generatie mai-iulie rod frunzele partial sau in intregime, pot ataca si bobocii florali. [7]

Pentru a preintampina pagubele produse la aparitia larvelor, este necesar sa se execute tratamente fitosanitare de combatere chimica, folosind unul din urmatoarele produse: Helarat 2,5EC; Sumi Alpha 5; Decis Mega 50 EW sau Fastac 10 EC; etc. [8]

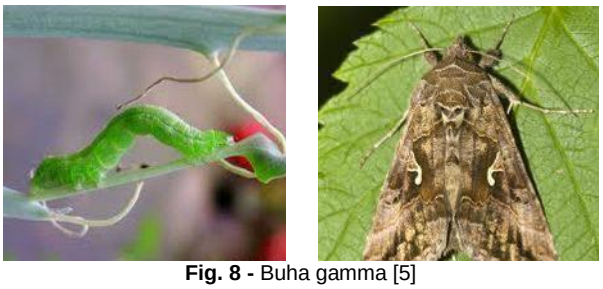

Fig. 8 - Buha gamma [5]

RESULTS

In our country were carried out research for the ICCPT Fundulea to improve soybean aiming at a series of objectives, the implementation of which depended on the introduction and expansion of soybean varieties indigenous culture. Among these objectives, we can mention: improving productivity, improving adaptability to the environment and culture, improvement of protein and oil content and quality, improved disease resistance [10].

In order to optimize the production technology and culture, can consider the following elements:

- planting dates (three periods) early sowing (April 1st), the optimum period (April 15th), sowing later (April 30);
- distance between rows sowing: 12.5 cm, 25 cm, 50 cm;
- grain sowing density: 45, 60 and 75 seeds germinate / sq m;
- weed: preemergence and postemergence [9];
- water management [12].

To combat or avoid diseases plant are several possible ways, such as: creation and cultivation of resistant varieties, production and use of seed free of disease (in areas free of those diseases), chemical treatment of the complex and not separately, or seed during the growing season. The most effective way to fight diseases, it can be done, it remains the creation and cultivation of resistant

REZULTATE

La noi in tara s-au desfasurat lucrări de cercetare de catre I.C.C.P.T. Fundulea pentru ameliorarea soiei urmarindu-se o serie de obiective, de realizarea cărora a depins introducerea şi extinderea în cultură a soiurilor de soia autohtone. Dintre aceste obiective se pot aminti: ameliorarea productivității, ameliorarea capacității de adaptare la condițiile de mediu şi de cultură, ameliorarea conținutului şi calității proteinelor şi uleiului, ameliorarea rezistenței la boli [10].

In vederea optimizarii tehnologiei de cultura si a productiei, se pot lua in considerare urmatoarele elemente:

epoci de semanat (3 epoci): semanat timpuriu (1 aprilie), perioada optima (15 aprilie), semanat tarziu (30 aprilie);

distanta intre randuri la semanat: 12,5 cm, 25 cm, 50 cm;

densitatea de boabe la semanat: 45, 60 si 75 boabe germinabile/mp;

combaterea buruienilor: preemergenta si postemergenta [9];

gestionarea resurselor de apa [12].

Pentru combaterea sau evitarea bolilor plantei sunt posibile mai multe căi, cum ar fi: crearea şi cultivarea de soiuri rezistente, producerea şi folosirea de sămânță liberă de boli (în zonele indemne bolilor respective), tratamente chimice aplicate, în complex si nu separat, în perioada de vegetație sau la sămânță. Cel mai eficient mijloc de luptă împotriva bolilor,când poate fi realizat, rămâne însă

varieties [10].

From an agronomic point of view, soy is of particular importance in that it leaves a large amount of nitrogen in the soil (approx. 80 -120 kg / ha) as a result of symbiosis with nitrogen-fixing bacteria. Early varieties of soybean plants are good prior to winter cereals [9].

Soybean plants using the nitrogen of the soil solution (at a rate of 35-50%) and nitrogen from the symbiotic bacteria Bradyrhizobium japonicum (in a proportion of 50-65%) living in the lymph from the soybean roots.

The soil nitrogen needed soybean plants growing in the first phase (the first 25-35 days) until it starts working symbiosis with nitrogen-fixing bacteria. After achieving symbiotic soybean plants procure between 20 and 80% of the nitrogen in this way [9].

CONCLUSIONS

Because of the many advantages they offer soy, both in human food and animal worlds is important paying attention to optimizing culture technology in order to obtain high yields and good quality.

To prevent the risk of developing diseases in soybeans is recommended for healthy seed, respect the rotation, age and density of seeding and seed treatment before sowing.

The positive role it plays bacteria *Rhizobium japonicum* in nitrogen fixation, this plant gives an extraordinarily important advantage within the short and long term crop rotations.

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crearea şi cultivarea de soiuri rezistente [10].

Din punct de vedere agronomic, soia are o importanţă deosebită prin faptul că lasă o cantitate mare de azot în sol (cca. 80 -120 kg/ha), ca urmare a *simbiozei cu bacteriile fixatoare de azot*. Soiurile timpurii de soia sunt bune plante premergătoare pentru cerealele de toamnă [9].

Plantele de soia utilizează azotul din soluţia solului (în proporţie de 35-50%) şi azotul obţinut din simbioza cu bacteriile *Bradyrhizobium japonicum* (în proporţie de 50-65%) care trăiesc în nodozităţile de pe rădăcinile soiei.

Azotul din sol este necesar plantelor de soia în primele faze de vegetaţie (în primele 25-35 zile), până când începe să funcţioneze simbioza cu bacteriile fixatoare de azot. După realizarea simbiozei, plantele de soia îşi procură între 20 şi 80% din necesarul de azot pe această cale [9].

CONCLUZII

Datorită multiplelor avantaje pe care le oferă soia, atât în hrana umană cât şi în cea animală, este importantă acordarea unei atenţii deosebite optimizării tehnologiei de cultură în vederea obţinerii unor recolte mari şi de bună calitate.

Pentru a preveni riscul dezvoltarii bolilor in cultura de soia se recomandă folosirea de sămânţă sănătoasă, respectarea rotaţiei, a epocii şi a densităţii de semănat, precum şi tratarea seminţei înainte de semănat.

Rolul pozitiv pe care îl joacă bacteria *Rhizobium japonicum* în fixarea azotului atmosferic, conferă acestei plante un avantaj extraordinar de important în cadrul unor asolamente de scurtă şi lungă durată.

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THE IMPORTANCE OF USING RENEWABLE ENERGY IN THE FORM OF BIOMASS / *IMPORTANȚA UTILIZĂRII ENERGIEI REGENERABILE SUB FORMĂ DE BIOMASĂ*

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Abstract: *Currently, many countries in the world face the serious consequences of global warming, such as: floods, landslides, excessive heat during summer, drought and many others. The material consequences of climate changes on the economy, on human life and on the environment are very serious. Human activity overloads the atmosphere with carbon dioxide and other emissions that cause global warming, capture heat, slowly increase the planet's temperature and have a significant and harmful impact on our heath, on the environment and on the climate. The increase of providing renewable energy would allow replacing energy sources that have high carbon emissions and would lead to the reduction of global warming. The paper presents aspects regarding the importance of using renewable energy, as alternatives to using conventional energy sources (coal, petrol, wood, etc.).*

Keywords: renewable energy, global warming, greenhouse gas, biomass.

INTRODUCTION

Nowadays, more and more countries worldwide are confronting the consequences of global warming, such as floods, storms, landslides, excessive heat during summer, drought and others. The material consequences of climate changes on the economy, on people's lives and on the environment are very serious. Global warming by 1.8 - 4.0^{o} C by 2100 could lead in this century to a rise in the sea level of 18-59 cm. According to the Stern Review, climate changes, caused by greenhouse gas emissions from the energetic sector, are considered as being "the greatest and the widest-ranging market failure ever seen" and a major threat to the global economy [1, 8].

Greenhouse gas emission is a serious threat in terms of producing climate changes, with potentially disastrous effects on humankind. The use of renewable energy sources (RES), together with improving energy efficiency (EE) can contribute to reducing fuel consumption, reducing greenhouse gas emissions and, therefore, to preventing dangerous climate changes [3].

These two severe problems – energetic crisis and the impact on the environment – represent global humankind problems whose solution lies on the shoulders of engineers. Because the world is so dependent on energy, because the majority of the world population uses fossil fuels to satisfy their energetic needs, a fact causing a high degree of pollution for the environment, arises the strict need to search for new sustainable and environment friendly sources of energy. All traditional energy sources used pollute the environment, whereas renewable energy is basically devoid of this negative effect of polluting the environment.

The potential of renewable energy sources is huge, because these sources can surpass many times the global demand for energy. Renewable energy sources such as biomass, wind energy, solar energy, water energy and geothermal energy can supply sustainable energy

Rezumat: *În prezent, tot mai multe țări ale lumii se confruntă cu consecințele serioase ale încălzirii globale, precum sunt inundațiile, furtunile, alunecările de teren, căldura excesivă în perioada de vară, seceta şi altele. Consecințele materiale ale modificărilor climatice asupra economiei, vieții oamenilor şi mediului înconjurător sunt foarte serioase. Activitatea oamenilor supraîncarcă atmosfera cu dioxid de carbon şi alte emisii ce provoacă încălzirea globală, captează căldura, cresc încet temperatura planetei şi au un impact signifiant şi dăunător asupra sănătății noastre, asupra mediului şi climei. Creşterea furnizării de energie regenerabilă ar permite înlocuirea surselor de energie cu emisii mari de carbon şi ar duce la reducerea încălzirii globale. Lucrarea prezintă importanța utilizării energiei regenerabile, ca alternativă la utilizarea surselor conventionale de energie (cărbune, petrol, lemn, etc.).*

Cuvinte cheie: energie regenerabilă, incălzire globală, gaze cu efect de seră, biomasă, .

INTRODUCERE

În prezent, tot mai multe țări ale lumii se confruntă cu consecințele serioase ale încălzirii globale, precum sunt inundațiile, furtunile, alunecările de teren, căldura excesivă în perioada de vară, seceta şi altele. Consecințele materiale ale modificărilor climatice asupra economiei, vieții oamenilor şi mediului înconjurător sunt foarte serioase. Încălzirea globală cu 1,8 – 4,0°C până în anul 2100 ar putea conduce la ridicarea nivelului mărilor în acest secol cu 18 – 59 cm. Conform Raportului Ştern, schimbările climatice, provocate de emisiile de gaze cu efect de seră din sectorul energetic, sunt considerate ca fiind „*cel mai mare şi mai de amploare eşec de piață din toate timpurile*" şi o amenințare majoră pentru economia mondială [1, 8].

Emisia gazelor cu efect de seră reprezintă o amenințare serioasă în ceea ce priveşte producerea schimbărilor climatice, cu efecte potențial dezastruoase asupra omenirii. Utilizarea surselor regenerabile de energie (SRE), împreună cu îmbunătățirea eficienței energiei (EE), pot contribui la reducerea consumui de energie, la reducerea emisiilor gazelor cu efect de seră şi, în consecință, la prevenirea schimbărilor climatice periculoase [3].

Aceste două probleme grave – criza energetică şi impactul asupra mediului – reprezintă problemele globale ale Omenirii, a căror soluționare cade pe umerii inginerilor. Deoarece lumea este atât de dependentă de energie, deoarece majoritatea populației Terrei foloseşte combustibili fosili pentru a-şi satisface necesitățile energetice, fapt ce provoacă un grad înalt de poluare a mediului, apare stricta necesitate de a căuta surse noi de energie durabile şi prietenoase mediului. Toate sursele tradiționale de energie utilizate poluează mediul ambiant, în timp ce energia regenerabilă este practic lipsită de acest efect negativ de poluare a mediului.

Potențialul surselor regenerabile de energie este enorm, deoarece aceste surse pot să depăşească de mai multe ori cererea mondială de energie. Sursele

services, based on the regular use of available native resources. The transition towards renewable energy systems seems more and more possible as their costs decreases while the price of oil and natural gas continues to fluctuate [9].

Human activity is overloading the atmosphere with carbon dioxide and other emission that cause global warming, capture heat, slowly increase the planet's temperature and have a significant and harmful effect on our health, on the environment and on the climate. The increase of supplying renewable energy could allow replacing the energy sources that have high carbon emissions and could lead to the reduction of global warming.

regenerabile de energie cum ar fi biomasa, energia eoliană, energia solară, energia hidrologică şi cea geotermală pot furniza servicii energetice durabile, bazate pe utilizarea în mod regulat a resurselor disponibile, indigene. Tranziția către sisteme regenerabile de energie pare din ce în ce mai posibilă atâta timp cât costurile lor scad în timp ce prețul petrolului şi al gazelor naturale continuă să fluctueze [9].

Activitatea oamenilor supraîncarcă atmosfera cu dioxid de carbon şi alte emisii ce provoacă încălzirea globală, captează căldura, cresc încet temperatura planetei şi au un impact signifiant şi dăunător asupra sănătății noastre, asupra mediului şi climei. Creşterea furnizării de energie regenerabilă ar permite înlocuirea surselor de energie cu emisii mari de carbon şi ar duce la reducerea încălzirii globale.

MATERIAL AND METHOD

The use of renewable energy is one of the most effective ways to ensure a more clean character to the supply of energy. Numerous citizens desire to be better informed about what renewable energy sources mean and how they can use them optimally. Romania has the capacity to produce energy from a multitude of sources, but the most important are biomass and water energy, as shown in table 1.

MATERIAL ŞI METODĂ

Utilizarea energiei regenerabile este una dintre modalitățile eficace de a asigura un caracter mai curat al aprovizionării cu energie. Numeroşi cetățeni îşi doresc să fie mai bine informați despre ce sunt sursele regenerabile de energie şi cum pot fi ele utilizate optim. România are capacitatea de a produce energie din o multitudine de surse, dar cele mai însemnate sunt biomasa şi hidrologia, după cum se poate observa din tabelul 1.

Table 1 [10]

Renewable energy production in Romania by type

Energy type	2010	2011	2012	2013
	-equivalent for 1 ton of oil-			
Water energy	1709.6	1266.4	1037.5	1286.1
Wind energy	26.3	119.3	227.0	388.7
Solar energy	0.1	0.0	0.1	0.2
Photovoltaic energy	0.0	0.1	0.7	36.1
Solid bio-fuels (excluding coal)	3900.0	3475.9	3795.1	3656.7
Biogas	3.1	13.1	27.3	19.6
Urban waste (reusable)	0.0	0.0	0.0	0.2
Bio-gasoline	35.4	34.8	42.5	26.5
Biodiesel	10.8	94.1	88.7	120.8
Geothermal energy	23.0	23.8	23.3	26.0
TOTAL renewable energy	**5708.3**	**5027.5**	**5242.2**	**5560.9**

Different sources of renewable energy are situated in different stages of technological and commercial development. In favorable conditions, wind energy, water energy, biomass and solar-thermal energy are viable alternatives from the economic point of view. Other types, such as photovoltaic energy (the production of electricity from sunlight using silicon panels) require an increase in demand in order to improve their economies of scale [7].

EU has committed, to reduce, by the year 2050, greenhouse gas emissions by 80-95% compared to the levels registered in 1990, in the context of the necessity to reduce emissions by developed countries. In the 2050 energy perspective, the Commission examines the challenges linked to fulfilling the EU objective in terms of decarbonisation ensuring, in the same time, the safety of energy supply and the competitiveness.

In the view of the year 2050, the European Commission announces very ambitious targets for reducing greenhouse gas emissions with 80-95% and relies especially on reducing them by increasing the share of energy from renewable sources.

Diferite surse regenerabile de energie se află în stadii diferite de dezvoltare tehnologică şi comercială. În condiții favorabile, energia eoliană, hidroenergia, biomasa şi energia solară-termală reprezintă alternative viabile din punct de vedere economic. Alte tipuri, precum energia fotovoltaică (producerea de electricitate pe baza luminii solare cu ajutorul panourilor de silicon) au nevoie de o creştere a cererii pentru a-şi îmbunătăți economiile de scară [7].

UE s-a angajat ca, până în 2050, să reducă emisiile de gaze cu efect de seră cu 80-95 % față de nivelurile înregistrate în 1990, în contextul necesității reducerii emisiilor de către țările dezvoltate. În perspectiva energetică 2050, Comisia examinează provocările legate de îndeplinirea obiectivului UE în materie de decarbonizare, asigurând, în acelaşi timp, siguranța aprovizionării cu energie şi competitivitatea.

În perspectiva anului 2050, Comisia Europeană anunță ținte mult mai ambițioase de reducere a emisiilor de gaze cu efect de seră: cu 80-95% şi mizează, în special, pentru reducerea acestora, pe creşterea ponderii energiei din surse regenerabile.

Table 2 [5, 6]

The share of renewable energy in gross final energy consumption

Country	RE share in 2005 -%-	RE share in 2012 -%-	Objective on RE share for 2020 -%-
Romania	17.8	22.9	24
Total EU-28	**8.7**	**14.1**	**20**

Romania has a diversified, but reduced quantitatively range of fossil and mineral resources for primary energy: petrol, natural gas, coal, uranium, as well as an important potential of renewable resources that can be valorized.

Romania remains an economy with a big consumption of energy, despite the tendency to decrease registered in recent years (a decrease of energy consumption of 36.4% between 1999 and 2010, and as an effect of reducing industrial activity due to the economic crisis).

România dispune de o gamă diversificată, dar redusă cantitativ, de resurse de energie primară fosile şi minerale: ţiţei, gaze naturale, cărbune, minereu de uraniu, precum şi de un important potenţial valorificabil de resurse regenerabile.

România rămâne o economie cu consum mare de energie, în ciuda tendinţei de scădere din ultimii ani (scădere a consumului energetic de 36,4% între 1999 şi 2010, şi ca efect al reducerii activităţii industriale din cauza crizei economice).

Table 3 [5, 6]

Final energy consumption in Romanian Households %

Product	2007	2008	2009	2010	2011	2012	2013
Total petrol products	8.0	3.7	4.0	2.9	3.0	2.5	2.6
Gas	27.5	27.1	26.8	27.2	29.7	31.6	31.7
Solid fuels	0.1	0.6	0.2	0.1	0.2	0.3	0.3
Electric energy	11.9	11.1	11.8	12.0	12.7	12.8	13.2
Renewable energy	**35.8**	**42.5**	**42.5**	**43.7**	**40.2**	**40.9**	**40.4**
Derived heat	16.7	14.9	14.7	14.0	14.3	11.9	11.7

According to the Romanian Energetic Strategy for the period of 2007-2020, the national potential for renewable energy sources is estimated at 14,718 ktoe and is larger than Romania's import of primary energy in 2010 (11,239 ktoe) and is as follows:

- Solar thermal energy - 1433 ktoe;
- Solar photovoltaic energy - 103 ktoe;
- Wind energy - 1978 ktoe;
- Water energy - 3440 ktoe;
- Biomass and biogas - 7597 ktoe;
- Geothermal energy – 167 ktoe.

Potrivit Strategiei energetice a României pentru perioada 2007–2020, potenţialul naţional al surselor regenerabile de energie este estimat la 14.718 ktep şi este mai mare decât importul de energie primară al României în 2010 (11.239 ktep) şi se prezintă astfel:

- Energie solară termică - 1433 mii tep
- Energie solară fotovoltaică - 103 mii tep
- Energie eoliană 1978 - mii tep
- Energie hidroelectrică - 3440 mii tep
- Biomasă şi biogaz - 7597 mii tep
- Energie geotermală - 167 mii tep

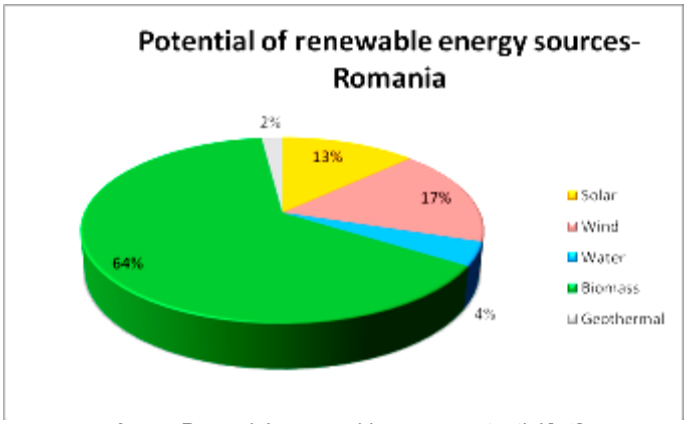

Fig. 1 –*Romania's renewable energy potential* [12]

For Romania, harnessing the potential of renewable energy sources aims at increasing the safety of energy supply by diversifying sources and decreasing the share of imports of classic energetic resources, aiming at a sustainable development for the energetic sector and the protection of the environment. Reducing the dependency for imports of energy resources is a goal all the more important as strategic documents in the field (among which *The Romanian Energetic Strategy for 2010-2035)* brings forward the perspective of an increase of the dependency for energy imports from about 35-40% presently to 60-70% on medium term, if the current structure and dynamics of consumption are maintained.

Biomass is the biodegradable part of products, waste

Pentru România, valorificarea potenţialului surselor regenerabile de energie are ca scop *creşterea securităţii aprovizionării cu energie, prin diversificarea surselor şi diminuarea ponderii importului de resurse energetice clasice, având ca finalitate dezvoltarea durabilă a sectorului energetic şi protejarea mediului înconjurător.* Reducerea dependenţei de importul de resurse energetice constituie un deziderat cu atât mai important cu cât documentele strategice în domeniu (între care *Strategia energetică a României 2010-2035*) avansează perspectiva unei creşteri a dependenţei de importurile energetice de la cca 35-40% în prezent la 60-70% pe termen mediu, în condiţiile în care structura şi dinamica actuală a consumului se vor menţine.

and residues from agriculture, including plant and animal substances, forestry and related industries, as well as biodegradable part of industrial and urban waste (Definition given in HG 1844 from 2005 on promoting the use of bio-fuels and other renewable carburant for transport).

Biomass comprises all forms of plant and animal material grown on the surface of the earth, in the waters or on waters, as well as substances produced by biological development.

Biomass is the most abundant renewable resource on the planet and includes absolutely all the organic matter produced by the metabolic processes of live organisms.

Energy stored in biomass is released through various methods, which however, represent the chemical process of burning (chemical transformation in the presence of molecular oxygen, which is an exergonic process).

Biomasa este partea biodegradabilă a produselor, deşeurilor şi reziduurilor din agricultură, inclusiv substanțele vegetale şi animale, silvicultură şi industriile conexe, precum şi partea biodegradabilă a deşeurilor industriale şi urbane. (Definiție cuprinsă în Hotărârea nr. 1844 din 2005 privind promovarea utilizării biocarburanților şi a altor carburanți regenerabili pentru transport).

Biomasa cuprinde toate formele de material vegetal şi animal, crescute pe suprafața terestră, în apă sau pe apă, precum şi substanțele produse prin dezvoltarea biologică.

Biomasa reprezintă resursa regenerabilă cea mai abundentă de pe planetă şi include absolut toată materia organică produsă prin procesele metabolice ale organismelor vii.

Energia înglobată în biomasă se eliberează prin metode variate, care însă, în cele din urmă, reprezintă procesul chimic de ardere (transformare chimică în prezenţa oxigenului molecular, proces prin excelență exergonic).

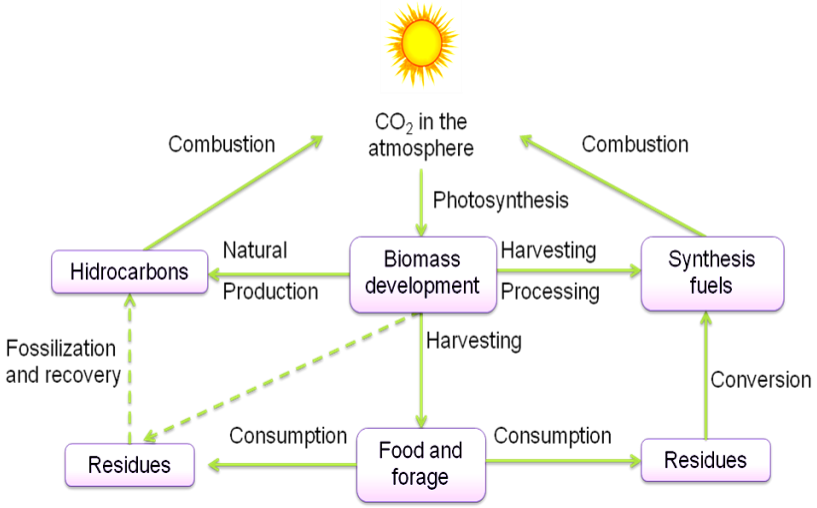

Fig. 2 – *The circuit of biomass energy* [2]

There is a large variety of sources of biomass, among which are counted the fast growing trees (poplar, willow, eucalyptus), sugar cane, rape, fast growing herbaceous plants and various types of residues, such as wood from trimming trees and from constructions, straws and stems of cereals, residues resulting from wood processing, paper waste and used vegetable oils. The main biomass resource is however represented by wood.

Există o largă varietate de surse de biomasă, printre care se numără copacii cu viteză mare de dezvoltare (plopul, salcia, eucaliptul), trestia de zahăr, rapița, plantele erbacee cu rapiditate de creştere şi diverse reziduuri cum sunt lemnul provenit din toaletarea copacilor şi din construcții, paiele şi tulpinile cerealelor, deşeurile rezultate după prelucrarea lemnului, deşeurile de hârtie şi uleiurile vegetale uzate. Principala resursă de biomasă o reprezintă însă lemnul.

RESULTS

The use of biomass has several advantages: offers an efficient solution for eliminating solid household residues and reduces emissions of carbon dioxide and nitrogen acids by replacing coal in thermal plants, thus contributing to decreasing environment pollution. Also, is presents an economic benefit. According to a study conducted by the Institute of Political Economy of Energy and Environment, conducted by specialist from the Bocconi University in Milano, electricity produced using biomass has the lowest cost of generating compared to any other source of renewable energy.

Fresh biomass is used for the production of energy, for nutrition and as raw material for the industry, but these applications imply a powerful interaction with the biosphere and its damage. Heat production from biomass is carried out through combustion processes, whose efficient

REZULTATE

Utilizarea biomasei prezintă mai multe avantaje: oferă o soluție eficientă pentru eliminarea resturilor menajere solide şi reduce emisiile de dioxid de carbon şi acizi de azot prin înlocuirea cărbunelui în termocentrale, deci contribuie la diminuarea poluării mediului. De asemenea, prezintă şi un beneficiu economic. Potrivit unui studiu efectuat de Institutul de Economie şi Politică a Energiei şi Mediului, desfăşurat de specialişti ai Universității Bocconi din Milano, electricitatea produsă cu ajutorul biomasei are cel mai mic cost de generare în comparație cu orice altă sursă energetică regenerabilă.

Biomasa proaspătă este utilizată pentru producția de energie, pentru nutriție şi ca materie primă industrială, dar aceste aplicații implică o interacțiune profundă cu biosfera şi afectarea acesteia. Producerea căldurii din biomasă se realizează prin procesele de combustie, a căror producere

production requires prior drying, the energy necessary for this process being significant in ratio to the energy value of the product, being recommended to use solar energy for drying biomass.

eficientă presupune uscarea prealabilă; energia necesară acestui proces fiind semnificativă în raport cu valoarea energetică a produsului, este recomandabilă recurgerea la energia solară pentru uscarea biomasei.

Table 4 [10]

Forecasted production of electric energy from renewable sources for 2015 compared to 2010

Renewable energy sources	2010 (GWh)	2015 (GWh) -estimates-
Solar energy	1860	1160
Wind energy	314	1001
Water energy – total, out of which: Low power hydro-energy (max. 10 MW)	18200 1100	18700 1600
Biomass	**1134**	**3654**
Geothermal energy	-	-
Total	22608	26115
Share of ERES in the consumption of electric energy	30.00%	30.40%

Wet biomass represents biomass with a relatively high content of water and a low content of lignin. Wet biomass is adequate for the production of biogas by anaerobic conversion due to these composition properties.

Dry biomass is represented by biomass with a high content of lignin and a low content of water. This type of biomass is not adequate for anaerobic treatment in the purpose of producing biogas, because the content of lignin cannot be converted anaerobically and so it does not contribute to the conversion into useful energy. Due to the low content of water, these residues are ideal for thermal use. For this purpose, the following types of residues are used: residues from forestry, community waste or trees and bushes cut from private properties, old wood, wood waste and fire wood.

Regional distribution of dry biomass (wood) in Romania varies: approximately 90% of the fuel wood and 55% of wood residues are found in the area of the Carpathians and Sub-Carpathians. Over 54% of agricultural waste is found in the South part of Romania and in Moldavia [11].

In Romania, large quantities wood residues in the form of small pieces are found, but it lacks the organization of collecting and transporting them. Studies conducted show that these waste represent highly valuable resources.

Biomass is currently used in Romania for the production of heat, especially in furnaces (0.8 – 4 kW) for cooking and heating water. 95% of biomass is used like this at the moment, the rest of 5% being used industrially to generate hot water and steam, for example in wood processing factories. The average installed power for industrially used biomass is from 3.3 MW to 4.7 MW.

Renewable energy can be used for all energy requirements: producing electricity, transport and household heating. Different types of renewable energy can be used in different ways, not all being adequate for every application. Water energy and wind energy are used exclusively for generating electricity, while other sources, such as biomass (organic matter), geothermal energy and solar energy can be used both for electricity and for heating.

CONLUSIONS

Romania has wide research experience in the agricultural field, including in cultivating biomass. There is a strong scientific base that can be used for improving the existing energy plants and introducing new plants in

Biomasa umedă reprezintă biomasa cu un conținut relativ ridicat de apă şi scăzut de lignină. Biomasa de tip umed este adecvată producției de biogaz prin conversie anaerobă datorită acestor proprietăți ale compoziției.

Biomasa uscată este reprezentată de biomasa cu conținut ridicat de lignină şi conținut scăzut de apă. Acest tip de biomasă nu este adecvată tratamentul anaerob în scopul producției de biogaz, deoarece conținutul de lignină nu se poate converti anaerob şi astfel nu contribuie la conversia în energie utilă. Datorită conținutului redus de apă aceste deşeuri sunt ideale pentru utilizarea termică. Pentru acest scop intră în discuție următoarele tipuri de deşeuri: deşeuri din silvicultura, deşeuri comunale sau pomi şi tufişuri defrişate de pe proprietăți private, lemn vechi, deşeuri de lemn şi lemn de foc.

Distribuția regională în România a biomasei uscate (lemnul) este variată: aproximativ 90% din lemnul combustibil şi 55% din deşeurile de provenienţă lemnoasă se regăsesc în zona Carpaților şi a Subcarpaților. Peste 54% din deşeurile agricole se găsesc în zona de sud a României şi în Moldova [11].

În România se regăsesc mari cantități de deşeuri lemnoase sub formă de bucăți mici, însă lipseşte organizarea colectării şi transportului acestora. Studiile făcute arată că aceste deşeuri reprezintă resurse valoroase.

Biomasa este utilizată momentan la nivelul României în scopul producerii de căldură, în mod special utilizând cuptoare (0,8 – 4 kW) pentru gătit şi încălzirea apei. 95% din biomasă este utilizată astfel momentan, restul de 5% fiind utilizat industrial la generarea de apă caldă şi aburi, de exemplu în fabrici de prelucrarea lemnului. Puterea medie instalată pentru biomasa utilizată industrial este de 3,3 MW până la 4,7 MW.

Energia regenerabilă se poate utiliza pentru toate cerințele energetice: producerea de electricitate, transport şi încălzirea locuințelor. Diferitele tipuri de energie regenerabilă se pot folosi în diferite moduri, nefiind toate adecvate pentru fiecare aplicație. Hidroenergia şi energia eoliană se folosesc exclusiv pentru generarea de electricitate, în timp ce alte surse, precum biomasa (materia organică), energia geotermală şi cea solară, se pot folosi pentru a produce atât electricitate, cât şi căldură.

CONCLUZII

România are o vastă experienţă de cercetare în domeniul agricol, inclusiv în cultura biomasei. Există o bază ştiinţifică puternică care poate fi utilizată pentru ameliorarea plantelor energetice existente şi introducerea în cultură a unor noi plante.

Valorificarea optimă a biomasei poate contribui la

plantations.

The optimal valorization of biomass can contribute to increasing revenues from agricultural exploitations.

Forestry exploitations can supply an important quantity of biomass from forestry waste (branches etc.) to which are added those resulted from wood processing (wood chips, sawdust).

In Romania there is a high quantity of agricultural waste (ex. straws) available for producing bio-fuels.

The high costs of energy require finding a solutions for reducing them, by valorizing local resources (much cheaper).

Currently, the problem of replacing fossil fuels is heavily posed, both from the point of view of reducing CO_2 emissions, but also as an alternative to the inherent decrease of fossil fuel reserves. The demand for natural resources has grown rapidly, surpassing long-term capabilities ensured by the planet.

The main difference between the two forms of energy is the following one: fossil fuels can only be transformed into usable energy after thousands of years, while the energy from biomass is renewable, being possible to use it year by year. The simplest method of producing heat from biomass is that of burning it. This method is known as *direct combustion*. Other technologies used to convert biomass into usable energy include: *gasification, combined combustion and modular systems*.

Acknowledgement

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creşterea veniturilor exploatațiilor agricole.

Exploatațiile forestiere pot furniza o importantă cantitate de deşeuri de biomasă: forestiere (crengi, etc.) la care se adaugă şi cele rezultate din prelucrarea lemnului (aşchii, rumeguş).

În România există o cantitate mare de deşeuri agricole (ex. paie) disponibile pentru producerea de biocarburanti.

Costul ridicat al energiei impune găsirea unor soluții pentru reducerea acesteia prin valorificarea resurselor locale (mult mai ieftine).

În prezent se pune pregnant problema înlocuirii combustibililor fosili şi în producerea de energie atât din punct de vedere al reducerii emisiei de CO_2 cât şi ca alternativă la scăderea inerentă a rezervelor de combustibil fosil. Cererea de resurse naturale a crescut rapid, depăşind capabilitățile pe termen lunga ale planetei.

Principala diferență dintre cele două forme de energie este următoarea: combustibilii fosili nu pot fi transformați în energie utilizabilă decât după mii de ani, în timp ce energia biomasei este regenerabilă, putând fi folosită an de an. Cea mai simplă metodă de a produce căldură din biomasă este aceea de a o arde. Această metodă este cunoscută sub numele de *ardere directă*. Alte tehnologii folosite pentru a converti biomasa în energie utilizabilă includ *gazeificarea*, *arderea combinată* şi *sistemele modulare*.

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FARINOGRAPH CHARACTERISTICS OF WHEAT FLOUR DOUGH AND RYE FLOUR DOUGH / *CARACTERISTICI FARINOGRAFICE ALE ALUATURILOR DIN FĂINĂ ALBĂ DE GRÂU ŞI FĂINĂ DE SECARĂ*

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Abstract: *Farinograph characteristics of dough bread are determined to establish quality flour and are estimated with one of the most important and used laboratory instruments, namely the Farinograph. The Farinograph measures and records the mechanical strength of the dough during kneading, highlighting the farinograph characteristics by a called farinogram. Thus, on a farinogram can read the following parameters: flour water absorption, dough development time, dough stability, dough softening degree and farinograph quality number (FQN).*

This paper presents the results of experimental research on farinograph characteristics variation of dough from wheat flour and rye flour, and dough made from a mixture of the two types of flour (50% flour and 50% rye flour).

Keywords: *farinograph characteristics, farinogram, wheat flour, rye flour, flour mixture.*

Rezumat: *Caracteristicile farinografice ale aluaturilor de panificaţie sunt determinate în vederea stabilirii calităţii făinii şi sunt estimate cu unul dintre cele mai importante şi folosite instrumente de laborator, şi anume Farinograful. Farinograful măsoară şi înregistrează rezistenţa mecanică a aluatului în timpul procesului de frământare, evidenţiind caracteristicile farinografice printr-o curbă numită farinogramă. Astfel, pe farinogramă pot fi citiţi următorii parametrii: capacitatea de hidratarea a făinii, timpul de dezvoltare al aluatului, stabilitatea aluatului, gradul de înmuiere al aluatului şi indicele farinografic. În această lucrare sunt prezentate rezultatele cercetărilor experimentale privind variaţia caracteristicilor farinografice ale aluaturilor din făinii de grâu şi făina de secară, precum şi aluatului obţinut din amestecul celor două tipuri de făină (50% făină de grâu şi 50% făină de secară).*

Cuvinte cheie: *caracteristici farinografice, farinogramă, făină de grâu, făină de secară, amestec de făină.*

INTRODUCTION

Farinograph dough characteristics are of particular importance in the process of obtaining the bakery products. One of the best known and widely used methods of determining the rheological characteristics of dough is farinograph method (AACC 54-21, ICC 115/1, ISO 5530-1). The Farinograph, the instrument that determines the characteristics of dough farinograph bakery, measures and records the mechanical strength of the dough during kneading.

The rheological behavior of the dough is influenced by the type of flour (the species of grain that is obtained flour - wheat, rye), the quality of the flour and the quality of the other raw materials (water, salt, yeast, fats, etc.). As shown in the paper [5], dough rheological behavior is nonlinear.

Farinograph method comes to help operators, contributing with important information regarding their decision in choosing the proper working regime parameters of equipment on the technological bakery. Also, know the characteristics of dough farinograph helps to achieve optimal flour mixtures of different kinds, from which to obtain quality breads. The dough properties influence the quality bakery products, in [7] showing that there is a close connection between the rheological properties of dough (development time, dough stability) and bread quality (specific volume). The mixture of wheat flour with Flaxseed flour has a significant impact on the properties of farinograph dough (decrease of water absorption by increasing the proportion of Flaxseed flour, low stability and development time of the dough) and the quality characteristics of bread (volume loss) [9].

Knowing the rheological properties of dough (gluten)

INTRODUCERE

Caracteristicile farinografice ale aluatului prezintă o importanţă deosebită în procesul tehnologic de obţinere a produselor de panificaţie. Una dintre cele mai cunoscute, răspândite şi utilizate metode de determinare a caracteristicilor reologice ale aluatului este metoda farinografică (AACC 54-21, ICC 115/1, ISO 5530-1). Farinograful, instrumentul cu ajutorul căruia se determină caracteristicile farinografice ale aluaturilor pentru panificaţie, măsoară şi înregistrează rezistenţa mecanică a aluatului în timpul procesului de frământare.

Comportarea reologică a aluatului este influenţată de tipul făinii (specia de cereale din care este obţinută făina – grâu, secară), calitatea făinii din care este obţinut, precum şi de calitatea celorlalte materii prime şi materiale (apă, sare, drojdie, grăsimi, etc.). Aşa cum a fost arătat în lucrarea [5], comportarea reologică a aluatului este neliniară.

Metoda farinografică vine în ajutorul tehnologilor, contribuind cu informaţii importante în ceea ce priveşte decizia acestora în alegerea corespunzătoare a parametrilor regimului de lucru al echipamentelor de pe fluxul tehnologic de panificaţie. De asemenea, cunoaşterea caracteristicilor farinografice ale aluatului ajută la realizarea amestecurilor tehnologice optime de făinuri din diferite sortimente, din care să se obţină produse de panificaţie de calitate. Proprietăţile aluatului influenţează calitatea produselor de panificaţie, în lucrarea [7] arătându-se faptul că există o strânsă legătură între proprietăţile reologice ale aluatului (timp de dezvoltare, stabilitate) şi calitatea pâinii (volumul specific). Amestecul făinii de grâu cu făină din seminţe de in are un impact semnificativ asupra proprietăţilor farinografice ale aluatului obţinut (scăderea capacităţii de absorbţie cu creşterea procentul de făină de in, scăderea stabilităţii şi timpului de dezvoltare a aluatului) şi asupra caracteristicilor de calitate ale pâinii (scăderea în volum) [9].

Prin cunoaşterea proprietăţilor reologice ale aluatului

decides the quality of proteins who belongs to an assortment of flour [8]. The addition of wheat flour proteins (soy protein, mushrooms, whey) recorded significant changes of dough farinograph parameters: water absorption, development time and stability of the dough increased [1,6].

Rye bread is the main form in which this type of cereal is consumed (Secale Cereale). Because rye bread consumption shows an increasingly higher, it is important to know the quality characteristics of rye flours.

In the paper [2] showed that the rheological parameters of dough from flour of rye are influenced by the particle size of the flour, having an effect on the binding capacity of the water (in the flours which have large particle sizes, high content in pentosan, is obtained dough with thick consistency).

The dough made from rye flour is not the same elastic properties of wheat flour dough, it is rather plastic [4]. The paper presents results of experimental research on farinograph characteristics variation of dough from wheat flour and rye flour, and dough made from a mixture of the two types of flour (50% flour and 50% rye flour).

MATERIAL AND METHOD

To highlight the characteristics of dough farinograph wheat and rye flour was used to determine farinograph model Brabender Farinograph-E [3], according to Worldwide Standard for Testing Flour Quality AACC 54-21, ICC 115/1, ISO 5530-1. The Brabender Farinograph is the most important laboratory instrument used to determine the rheological properties of dough to establish quality flour. It measures and records the mechanical strength of the dough during the kneading. Brabender farinograph used for measurements is equipped with a mixer with a capacity of 300 g, double wall through which the distilled water is heated to 30°C, and having two kneading arms in the form of "Σ". Mechanical strength opposite dough kneading arms is recorded and showed on farinograph curve, called farinogram. On farinograph curve (Figure 1) can read the following parameters:

- Water absorption - the amount of water required to the flour dough to reach the standard consistency of 500 BU;
- Dough development time - the period of time in which the dough is formed and achieve consistency of 500 UB;
- Dough stability - the period of time in which dough keeps its standard consistency with the continuing of kneading process;
- Degree of softening - it is calculated as the difference between the standard consistency (500 UB) and the consistency of the dough after 12 minutes from reaching the standard consistency (the end of the formation of the dough);
- Farinograph quality number (FQN) - establishing whether a type of flour is weak or strong.

For determinations were used two types of flour: white wheat flour type 650 (FA-650), commercially available and rye flour produced at the mill SC ILSA SA Calarasi, Romania, in 2014 wheat production.

Farinograph characteristics were determined for each of the two kinds of flour as well as a mixture from this, in

(glutenului) se stabileşte calitatea proteinelor unui sortiment de făină [8]. Adaosul de proteine în făina de grâu (proteine din soia, ciuperci, zer) înregistrează modificări importante ale parametrilor farinografici ai aluatului: capacitatea de hidratarea, timpul de dezvoltare a aluatului şi stabilitatea aluatului cresc [1,6].

Pâinea de secară reprezintă principala formă sub care se consumă acest tip de cereală (Secale Cereale). Datorită faptului că pâinea de secară prezintă un consum din ce în ce mai ridicat, este important să fie cunoscute caracteristicile de calitate ale făinurilor de secară.

În lucrarea [2] s-a arătat faptul că parametrii reologici ai aluaturilor din făină de secară sunt influenţati de dimensiunile particulelor de făină, având efect asupra capacităţii de legare a apei (din făinurile care prezintă dimensiunile particulelor mari, bogate în pentozani, se obţin aluaturi de consistenţă mare).

Aluatul obţinut din făină de secară nu prezintă aceleaşi proprietăţi elastice ca aluatul din făină de grâu, fiind mai mult plastic [4].

Lucrarea prezintă rezultatele cercetărilor experimentale privind variaţia caracteristicilor farinografice ale aluaturilor din făinii de grâu şi făina de secară, precum şi aluatului obţinut din amestecul celor două tipuri de făină (50% făină de grâu şi 50% făină de secară).

MATERIAL ŞI METODĂ

Pentru a pune în evidenţă caracteristicile farinografice ale aluaturilor din făină de grâu şi secară au fost efectuate determinări cu farinograful model Farinograph-E Brabender [3], conform metodologiei standard de testare a calităţii făinurilor AACC 54-21, ICC 115/1, ISO 5530-1. Farinograful Brabender reprezintă cel mai important instrument de laborator folosit pentru determinarea proprietăţilor reologice ale aluatului în vederea stabilirii calităţii făinii. Acesta măsoară şi înregistrează rezistenţa mecanică a aluatului în timpul procesului de frământare. Farinograful Brabender folosit la determinări este echipat cu un mixer cu capacitatea de 300 g, cu pereţi dubli prin care circulă apă distilată aflată la temperatura de 30° C şi prevăzut cu două braţe de frământare în formă de "Σ". Rezistenţa mecanică opusă de aluat braţelor de frământare este înregistrată şi redată prin curba farinografică, numită farinogramă. Pe curba farinografică (fig.1) se pot citi următorii parametrii:

- capacitatea de absorbţie a apei - cantitatea de apă necesară făinii pentru ca aluatul să ajungă la consistenţa standard de 500 UB;
- timpul de dezvoltare al aluatului – durata de timp în care aluatul se formează şi atinge consistenţa de 500 UB;
- stabilitatea aluatului – perioada de timp în care aluatul îşi păstrează consistenţa standard cu continuarea procesului de frământare;
- gradul de înmuiere a aluatului – se calculează ca fiind diferenţa între consistenţa standard (500 UB) şi consistenţa aluatului după 12 minute de la atingerea consistenţei standard (de la terminarea formării aluatului);
- indicele farinografic (FQN – farinograph quality number) – stabileşte dacă o făină este de tipul slabă sau puternică.

Pentru determinări au fost folosite două tipuri de făină: făină albă de grâu tip 650 (FA-650), procurată din comerţ şi făină de secară obţinută la moara SC ILSA SA Călăraşi, România, din producţia de grâu a anului 2014.

Au fost determinate caracteristicile farinografice pentru fiecare din cele două tipuri de făină, precum şi pentru un amestec format din acestea, în procente egale

equal proportions (50% FA-650 + 50% of rye flour).

(50% FA-650 + 50% făină de secară).

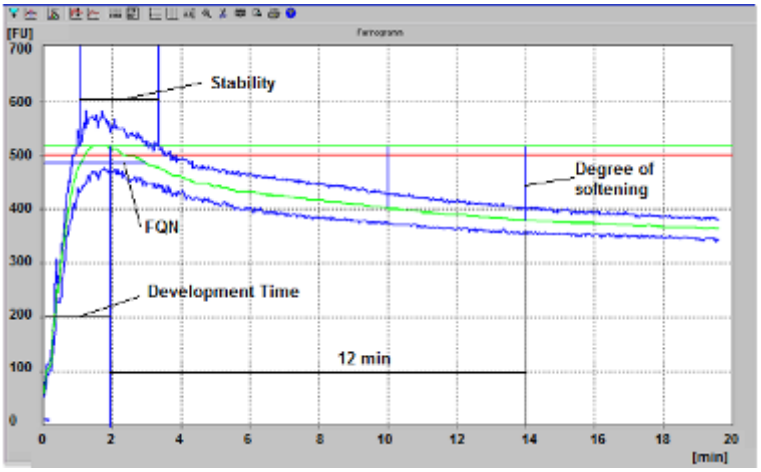

Fig.1. Exemple of Farinogram of a wheat flour

RESULTS

Farinograph characteristics for the three types of dough are shown in table 1, and obtained farinographic curves for the three types of doughs formed are shown in figure 2.

REZULTATE

Caracteristicile farinografice pentru cele trei tipuri de aluaturi formate sunt prezentate în tabelul 1, iar curbele farinografice obținute pentru cele trei tipuri de aluaturi formate sunt prezentate în figura 2.

Table 1

Farinograph characteristics for FA-650, rye flour and flour mixture

Farinograph characteristics	FA-650	Rye flour	FA-650 and rye flour mixture
Water absorbtion, (%) Correction for 500 FU	66.3 67.0	59.7 59.0	64.6 63.5
Development Time, min	2.2	1.7	2.0
Dough Stability, min	10.9	0.4	1.3
Degree of Softening, FU After 10 minutes After 12 minutes (ICC)	 33 38	 198 214	 57 93
Farinograph Quality Number	48	21	77

Analyzing the data presented in Table 1 and of farinographic curves from fig.2 (a, b, c) is noted that wheat flour analyzed (FA-650) is a flour for bakery which have very good stability (DS = 10.9 min) during processing (fig.2a) and a medium time for the development of the dough (DT = 2.2 min), with a good hydration capacity and a farinograph index also of average value. Farinogram aspect shows a strong flour with a degree of softening under 38 UF at 12 minutes from achieving the maximum consistency

By comparison with the wheat flour, rye flour, develop an dough with rheological and farinographic characteristics much different (see fig. 2,b). If development time is only of 1.7 minutes stability time of dough from rye flour is of 0.4 minutes, which shows a very weak flour, especially that the degree of softening is very high (214 UF after 12 minutes from the achieving of the maximum consistency), and farinographic index has a small value (FQN = 21).

If it forms a dough of wheat flour and rye flour (in equal ratio) then the rheological characteristics, respectively the farinographic one of the obtained dough are improving, although do not reach at values presented by simple dough, only from wheat flour. It shows a development time of about 2 min, respectively a stability time of 1.3 min.

Din analiza datelor prezentate in tabelul 1 şi a curbelor farinografice din fig.2 (a, b, c) se constată că făina de grâu analizată (FA-650) este o făină de panificație care prezintă o foarte bună stabilitate (DS = 10,9 min) la prelucare (fig.2a) şi un timp de dezvoltare a aluatului mediu (DT = 2,2 min), cu o bună capacitate de hidratare şi un indice farinografic, de asemenea de valoare medie. Aspectul farinogramei denotă o făină puternică cu un grad de înmuiere sub 38 UF la 12 minute de la atingerea consistenței maxime.

Prin comparatie cu fănia de grâu, făina de secară, dezvolta un aluat cu caracteristici reologice şi farinografice mult diferite (vezi fig.2,b). Dacă timpul de dezvoltare este de numai 1,7 minute, timpul de stabilitate a aluatului din făină de secară este de 0,4 minute, ceea ce arată o făină foarte slabă, mai ales că gradul de înmuiere este foarte mare (214 UF după 12 minute de la atingerea consistenței maxime), iar indicele farinografic are o valoare mică (FQN = 21).

Dacă se formează un aluat din făină de grâu şi făină de secară (în proporții egale) atunci caracteristicile reologice, respectiv farinografice ale alutului obținut se imbunătățesc, deşi nu ajung la valorile prezentate de aluat simplu, numai din făină de grâu. Acesta prezintă un timp de dezvoltare de circa 2 min, respectiv un timp de stabilitate de 1,3 min.

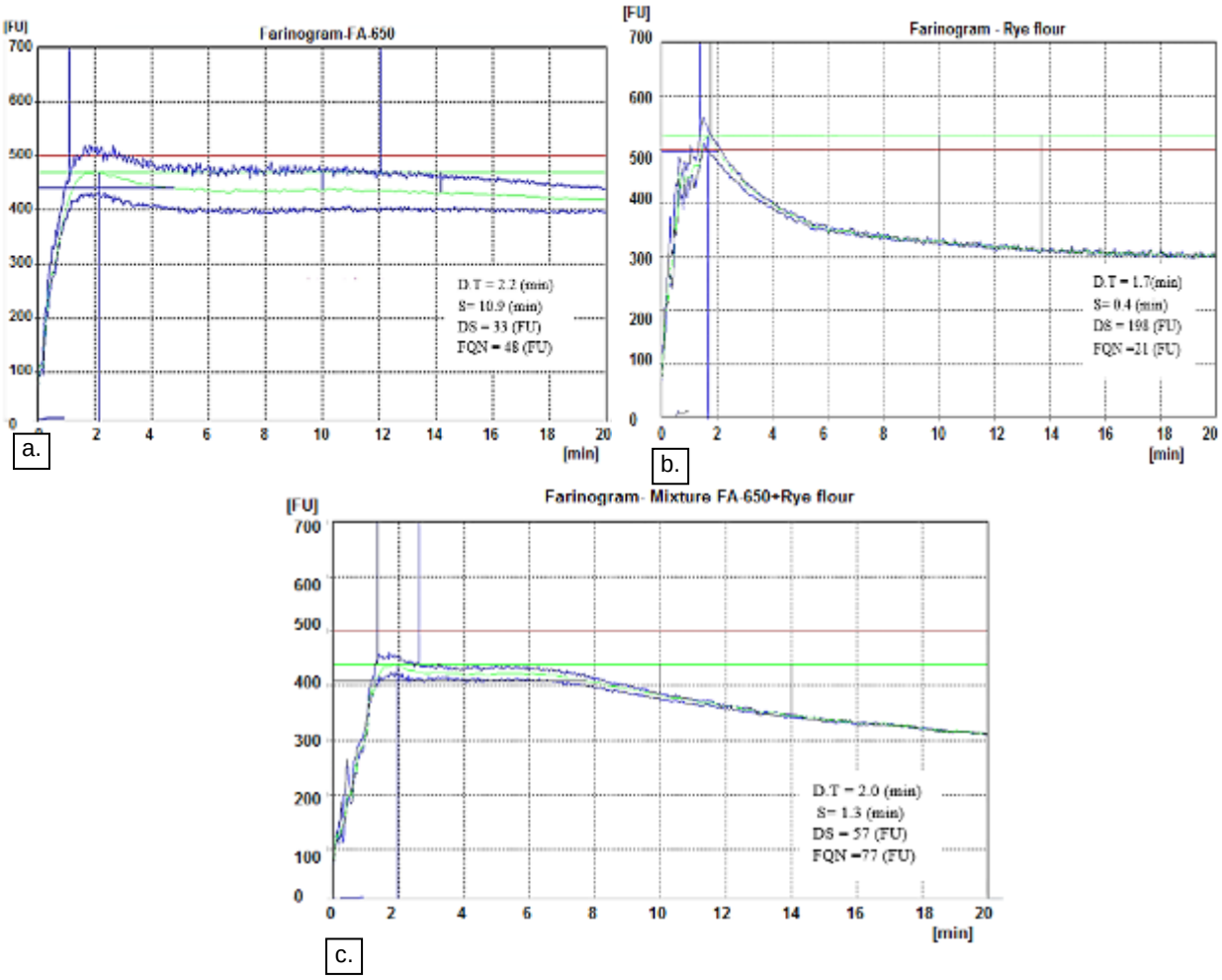

Fig. 2 – Farinogram curves obtained for FA-650, rye flour and mixture of 50% FA-650 + 50% rye flour

It improves the degree of softening which is reduced at approximately 93 UF, at 12 minutes from achieving maximum consistency (see fig.2,c).

It may be noted, still, that the farinographic index value FQN is improved towards both doughs obtained from simple wheat flour, respectively rye (FQN= 77).

Also, is noticeable the lower value of water absorption capacity of the rye flour (~59%), compared to mixture flour which have a hydration capacity of about64%.

It thus proves that a flour mixture (as is the case of the flour with 50% white wheat flour FA 650 and 50% rye flour) will present farinographic characteristics with values among those presented by doughs formed only from one of the two kinds of flour analyzed.

In figure 3 are presented farinographic index variations of the three types of dough analyzed, depending on the content of rye flour in the used flour.

It appears that development time follows a decreasing linear variation with the content of rye flour in the dough, (fig. 3a) the regression equation being shown in the chart, together with the coefficient of correlation value (R^2= 0,987). Still, for other values of the content of rye flour (ex: 25%, 75%) experimental tests are needed on the Brabender farinograph, to confirm (or to refute) conclusions expressed here. Still, experiments clearly shows that dough development time decrease with the increasing of the rye flour content, in the dough prepared with wheat flour FA-650 (mixed with rye flour).

Se imbunătățește şi gradul de înmuiere care scade la circa 93 UF, la 12 minute de la atingerea consistenței maxime (vezi fig.2,c).

Este de semnalat, totuşi, că valoarea indicelui frinografic FQN se îmbunătățește față de ambele aluaturi obținute din făină simplă de grâu, respectiv secară (FQN= 77). De asemenea, este de remarcat valoarea mai scăzută a capacității de absorbție a apei a făinii de secară (~59%), față de făina amestec care are o capacitate de hidratare de circa 64%.

Se dovedeşte astfel că o făină de amestec (aşa cum este cazul făinii cu 50% făină albă de grâu FA 650 şi 50% făină de secară) va prezenta caracteristici farinografice cu valori între cele prezentate de aluaturile formate numai din una din cele doua tipuri de făină analizate.

În figura 3 sunt prezentate variatiile indicilor farinografici ale celor trei tipuri de aluaturi analizate, în funcție de conținutul de făină de secară în făina utilizată.

Se constată că timpul de dezvoltare urmează o variație liniară descrescătoare cu conținutul de făină de secară în aluat, (fig. 3a) ecuația dreptei de regersie fiind prezentată pe grafic, impreună cu valoarea coeficientului de corelație R^2 (= 0,987). Totuşi, pentru alte valori ale conținutului de făină de secară (ex: 25%, 75%) sunt necesare teste experimentale pe farinograful Brabender, care sa confirme (sau sa infirme) concluziile exprimate aici. Totuşi, experimentele arată clar că timpul de dezvoltare a aluatului scade cu creşterea conținutului de făină de secară, în aluatul preparat cu făină de grâu FA-650 (în amestec cu făină de secară).

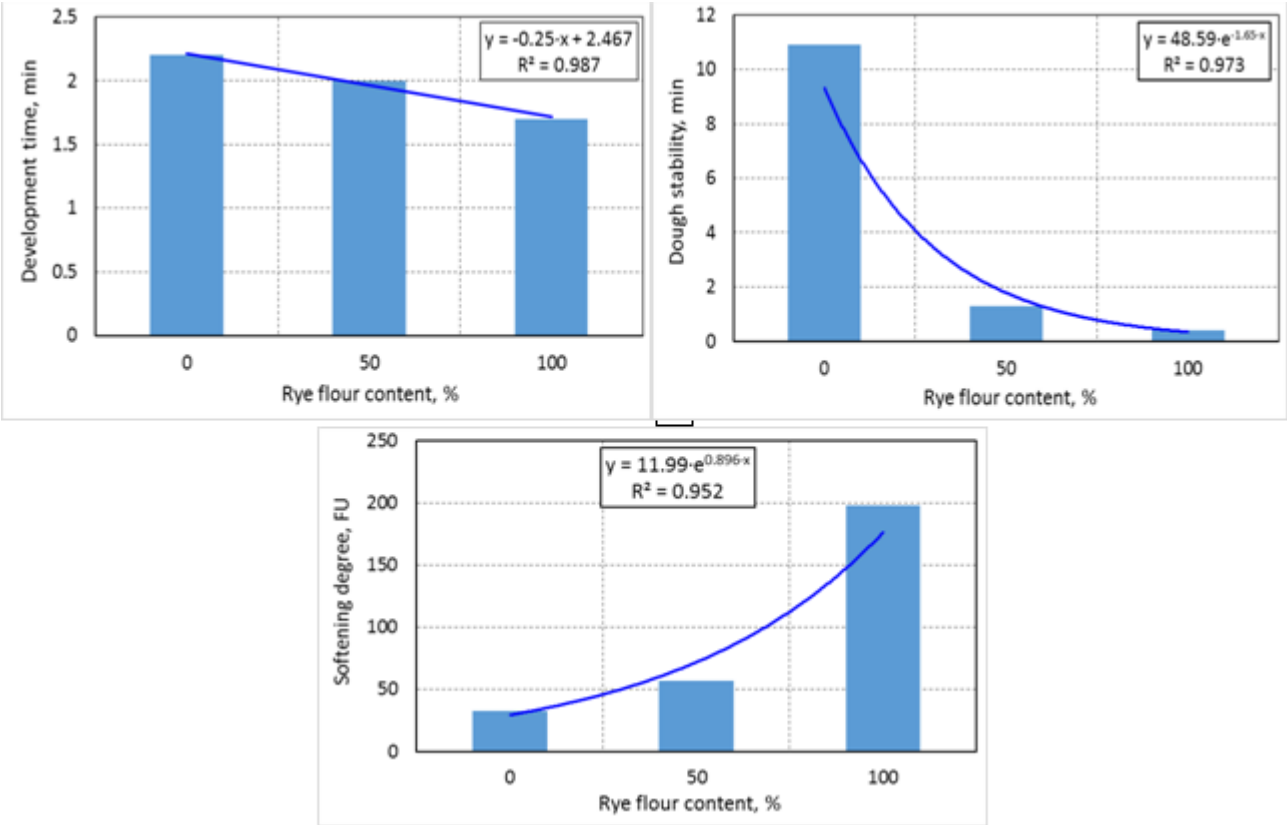

Fig.3. – Farinographic index variations of the three types of dough analyzed, depending on the content of rye flour in the used flour.

Regarding the variation of dough stability time, from fig. 3,b, it is noted that it has a decreasing exponential variation, according to the law displayed in the chart, together with the coefficient of correlation value (R^2 = 0,973). The decrease is more accentuated for the interval 0 -50 % rye flour in the dough, which means that the stability of panification dough it is adversely affected by the introduction of rye flour in the dough, even if it would have benefits for the human body (reducing cholesterol and being an important source of magnesium).

To improve the appearance of bread with the addition of rye flour can add in the recipe 2% molasses and, eventually, increase the content of yeast (best would be to use natural yeast with wild yeasts), and rekneading of 2-3 times at every 15-20 minutes with storage in the refrigerator for 4-5 hours, then 7-8 hours at 22-25^{0}C, before baking.

Variation of softening degree of dough at 10 minutes from the beginning of the test process, depending on the content of rye flour in the dough, is shown in fig. 3,c. After a simple linear regression analysis was noriced an increasing exponential variation, the regression equation being displayed on the chart. The correlation of experimental data is expressed through the value of coefficient R^2 = 0,952.

It is noted that the values of the degree of softening increases exponentially with increasing content of rye flour in bread dough.

For all three laws of variation shown in Figure 3, coefficient values of the regression equations may differ with type of kneading machine and its functional parameters, but also with other physico-chemical characteristics of flours and content components of manufacturing recipe.

CONCLUSIONS

Referitor la variația timpului de stabilitate a aluatului, din fig.3b, se observă că acesta prezintă o variație exponențială descrescătoare, după legea afişată pe grafic, împreună cu valoarea coeficientului de corelație R^2 (= 0,973). Descreşterea este foarte pronunțată mai ales pentru intervalul 0 -50 % făină de secară în aluat, ceea ce înseamnă că stabilitatea aluatului de panificație este afectată negativ de introducerea în aluat de făina de secară, chiar dacă aceasta ar avea alte beneficii pentru organismul uman (reducerea colesterolului şi o sursă importantă de magneziu).

Pentru îmbunătățirea aspectului pâinii cu adaos de făină de secară se poate adăuga în rețetă 2% melasă şi, eventual, creşte conținutul de drojdie (cel mai bine ar fi de utilizat maia naturală cu drojdii sălbatice), dar şi refrământarea de 2-3 ori la intervale de 15-20 minunte cu păstrare la frigider 4-5 ore, apoi 7-8 ore la 22-25^{0}C, înainte de coacere.

Variația gradului de înmuiere a aluatului la 10 minute de la începutul proceului de testare, în funcție de conținutul de de făină de secară în aluat, este prezentată in fig. 3,c. După o analiză de regersie neliniară simplă s-a constat o variație exponențială crescătoare, ecuația de regresie fiind afişată pe grafic. Corelația datelor experimentale este exprimată prin valoarea coeficientului R^2 = 0,952.

Se constată că valorile gradului de înmuiere cresc exponențial cu creşterea conținutului de făină de secară în aluatul de pâine.

Pentru toate cele trei legi de variație prezentate in fig. 3, valorile coeficientului ecuațiilor de regresie ar putea varia cu tipul frământătorului şi parametrii funcționali ai acestuia, dar şi cu celelalte caracteristici fizico-chimice ale făinurilor şi conținutul componentelor rețetei de fabricație.

CONCLUZII

Farinograph characteristics of dough from mixtures of wheat and rye flour depend on the content of rye flour introduced into the mixture.

În general, rye flour introduced into the flour mixture from which is prepared the dough adversely affect the farinographic characteristics of dough, but it has other properties that make bread manufacturers to use it (higher content of fiber, iron, potassium, magnesium).

Increasing the content of rye flour in the dough lead to reduced development time at kneading dough and its stability period, even if farinographic index FQN (which gives an indication of the flour strength) is increasing.

Furthermore, increasing of rye flour content in panification dough lead to reduced hydration of the flour.

The data presented in the paper can be a real help to specialists and to workers in the panification industry, at choosing the optimum working regime.

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Caracteristicile farinografice ale aluaturilor din amestec de făină de grâu şi de secară depind de conținutul de făină de secară introdus în amestec.

În general, făina de secară introdusă în amestecul de făină din care se prepară aluatul afectează negativ carcateristicile farinografice ale aluatului, dar prezintă alte proprietăți care îi fac pe fabricanții de pâine să o folosească (conținut mai mare de fibră, fier, potasiu, magneziu).

Creşterea conținutului de făină de secară în aluat conduce la scăderea timpului de dezvoltare a aluatului la frământare şi a perioadei de stabilitate a acestuia, chiar daca indicele farinografic FQN (care dă indicații despre puterea făinii) creşte.

De asemenena, creşterea conținutului de făină de secară în aluatul de pâine conduce la scăderea capacității de hidratare a făinii.

Datele prezentate în lucare pot fi de un real folos specialiştilor şi lucrătorilor în industria de panificație, la alegerea regimurilor optime de lucru.

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CONSIDERATIONS REGARDING THE CURRENT STATE OF PROGRAM CONTROLLED MACHINES FROM THE PROCESSING INDUSTRY
/
CONSIDERAȚII PRIVIND STADIUL ACTUAL AL MAŞINILOR CU COMANDĂ PROGRAM DIN INDUSTRIA PRELUCRĂTOARE

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Abstract: *Evolution, development, progress are essential requirements for finding and applying continuously and quickly of the new solutions in the goods production, products and equipment, these leading and stimulating the research to innovate and invent more efficient technologies and machine tools. This paper brings into focus a few steps from the evolution of machine tools with program control (CNC- s), being presented several types of the latest generation.*

Keywords: *machine, numerical control, precision, productivity*

INTRODUCTION

The machines tools represented the essential evolution in the development of humanity, by the fundamental contribution in the production of tools, machinery, equipment and installations from all activity domains of any society, since the beginning of industrialization. The permanent improvement of means of production, from the first devices and manual machines used in the production of parts and until now, up to those numerically controlled was the natural way, the research having the lead and essential role. Having to resolve goals as precision and speed of execution, the observance of the quality of the processed surfaces, the flexibility of the processing process of the various sizes as well as the repeatability in keeping all the conditions imposed by designer and benefiting from the development of computational techniques, the research has led to the implementation of computer programming and controlling the manual machine tools, over time these becoming MACHINE TOOLS WITH PROGRAM CONTROL. Thus, the control of the machine and tools movements, adjustments, measuring their dimensions and corrections due to the wear, the security elements during operation to avoid accidents have been taken over by the computer through the programs designed by the specialized engineers and loaded in the machine's CNC.

The CNC-controlled machine tools have been developed for sheet metal processing (plasma cutting, water jet, laser or classically by the punching and bending machines) and by splintering (lathes or CNC machining centers).

The most complex are the 5-axis machining centers that can process, in a single gripping, five sides of the blank. This ensures a high precision of shape, dimension and tolerances in workpiece machining.

Among the many companies and types of CNC

Rezumat: *Evolutie, dezvoltare, progres sunt imperative necesare gasirii si aplicarii continue si cat mai repede a noilor solutii in productia de bunuri, produse si echipamente, acestea conducand si stimuland cercetarea sa inoveze si sa inventeze tehnologii si masini unelte cat mai performante. Prezenta lucrare aduce in atentie cativa pasi din evolutia masinilor unelte cu comanda program, CNC- uri, fiind prezentate cateva tipuri din cele de ultima generatie.*

Cuvinte cheie: *maşină, comandă numerică, precizie, productivitate*

INTRODUCERE

Masinile unelte au reprezentat evolutia esentiala in dezvoltarea umanitatii, prin contributia fundamentala in productia uneltelor, masinilor, echipamentelor si instalatiilor din toate domeniile de activitate ale oricarei societati de la inceputul industrializarii. Permanenta imbunatatire a mijloacelor de productie, de la primele dispozitive si masini manuale folosite in productia de piese si pana in prezent, la cele cu masinile cu comanda numerica a fost drumul firesc, cercetarea avand rolul principal si esential. Avand de rezolvat deziderate ca precizia si rapiditatea de executie, respectarea conditiilor de calitate a suprafetelor prelucrate, flexibilitatea procesului de prelucrare a diverselor tipodimensiuni precum si repetabilitatea in pastrarea tuturor conditiilor impuse de proiectant precum si beneficiind de permanenta dezvoltare a tehnicilor de calcul, cercetarea a condus la implementarea calculatorului in programarea si comandarea masinilor unelte manuale acestea devenind in timp MASINI UNELTE CU COMANDA PROGRAM. Astfel, comanda miscarilor masinii si sculelor, ajustarile, masurarea dimensiunilor si corectii ale acestora datorate uzurilor, elementele de siguranta in timpul functionarii pentru evitarea accidentelor au fost preluate de catre calculator prin programele proiectate de inginerii de specialitate incarcate in CNC-ul masinii.

MU comandate CNC s-au dezvoltat pentru prelucrarea tablelor (debitare cu plasma, jet de apa, laser sau clasic prin stantare si prese de indoit) si prin aschiere (strunguri sau centre de prelucrare cu comanda numerica).

Cele mai complexe sunt centrele de prelucrare cu 5 axe care pot prelucra, dintr-o singura prindere, 5 fete ale semifabricatului. Acest lucru asigura o precizie ridicata de forma, dimensiune si tolerante in prelucrarea pieselor.

Dintre multitudinea de firme si tipuri de centre de

machining centers with 5-axis , we will list some with significant characteristics, without specifically recommending them or exclude the others.

MATERIAL AND METHOD

The program controlled machines from the manufacturing industry are classified as follows:

- CNC lathes ;
- CNC vertical machining centers;
- CNC horizontal machining centers;
- cutting machines:
  - with plasma: for medium and large thicknesses;
  - with laser: for small and medium thickness.

RESULTS

RAIS [1]

- CNC machining center in 5 axis GM 350 (fig. 1): it allows processing of parts with maximum dimensions of Ø 350, with optional mass of 800x480 and 300 kg; cycles X-812 mm,Y-900 mm and Z-500 m; max. dimensions of tools Ø 70 and 16 Kg.

- CNC lathe – T252-2S (fig. 2): it allows processing of parts with maximum dimensions of Ø 250, with a height over framing Ø 510, 12 tool in repository and cycles X1,X2 – 170mm and Z1 – 280mm, Z2 – 780mm.

prelucrare cu comanda numerica cu 5 axe vom enumera cateva, cu caracteristici semnificative, fara a le recomanda in mod special sau exclude pe celelalte.

MATERIAL ŞI METODĂ

Maşinile cu comandă program din industria prelucrătoare se clasifică în:

- strunguri CNC ;
- centre de prelucrare verticale CNC;
- centre de prelucrare orizontale CNC;
- maşini de debitat:
  - cu plasmă: pentru grosimi medii şi mari;
  - cu laser: pentru grosimi mici şi medii.

REZULTATE

RAIS [1]

- Centru de prelucrare CNC in 5 axe GM 350 (fig. 1): acesta permite prelucrarea pieselor cu dimensiuni maxime de Ø 350, cu masa optionala 800x480 si 300 kg; curse X-812 mm,Y-900 mm si Z-500 m; dimensiuni max. scule Ø 70 si 16 Kg.

- Strung CNC – T252-2S (fig. 2): acesta permite prelucrarea pieselor cu dimensiuni maxime de Ø 250, cu inaltimea peste batiu Ø 510, 12 scule in magazie si curse X1,X2 – 170mm si Z1 – 280mm, Z2 – 780mm.

Fig. 1 - CNC machining center in 5 axis GM 350 [1]

Fig. 2 - CNC lathe – T252-2S [1]

HURCO [2]

- CNC machining center in 5 axis VCX 600i (fig. 3):

HURCO [2]

- Centru de prelucrare CNC in 5 axe VCX 600i (fig. 3):

allows processing of parts with maximum dimensions of 600 x 600 si 350 kg, allowing the following maximum cycles: X-750 mm, Y-550 mm si Z-500 mm; max. dimensions of tools: Ø 80 si 7 kg.

- CNC lathe TMM 10i (fig. 4): allows processing of parts with maximum dimensions of Ø 295, the length of the processing of 700mm, 12 tool in repository and cycles on the X axis – 250mm and on Z – 750mm.

permite prelucrarea pieselor cu dimensiuni maxime de 600 x 600 si 350 kg, permițând următoarele curse maxime: X-750 mm, Y-550 mm si Z-500 mm; dimensiuni max. scule: Ø 80 si 7 kg.

- Strung CNC TMM 10i (fig. 4): permite prelucrarea pieselor cu dimensiuni maxime de Ø 295, lungimea de prelucrare de 700mm, 12 scule in magazie si curse pe axa X – 250mm si Z – 750mm.

Fig. 3 - CNC machining center in 5 axis VCX 600i [2]

Fig. 4 - CNC lathe – TMM 10i [2]

HWACHEON [3]

- CNC machining center in 5 axis M2 – 5AX (fig. 5): allows processing of parts with maximum dimensions of Ø 500 si 300 kg. Allows max. Cycles of X-750 mm, Y-650 mm and Z-500 mm, on the axis C 360º.

- CNC lathe HI – TECH 550A (fig. 6): it allows processing of parts with maximum dimensions of Ø 590, processing length 1100mm, 12 tools into repository with sizes □ 32 / Ø 60 mm

HWACHEON [3]

- Centru de prelucrare CNC in 5 axe M2 – 5AX (fig. 5): permite prelucrarea pieselor cu dimensiuni maxime de Ø 500 si 300 kg. Permite curse max.: X-750 mm, Y-650 mm si Z-500 mm, pe axa C 360º.

- Strung CNC HI – TECH 550A (fig. 6): acesta permite prelucrarea pieselor cu dimensiuni maxime de Ø 590, lungimea de prelucrare 1100mm, 12 scule in magazie cu dimensiunile □ 32 / Ø 60 mm.

Fig. 5 - CNC machining center in 5 axis M2 - 5AX [3]

Fig. 6 - CNC lathe – HI-TECH 550A [3]

LITZ [4]

- CNC machining center in 5 axis LU - 880 (fig. 7): allows processing of parts with maximum dimensions of Ø 800 si 1000 kg. Maximum cycles performed: X-800 mm, Y-900 +330mm si Z-620 mm.
- CNC lathe LT-400M (fig. 2): allows processing of parts with maximum dimensions of Ø 215, processing length 570/1200mm, 12 tool in repository and cycles X – 190mm and Z – 530mm.

LITZ [4]

- Centru de prelucrare in 5 axe LU - 880 (fig. 7): permite prelucrarea pieselor cu dimensiuni maxime de Ø 800 si 1000 kg. Curse maxime realizate: X-800 mm, Y-900 +330mm si Z-620 mm.
- Strung CNC LT-400M (fig. 2): permite prelucrarea pieselor cu dimensiuni maxime de Ø 215, lungimea de prelucrare 570/1200mm, 12 scule in magazie si curse X – 190mm si Z – 530mm.

Fig. 7 - CNC machining center in 5 axis LU-880 [4]

Fig. 8 - CNC lathe – HI-TECH 550A [4]

PROFIMACH [5]

- CNC machining center in 5 axis HSVMC 4550 (fig. 1): allows processing of parts with maximum dimensions of 550 X 480 mm si 250 kg. Maximum permitted cycles: X-450 mm, Y-500 mm si Z-230 mm, pe axa C 360º.
- CNC lathe – PHT-150 (fig. 2): allows processing of parts with maximum dimensions of Ø 50, processing length 400mm and tool holder sizes 25x25.

PROFIMACH [5]

- Centru de prelucrare CNC in 5 axe HSVMC 4550 (fig. 1): permite prelucrarea pieselor cu dimensiuni maxime de 550 X 480 mm si 250 kg. Curse maxime permise: X-450 mm, Y-500 mm si Z-230 mm, pe axa C 360º.
- Strung CNC – PHT-150 (fig. 2): permite prelucrarea pieselor cu dimensiuni maxime de Ø 50, lungimea de prelucrare 400mm si dimensiuni port scula 25x25.

Fig. 9 - CNC machining center in 5 axis HSVMC 4550 [5]

Fig. 10 - CNC lathe – PHT-150 [5]

CONCLUSIONS

The program controlled machine tools CNC-s in 5-axis is the top technology of mechanical processing, allowing to obtain a very high productivity but especially a precision of up to several microns, because all the operations are performed in a single gripping.

These equipments are very expensive and therefore are suitable to be used only in the case of processing of large and very large orders or of some unique parts with high value, requiring high precision.

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CONCLUZII

Masinile unelte cu comanda program, CNC- uri în 5 axe reprezintă vârful tehnologiei de prelucrări mecanice, permițând obținerea unor productivități foarte mari dar mai ales a unei precizii de până la câțiva microni deoarece realziaează toate operațiilor dintr-o singură prindere.

Aceste echipamente sunt foarte scumpe şi ca atare se pretează a fi utilizate numai în cazul prelucrării unor comenzi mari şi foarte mari sau a unor piese unicat cu valoare ridicată ce necesită precizii ridicate.

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REDUCING POLLUTING EFFECTS FROM THE MECHANIZED EXECUTION OF AGRICULTURAL WORKS
/
REDUCEREA EFECTELOR POLUANTE LA EXECUTAREA MECANIZATĂ A LUCRĂRILOR ÎN AGRICULTURĂ

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Abstract: *Pollution is the degradation of a natural environment through the action of toxic products. Human activities have modified the Earth over the centuries. Humans strive nowadays to protect and preserve the planet. Agriculture is a science, art or practice that handles the process of producing plant animal food, fibers, respectively various useful materials through systematic cultivation of certain plants and growing animals [1]. Due to intensive agriculture, to the use of pesticides, to chemical fertilizers, the soil is the first one to be affected. The majority of soils lose nutrients and organic matter, which in the end lead to their exhaustion.*
This paper presents a series of methods to reduce pollution caused by agricultural mechanization through the reduction of fuel consumption and the efficient use of agricultural machinery.

Keywords: *agriculture, pollution sources, environment, residues, environment protection.*

INTRODUCTION
The action of agricultural mechanization on the environment

Agricultural mechanization is the execution by machines and tools of agricultural works. Mechanized works are not only a feature of modern agriculture. The mechanized execution of farming operations is not optional; without mechanization, agricultural production cannot be achieved.

It provides favorable conditions for field crops and provides appropriate technologies, through mechanization ensuring an increase in the general quality level of production, through accuracy, promptitude and the reduction of losses.

Agricultural mechanization favorably influences human activity, by removing the hard efforts and stressful work by increasing labor productivity, reducing work time and optimum configuration of the work program.

The making available the appropriate technical solutions through mechanization, it becomes possible to practice sustainable agriculture, sparing the soil and ground water, sparing the global atmosphere and close environment. Thus, agriculture plays a positive role in this regard, particularly important from the ecological point of view.

The execution of mechanized works in agriculture is accompanied at the same time, by some negative effects of different magnitude. These effects are basically unavoidable, but by rational exploitation of equipment and the judicious choice of technologies, they can be maintained at a lower level. Mechanization of agriculture has its share of guilt in terms of environmental pollution by the specific of the actual activity, but in combination with other factors of agricultural production [2].

The share and severity of polluting effects due to agricultural mechanization is very different. Many of the polluting effects are produced directly, by the use of technical means, tractors and agricultural machines for mechanizing agricultural works. Other effects are indirect, for example those related to the building in the industry for manufacturing tractors and agricultural machinery, or specialized workshops for repairing agricultural machinery [2].

Rezumat: *Poluarea este degradarea unui mediu natural prin acțiunea produselor toxice. Activitățile oamenilor au modificat de-a lungul secolelor, Pământul. Oamenii se străduiesc astăzi să protejeze şi să conserve planeta. Agricultura este ştiința, arta sau practica care se ocupă cu procesul producerii de hrană vegetală şi animală, fibre, respectiv diverse materiale utile prin cultivarea sistematică a anumitor plante şi creşterea animalelor [1]. Datorită agriculturii intensive, folosirii de pesticide, îngrăşăminte chimice, solul este principalul afectat. Majoritatea solurilor îşi pierd din elementele nutritive şi materia organică, ceea ce în final duce la epuizarea lor. Lucrarea prezintă o serie de metode de reducere a poluării cauzată de mecanizarea agriculturii prin reducerea consumului de combustibili şi eficientizarea utilizării maşinilor agricole.*

Cuvinte cheie: *agricultură, surse de poluare, mediu, reziduuri, protecția mediului.*

INTRODUCERE
Acțiunea mecanizării agriculturii asupra mediului:

Mecanizarea agriculturii înseamnă executarea cu ajutorul maşinilor şi uneltelor a lucrărilor agricole. Lucrările mecanizate nu reprezintă o caracteristică doar a agriculturii moderne. Executarea mecanizată a lucrărilor agricole nu este facultativă; fără mecanizare nu poate fi realizată producția agricolă.

Aceasta asigură condiții favorabile pentru culturile de câmp şi pune la dispoziție tehnologii adecvate, prin mecanizare asigurându-se creşterea nivelului calitativ general al producției, prin precizie, promptitudine şi reducerea pierderilor.

Mecanizarea agriculturii influențează favorabil activitatea omului, prin eliminarea eforturilor mari şi a lucrărilor stresante, prin creşterea productivității muncii, reducerea timpului de lucru şi configurarea optimă a programului de lucru.

Prin punerea la dispoziție de către mecanizare a soluțiilor tehnice adecvate devin posibile practicarea agriculturii durabile, menajarea solului şi a apei din sol, menajarea atmosferei globale şi a mediului apropiat. Astfel, agricultura joacă în acest sens un rol pozitiv, deosebit de important din punct de vedere ecologic.

Executarea mecanizată a lucrărilor din agricultură este însoțită, în acelaşi timp, de unele efecte negative, de amploare diferită. Aceste efecte sunt în principiu inevitabile, dar prin exploatarea rațională a utilajelor şi alegerea judicioasă a tehnologiilor, ele pot fi menținute la un nivel mai scăzut. Mecanizarea agriculturii are partea sa de vină, în ceea ce priveşte poluarea mediului, prin specificul activității propriu-zise, dar şi în combinație cu alți factori ai producției agricole [2].

Ponderea şi gravitatea efectelor poluante din vina mecanizării agriculturii este foarte diferită. Multe din efectele poluante se produc direct, prin utilizarea mijloacelor tehnice, tractoare şi maşini agricole, pentru mecanizarea lucrărilor în agricultură. Alte efecte sunt indirecte, de exemplu cele aferente fabricării în industria constructoare de tractoare şi de maşini agricole, sau atelierele specializate de reparare a utilajelor agricole [2].

MATERIAL AND METHOD

The phenomenon of polluting the environment first appeared as a consequence of industrialization and then as a result of intensified transport and urbanization, and eventually, of intensive agriculture based on mechanization, use of chemicals, irrigations, concentration and specialization lead to the emergence of the pollution phenomenon in agriculture [3].

The main sources of soil pollution are:

- large scale application of fertilizers and pesticides in agriculture;
- using extensive irrigation systems;
- depositing solid waste;
- atmospheric depositions of toxic substances from human activities [4].

In order to reduce polluting effects from mechanized works on the soil in agriculture, several directions should be followed in this purpose:

• large agricultural exploitations should comply to crop technologies and to identify possible harm to the environment factors;
• chemical fertilizers, fuels and phyto-sanitary products should be managed properly;
• animal farms should be exploited adequately taking into account the technologies recommended and the management of animal manure in conditions of minimum impact on the environment;
• updating the situation regarding stocks of pesticide waste (expired, unapproved, unidentified pesticides, including pesticide packages);
• managing other types of residues produced in the units with agricultural profile (discarded vehicles and machinery, used tires, used batteries, used oils, etc.);
• in some cases is important to highlight degraded fields and to perform agricultural works for improvement [5].

RESULTS

Possibilities to reduce polluting effects from mechanized execution of agricultural works.

- ***Atmosphere pollution due emissions from internal combustion engines from agricultural machinery.*** For self-propelled agricultural machines and tractors, diesel fuel combustion in Diesel engines is accompanied by emissions from combustion gases, namely CO_2, C, NOx, Sox. Substances from combustion gases cause both global and local pollution of the atmosphere.

MATERIALE ŞI METODĂ

Fenomenul de poluare a mediului înconjurător a apărut mai întâi ca o consecință a industrializării şi apoi ca urmare a amplificării transporturilor şi urbanizării; în cele din urmă, agricultura intensivă bazată pe mecanizare, chimizare, irigații, concentrare şi specializare a condus la apariția fenomenului de poluare în domeniul agricol [3].

Sursele principale ale poluării solurilor sunt :

- aplicarea pe scara larga a îngrăşămintelor si pesticidelor in agricultura;
- folosirea sistemelor extinse de irigații;
- depozitarea deşeurilor solide;
- depunerile atmosferice de substanțe toxice produse ca urmare a activităților umane [4].

Pentru reducerea efectelor poluante ale lucrărilor mecanizate asupra solului, în agricultură, trebuie să se urmărească multe direcții în acest sens:

• marile exploatații agricole trebuie să respecte tehnologiile de cultură şi să identifice posibilele afectări ale factorilor de mediu;
• îngrăşămintele chimice, combustibilii si produsele de uz fitosanitar trebuie gestionate corespunzător;
• fermele de animale trebuie exploatate corespunzător ținând cont de tehnologiile recomandate şi gestionarea deşeurilor zootehnice în condiții de impact minim asupra factorilor de mediu;
• actualizarea situației referitoare la stocurile de deşeuri de pesticide (pesticide expirate, neomologate, neidentificate, inclusiv ambalaje de pesticide);
• gestionarea altor tipuri de deşeuri produse în unitățile cu profil agricol (mijloace auto şi utilaje casate, cauciucuri uzate, baterii şi acumulatori uzați, uleiuri uzate s.a.);
• în unele situații se impune evidențierea terenurilor degradate şi efectuarea lucrărilor de ameliorare a acestora [5].

REZULTATE

Posibilități de reducere a efectelor poluante la executarea mecanizată a lucrărilor în agricultură.

- ***Poluarea atmosferei din cauza emisiilor de la motoarele cu ardere internă ale utilajelor agricole.*** La maşinile agricole autopropulsate şi tractoare arderea motorinei în motoarele Diesel este însoțită de emisiile din gazele de ardere şi anume C02, C, NOx, SOx. Substanțele din gazele de ardere provoacă atât poluarea globală a atmosferei, cât şi poluarea locală.

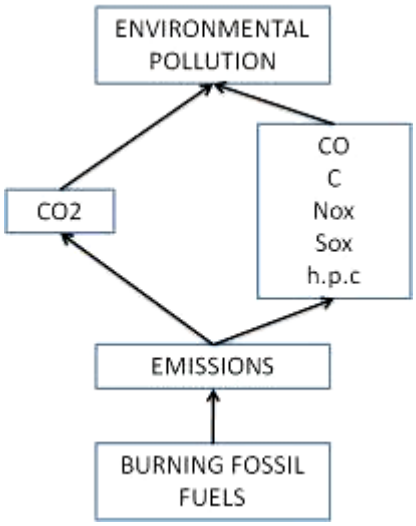

Fig. 1 – Atmosphere pollution from the mechanized execution of agricultural works [2]

Among the polluting effects from the mechanized execution of agricultural works, CO_2 emissions are the most severe polluting factor. Carbon dioxide inevitably results from burning and arrives, after a certain time in the upper layers of the atmosphere, causing, together with other amounts of CO_2 from activities in different fields, the worsening of the greenhouse effect, with serious negative consequences on the global climate [2].

Ways to reduce pollution due to CO_2 emissions

The main way to reduce CO_2 emissions is constituted by reducing fuels consumption. Reducing specific fuel consumption for mechanized agricultural works can be achieved through: the correct choice of technologies, giving priority to those that require low energy consumption, giving up works that are not compulsory and do not bring increases n production, rational use of mechanizing equipment at their normal capacity, avoiding overcharging, correct maintenance and adjustment of engines from tractors and other self-propelled agricultural machines (correctly adjusting the injection pump and the injectors, using clean air and fuel filters) [2].

Dintre efectele poluante ale executării mecanizate a lucrărilor în agricultură, emisia de CO_2 constituie factorul poluant cel mai grav. Dioxidul de carbon rezultă inevitabil prin ardere şi ajunge, după un anumit timp, în straturile superioare ale atmosferei, provocând, împreună cu alte cantități de CO_2 rezultat din activități din diferite domenii, la agravarea efectului de seră, cu consecințe negative serioase asupra climei globului [2].

Căi de reducere a poluării din cauza emisiilor de CO_2 .

Principala cale de reducere a emisiilor de CO_2 o constituie reducerea consumurilor de combustibil. Reducerea consumurilor specifice de motorină la lucrări agricole mecanizate, poate fi realizată prin: alegerea corectă a tehnologiilor, dând prioritate celor care necesită consumuri reduse de energie, renunțarea la lucrări care nu sunt obligatorii şi nu aduc sporuri de producție; folosirea rațională a utilajelor de mecanizare, la capacitatea lor normală, evitarea subîncărcării; întreținerea şi reglarea corectă a motoarelor de tractor şi ale maşinilor agricole autopropulsate: reglarea corectă a pompei de injecție şi a injectoarelor, folosirea de filtre curate de aer şi de combustibil [2].

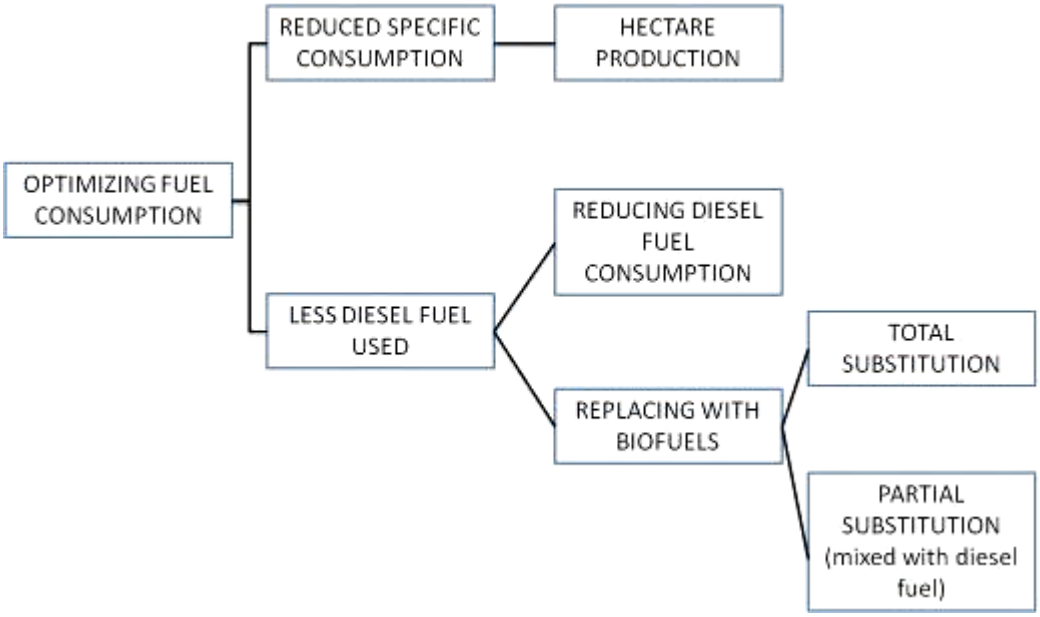

Fig. 2- Possibilities of optimize fuel consumption [2]

If we try to make savings of diesel fuel it translates in a contribution to the protection of global environment. If 1 kg of diesel fuel is saved, about 0.92...0.79 kg less of oil is used, meaning that 2.94...3.2 kg less CO_2 is emitted. [7]

To the reduction of diesel fuel consumption and CO_2 emissions in agriculture contribute both technical measures and the agro-technical and management ones.

Dacă încercăm să facem o economie de motorină asta înseamnă o contribuție la protecția mediului global. Dacă se economiseşte 1 kg motorină se consumă circa 0,92...0,79 kg mai puțin petrol, ceea ce înseamnă că se emit 2,.94...3,2 kg CO_2 mai puțin. [7]

La reducerea consumului de motorină în agricultură şi a emisiilor de CO_2 contribuie atât măsurile tehnice, cât şi cele agrotehnice şi de management.

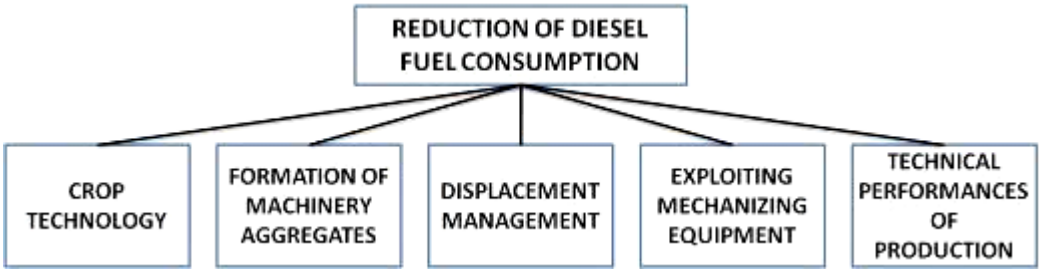

Fig. 3 – General ways to reduce diesel fuel consumption in agriculture [2]

Reducing fuel consumption through the rational exploitation of mechanizing equipment. The main ways to reduce fuel consumption through optimum exploitation of mechanizing equipment are: optimum configuration of the kinematics of agricultural machinery; optimum use of the available power; reducing skidding, choice of tires and adequate adjustment of the pressure in the tires; adapting to conditions in the field and choosing the moment to perform the work depending on the state of the field.

Atmosphere pollution due to other substances in the combustion gases. Local pollution through emissions from burning fuels used for internal combustion engines was underestimated for a long time. In the past, there were preoccupations regarding the harmful action on the human body from lead, respectively from its compounds from combustion gases from engines working with leaded fuel, for example with tetraethyl lead.

Reducerea consumului de combustibil prin exploatarea rațională a utilajelor de mecanizare. Principalele căi de reducere a consumurilor de combustibil prin exploatarea optimă a utilajelor de mecanizare sunt: configurarea optimă a cinematicii agregatelor de maşini agricole; utilizarea optimă a puterii disponibile; reducerea patinării; alegerea pneurilor şi reglarea adecvată a presiunii în pneuri; adaptarea la condițiile de teren şi alegerea momentului de executare a lucrării în funcție de starea terenului.

Poluarea atmosferei din cauza altor substanțe din gazele de ardere. Poluarea locală prin emisii de la arderea combustibililor folosiți la motoare cu ardere internă a fost multă vreme subestimată. In trecut existau unele preocupări în ceea ce priveşte acțiunea nocivă asupra organismului uman a plumbului, respectiv a compuşilor acestuia din gazele de ardere de la motoarele care funcționează cu benzină etilată, de exemplu cu tetraetil de plumb.

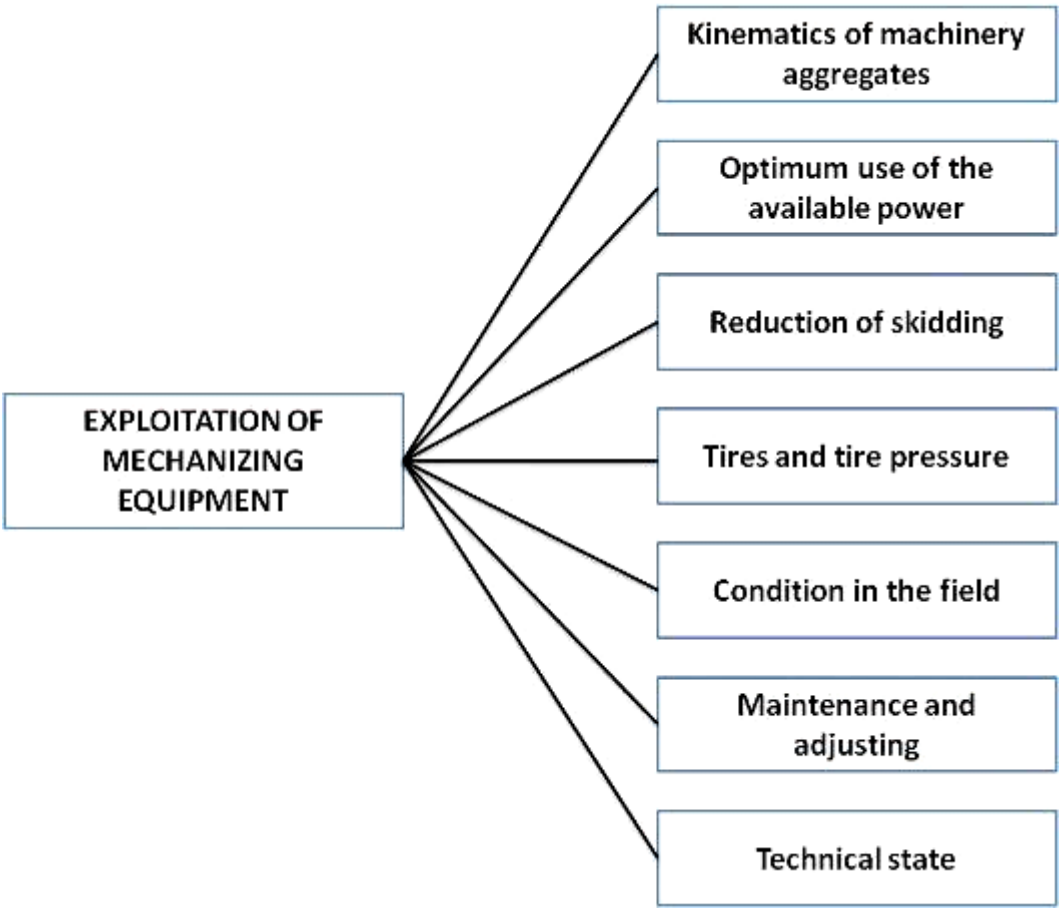

Fig. 4 – Reduction of diesel fuel consumption through optimum exploitation of mobile aggregates of agricultural machinery [2]

CO_2 emissions from burning fuels in internal combustion engines is higher if combustion is incomplete, this coming from an inadequate adjustment made to the feeding system of the engine, from an unfavorable fuel-air ratio, from an inadequate advance in injection, for Diesel engines; from an incorrect adjustment of the carburetor and of the ignition system for spark ignition engines. [7]

○ ***Pollution due to powders released from mechanized execution of agricultural works.*** Powder emissions from the mechanized execution of agricultural works are harmful for the health of the people working

Emisia de CO la arderea combustibililor în motoarele cu ardere internă este mai mare dacă arderea este incompletă, aceasta putând fi urmare a unei reglări necorespunzătoare a sistemului de alimentare al motorului, funcționarea cu un raport nefavorabil combustibil - aer, avans necorespunzător la injecție, la motoarele Diesel; reglarea incorectă a carburatorului şi a sistemului de aprindere la motoarele cu aprindere prin scânteie. [7]

○ ***Poluarea din cauza pulberilor degajate la executarea mecanizată a lucrărilor agricole.*** Emisiile de pulberi la executarea mecanizată a lucrărilor în agricultură sunt nocive pentru sănătatea oamenilor care

with the equipment or are situated in their vicinity. From some works, dust is released, with particles of different sizes, resulted from the pulverization of dry soil at certain works and from harvesting certain crops, for example with the combine for cereals. Larger dust particles, such as the ones in this category, reach the superior part of respiratory airways.

Mechanized works in agriculture can also cause the spreading in the close environment of the some powders from chemical substances with which the operator works, for example chemical fertilizers. Researches in specialized institution from different countries have highlighted the very high risks on the health of the human body, especially by causing severe pulmonary diseases from unwanted inhaling of combustion gases. The concentration of fine particles of combustion gases from internal combustion engines and from combustion installation varies during one day and depending on the season and weather conditions. During winter, more particles remain in the air compared to the summer. An average concentration of 3 µ g/m^3 $PM_{2,5}$ was estimated in the air due to combustion gases from Diesel engines.

In addition to emissions, in the close environment other factors act as pollutants: noise, vibrations, powders, etc. (fig. 5) [2].

lucrează cu utilajele sau se află în apropiere de acestea. La unele lucrări se răspândeşte praf, cu particule de dimensiuni diferite, rezultat din pulverizarea solului uscat la anumite lucrări ale solului şi la recoltarea anumitor culturi, de exemplu cu combina de cereale. Particulele mai mari de praf, cum sunt cele din această categorie, ajung în partea superioară a căilor respiratorii.

Lucrările mecanizate din agricultură mai pot provoca împrăştierea în mediul apropiat a unor pulberi din substanţele chimice cu care operatorul lucrează, de exemplu cu îngrăşămintele chimice. Cercetările din instituţii specializate din diferite ţări au scos în evidenţă riscurile deosebit de mari asupra sănătăţii organismului uman, în special prin provocarea de grave afecţiuni pulmonare la inhalarea involuntară a gazelor de ardere. Concentraţia de particule fine provenite din gazele de ardere de la motoare cu ardere internă şi de la instalaţii de ardere variază în cursul unei zile şi variază şi în funcţie de anotimp şi de starea vremii. In timpul iernii rămân în aer mai multe particule decât vara. A fost estimată o concentraţie medie de $PM_{2,5}$ în aer de 3 µ g/m^3 din cauza gazelor de ardere de la motoare Diesel.

In afară de emisii, în mediul apropiat acţionează poluant şi alţi factori: zgomotul, vibraţiile, pulberile ş.a. (fig. 5) [2].

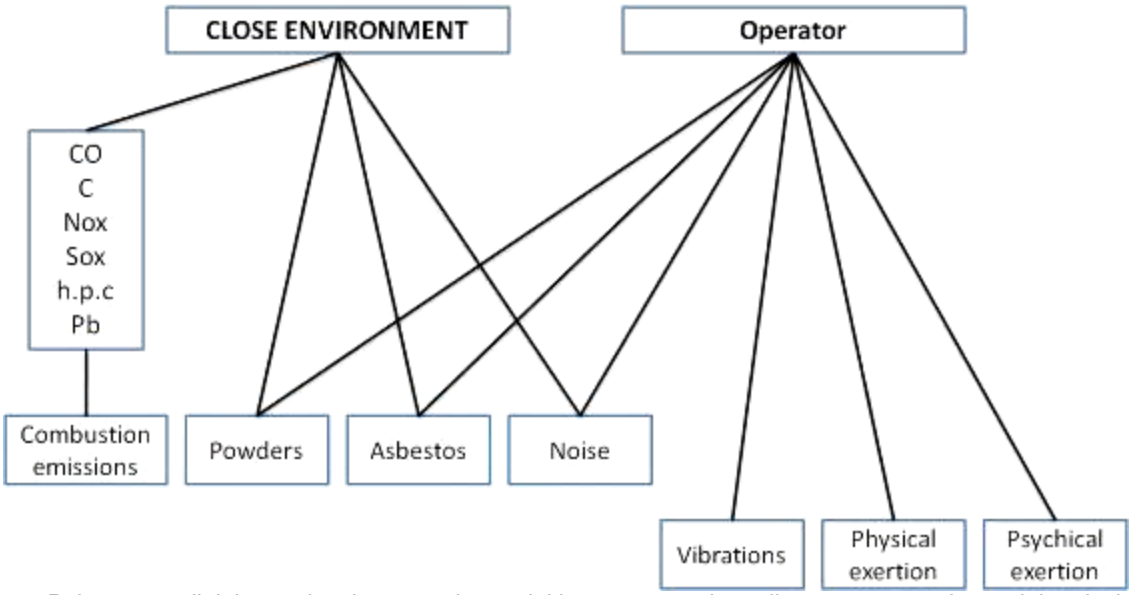

Fig. 5 - Poluarea mediului apropiat şi a mecanizatorului la executarea lucrărilor cu agregate de maşini agricole [2]

The protection of the close environment can be obtained by improving the construction of mechanizing equipment, in the view of reducing vibrations, noise and for eliminating sources of pollution with toxic fuel vapors, combustion gases, including harmful additives, waiving the components from asbestos fibers in clutches and brakes.

○ ***Soil and water pollution caused by mechanized works:***

Soil compaction, or excessive settlement represents one of the most frequent and pronounced forms of pollution due to mechanization. Surface compaction is usually caused by heavy machinery – wheels of heavy tractors, heavy agricultural machinery - and is aggravated by the repeated crossing with the machine aggregates. By the excessive compaction of, the characteristics of soils, the circulation regime of air and water are negatively modified. It is possible to prevent soil compaction by: limiting the use of heavy machinery, limiting the number of crossings on field with tractor in aggregate with agricultural machinery [3].

Menajarea mediului apropiat se poate obţine prin îmbunătăţirea construcţiei utilajelor de mecanizare, în vederea reducerii vibraţiilor, zgomotului şi eliminarea surselor de poluare cu vapori toxici de combustibil, gaze de ardere, inclusiv cu aditivi nocivi, renunţarea la componente din fibre de azbest la ambreiaje şi frâne.

○ ***Poluarea solului şi a apei din sol din vina lucrărilor mecanizate:***

Compactarea solului , sau tasarea exagerată reprezintă una dintre cele mai frecvente şi mai accentuate forme de poluare din cauza mecanizării. Compactarea de la suprafaţă este provocată în general din cauza utilajelor grele – roţile tractoarelor grele, maşini agricole grele – şi se agravează prin repetarea trecerilor cu agregate de maşini. Prin compactarea exagerată se modifică negativ însuşirile solului, regimul de circulaţie al aerului şi al apei. Prevenirea compactării solului la suprafaţă este posibilă prin: limitarea folosirii utilajelor grele; limitarea numărului de treceri pe teren a tractorului în agregat cu maşini agricole. [3] .

Soil erosion favored by some mechanical works. Soil erosion has many causes, but in certain conditions, mechanization can act aggravating, for example through the inadequate performing of soil works on slopes, but also through work that pulverize the soil, which is afterwards taken by the wind.

Technologies for soil preservation, which leave a large share of plant residues on the surface of the soil, reduce erosion in a proportion of 95% (no-till) compared to the classic processing systems. Plant residues that are evenly distributed on the soil surface and in a higher quantity on sloping land, where erosion is more pronounced by intercepting rain drops, absorbs their energy and reduce the process of detaching soil particles (the first step in the process of erosion), slow down water runoff of the surface of sloping terrains and reduce the transport of soil particles (the second step in the process of erosion). [7]

○ ***Soil and soil water pollution*** can be caused by the low precision of mechanized works with chemical substances, for example by applying chemical fertilizers and through the mechanized chemical fighting of weeds, diseases and pests. The main culprit for pollution is the use of chemicals, but high precision mechanized equipment can maintain the polluting effects in reasonable limits.

○ ***Pesticide pollution*** has a significant impact on the environment, this impact is primarily due to the chemical substances that were synthesized in pesticides, fertilizers, growth stimulators and other auxiliary products. Sources of pollution whose pollutants are pesticides are found in all three environment factors –water, air, soil, which eventually affects the whole food chain. [8]

○ ***Fertilizer pollution*** is caused by a wrong soil management, characterized by:

• increasing the ratio of arable field in the detriment of field with perennial vegetation (pastures, grasslands);
• insufficient use of perennial recovery crops (clover, alfalfa) in the rotation of agricultural crops;
• replacing and eliminating some valuable crops that are less profitable in the favor of high yield crops;
• using high power agricultural machinery, which cause the destruction of the soil's natural structure and intensify the process of physical degradation. [9]

By analyzing the statistical data, the following conclusions can be formulated:

• the failure to cultivate agricultural fields contributes to obtaining a lower quantity of agricultural products, but has beneficial effects on restoring, in a isolated ways, of biodiversity and reinstalling natural ecosystems, specific for each area;
• the reduction of the phenomenon of burning herbaceous vegetation and stubbles on agricultural fields has a beneficial effects on air quality;
• the significant reduction of livestock numbers, especially pigs and birds, has a favorable effect on the quality of environment factors, allowing the natural restoring of the areas affected by animal manure;
• the stocks of pesticide waste existing in agricultural unit continues to be a problem, due to the lack of funds necessary to incinerate them;
• the insufficient involvement of decision making factors in agricultural units concerning the management of other types of residues resulting from the specific activity;
• the irrigation of agricultural fields is performed on a very small surface, compared to the surface arranged, which leads in some areas to the increase of the phenomenon of desertification [9].

○ ***Soil and soil water pollution due to leaks of mineral oil and fuel from mechanizing equipment.***

Eroziunea solului favorizată de unele lucrări mecanizate. Eroziunea solului are multe cauze, dar în anumite condiții şi mecanizarea poate acționa agravant, de exemplu prin executarea neadecvată a lucrărilor solului pe pante, dar şi prin lucrări care pulverizează solul şi acesta este apoi antrenat de vânt.

Tehnologiile de conservare a solului, care lasă o mare parte de resturi vegetale pe suprafața solului, reduc eroziunea în proporție de 95 % (no-till) comparativ cu sistemele de prelucrare clasice. Resturile vegetale care sunt uniform distribuite pe suprafața solului şi în cantitate mai mare pe terenuri în pantă, unde eroziunea este mai accentuată prin interceptarea picăturilor de ploaie, absorb energia acestora şi reduc procesul de detaşare a particulelor de sol (primul pas în procesul de eroziune), încetinesc scurgerea apei pe suprafața solurilor în pantă şi reduc transportul particulelor de sol (al doilea pas în procesul eroziunii). [7]

○ ***Poluarea solului şi a apei din sol*** poate fi provocată din cauza preciziei reduse la lucrări mecanizate cu substanțe chimice, de exemplu de aplicare a îngrăşămintelor chimice şi la lucrări mecanizate de combatere chimică a buruienilor şi a bolilor şi dăunătorilor plantelor. Principalul vinovat de poluare este chimizarea, dar utilajele de mecanizare cu precizie mare pot menține efectele poluante în limite rezonabile.

○ ***Poluarea cu pesticide***, are un impact deosebit asupra mediului, acest impact se datorează în primul rând substanțelor chimice care au fost sintetizate în pesticidele, fertilizatorii, stimulatorii de creştere precum şi în alte produse auxiliare. Sursele de poluare a căror poluanți sunt pesticidele se găsesc în toți cei trei factori de mediu – apă, aer, sol – ceea ce în final afectează întregul lanț trofic.[8]

○ ***Poluarea cu îngrasaminte*** este provocata de o gestionare gresita a solului, caracterizata prin:

• cresterea terenurilor arabile în defavoarea terenurilor cu vegetatie perena (pasuni, fâneata);
• folosirea insuficienta a culturilor amelioratoare perene (trifoi, lucerna) în rotatia culturilor agricole;
• înlocuirea si eliminarea unor culturi valoroase mai putin rentabile, în favoarea culturilor de mare productivitate;
• utilizarea unor utilaje agricole grele de mare putere, care provoaca distrugerea starii structurale a solului si intensificarea proceselor de degradare fizica [9].

Analizând datele statistice, se pot prezenta urmatoarele concluzii:

• necultivarea terenurilor agricole contribuie la obtinerea unor cantitati mai reduse de produse agricole, dar are efecte favorabile asupra refacerii, în mod izolat, a biodiversitatii si reinstalarea ecosistemelor naturale, specifice fiecarei zone;
• reducerea fenomenului de ardere a vegetatiei ierboase si a miristilor pe terenurile agricole are un efect benefic asupra calitatii aerului;
• reducerea semnificativa a efectivelor de animale, în special la porcine si pasari, are un efect favorabil asupra calitatii factorilor de mediu, permitând refacerea naturala a zonelor afectate de dejectiile animaliere;
• continua sa fie o problema stocurile de deseuri de pesticide existente într-o serie de unitati agricole, din cauza lipsei fondurilor financiare necesare incinerarii acestora;
• insuficienta implicare a factorilor de decizie din unitatile agricole în ceea ce priveste gestionarea altor tipuri de deseuri rezultate din activitatea specifică;
• irigarea terenurilor agricole se realizeaza pe o suprafata foarte redusa, în comparatie cu suprafata amenajata, ceea ce duce în unele zone la accentuarea fenomenului de desertificare [9].

○ ***Poluarea solului şi a apei din sol din cauza curgerilor de ulei mineral şi de combustibil de la utilajele de***

Mineral oil leaked on the soil from the engine, from the transmission or from the hydraulic installation of the tractor or of an agricultural machine, is not biodegradable and slowly reaches the underground water, polluting it. This phenomenon is extremely severe, and its consequences cannot be eliminated. The results of researches conducted in different conditions in several countries have highlighted the risk of pollution caused by the leaks. According to these researches, a quantity of 1 ml of mineral oil causes the pollution of 10^3 ml of underground water, or otherwise expressed, 1 liter of mineral oil pollutes 1000000 liters of water. Diesel fuel leaks on the soil have similar effects. They occur because on incorrect sealing and defects of the fuel system, but also due to other causes. The risk of diesel fuel leaking does not only appear in the case of bad tractor maintenance. For two of the types tractor engines existing in our agriculture, is provided that when pumping the air from the fuel system, diesel fuel with air bubbles fall on the ground, and if the tractor is on the field, this means that it falls on the soil.

○ ***Indirect pollution caused by equipment for mechanizing agriculture***. Indirect pollution is considered to be the one caused by the manufacturing of tractors and agricultural machinery, as well as by the disposal-dismantling through the harmful effect on the environment due to paints, varnishes, solvents. Varnishes used for painting machines can be less pollutant, both by their chemical composition and by the process of applying them [2].

CONCLUSIONS

In *agriculture*, compliance with the Code of Good Agricultural practices represents the starting point for applying ecologic measures that will lead to the development of rural communities in tight relation with the protection of the natural environment.

The maintenance of the field in good conditions for practicing agriculture, but also for developing several specific ecosystems, includes complying with the standards for soil protection by maintaining its structure and content of organic substances and by preserving biodiversity [9].

Researches on the rational use of agricultural aggregates aims at substantiating and transmitting information regarding their impact on the environment, rational methods and means to optimize and harmonize the concept of sustainable agriculture as well as possibilities to reduce polluting effects from the mechanized execution of agricultural works.

Agriculture, along with the industry, can become one of the most important sources of polluting agents with negative impact on the quality of the environment, by degrading or even destroying some of its components. Today, it is virtually unanimously accepted that intensive agriculture can lead to soil and water pollution by the excessive use of fertilizers, pesticides, improper quality and quantity of irrigation water, especially on excessively loosened soils through various works.

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mecanizare . Uleiul mineral căzut pe sol, de la motor, de la transmisie, sau de la instalația hidraulică a tractorului sau a unei maşini agricole, nu este biodegradabil şi ajunge treptat în pânza de apă freatică, pe care o poluează. Fenomenul acesta este deosebit de grav, iar consecințele nu pot fi practic eliminate. Rezultatele cercetărilor efectuate în condiții diferite în mai multe țări au pus în evidență riscul poluării provocate de scurgeri. Potrivit acestor cercetări, cantitatea de 1 ml de ulei mineral provoacă poluarea unei cantități de 10^3 ml apă din pânzele freatice, sau exprimat altfel, 1 litru de ulei mineral poluează 1.000.000 litri de apă. Curgerile de motorină pe sol au efecte similare. Ele apar la neetanşări şi defecte ale sistemului de alimentare, dar şi din alte cauze. Riscul curgerii motorinei nu apare doar în cazul întreținerii proaste a tractorului. La două din tipurile de motor de tractor, existente în agricultura noastră, din fabricație este prevăzut ca la scoaterea prin pompare a aerului din sistemul de alimentare, motorina care mai conține bule de aer să curgă jos, iar dacă tractorul este în câmp, aceasta însemnă să curgă pe sol.

○ ***Poluarea indirectă provocată de utilajele pentru mecanizarea agriculturii.*** Poluare indirectă este considerată cea provocată la fabricația tractoarelor şi a maşinilor agricole, precum şi la casare-dezmembrare, prin efectul nociv asupra mediului în general din cauza vopselelor, lacurilor, solvenților. Lacurile folosite la vopsirea maşinilor agricole pot fi mai puțin poluante, atât prin compoziția lor chimică, cât şi prin procedeul de aplicare [2].

CONCLUZII

În *agricultură*, respectarea Codului Bunelor Practici Agricole reprezintă punctul de pornire pentru aplicarea măsurilor ecologice care să conducă la dezvoltarea comunităților rurale în strânsa corelare cu protejarea mediului înconjurător.

Menținerea terenului în bune condiții pentru practicarea agriculturii dar şi pentru dezvoltarea diverselor ecosisteme specifice, include respectarea standardelor pentru protejarea solului prin menținerea structurii şi conținutului în substanțe organice si conservarea biodiversității [9].

Cercetarea asupra folosirii raționale a agregatelor agricole are în vedere fundamentarea şi transmiterea, informațiilor cu privire la impactul acestora asupra mediului înconjurător, metode şi mijloace raționale de optimizare şi armonizare la conceptul de agricultură durabilă precum şi posibilități de reducere a efectelor poluante la executarea mecanizată a lucrărilor în agricultură.

Agricultura, alături de industrie, poate deveni una dintre sursele importante de agenți poluanți cu impact negativ asupra calității mediului, prin degradarea sau chiar distrugerea unor componente ale acestuia. Astăzi, este practic unanim acceptat că agricultura intensivă poate conduce la poluarea solului si apei prin utilizarea excesivă a îngrăşămintelor, a pesticidelor, a apei de irigație necorespunzătoare calitativ si cantitativ, în special pe terenurile arabile excesiv afânate prin diferite lucrări.

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THEORETICAL ASPECTS REGARDING THE PROCESS OF CONVECTIVE DRYING
/
ASPECTE TEORETICE PRIVIN PROCESUL DE USCARE CONVECTIVĂ

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Abstract: *In the present paper are presented theoretical research concerning the drying of vegetable products especially fruits and vegetables using convective dryers. There will be presented the main elements of that are take into account in the analysis of convective drying process, such as: the type of wet materials, related forms of humidity, equilibrium humidity, water activity and adsorption isoterms, methods of deteremination, but also the mechanism of transfer of moisture from the inside to the surface of bodies.*

Keywords: *Moisture balance, water adsorption isotherms, moisture transfer, lyophi, liophob, hydrophil, hydrophob.*

INTRODUCTION

Drying is the process that has as main goal the preservation of products subject to the process in this case of fruit and vegetables. Drying or dehydration may be defined as the process of removing a certain amount of water from the raw materials represented by fruit and vegetables. After this process is achieved a favorable physicochemical condition to maintain nutritional quality of them for a longer period on one side, and on the other side creates favorable condition under which the activity of the microorganisms is reduced, these were stopped to work in a negative way leading to their degradation products in a shorter time. Good progress of the microorganisms in fruit and vegetables is closely linked to the specific content of water in which they operate. Movement of water in fruits and vegetables subjected to be dehydrated depends on her primary forms, namely: free water, colloidal bound water and chemically bound water.

Drying is a complex operation involving transient heat and mass transfer together with various processes, such as physical and chemical transformations, which in turn can cause changes in product quality as well as mass and heat transfer mechanisms. Physical changes that may occur are contracting, swelling, crystallization, glass transformation. in some cases, chemical or biochemical reactions may occur that may affect the desired or undesired color, texture, smell, or other properties of the solid product. [1]

The drying process can be considered as a dual operation, namely heat transfer and mass transfer. In the first stage of drying food should be evaporated water. The most common method is the crossing of a stream of hot air over the food. The heat is transferred by convection from the air to the surface and by conduction inside the vegetables. Can also be used drying with direct contact of the food with a hot surface. In this case could bu used as heat sources a various types of electromagnetic radiation such as infrared, microwaves or radio waves.

MATERIAL AND METHOD

In the drying process it is iportant to know the

Rezumat: *În prezenta lucrare sunt prezentate cercetările teoretice privind procesul de uscare a produselor vegetale cu precădere fructe şi legume cu ajutorul uscătoarelor convective. Vor fi prezentate elementele principale de care se țin cont în analiza procesului de uscare convectivă, cum ar fi: tipul materialelor umede, formele de legătură a umidității, umiditatea de echilibru, activitatea apei şi izotermele de sorbție ale acesteia şi metodele de determinare ale acestora, dar şi mecanismul de transfer de umiditate din interiorul la suprafața corpurilor.*

Cuvinte cheie: *Umiditatea de echilibru, izoterme de sorbțiune ale apei, transfer de umiditate, liofil, liofob, hidrofil, hidrofob*

INTRODUCERE

Uscarea este procesul tehnologic ce are ca principal scop conservarea produselor supuse procesului, în cazul de față a fructelor şi legumelor. Uscarea sau deshidratarea poate fi definită ca fiind procesul tehnologic de îndepărtare a unei anumite cantități de apă din materia primă, reprezentată de fructe şi legume. În urma acestui proces se realizează o stare fizico-chimică favorabilă menținerii calităților nutritive a acestora pe o perioadă mai îndelungată pe de o parte, iar pe de altă parte se creează condițiile favorabile în care activitatea mircroorganismelor este redusă, acestea fiind împiedicate să îşi desfăşoare activitatea în mod negativ asupra produselor ducând la degradarea acestora într-un timp mult mai scurt. Buna desfăşurare a activității microorganismelor din fructe şi legume este strâns legată de un anumit conținut de apă în care acestea activează. Mişcarea apei în fructele şi legumele destinate deshidratării depinde de formele ei primare si anume: apa liberă, apa legată coloidal şi apa legată chimic.

Uscarea este o operație complexă care implică transfer tranzitoriu de căldură şi masă împreună cu diferite procese, cum ar fi transformări fizice şi chimice, care, la rândul lor, pot cauza schimbări ale calității produsului la fel ca şi mecanismele transferului de masă şi căldură. Schimbările fizice ce pot apare sunt: contrctarea, umflarea, cristalizarea, transformări în sticlă. În anumite cazuri, pot apare reacții chimice sau biochimice dorite sau nedorite ce pot afecta culoarea, textura, mirosul sau alte proprietăți ale produsului solid.[1]

Uscarea poate fi considerată o *operație dublă* de transfer termic şi de transfer de masă. În prima etapă a uscării apa din aliment trebuie evaporată. Cea mai utilizată metodă este cea de trecere a unui curent de aer cald peste aliment. Căldura se va transfera prin convecție de la aer către suprafața alimentului şi prin conducție în interiorul alimentului. Se mai poate utiliza şi uscarea prin contact direct al alimentului cu o suprafață caldă. În acest caz pot fi folosite ca surse de încălzire radiațiile electromagnetice de diverse tipuri cum ar fi radiațiile infraroşii, microundele sau undele radio.

MATERIAL ŞI METODĂ

În procesul de uscare este important să se cunoască

transport mechanism of water both inside the food, as well as on its surface. The movement of water can be a consequence of capillary forces, diffusion due to a concentration gradient, the diffusion of surface, the difussion of water vapors through the pores filled with air, of the flow because of a pressure gradient or vaporization and condensation.

Drying mechanism: When a wet material is dried with a current of hot air, heat is transferred from the surface of the material by convection. The vapors which are formed are transported by the air stream away from the material surface.To obtain the drying curves can be work in constant or variable conditions drying.

In the first case does not change the paraeters of the drying agent after passing through or over the material to be dried. This way of workig can be achieved by working practicaly in large hot air debits and the layer of material subjected to drying have a smaller thinckness. In these conditions after passing through or abouve the layer moisture content and temperature will remain constant.

mecanismul de transport al apei atât în interiorul alimentului, cât şi la suprafața acestuia. Deplasarea apei poate fi o consecință a forțelor capilare, a difuziei datorate unui gradient de concentrație, a difuziei de suprafață, a difuziei vaporilor de apă prin pori umpluți cu aer, a curgerii din cauza unui gradient de presiune sau a vaporizării şi condensării.

Când un material umed este uscat cu un curent de aer cald, căldura se transferă la suprafța materialului prin convecție. Vaporii care se formează sunt transportați de curentul de aer departe de suprafța materialului. Pentru a obține curbele uscării se poate lucra în condiții constante sau variabile de uscare.

În primul caz parametrii agentului de uscare nu variază în urma trecerii prin sau peste materialul supus uscării. Acest mod de lucru se poate realiza practic lucrând la debite mari de aer cald şi cu strat de material supus uscării de grosime mică. În aceste condiții după trecerea aerului peste sau prin strat conținutul său de umezeală şi temperatura sa rămân constante.

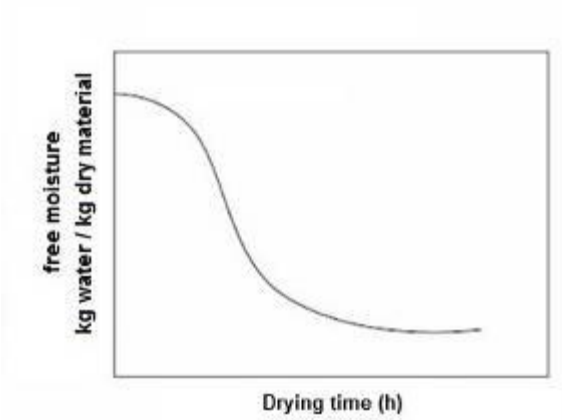

Fig. 1 Drying curve (free moisture content variation over time)

The drying process can be exemplified as a theoretically process consist of two cylindrical capilaries of a different diameters, connected trough a channel with negligiable resistance. In the most general case, there are three phases of the trials drying, which are shown in next figure in a chart witch indicates a change in drying rate (mass unitary flow) depending on the humidity of the material. [2] [6]

The first stage of drying. At the beginning of the drying process the surface of most of the materials is covered by a film of liquid. All the pores are filled with water and for a flat surface, the drying speed in the first phase $m_1$remains constant becouse the transport of water from the inside to the surface will continuously replace the amount of evaporated water. The process of evaporation of moisture from the body surface it is the same as the evaporation from the free surface of the liquid and is not influenced by the thermal-physical properties of the material.

The first stage of drying it is described mathematically by the equation:

Procesul de uscare poate fi exemplificat pe un proces teoretic, alcătuit din două capilare cilindrice de diametre diferite, legate între ele printrun canal de rezistență neglijabilă. În cazul del mai general, în desfăşurarea procesului se disting trei faze de uscare, care sunt prezentate în fig urmatoare într-o diagramă ce indică variația vitezei de uscare (fluxul unitar de masă) în fucție de umiditatea materialului. [2] [6]

Prima fază a uscării. La începutul procesului de uscare suprafața celor mai multe dintre corpuri este acoperită de un film de lichid. Toti porii sunt plini cu apă şi pentru o suprafață plană, viteza de uscare în prima fază m_1 rămâne constantă, deoarece transportul apei din interior către suprafață înlocuieşte continuu cantitatea de apă evaporată. Procesul de evaporare al umidității la suprafața corpului este identic cu evaporarea lichidului la suprafață liberă şi nu este influențat de proprietățile termo-fizice ale materialului.

Prima fază a uscării este descrisă matematic de ecuația:

$$m_1 = \frac{\beta}{R_v T}(p_s - p_{va}) = ct \qquad (1)$$

Where: β it is the mass transfer coefficient in m / s; R_v it is a specific constant of vapors in J/KgK; p_s it is the saturation pressure in Pa; p_{va} it is the water vapor pressure in Pa

unde: β este coeficientul de transfer de masă, în m/s; R_v este constantă specifică a vaporilor, în J/KgK; p_s este presiunea de saturație în Pa; p_{va} este presiunea vaporilor de apă în Pa.

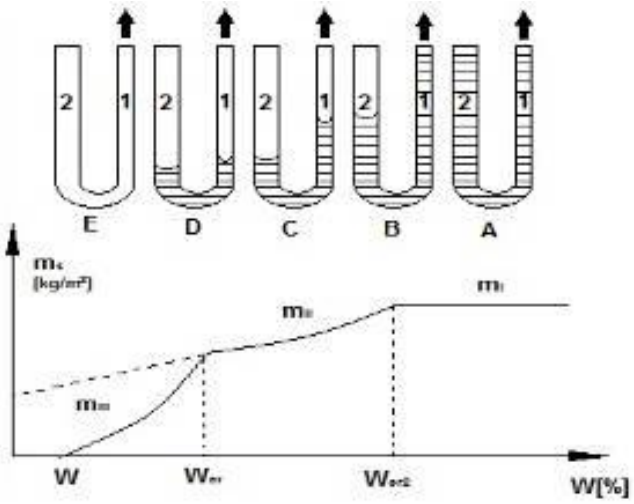

Fig. 2. The phases of the drying process [1]

The transfer of heat between the ambient air and the material can be expressed by the equation:

$$Q = \alpha S(t_a - t_{sup}) \quad (2)$$

where Q is equal to m_w*r is the heat flow received by the body and used to vaporize moisture in J/s; α it is the convective heat transfer coefficient in W/m^2*k; S it is the surface of the evaporation in m^2; ; t_a is air temperature in ^{o}C; t_{sup} it is the evaporation surface temperature in ^{o}C; m_w is evaporated water flow in kg/s; r is the latent heat of vaporization, in J.Kg.

From the previous relationships, namely 1 and 2 to obtain the rate of drying for this phase:

$$m_1 = \frac{m_w}{S} = -\frac{Q}{Sr} = \frac{\alpha}{r}(t_a - t_{sup}) \quad (3)$$

The temperature of the evaporation surface it is equal to the temperature at the free surface of the liquid which is evaporated and can be determined by the wet thermometer ($t_{sup} = t_u$).

The first phase of drying lasts until the first critical point which is obtained when the thick capillary mechanism reached the depth of δ_{2cr}, so large that the available capillary forces are no longer able to reach the frictional forces and the fluid can not be brought to the surface.

Many times drying speed variation m_1 depending on humidity represents a parallel line to the abscissa axis, however experimental results showing a small tilt to the critical point. This can be explained by the decrease of the effective surface of the evaporation material by drying some portions of the body and by contraction of the material in the first stage of drying. [8]

The second stage of drying. The first critical point (Fig.2, point B) marks the beginning of the second stage of drying, which is characterized by decreasing speed. From this point speed begins to decrease, because of moisture migration from the inside surface of the body can no longer compensate the evaporated water from the body. The area of evaporation penetrate inside the material. Humidity are redistributed in the material and moving to the surface, both in liquid form as well in vapor form. Migration of moisture into the interior of the material is determined by variation of concentration and of variation of humidity and temperature in the material. Body temperature increase, but the surface humidity decrease, tending to the equilibrium humidity. The drying process is not any more influenced by the superficial condition, being influenced by mode of distribution of moisture in the material. The second

Transferul de căldură între aerul înconjurător şi suprafaţa materialului poate fi exprimat prin relaţia:

unde: Q este egal cu m_w*r este fluxul termic primit de corp şi utilizat pentru evaporarea umidităţii în J/s; α este coeficientul de transfer de căldură convectiv, în W/m^2*k; S este suprafaţa de evaporare în m^2 ; t_a este temperatura aerului în ^{o}C; t_{sup} este temperatura suprafeţei de evaporare, în ^{o}C; m_w este debitul de apă evaporat în kg/s; r este căldura latentă de vaporizare, în J.Kg.

Din relaţiile anterioare şi anume 1 şi 2 se obţine viteza de uscare pentru această fază:

Temperatura suprafeţei de evaporare este egală cu temperatura la suprafaţa liberă a lichidului care se evaporă şi poate fi determinată cu ajutorul termometrului umed ($t_{sup} = t_u$).

Prima fază a uscării durează până la atingerea primului punct critic care se obţine cand mecanismul capilarului gros a atins adâncimea δ_{2crl}, atât de mare încât forţele capilare disponibile nu mai reuşesc să atingă forţele de frecare şi lichidul nu mai poate fi adus la suprafaţă.

De multe ori variaţia vitezei de uscare m_1 în funcţie de umiditate reprezintă o dreaptă paralelă cu axa absciselor, rezulatele experimentale arătând totuşi o uşoară înclinare către punctul critic. Acest lucru se explică prin micşorarea suprafeţei efective de evaporare, prin uscarea unor porţiuni de material de la suprafaţa corpului şi prin contracţia materialului în prima fază a uscării. [8]

A doua fază a uscării. Primul punct critic *(Fig.2 pct B)* marchează începutul fazei a doua de uscare, care este caracterizată de viteza descrescătoare. De la acest punct viteza începe să scadă, deoarece migraţia umidităţii dinspre interior spre suprafaţa corpului nu mai poate compensa apa evaporată la suprafaţa corpului. Zona de evaporare pătrunde în interiorul materialului.

Umiditatea se redistribuie în material şi se deplasează către suprafaţă, atât sub formă lichidă cât şi sub formă de vapori. Migraţia umidităţii în interiorul materialului este determinată de variaţia concentraţiei umidităţii şi de variaţia temperaturii în material. Temperatura corpului creşte, iar umiditatea la suprafaţă scade, tinzând către umiditatea de echilibru. Procesul de uscare nu mai este influenţat de condiţiile superficiale, ci de modul de repartiţie a umidităţii în material.

Faza a doua a uscării poate fi descrisă matematic sub forma:

phase of drying process can be described mathematically as:

$$m_{II} = \frac{D''}{\mu\delta_1} \cdot \frac{1}{R_v T}(p_s - p_0) = \frac{\beta}{R_v T}(p_0 - p_{va}), \quad (4)$$

where $D' = \frac{Dp_{atm}}{\Delta p_m} = D\frac{p_{atm}}{p_{atm}-p}$ δ_1 is the depth of penetration of the evaporation zone into the material, in m; p_0 it is the partial pressure of water vapor on the surface of the body in Pa; μ it is diffusion resistance factor, the number of times the diffusion of water vapor through the layer of material is smaller than an air layer through the same section and thickness, placed at the same pressure and temperature conditions; p_s it is the saturation pressure in Pa; $\Delta p_m = p_{atm} - p_m = p_{atm} - (p_s + p_0)/2$ – it is the logarithmic average difference of pressure, determined by analogy with the logarithmic average temperature difference; p_{atm} is the atmospheric pressure in Pa.

Eliminating p_0 in the system of equations 4, is obtained:

unde: $D' = \frac{Dp_{atm}}{\Delta p_m} = D\frac{p_{atm}}{p_{atm}-p}$; δ_1 este adâncimea de pătrundere a zonei de evaporare în interiorul materialului, în m; p_0 este presiunea parțială a vaporilor de apă la suprafața corpului în Pa, μ este factorul de rezistență la difuzie, care arată de câte ori difuzia vaporilor de apă printr-un strat de material este mai mică decât printr-un strat de aer de aceeaşi secțiune şi grosime, aflat în aceleaşi condiții de presiune şi temperatură; p_s este presiunea de saturație în Pa; $\Delta p_m = p_{atm} - p_m = p_{atm} - (p_s + p_0)/2$ – este diferența medie logaritmică de presiune, determinată prin analogie cu diferența medie logaritmică de temperatură; p_{atm} este presiunea atmosferică în Pa.

Eliminând p_0 în sistemul de ecuații 4 se obține:

$$m_{II} = \frac{1}{R_v T} \cdot \frac{1}{\frac{1}{\beta} + \frac{\mu\delta_1}{D'}}(p_s - p_{va}) \quad (5)$$

Becouse depth δ_1 through diffusing water vapors becomes increasingly higher, drying speed m_{II} becomes increasingly smaller.

The third phase of drying. There is a third point (Fig.2, point D) which is obtained when it reaches the maximum depth δ. At this stage, the material temperature increases and the vapor pressure decreases. Drying speed decreases more, because the difference between moisture concentration inside and outside the material becomes increasingly smaller. When the material moisture b ecomes equal to the equilibrium value corresponding to the thermal conditions of the drying process, the drying speed is reduced to 0 and the drying process ends. [9] Theoretically, if prolonged variation curve of speed drying with the humidity in the second stage of drying until intersecting ordered (at zero moisture content) is obtained apparent drying speed m_a. This speed is obtained substituting δ in relation 5 with δ_1

Deoarece adâncimea δ_1 prin care difuzează caporii de apă devine din ce în ce mai mare, viteza de uscare m_{II} devine din ce în ce mai mică.

A treia fază a uscării. Există un al treilea punct *(Fig 2.2. pct D)* care se obține când se atinge adâncimea maximă δ. În acest stadiu, temperatura materialului creşte şi presiunea vaporilor scade. Viteza de uscare scade şi mai mult deoarece diferența între concentrațiile de umiditate din interiorul şi exteriorul materialului devine din ce în ce mai mică. Când umiditatea materialului devine egală cu valoarea de echilibru corespunzătoare condițiilor termice ale procesului de uscare, viteza de uscare se redu;ce la 0 şi procesul de uscare încetează.[9] Teoretic, dacă se prelungeşte curba de variație a vitezei de uscare cu umiditatea din faza a doua a uscării până intersectează ordonata (la conținut nul de umiditate) se obține viteză de uscare aparentă m_a. Acestă viteză se obține înlocuind în relația (2.9) pe δ_1 cu δ:

$$m_a = \frac{1}{R_v T}\frac{1}{\frac{1}{\beta} + \frac{\mu\beta}{D'}}(p_s - p_{va}) \quad (6)$$

The apparent drying speed can be determined through experiments and used to calculate the diffusion resistance factor.

The third phase of drying is found in practice only to certain materials.

Viteza de uscare aparentă poate fi determinată pe cale experimentală şi este utilizată pentru calculul factorului de rezistență la difuzie.

Faza a treia a uscării se întâlneşte în practică numai la anumite materiale.

Drying process characteristic curves

Drying process of wet material is hard to express in mathematical relationships, because he represents common result of heat and mass transfer, modification of the properties of the drying agent and materials, contraction and deformation of the material in the process etc. [11]. For this reason the drying process is studied combining theoretical and experimental results. The experimental way determined curves drying, which indicates the variation of humidity and temperature of material in time, and the drying rate to getting curves like those presented in Fig. 3

Variation of mass samples ubjected to experiments allow the determination of average humidity Wj at moment τ_j.

Curbele caracteristice proceselor de uscare

Procesul de uscare al materialor umede este greu de cuprins în relațiile matematice, deoarece el reprezintă rezultatul comun al transferului de căldură şi de masă, modificării proprietăților agentului de uscare şi al materialelor, contracției şi deformației materialului pe parcurs etc. [11]. Din acest motiv procesul de uscare se studiază combinând rezultatele teoretice cu cele experimentale. Pe cale experimentală se determină curbele de uscare, care indică variația umidității şi temperaturii materialului în timp, precum şi a vitezei de uscare, obținânduse curbe de tipul celor prezentate în *Fig. 3.*

Variația masei probelor supuse experimentelor permit determinarea umidității medii Wj la momentul τ_j:

$$W_j = \frac{m_{aj}}{m_{usc}} \quad (7)$$

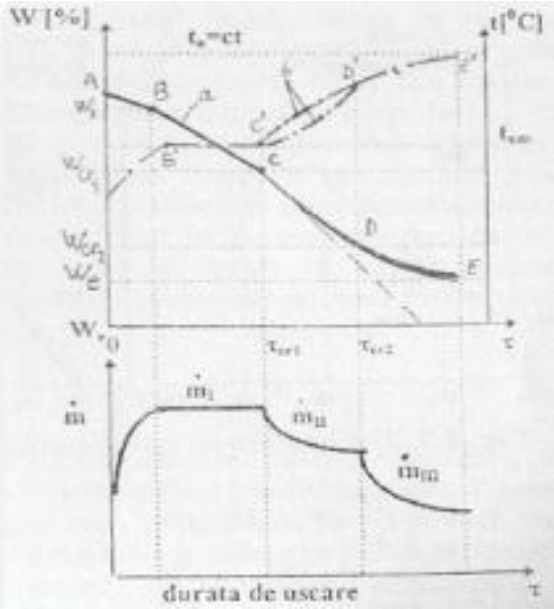

Fig.3 - Drying curves

where: m_{aj} is the mass of water from material at the time τ_j in kg.

In the initial period, A-B, relatively short, the heat received by the material it is used for the heating thereof also the internal water, little decreasing humidity. B-C portion is a straight line also corresponds to the first phase of drying (constant speed drying); material temperature remains constant and it is approximately equal to the wet thermometer temperature. Point C is the first critical point and highlights the firs reaching critical humidity. On the C-D section drying speed begins to decrease and increase the temperature of the material.

In D point the second critical point is reached and starts the third stage of drying.

Speed of drying will be be reduced further, temperature of material tending to temperature of the drying agent. For nonhygroscopic and porous materials, and for some hygroscopic material, the third phase of the drying does not exist.

When the material reaches equilibrium moisture content, drying speed is equal to 0, and the process is stopped. Drying curves can be used to determine the rate of drying, which indicates the variation speed of the drying with humidity:

unde: m_{aj} este masa de apă din material la momentul τ_j, în kg.

În perioada inițială A-B, relativ scurtă, căldura primită de material este utilizată pentru încălzirea acestuia şi a apei din interior, umiditatea scăzând puțin. Porțiunea B-C este o linie dreaptă şi corespunde primei faze a uscării (uscare cu viteză constantă); temperatura materialului rămâne constantă şi este aproximativ egală cu temperatura termometrului umed. Punctul C este primul punct critic şi pune în evidență atingerea primei umidități critice. Pe porțiunea C-D viteza de uscare începe să scadă şi temperatura materialului creşte.

În punctul D se atinge al doilea punct critic şi începe faza a treia a uscării.

Viteza de uscare se reduce şi mai mult, temperatura materialului tinzând către temperatura agentului de uscare. Pentru materialele nehigroscopice şi cele poroase, precum şi pentru unele materiale higroscopice, faza a treia a uscării nu există.

Când materialul atinge umiditatea de echilibru, viteza de uscare devine egală cu 0 şi procesul încetează.

Curbele de uscare pot fi utilizate pentru determinarea vitezei de uscare, care indică variația vitezei de uscare cu umiditatea:

$$m_j = \frac{1}{S}\frac{dm_{aj}}{d\tau} \simeq \frac{m_{usc}}{S\,100}\frac{\Delta W}{\Delta\tau} \quad (8)$$

The sizes S and m_{usc} are known from measurements, and the values of W and T is determined from the drying curves. If drying speed curves have been established, these may be used to determine the duration of the drying process. So, the time required to reduce the humidity from W_1 to W_2 is given by:

Mărimile S şi m_{usc} sunt cunoscute din măsurători, iar valorile W şi T se determină din curbele de uscare. Dacă au fost stabilite curbele vitezelor de uscare, acestea pot fi utilizate pentru determinarea duratei procesului de uscare. Astfel, durata necesară pentru reducerea umidității de la W_1 la W_2 este dată de relația:

$$\tau = \frac{\rho_{usc}\delta^2}{100}\int_{W2}^{W1}\frac{dW}{m\delta} \quad (9)$$

where: δ is the thickness of the material in meters.

Knowing the speed drying curves can be drawn function f (W) = 1 / mδ, as can be seen from figure 4. The limited area of this curve and abscissa axis r epresents the size of the integral from relation (9). In the first phase of product $m_1\delta$ m1δ = constant drying and the drying time is obtained:

unde: δ este grosimea materialului în m.

Cunoscând curbele vitezelor de uscare se poate trasa funcția f(W)=1/mδ, după cum se poate observa în figura 4. Suprafața limitată de această curbă şi axa absciselor reprezintă mărimea integralei din relația (9) În prima fază a uscării produsul $m_1\delta$ = constant şi pentru durata de uscare se obține:

$$\tau_1 = \frac{\rho_{usc}\delta^2}{100\,m_{II}}(W_1 - W_{ct}) \quad (10)$$

In the second phase of the process is determined with relation 9.

În a doua fază a uscării durata procesului se determină cu relația 9.

An approximate method of determining the drying time is based on the drying coefficient k.

This parameter is determined by the drying rate curve and it is equal to the tangent of the angle of the line connecting critical moisture value with the final state (Fig. 4)

O metodă aproximativă de determinare a duratei de uscare se bazează pe coeficientul de uscare k.

Acest parametru se determină cu ajutorul curbei vitezei de uscare şi este egal cu tangenta unghiului format de dreapta care uneşte valoarea umidității critice cu starea finală (*Fig. 4.*)

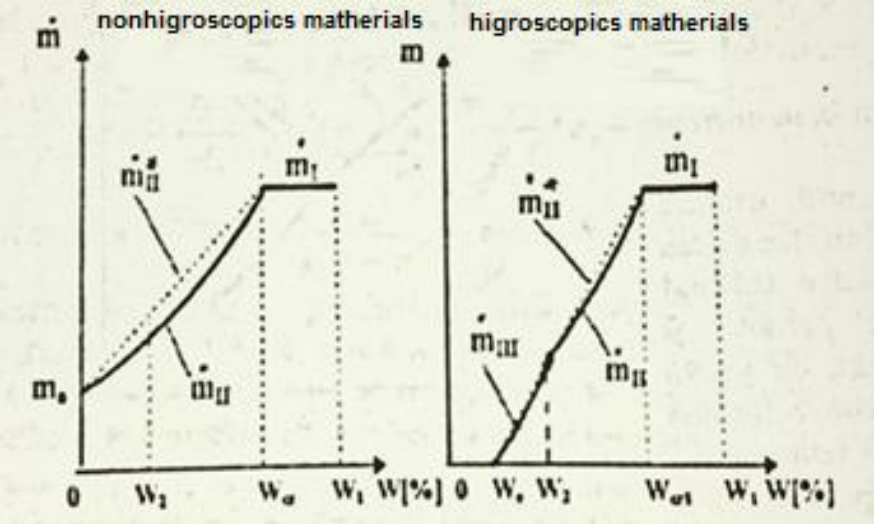

Fig. 4 - Determination of drying coefficient K

For nonhigroscopics materials the drying time, on stage, it is:

Pentru materialele nehigroscopice durata de uscare, pe faze, este:

$$\tau_I = \frac{\rho_{usc}\delta}{100}(W_1 - W_{cr}) \quad (11)$$

$$\tau_{II} = \frac{\rho_{usc}\delta}{100K} ln \frac{m_a + KW_{cr}}{m_a KW_2} \quad (12)$$

For higroscopics materials the drying time, on stage, it is:

Pentru materialele higroscopice durata de uscare, pe faze, este:

$$\tau_I = \frac{\rho_{usc}\delta}{100K} ln \frac{W_1 + W_{crI}}{W_{crI} - W_e} \quad (13)$$

$$\tau_{II} = \frac{\rho_{usc}\delta}{100K} ln \frac{W_{crI} - W_e}{W_2 - W_e} \quad (14)$$

CONCLUSIONS

Heat transfer is one of the most common energy exchanges, occurs naturally between two systems in contact directly or indirectly, characterized by different temperatures.

The most of wet bodies wich are subjected to drying have a complex system of large and small channels (pores), , where it is possible to move the moisture both in liquid form and also in vapor form. If the pores are partially filled with water at sufficiently small transversal sections, forces of attraction to material wall excess conection forces between liquid molecules and forming a convex mechanism that causes water drying in these capillary. In drying process t he evaporation of water is produced initially at the surface of the material and diffuse formed vapors into the ambient. Gradually, the evaporation zone, penetrate inside the material and formed vapors are forced to diffuse through dry material layer to the surface of the body and then from its surface to the ambient. The mechanism for transferring the moisture inside and from the body surface is a complex phenomenon which depends on many factors including: structure and material moisture, superficial tension and viscosity of water, temperature and relative humidity of the drying agent, etc.

In the process of drying, the heat and mass transfer is made through boundary layer, of molecular thickness, existing on the walls of the pores or on the surface of wet bodies, which separates the absorded water from its vapor. Molecules that are found in the boundary

CONCLUZII

Transferul de căldură, unul din cele mai comune schimburi energetice, intervine în mod natural între două sisteme aflate în contact direct sau indirect, caracterizate de temperaturi diferite.

Majoritatea corpurilor umede supuse uscării au un sistem complex de canale mari şi mici (pori), în care este posibilă mişcarea umidității, atât sub formă lichidă, cât şi sub formă de vapori. Dacă porii sunt parțial umpluți cu apă, la secțiuni transversale suficient de mici, forțele de atracție la peretele materialului depăşesc forțele de legătură dintre moleculele lichidului şi formează un mecanism convex care porvoacă uscarea apei în astfel de capilare. În procesul de uscare evaporarea apei se prodice inițial la suprafața materialului iar vaporii formați difuzează în mediul înconjurător. Treptat, zona de evaporare, patrunde în interiorul materialului şi vaporii formați sunt obligați să difuzeze prin stratul de material uscat până la suprafața corpului şi apoi de la suprafața acestuia în mediul înconjurător. Mecanismul transferului de umiditate în interiorul şi de la suprafața corpului este un fenomen complex care depinde de foarte mulşi factori printre care: structura şi umititatea materialului, tensiunea superficială şi vâscozitatea apei, temperatura şi umiditatea relativă a agentului de uscare etc.

În procesul de uscare, transferul de căldură şi masă se face prin stratul limită, de grosime moleculară, existent pe pereții porilor sau la suprafața corpurilor umede, care separă apa absorbită de vaporii săi. Moleculele care se găsesc în stratul limită de separație ale fazelor nu sunt

separation layer of the phases are not subjected to molecular actions with equal forces but is in the field of action of other forces. Phase boundary layer, which may have a few molecules thick, admits a permanent switch between phases and is found in a different state than it delimits homogeneous phases.

The most important aspects of the drying process are heat and mass transfer during drying and the simultaneity relationship between them, as well as the characteristic curves of the drying process or material contraction during the drying process.

acestuiaAcknowledgement

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supuse la acțiuni moleculare cu forțe egale ci se află în câmpul de acțiune al altor forțe. Stratul limită de fază, care poate avea o grosime de câteva molecule, admite o trecere permanentă între faze şi se găsşte întro altă stare decât fazele omogene care îl delimitează.

Cele mai importante aspecte ale procesului de uscare sunt transferul de masă şi de căldură în timpul uscării şi relația de simultaneitate dintre acestea, dar şi curbele caracteristice ale proceselor de uscare sau contracția materialelor în timpul procesului de uscare.

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EXPERIMENTAL RESEARCH ON PROCESS WORK OF FORAGE DISTRIBUTING MACHINE / *CERCETĂRI EXPERIMENTALE ASUPRA PROCESELOR DE LUCRU ALE MAŞINII DE DISTRIBUIT FURAJE*

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Abstract:
Within the technology for feeding cattle and sheep, the works of transport, loading, chopping, mixing and distributing forage contribute to the preservation of nutritional properties, eliminating losses and physical effort. Currently, for the mechanization of these works, technical equipment for chopping and distributing round straw and hay bales were built, mounted and driven from the agricultural tractor or frontal loaders, as well as complex machines from the constructive and functional point of view that perform multiple works within the technology. For the study of methods and means to achieve a high performance technology for the distribution of forage, two different machines were built and researched, capable to perform several activities within the technology for preparing and distributing forage to cattle. In this article are presented the results of experimental researches carried out at a livestock farm, on a lot of milk cows, in similar working conditions, emphasizing the technical performances, the structure of working times, the working capacity of machines, important indicators for obtaining high production and increasing work productivity

Keywords: *livestock, cattle, equipment for forage distribution*

Rezumat: *În tehnologia de furajare a bovinelor şi ovinelor lucrările de transport, încărcarea, tocarea, amestecarea, şi distribuirea furajelor contribuie la conservarea proprietăților nutritive, eliminarea pierderilor si a efortului fizic. In prezent, pentru mecanizarea acestor lucrări s-au realizat echipamente tehnice pentru tocat şi distribuit baloturi rotunde din paie si fân montate şi acționate de tractorul agricol sau încărcătoare frontale, precum şi maşini complexe din punct de vedere constructiv şi funcțional care efectuează mai multe lucrări din cadrul tehnologiei. Pentru studierea metodelor şi mijloacelor de realizarea a unei tehnologii performante de distribuire a furajelor s-au realizat şi cercetat doua maşini deosebite constructiv, capabile să execute mai multe activități din cadrul tehnologiei de pregătire şi distribuire a nutrețurilor la bovine. În cadrul acestui articol sunt prezentate rezultate ale cercetărilor experimentale desfăşurate la o fermă zootehnică, pe un lot de vaci de lapte şi în condiții asemănătoare de lucru, cu accent pe performanțele tehnice, structura timpilor de lucru, capacitatea de lucru a maşinilor, indicatori importanți pentru obținerea de producții ridicate şi creşterea productivității muncii.*

Cuvinte cheie: *zootehnie, bovine, maşini pentru distribuit furaje*

INTRODUCTION

Agricultural scientific research, by its research object - soil, plant, animal – aims to offer high quality biological products, raw material, technologies, appropriate knowledge that should contribute to promotion of sustainable agriculture and rural development, increase food security and safety according to general and specific requirements of the market.

For the economy, the agriculture can represent an opportunity, in recent years, being manifest trends of its diversification and consolidation, farming becoming more attractive to investors, [12; 13]. In Romania, almost all the species from animal farms are being breeding, assuring the whole variety of agro-food products of animal origin of natural and cultivated lawns, as well as the outstanding potential of cereal and fodder vegetable production can help to obtain important animal origin products for exportation, as “organic or ecological product”.

Cattle growing is a traditional activity in rural and especially mountain and hill area of Romania. Diversity of productions achieved, reduced energy consumption and type of fodder used make from cattle breeding a sustainable and perspective activity.

In 2011, the value of animal production represented 28% out of agricultural production amount (Eurostat), severely decreasing from 44%, as was registered in

INTRODUCERE

Cercetarea ştiințifică agricolă, prin natura obiectului de cercetare - sol, plantă, animal - are ca obiectiv să ofere produse biologice de înaltă valoare, materii prime, tehnologii, cunoştințe adecvate, care să contribuie la promovarea agriculturii durabile şi dezvoltării rurale, la creşterea securității alimentare şi a siguranței alimentului în concordanță cu cerințele generale şi specifice ale pieței.

Pentru economie, agricultura poate constitui o oportunitate, in ultimii ani manifestându-se tendințe de diversificare şi consolidare, devenind mai atractivă din punctul de vedere al investitorilor, [12; 13]. În România se cresc aproape toate speciile de animale de ferme, existând posibilitatea de asigurare a întregului sortiment de produse agroalimentare de origine animală. În acelaşi timp, întinsele suprafețe de pajişti naturale şi cultivate, ca şi potențialul deosebit în ceea ce priveşte producția de cereale şi leguminoase furajere, pot crea importante disponibilități de produse animale pentru export, obținute în condiții de „produs naturist” sau ecologic.

Creşterea bovinelor este o activitate tradiționala a populației din zona rurala şi în special din zona montana şi deluroasă. Diversitatea producțiilor pe care le realizează, consumul redus de energie si natura furajelor pe care le valorifica, conferă creşterii şi exploatării bovinelor caracterul unei activități durabile şi de perspectivă.

În 2011, valoarea producției animale a reprezentat 28% din valoarea producției agricole (Eurostat), în scădere drastică de la 44% cât se înregistra în 1998.

1998. Cattle population (approximately 2 millions of heads in 2012, used especially for milk production) is mainly concentrated in North and North-Eastern of Southern Plain.

Cattle food has a specific structure, being based on producing high quality forage in sufficient quantity able to ensure balanced ratios for animal daily necessity, especially volume forage (hay juicy fodder, green matter) and concentrated fodder. Ensiling represents on e of the three methods of current use of fodder plants in animal feeding, the other two being grazing and hay production [2, 5, 11].

Quality of food designed to animals must have an appropriate quality and be in suitable quantity with a nutritive value appropriate to physiological requirements of each breed, age or weight category, absence of contaminants, as important values of free access to food and water, depending on feeding, number of daily portions correlated to growing and maintenance system, [8]. The feeding technique is characteristic on categories of animals and ecological areas, depending on variety and quality of fodder produced, specialty and endowment level of respective units and even on area tradition [3, 4].

Fodder UNIC corresponds to method of feeding with balanced ratios made of several types of forages (fibrous, raw, root and concentrated) mixed in a technological trailer. Quality of UNIC fodder depends on components quality and mincing and mixing processes quality, for homogenizing it in machines storage hopper [1, 4].

In recent years, the modern technique has highly developed in this field, being manufactured mobile or fixed machines which perform several operations (dosing, mixing and distributing food to stables or paddock) [3, 5]

Working systems of foddering machines are known as tillage cutter which breaks and loads into the silage, rotor with blades or spires for mincing and mixing the forage, conveyor that distributes the fodder mixture to animals. For reducing the manpower and especially for obtaining high quality works, scientific studies and researches on this equipment working processes have been achieved [7].

MATERIAL AND METHOD

For studying the methods of achieving a state-of-the art technology for fodder distribution, within INMA, two variants of machines designed to prepare and distribute food to farm animals, were designed, manufactured and tested, namely: *Technological trailer for chopping, mixing and distributing the forage, RTF* (fig.1), *Fodder machine, MF8* (fig.2), having specific technical and functional characteristics each, determined by the constructive requirements of main technical equipment designed to loading, , chopping, mixing and distributing the fodder..

The technological sequences within the technology of distribution of fodder, which were analyzed, are the following:

- movement of tractor-machine aggregate to feeding points;
- dislodging from the store and loading into the body of fibrous forages;

Populația de bovine (aproximativ 2 milioane de capete în 2012, utilizate în special pentru producția de lapte) este concentrată în principal în partea de nord şi nord-est a câmpiei sudice.

Alimentația bovinelor are o structură specifică bazându-se pe producerea unor furaje de calitate superioara şi în cantități suficiente care să asigure rații echilibrate ce vor satisface cerințele zilnice ale animalului, se folosesc în principal furaje de volum (fân, suculente, masă verde) şi furaje concentrate. Însilozarea reprezintă una din cele trei metode de folosire curenta a plantelor furajere în nutriția animalelor, celelalte doua fiind păşunatul şi producerea fânului [2, 5, 11].

Calitatea hranei pentru animale presupune cantitate si calitate corespunzătoare, o valoare nutritiva la nivelul cerințelor fiziologice, specifice fiecărei specii, rase, categorii de vârsta sau greutate, absenta contaminanților, ca valori importante in accesul liber la hrana si apa, in funcție de tipul de hrănire, de numărul de tainuri zilnice corelat cu sistemul de creştere şi întreținere, [8]. Tehnica de alimentație este caracteristică pe categorii de animale şi pe zone ecologice, după sortimentul şi calitatea furajelor produse, după gradul de specializare şi de dotare al unităților şi chiar după tradiția zonală [3, 4].

Furajul UNIC corespunde modului de hrănire cu rații echilibrate alcătuite în principiu din câteva sortimente (fibroase, grosiere, rădăcinoase şi concentrate) amestecate într-o remorca tehnologica. Calitatea furajului UNIC depinde de calitatea componentelor şi de calitatea procesele de mărunțire şi amestecare, în vederea omogenizării, care au loc în buncărul maşinilor specializate [1, 4].

În ultimii ani, tehnica modernă a făcut progrese mari în acest domeniu, realizându-se maşini mobile sau fixe care efectuează mai multe lucrări: dozarea, tocarea, amestecarea şi distribuirea hranei în grajduri sau la padoc [3, 5]

Sistemele de lucru ale maşinilor de furajare care realizează aceste procese de lucru sunt cunoscute sub denumirea de freza de dislocare şi încărcare siloz, rotor cu palete sau spire pentru mărunțirea şi amestecarea nutrețurilor în bena maşinii, transportor de distribuire a amestecului de furaje la animale. Pentru reducerea forței de muncă şi mai ales pentru obținerea unor lucrări de calitate s-au realizat studii şi cercetări ştiințifice asupra proceselor de lucru specifice acestor echipamente tehnice [7].

MATERIAL ŞI METODĂ

Pentru studierea metodelor şi mijloacelor de realizarea a unei tehnologii performante de distribuire a furajelor, în cadrul INMA Bucureşti, au fost proiectate, executate şi încercate două variante de maşini pentru pregătirea şi distribuirea hranei la animale: *Remorca tehnologică pentru tocat, amestecat şi distribuit furaje, RTF* (fig.1), *Maşina de furajare, MF8* (fig.2), diferențiate de caracteristicile tehnice şi funcționale specifice fiecăreia, determinate de soluțiile constructive ale principalelor echipamente tehnice pentru încărcat, mărunțit, amestecat şi distribuit.

Secvențele tehnologice din cadrul tehnologiei de distribuire a furajelor care au fost analizate sunt următoarele:

- deplasarea agregatului tractor - maşina la punctele de alimentare cu componentele rețetei furajere;
- dislocarea din depozit şi încărcarea în benă a nutrețurilor fibroase;
- încărcarea din buncărul maşinii a nutrețurilor concentrate (cereale, şroturi, reziduuri de la industria de morărit);

- automated weighing or special platform of fodder weighed;
- chopping and homogenizing the fodder mixing;
- aggregate movement to distribution points;
- distribution of fodder to animals.

- dislocarea şi încărcarea de pe platformă a nutreţurilor însilozate;
- cântărirea automată sau la platformă specială a furajelor încărcate;
- mărunţirea şi omogenizarea amestecului furajer;
- deplasarea agregatului la punctele de distribuire;
- distribuirea furajului obţinut la animale.

Fig. 1 – Technological trailer for chopping, transporting and distributing the forage, RTF

Fig. 2 – Fodder machine, MF8

With *Technological trailer for chopping, mixing and distributing the forage, RTF*, that is simpler as construction, the technological processes of chopping and mixing the fodder loaded into the body, transport and distribution of fodder to animals, were performed; with *Fodder machine, MF8*, a real domestic kitchen, the technological processes of silage forage dislodging and loading, chopping and mixing of fodder ensilaged, straw or hay bales chopping, automated weighing of recipe fodder, homogenization and distribution of resulted fodder mixture, were performed.

The two machines were tested at a livestock farm for cattle growing from S.C. AGROINDUSTRIALA Pantelimon S.A.

Cu *Remorca tehnologică pentru tocat, amestecat şi distribuit furaje, RTF*, mai simplă constructiv s-au efectuat procesele tehnologice de tocare şi amestecare a sortimentelor de furaje încărcate în benă, transportarea si distribuirea furajului obţinut la animale, iar cu *Maşina de furajare, MF8*, o adevărată bucătărie furajeră, s-au efectuat procesele de tehnologice de dislocare şi încărcare siloz, mărunţirea şi amestecarea nutreţului însilozat, tocarea baloturilor din paie sau fân, cântărirea automată a furajelor din reţetă, omogenizarea şi distribuirea amestecului furajer rezultat.

Cele două maşini au fost testate la ferma zootehnică pentru creşterea bovinelor de la S.C. AGROINDUSTRIALA Pantelimon S.A.

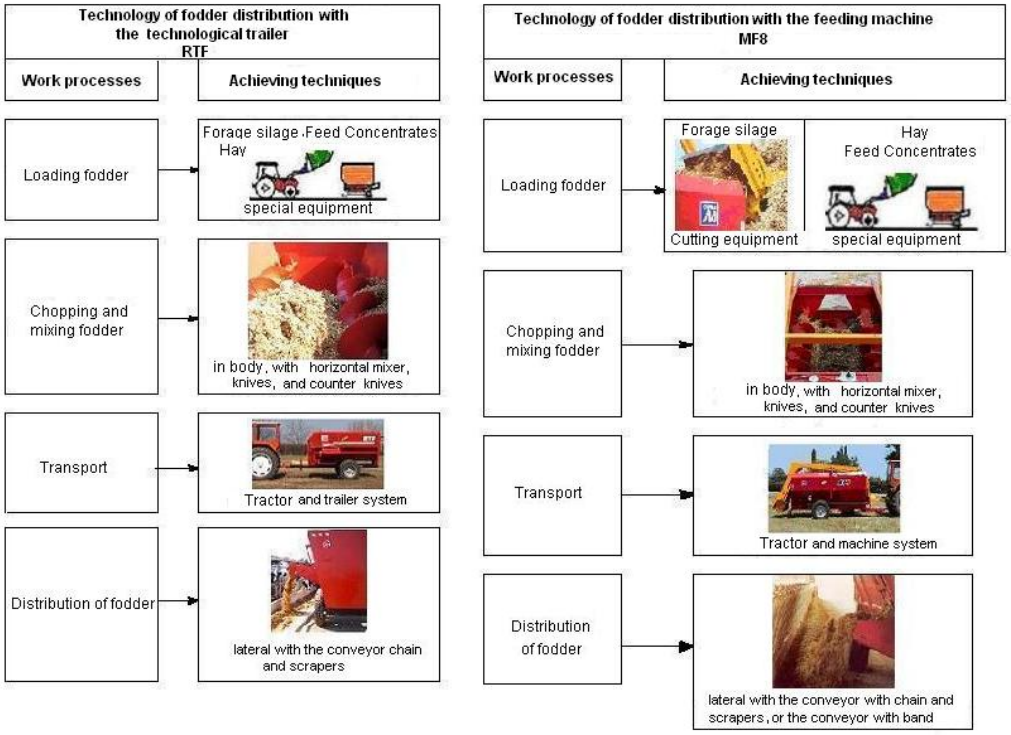

Fig.3 – Scheme of foraging technology with achieving variants according to equipment used

In figure 3, are shown the technological variants achieved by the two types of technical equipment, emphasizing the working processes and methods of achieving them.

Within the technology of preparing and distributing the fodder to cattle, measurements for determining the working parameters of equipment loaded, were achieved, namely: moments, distribution height, time and qualitative working and exploitation indexes. [7].

The tests were made with wheeled tractor U 650, suitably equipped with lower traction coupler and system of taking over the vertical loads, independent PTO with rotating speed of n=540 rev/min; storage battery 12 V; 12/150 Ah, tensiometer plug with moment transducer HBMT4Wa-S3, centrifugal tachometer (40…48000 rev/min, mechanical chronometer, weighing lever 250 - 10000 kg and other specific measuring instruments.

In the machine body were loaded especially the ensiled material and different proportions of hay and straw bales, according to recipe established by the specialist.

Corn silage loading was made in a silage cell where the material density per worked surface has varied from upper to lower part ranging between: 520…756 kg/m^3.

Material ensilaged was dislodged and loaded with fodder machine cutter MF8, and in technological trailer RTF with special equipment of IFRON type.

Power, *P*, necessary for driving each working equipment was calculated with relation (1), [9,10]:

În figura 3, sunt prezentate variantele tehnologice realizate cu cele două tipuri de echipamente tehnice, cu evidențierea proceselor de lucru şi modului în care au fost realizate.

În cadrul tehnologiei pentru prepararea şi distribuirea nutrețurilor la bovine, realizată cu maşinile studiate, s-au efectuat măsurători pentru determinarea parametrilor de lucru în sarcină ai echipamentelor cercetate: momente, înălțimi de distribuție, timpi şi indicii calitativi de lucru precum şi indici de exploatare. [7].

Pentru realizarea experimentărilor s-a lucrat în sistem cu tractorul U 650 pe roți, echipat corespunzător cu cuplă inferioară de tracțiune şi preluarea de sarcini verticale, priză de putere independenta cu turația de n=540 rot/min; baterie de acumulatoare 12 V; 12/150 Ah, priza tensometrică cu traductor de moment HBMT4Wa-S3, tahometru centrifugal (40…48000 rot/min, cronometru mecanic, basculă 250 - 10000 kg şi alte instrumente de măsură specifice.

În bena maşinilor au fost încărcate în special material însilozat şi baloturi din paie şi fan în proporții diferite în funcție de rețeta stabilită de specialist.

Încărcarea cu siloz de porumb s-a efectuat dintr-o celulă de siloz în care densitate materialului, la suprafața lucrată, a variat de la partea superioara spre baza în intervalul: 520…756 kg/m^3 .

Materialul însilozat a fost dislocat şi încărcat cu echipamentul freză la maşina de furajare MF8, iar în remorca tehnologică RTF cu echipamente speciale tip IFRON.

Puterea, *P*, necesară pentru acționarea fiecărui echipament de lucru s-a calculat cu relația (1), [9,10]:

$$P = \frac{M \cdot n}{9550} \quad \text{[kW]} \qquad (1)$$

where: M – moment measured [Nm]
n – rotating speed [rev/min]

Aggregate moving to loading or distribution points has been done with constant speed in a horizontal road and that is why the traction force and traction power are calculated with relations (2).

unde: M – moment măsurat [Nm]
n – turația [rot/min]

Deplasarea agregatului la punctele de încărcare sau distribuire s-a efectuat cu viteză constanta şi pe drum orizontal, în acest caz forța de tracțiune şi puterea de tracțiune se calculează cu relațiile (2).

$$F_t = f \cdot Q \quad \text{[N]} \qquad (2)$$

$$P = \frac{F_t \cdot v_l}{1000} \quad \text{[kW]}$$

where:
F_t - traction force in towing point, N;
f – coefficient of resistance to running;
f = 0.018…0.020, on worn asphalt or concrete road [10];
Q – weight of machine including the load, N;
V_l – rate of travel, m/s.

Performing the operations with mechanized methods greatly contributes to increasing work productivity, due to the quality of work.

Working capacity of aggregate, *W*, represents the average volume of suitable quality operations, *U*, achieved in time unit T_i according to relation (3).

Structure of working time represents the group of elements belonging to a shift time, being calculated with relation (4) [9].

unde:
F_t - forța de tracțiune în punctul de remorcare, N
f – coeficientul de rezistență la rulare;
f = 0,018…0,020, pe drum de asfalt sau beton uzat [10];
Q – greutatea maşinii cu încărcătura, N;
V_l – viteza de deplasare, m/s.

Executarea lucrărilor cu mijloace mecanizate contribuie, în mare măsură, la mărirea productivității muncii , deoarece acestea pot fi executate în termeni optimi şi de calitate.

Capacitatea de lucru a agregatului, *W*, reprezintă volumul mediu de lucrări, *U*, de o calitate corespunzătoare cerințelor impuse, realizată în unitatea de timp T_i conform relația (3).

Structura timpului de lucru reprezintă gruparea elementelor timpului unui schimb, calculându-se cu relația (4) [9].

$$W = \frac{60 \cdot U}{T_i} \quad \text{[UM/h]} \qquad (3)$$

$$
\begin{aligned}
T_{02} &= T_1 + T_2 \\
T_{03} &= T_{02} + T_3 \\
T_{04} &= T_{03} + T_4 \qquad \text{[min]} \qquad (4) \\
T_{07} &= T_{04} + T_5 + T_6 + T_7 \\
T_{08} &= T_{07} + T_8
\end{aligned}
$$

where:

T_1 – working time; T_2 – additional time, T_3 – time designed to technical service of the machine; T_4 – time for remediation of technological failures, T_5 – time for personal rest; T_6 – time for changing the workplaces; T_7 – time for technical maintenance, T_8 – total working time.

Knowing the structure of time , the coefficients of time utilization are calculated, as well as the exploitation indexes characterizing the working time and contribute to estimation of technological and technical deficiencies.

în care:

T_1 – timp efectiv de lucru; T_2 – timp ajutător; T_3 – timp pentru deservirea tehnica a maşinii; T_4 – timp pentru remedierea deficienţelor tehnologice, T_5 – timp pentru repaus personal; T_6 – timp pentru schimbarea locului de munca; T_7 – timp pentru întreţineri tehnice, T_8 – timpul total de lucru.

Cunoscând structura bilanţului timpului se stabilesc prin calcule coeficienţii de folosire a timpului, indici de exploatare ce caracterizează parcursul timpului de lucru şi contribuie la aprecierea deficienţelor tehnologice şi tehnice ale maşinilor încercat.

RESULTS

Within the tests, measurements were made for determining the dimensional characteristics shown in table 1.

During the basis operations of the technology one or several main assemblies will be put in function, depending on variant of machine used; when measuring the moments and analyze the power consumption one will take into account all these.

REZULTATE

În cadrul încercărilor s-au făcut măsurători pentru determinarea caracteristicilor dimensionale, prezentate în tabelul 1.

În timpul desfăşurării operaţiilor de bază ale tehnologiei vor fi în funcţiune unul sau mai multe ansambluri principale, în funcţie de varianta de maşină utilizată, de acest lucru se va ţine seama la măsurarea momentelor şi la analiza consumului de putere.

Table1

Main technical characteristics of tested equipment

Technical characteristics	MU	Technical equipment	
		Tecnological trailer for chopping, transporting and distributing fodder RTF	Fodder machine MF 8
Category		Machine for works	Machine for works
Type		uniaxial	uniaxial
Overall dimensions: - length - width - height	 mm mm mm	 4280 2860÷2550 2275	 6250 2350 2445
Distribution height	mm	600 ÷1340 (depending on conveyor type)	400÷630 (adjustable working position)
Wheel track	mm	1600	1800
Useful volume	m^3	3.5	8
Own mass	kg	2000	3650
Loading equipment	-	-	Cutter type
Type of distrbuting conveyor	-	With chain and blades	With chain and blades
Working speed	km/h	2÷4	2÷4

In table 2 were comparatively identified the assemblies which participate in performing the working processes appropriate to technology of foraging.

During forage loading into the machine body, the mixing worms are permanently operating, being driven from tractor's PTO through the mechanical transmission; at the same time, if the body is loaded with fodder and moves to the distribution points, the worms will be driven for chopping and mixing in order to homogenize the matter.

In table 3 are given the average values of rotating speed and moments measured at the main axle driving the working parts for loading, mincing, mixing and distributing the fodder.

În tabelul 2 s-a realizat, comparativ, identificarea ansamblurilor care participă la realizarea proceselor de lucru specifice tehnologiei de distribuit furaje.

În timpul procesului de încărcare a furajelor în benă, melcii amestecători funcţionează continuu acţionaţi de la priza de putere a tractorului prin intermediul transmisiei mecanice din dotarea maşinilor, de asemenea, dacă bena este încărcată cu furaje si se deplasează către punctele unde vor fi distribuite, melcii vor fi acţionaţi pentru mărunţirea şi amestecarea încărcăturii în vederea omogenizării.

În tabelul 3 sunt prezentate valorile medii ale turaţiilor şi momentelor măsurate la axul principal de antrenare al organelor de lucru pentru încărcarea, mărunţirea, amestecarea şi distribuirea furajelor.

Table 2

Table of consumers of power developed by tractor from the PTO

Working process	Operating assemblies				
	Technological trailer, RTF		Fodder machine, MF8		
	Mixing worms	Conveyor	Mixing worms	Cutter	Conveyor
Motion of unloaded machine	-	-	-	-	-
Loading of fibrous ensilaged fodder	X	-	X	X	-
Loading of concentrated or other types of forage	X	-	X	-	-
Movement to points of fodder feeding	X	-	X	-	-
Chopping, mixing and travel to distribution points	X	-	X	-	-
Distribution of forage mixture	X	X	X	-	X

PTO's rotating speed when the machine is unloaded has had values ranging within 500…540 rev/min

Turația în gol la priza de putere a tractorului a avut valori în intervalul 500…540 rot/min.

Table 3

Determinations per different working stages

Working process	Technological trailer - RTF			Fodder machine - MF 8		
	Operating assemblies	Moment [N m]	Power necessary [KW]	Operating assemblies	Moment [N m]	Power necessary [KW]
Silage fodder loading	Mixing worms	200…230	11.31…13.1	Worms and cutter	330…400	18.7…22.6
Other fodder loading according to recipe	Mixing worms	200…250	11.31…14.2	Mixing worms	300…350	17…19.8
Blending and grinding	Mixing worms	220…280	12.5…15.8	Mixing worms	320…390	18…21.5
Fodder distribution	Mixing worms and conveyor	260…290	14.70…16.4	Mixing worms and conveyor	340…400	19.2…22.6

Power necessary to drive the working systems for the main working processes within the technology studied, were calculated with relation (1), where the rotating speed n= 540 rev/min (according to Tractor technical book), results being synthesized in table 4.

In order to test the machine operation and determine their functional characteristics, different types of silage fodder were loaded in machines body: silage corn, hay and straw bales, fodder combined in different proportions according to recipe.

Fodder matter loaded in machine body during works:

- technological trailer, RTF, m=1000 kg
- fodder machine, MF 8, m=2000 kg

For f=0.02, the working speed v=2…4 km/h and fodder mass loaded, the following values for traction force and power necessary to traction, were registered:

- technological trailer RTF, F_t=600N; P_t=0.36…0.66 kW
- fodder machine, MF 8 , F_t = 1130N, P_t=0.63…1.25 kW.

Wheeled tractor U 650 with which tests were performed, is an average power tractor, equipped with Diesel engine of 47.8 kW (65 HP) at 1800 rev/min.

In table 4 are shown the values for power stock in different stages of technology, calculated for the working speed v = 4km/h.

Within the technology for preparing and distributing fodder to cattle, performed with the machine studied, besides the functional characteristics were determined also the working time, working capacity and the results obtained were analyzed and a series of exploitation indexes shown in testing reports according [9], were established.

Puterea necesară pentru acționarea sistemelor de lucru pentru principalele procese de lucru din cadrul tehnologiei studiate s-a calculat cu relația (1), unde turația n= 540 rot/min (conform Carte tehnică a tractorului), rezultatele fiind sintetizate în tabelul 4.

Pentru testarea funcționalității şi determinarea caracteristicilor funcționale ale maşinilor s-a încărcat în bena maşinilor furaje diverse: siloz de porumb, baloturi din paie şi fân, nutrețuri combinate în proporții diferite în funcție de rețeta.

Masa de furaj încărcată în bene în timpul încercărilor:

-remorca tehnologica, RTF, m=1000 kg
-maşina de furajare, MF 8, m=2000 kg

Pentru f=0.02, viteza de lucru v=2…4 km/h şi masa de furaj încărcată s-au înregistrează următoarele valori pentru forța de tracțiune şi puterea necesară la tracțiune:

-remorca tehnologică RTF, F_t=600N; P_t=0,36…0,66 kW
-maşina de furajare, MF 8 , F_t = 1130N, P_t=0,63…1,25 kW.

Tractorul U 650 pe roți cu care s-au realizat experimentările este un tractor de putere mijlocie, echipat cu motor Diesel de 47.8 kW (65 CP) la 1800 rot/min.

În tabelul 4 sunt prezentate valorile pentru rezerva de putere a tractorului în diferite faze ale tehnologiei, calculata pentru viteza de lucru v = 4km/h.

În cadrul tehnologiei pentru prepararea şi distribuirea nutrețurilor la bovine, realizată cu maşinile studiate, s-au determinat pe lângă caracteristicile funcționale, timpii de lucru, capacitatea de lucru, iar rezultatele obținute au fost analizate şi s-au stabilit o serie de indici de exploatare prezentați în rapoartele de încercări conform [9].

Table 4

Power consumption during different working stages

Operation	Technological trailer - RTF		Forage machine - MF 8	
	Max. power consumed [KW]	Power stock [KW]	Power necessary [KW]	Power stock [KW]
Silage forage loading (stationary)	13.1	34.7	22.6	25.2
Other fodder loading according to recipe (stationary)	14.2	33.6	19.8	28
Mixing and grinding (stationary)	15.8	32	21.5	26.3
Mixing, grinding and travel to distribution point	16.46	31.34	22.75	25.05
Forage distribution	17.1	30.7	23.85	23.95

Structure of working time was estimated when the forage was distributed to 100 milk cows, and the feeding portion was of 35...40 kg/zi [5,7,9].

Structura timpului de lucru s-a apreciat în condițiile în care furajul obținut a fost distribuit la un lot format din 100 vaci pentru lapte, iar tainul a fost apreciat la 35...40 kg/zi [5, 7, 9].

Table 5

Structure of working time

Parameter	Symbol	Technological trailer, RTF	Fodder machine, MF 8
		Values measured	Values measured
Working hours for one charge [min	T_1	36	28.5
Number of charges per day [min]	N_S	4	4
Additional time (unloaded machine movement) [min]	T_2	5	3
Time for machine technical service (preparation of working machine) [min]	T_3	5	5
Time for remedying the deficiencies {min]	T_4	6	4
Operating time [min]	T_{02}	41	31,5
Total operating time, [min]	T_{03}	46	36,5
Time of production [min]	T_{04}	52	40,5
Working hours per day [min]	$T_{zi} = N_S \times T1$	144	57
Total working time (one day) [min]	$T_{08}=N_S \times T_{04}$	208	114
Hourly working capacity appropriate to one charge production time [kg/h]	W_{04}	1154	2963
Coefficient of utilization of operating time for one charge	K_{04}	0.69	0.70
Coefficient of safety operation	$k_4 = \frac{T_1}{T_1 + T_4}$	0.86	0.88

CONCLUSIONS

- the both machines differ from constructive point of view, which resulted in specific characteristics for each of them, according to table 1, as well as different involvement in achieving technological sequences within the technology;
- after the analysis of moments measured and power driving the working parts, the following have been found:
- at technological trailer RTF, loaded with 1000 kg forage, the max. necessary power is of 16.46 kW suitable to transport and distribution processes (the mixing worms operate simultaneously with chain and rake conveyor);
- at fodder machine MF8, loaded with 2000 kg of forage, the maximum necessary power is of 23.85 kW corresponding to forage transport and distribution the (mixing worms operate simultaneously with chain and rake conveyor);
- at the fodder machine MF8, loaded with 2000 kg of forage, the maximum power necessary is of 23.85 kW corresponding to transport and distribution processes (mixing worms operate simultaneously with chain and rake conveyor).
- for both variants of machines, a power stock has remained during operations performing;

CONCLUZII

- cele două maşini sunt diferite din punct de vedere constructiv ceea ce a determinat obținerea unor caracteristici tehnice specifice fiecăreia, conform Tabel 1 cât şi implicarea diferită în realizarea secvențelor tehnologice din cadrul tehnologiei;
- din analiza momentelor măsurate şi a puterii necesare pentru acționarea organelor de lucru s-au constat următoarele:
- la remorca tehnologică RTF, încărcată cu 1000 kg de furaje puterea necesară max. este 16.46 kW corespunzătoare proceselor de transport şi distribuire (funcționează simultan melcii amestecători şi transportorul cu lanț şi raclete);
- la maşina de furajare MF8, încărcată cu 2000kg de furaje puterea necesară maximă este de 23.85 kW corespunzătoare proceselor de transport şi distribuire furaje (funcționează simultan melcii amestecători şi transportorul cu lanț şi raclete).
- pentru ambele variante de maşini în timpul efectuării operațiilor de lucru rămâne rezervă de putere;
- dotarea maşinii de furajare, MF 8, cu echipament propriu de dislocare şi încărcare siloz şi instalație proprie de cântărire a determinat obținerea unor timpii de încărcare şi de deplasare mai mici, rezultând o valoare

- endowment of fodder machine, MF 8 with own dislodging and loading equipment and weighing installation has led to obtaining smaller time of loading and movement, thus, resulting smaller working hours: T1=28.5min for the machine MF8, instead of T1=36min for trailer RTF, influencing also the other components of time structure and hourly working capacity.

- operation safety coefficient, K_4, calculated for the two variants of machines are very close.

- utilization of fodder machine, MF8, has been more advantageous than the technological trailer, RTF, because it performs with its own equipment the silage forage dislodging and loading in its own body.

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mai mică pentru timpul efectiv de lucru: T1=28.5min pentru maşina MF8, faţă de T1=36min pentru remorca RTF, influenţând în acest sens şi celelalte componente ale structurii timpului de lucru şi capacitatea de lucru orară

- coeficientului de siguranţă în exploatare, K_4 , calculat pentru cele două variante de maşini sunt apropiaţi ca valoare.

- utilizarea maşinii de furajare, MF8, aduce avantaje faţă de remorca tehnologică, RTF, deoarece realizează mecanizat, cu echipament propriu, lucrările de dislocare şi încărcare siloz în bena proprie.

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RESEARCH CONCERNING THE DEVELOPMENT OF FERTIGATION INNOVATIVE EQUIPMENT
/
CERCETĂRI PRIVIND DEZVOLTAREA UNOR ECHIPAMENTE INOVATIVE DE FERTIRIGAȚIE

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Abstract: *The paper shows the contribution of the research team to the fertigation equipment field, as following:*
- For the design and implementation of the proposed equipment there have been used technical solutions which are innovative and original for fertigation field and targeted especially the injection device; it was of type double pump with diaphragms, with hydraulic drive (switch of sliding valve of distributor is done hydraulically);
- Injection device uses as a working (drive) fluid irrigation water, taken from the same pipeline in which primary solution is injected, that combined with irrigation water forms the fertilizing solution. Compared to the diaphragm pumps common on the market, manufactured by prestigious companies in the field, the injectors developed do not require electricity or compressed air, which gives them operating autonomy at any point of the arrangement for irrigation;
- Injection pressure has been achieved on the principle of difference between the active surfaces of drive chambers and those of injection chambers, and it can be determined very precisely, depending on the hydraulic parameters of irrigation facility with which the fertigation equipment operates in an aggregate, even since the stage of designing the device. Primary substance flow can be adjusted within a very wide range, by changing the feed rate of the drive chambers, modifying frequency of the pump central shaft (joint with membranes that separate drive chambers from injection chambers).

Keywords: *fertigation equipment, injection device, primary substance, fertilizer*

Rezumat: *Lucrarea prezintă contribuția proprie a echipei de cercetare în domeniul echipamentelor de fertirigație prin următoarele:*
- în conceperea și realizarea echipamentului propus au fost utilizate soluții tehnice inovative și originale pentru domeniul fertirigației, care au vizat în special dispozitivul de injecție; acesta a fost de tipul pompă dublă cu membrane, cu comandă hidraulică (comutația sertarului distribuitorului se realizează hidraulic);
- dispozitivul de injecție utilizează ca fluid de lucru (motor) apa de irigat, prelevată din aceeași conductă în care se injectează soluția primară, care în combinație cu apa de irigat formează soluția fertilizantă. Comparativ cu pompele cu membrane întâlnite pe piață, produse de firme de prestigiu în domeniu, injectoarele realizate nu necesită energie electrică sau aer comprimat, ceea ce le asigură autonomie de funcționare în orice punct al amenajării pentru irigații;
- presiunea de injecție s-a realizat pe principiul diferenței între suprafețele active ale camerelor motoare şi camerelor de injecție, putând fi stabilită foarte precis, în funcție de parametrii hidraulici ai instalației de irigat cu care echipamentul de fertirigație lucrează în agregat, din faza de proiectare a dispozitivului. Debitul de substanță primară se poate regla în limite foarte largi, prin modificarea debitului de alimentare a camerelor motoare, modificând frecvența axului central al pompei (solidar cu membranele care delimitează camerele motoare şi de injecție).

Cuvinte cheie: *echipament de fertirigație, dispozitiv de injecție, substanță primară, fertilizant*

INTRODUCTION

Under the project PN-2-PT-PCCA-2013-4-0114, contract no. 158, there has been designed a fertigation pump meeting the conditions imposed by an irrigation facility for orchards. To determine parameters necessary for fertigation pump design there have been used data provided by ICDP- Pitesti Maracineni. Here the specialists try to apply the most modern methods of cultivation of fruit trees. In the Institute good results have been obtained with drip irrigation systems and with micro sprinklers due to high efficiency in applying irrigation water.

Figure 1 shows irrigation of trees by using the micro sprinkler system. The two micro sprinklers which are near the tree form two irrigated areas (bulbs) comprising the root area.

In current practice of the Institute there are applied fertigation technologies by Venturi tube method or mixing vessel method.

INTRODUCERE

In cadrul proiectului PN-2-PT-PCCA-2013-4-0114, contract 158, a fost concepută o pompa de fertirigații care să corespundă condițiilor impuse de instalațiile de irigare din plantațiile pomicole. Pentru determinarea parametrilor necesari proiectării pompei de fertirigație au fost folosite date furnizate de ICDP- Pitești Mărăcineni. Aici se încearcă cele mai noi metode de cultivarea a pomilor fructiferi. În cadrul Institutului au fost obținute rezultate bune la sistemele de irigare prin picurare şi microaspersiune datorită eficienței ridicate în aplicarea apei de udare.

În Fig. 1 se prezintă irigarea pomilor utilizând sistemul cu microaspersoare. Cele două microaspersoare care sunt în apropierea pomului formează două zone (bulbi) irigate ce cuprind zona radiculară.

În practica Institutului se aplică tehnologii de fertirigare prin metoda tubului Venturi sau metoda vasului de amestec.

Fig. 1 – Irrigation by micro sprinkling of apple tree species

MATERIAL AND METHOD

To develop a volumetric system for injection of fertilizers, which would introduce a control of the system raising quality of fertilizing operation, data have been collected from systems watering plots with different varieties of fruit trees.

Example of characteristic data of irrigation systems from a plot of ICDP Maracineni [4]:

Plot 2: Apple tree, sensitive varieties

- Pipeline supplying water to plot = Ø 100 mm
- Pipeline connecting the fertigation pump to the irrigation facility = Ø 60 mm
- Irrigation hoses along rows of trees = Ø 16 mm
- Distance between drippers along irrigation hoses = 50 cm
- Flow rate of drippers = 2 l/h
- Length of rows of trees (length of irrigation hoses) = 160 m
- No. of hoses (of rows) = 45
- Dose of mixture (fertilizing solution) is 100 -150 l
- Time of administering = 60 -120 min, or even less.

In developing the injection pump there have been taken into account conditions imposed on fertilizers used in fertigation [2]:

- chemical fertilizers must have good solubility in water;
- fertilizers containing insoluble components (such as calcium carbonate) quickly clog filters and their use is not recommended;
- fertilizing solution must be neutral or acidic, never alkaline;
- one must know that ammonia (alkaline) will cause an increase in pH of water, and by combining itself with calcium in the water it will form calcium carbonate, that accumulates in the sections through which water passes towards the irrigation facility;
- it is recommended to use phosphates with caution because sedimentation of tricalcium phosphate will block the ports of the installations;
- one can use mono-ammonia phosphate fertilizers, in lime-containing water, which has been acidified till obtaining a value of pH equal to 6;
- all products correcting deficiencies (faults related

MATERIAL ŞI METODĂ

Pentru realizarea unui sistem de injectare volumetric a fertilizanților, care ar introduce un control asupra sistemului ridicând calitatea operației de fertilizare, au fost prelevate date de pe sistemele de udare a parcelelor cu diferite soiuri de pomi fructiferi.

Exemplu de date caracteristice ale sistemelor de irigații de pe o parcela de la ICDP Mărăcineni [4]:

Parcela 2: Măr, soiuri sensibile

- Conducta de aducțiune a apei în parcelă = Ø 100 mm
- Conducta de branşare a pompei de fertirigare = Ø 60 mm
- Furtunuri de irigare pe rândurile de pomi = Ø 16 mm
- Distanța între picuratoare pe furtunurile de udare = 50 cm
- Debitul picurătoarelor = 2 l/h
- Lungimea rândurilor de pomi (a furtunelor de udare) = 160 m
- Nr. de furtunuri (rânduri) = 45
- Doza de amestec (soluție fertilizantă) este de 100 -150 l
- Timp de administrare = 60 -120 min sau chiar mai putin.

În realizarea pompei de injecție s-a tinut seama de condițiile impuse îngrăşămintelor chimice folosite în fertirigare [2]:

- îngrăşămintele chimice trebuie să aibă o bună solubilitate în apă;
- îngrăşămintele care conțin elemente insolubile (cum ar fi carbonatul de calciu) înfundă rapid filtrele şi nu se recomandă utilizarea lor;
- soluția fertilizantă trebuie să fie neutră sau acidă şi niciodată bazică;
- trebuie să se ştie că amoniacul (bazic) va provoca o creştere a pH-ului în apă, iar prin combinarea cu calciul din apă va forma carbonatul de calciu, carbonat care se depune în secțiunile de trecere ale apei în instalația de irigat;
- se recomandă să se utilizeze cu prudență fosfații pentru că depunerile de fosfat tricalcic vor obtura orificiile instalațiilor;
- se pot utiliza îngrăşăminte cu fosfați mono-amoniacali, în apa ce conține calcar, care a fost acidificată până la obținerea unei valori a pH-ului de 6;
- toate produsele corectoare de carențe (defecte

to hematicide and adsorption), after a couple of applications, should be used with caution before injection into the irrigation facility;
- the following types of fertilizers are not recommended for use in the process of fertigation: calcium nitrate, diluted ammonia, potassium calcium nitrate, powdered potassium chloride, potassium sulfate, superphosphate, zinc sulphate and nitrate and ferric sulphate;
- ammonium sulphate cannot be used in water with a calcium content greater than 70 mg/l;
- crystalline potassium chloride requires additional filtration;
- for fertilizers with or without microelements concentration should be up to 1 %, and water temperature should not exceed 50 °C;
- fertilizers of the type liquid ammonium nitrate, urea, liquid or crystalline potassium nitrate, liquid potassium chloride and nitrogen- potassium based fertilizers without phosphate, with or without microelements require no special measures;

hematicidice şi deserbante), după câteva utilizări, trebuie să fie utilizate cu precauție înaintea injecției în instalația de udare;
- nu se recomandă utilizarea următoarelor tipuri de îngrăşăminte în procesul de fertirigație: nitrat de calciu, amoniac diluat, nitrat potasic de calciu, clorură de potasiu pudră, sulfat de potasiu, superfosfat, sulfat şi nitrat de zinc şi sulfat de fier;
- sulfatul de amoniu nu poate fi utilizat în apa cu un conținut de calciu mai mare de 70 mg/l;
- clorura de potasiu cristalizată necesită o filtrare suplimentară;
- pentru îngrăşămintele cu sau fară microelemente concentrația trebuie să fie de până la 1 %, iar temperatura apei să nu depăşească 50 °C;
- îngrăşămintele de tipul amonitratul lichid, ureea, nitratul de potasiu lichid sau cristalizat, clorura de potasiu lichidă şi îngrăşămintele pe bază de azot-potasiu fară fosfat, cu sau fară microelemente nu reclamă măsuri speciale;

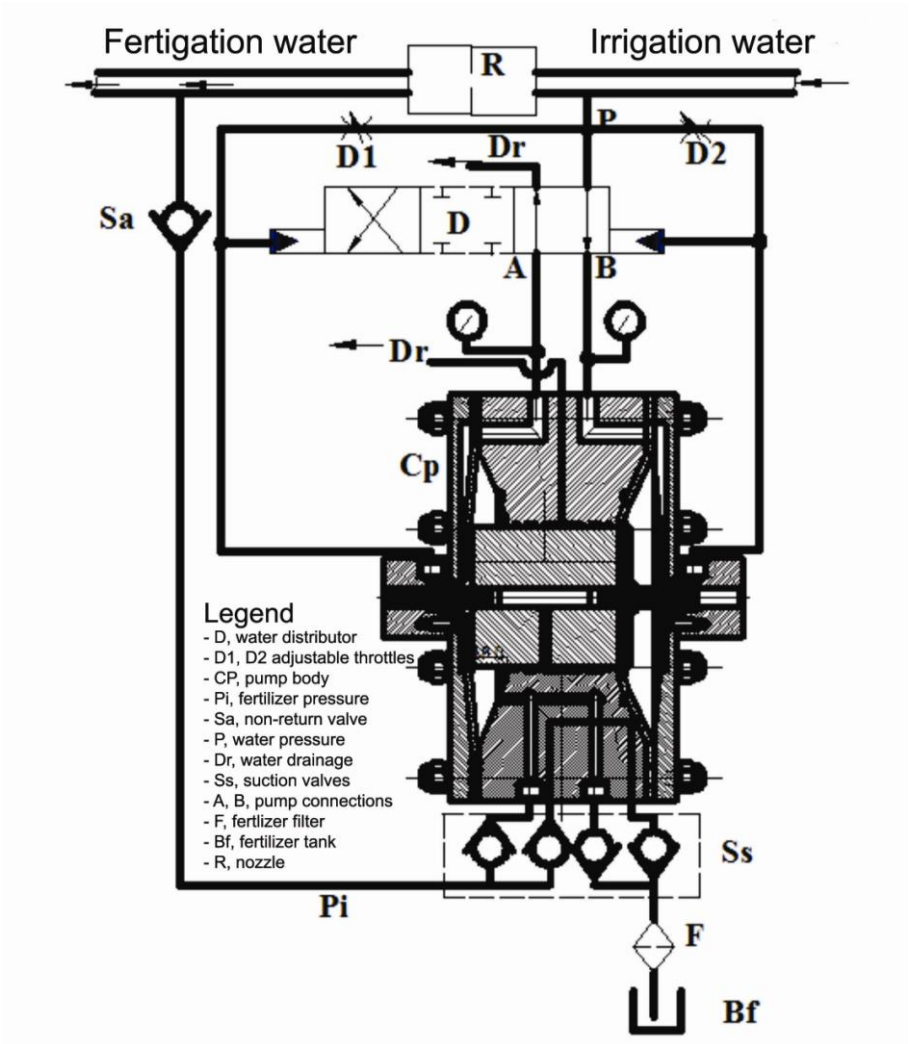

Fig. 2 - Diagram of fertigation equipment, where Cp is body of double diaphragm pump with the two pistons being integral with the assembly of membranes, D- distributor, D1and D2 adjustable throttles, SS- group of check valves for primary solution injection, F- filter, Bf- fertilizer tank, R- adjustable diaphragm

- fertilizers based on nitrogen and potassium cause no problems in achieving dilution and injection;
- primary solution can be achieved by combining various types of fertilizers, so as to be possible to administer the required dose.

For precise control of the amount of fertilizer injected in the irrigation pipeline a fertigation equipment (Fig.2) has been conceived which should give a precise amount of solution in a measurable time.

INOE 2000-IHP, specialized in hydraulic systems, has developed under the project an experimental model of a volumetric double diaphragm pump [1, 3, 5] driven by a hydraulic distributor (Fig.3), which is the subject of a patent application.

- îngrăşămintele pe bază de azot şi potasiu nu crează probleme la realizarea diluției şi a injecției;
- realizarea soluției primare se poate efectua prin combinarea mai multor tipuri de îngrăşăminte, astfel încât să se poată administra doza dorită.

Pentru controlul de precizie a cantității de fertilizant injectat în conducta de irigare a fost gandit un echipament de fertirigație (Fig.2) care sa dea o cantitate exactă de soluție într-un timp măsurabil.

INOE 2000-IHP, specializat în sisteme hidraulice, a realizat în cadrul proiectului un model experimental al unei pompe volumetrice cu membrane duble [1, 3, 5] comandată printr-un distribuitor hidraulic (Fig.3), care face obiectul unei cereri de brevet.

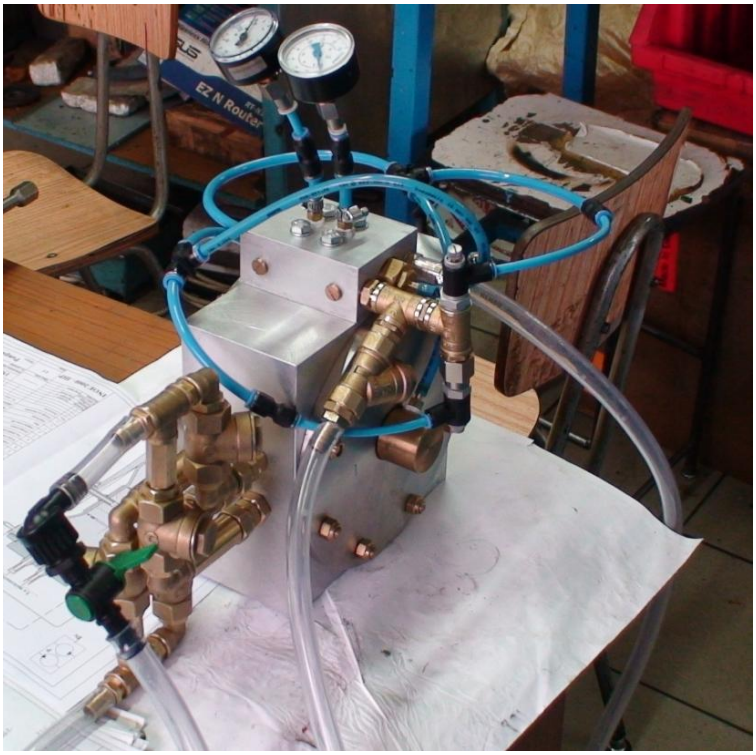

Fig. 3 – Fertigation pump experimental model

In INOE 2000-IHP there has been developed, in collaboration with project partners, the experimental model that has successfully passed functional tests.

The pump consists of pump with double membranes, a distributor with hydraulic control, a system of throttles that allow switching of the distributor, group of check valves that allow primary solution injection.

To test the pump, which is in the phase of ME, there has been developed a stand for tests in the laboratory of INOE 2000- IHP, according to the diagram in Fig. 4, where: P is the pump to be tested, R1-4 isolation or throttling tap valves, M1-4 pressure gauges, S valve reducing pressure inside the network to p = 2.2- 2.5 bar, D1-2 decalitre, F fertilizer filter, BF fertilizer tank.

Procedure: Water is taken from the network from tap valve R1, tap valve R2 being used as a throttle, and R3 being closed; pressure is reduced to 2.2-2.5 bar at pressure gauge M2 by use of reducing valve S. The amount of water per chosen unit of time is measured using decalitre D1. Thus can be found the flow rate of power unit at pump working pressure.

To test the pump close the tap valve R2 and open the

În cadrul INOE 2000–IHP a fost realizat, în colaborare cu partenerii de proiect, modelul experimental care a trecut cu succes de probele funcționale.

Pompa este formată din pompa cu membrane duble, un distribuitor cu comandă hidraulică, un sistem de drosele care permit comutarea distribuitorului, grupul de supape de sens care permit injecția soluției primare.

Pentru încercarea pompei, aflate in faza de ME, a fost conceput un stand de probare în laboratorul INOE 2000-IHP, conform cu schema din Fig. 4, unde: P este pompa de încercat, R1-4 robineți de izolare sau de droselizare, M1-4 manometre, S supapa de reducere a presiunii din rețea la p = 2,2- 2,5 bar, D1-2 decalitru, F filtru fertilizant, BF bazin fertilizant.

Mod de lucru: Se preia apa de la rețea din robinetul R1, robinetul R2 fiind folosit ca drosel, iar R3 închis; se reduce presiunea la 2.2-2.5 bar la manometrul M2 cu supapa de reducere S. Se masoară cantitatea de apa în unitatea de timp aleasă cu ajutorul decalitrului D1. Astfel se poate afla debitul sursei la presiunea de lucru a pompei.

Pentru probarea pompei se închide robinetul R2 şi se

tap valve R3.

deschide R3.

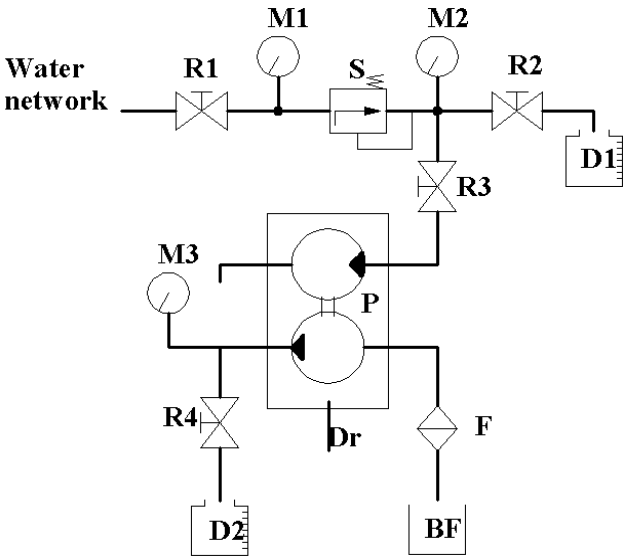

Fig. 4 - Diagram of stand for testing the fertigation pump in laboratory conditions

The volumetric pump type pump with double membranes consists of a drive chamber and a chamber for pumping fertilizers. These chambers have a geometric volume V per stroke. Also in the pump structure there is the control distributor that has water loss Dr, drainage.

So flow introduced into the pump is:

Pompa volumetrică de tip cu membrane duble este formată din o cameră motoare şi o cameră de pompare a fertilizanților. Aceste camere au un volum geometric V pe cursă.

Tot în construcția pompei intră şi distribuitorul de comandă care are o pierdere de apă Dr, un drenaj.

Deci debitul introdus în pompa este:

$$D = V_C x N_C + D_r \quad \text{[l/min]} \tag{1}$$

where:

Vc is geometric volume of drive chamber, [l];

Nc number of strokes per minute, [s^{-1}];

Dr flow collected at drainage, [l/min].

Knowing the number of strokes Nc and also knowing geometric volume of pumping chamber one can find out fertilizer flow provided by the pump:

unde:

Vc volumul geometric al camerei motoare, [l];

Nc numărul de curse într-un minut, [s^{-1}];

Dr debitul colectat la drenaj, [l/min].

Cunoscând numărul de curse Nc şi ştiind volumul geometric al camerei de pompare se poate afla debitul de fertilizant furnizat de pompă:

$$D_f = V_f x N_C \tag{2}$$

where

Df fertilizer flow provided by pump at pressure read on the pressure gauge M3 on resistance given by the tap valve R4, [l/min];

Vf geometric volume of pumping chamber, [l].

After collecting data, which is done following the experiments, one can calculate yields and take action to improve performance.

unde

Df debitul de fertilizant furnizat de pompă la presiunea citită pe manometrul M3 pe rezistența dată de robinetul R4, [l/min];

Vf volumul geometric al camerei de pompare, [l].

După colectarea datelor făcută în urma experimentărilor se pot calcula randamente şi lua măsuri de îmbunătățire a performanțelor.

CONCLUSIONS

Following collaboration between project partners there has been developed a fully functional fertigation pump at the stage of experimental model, covering the necessary parameters for fertigation of orchards. The project has started from an idea which was confirmed following the development of the experimental model.

CONCLUZII

În urma colaborării dintre partenerii proiectului a fost realizată o pompă de fertirigații în faza de model exprimental perfect funcțională care acoperă parametrii necesari fertirigării plantațiilor de pomi fructiferi. În realizarea proiectului s-a plecat de la o idee care a fost confirmată în urma realizării modelului experimental.

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VELOCITYS AND PRESSURE DISTRIBUTION ANALYSIS IN THE CICLON / ANALIZA DISTRIBUȚIEI VITEZELOR ŞI PRESIUNILOR ÎN CICLON

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Abstract: *Air purification contains all physicochemical purification procedures taken from a source to improve the quality and characteristics to become relevant to consumer needs. This article presents a biphasic mixture flow into the cyclone and the mechanical separation process in cyclones using 3D geometric modelling methods and numerical analysis program of fluid flow CFD.*

Keywords: *CFD, cyclone, the flow of fluids, purification;*

INTRODUCTION

Pollution is called any concentration of pollutants in the environment that exceeds natural valid today. It defines air pollution as the introduction into the atmosphere by man, directly or indirectly, of substances or energy having harmful action, to endanger human health, to damage biological resources, ecosystems, damaging material assets, locations recreation and other utilities legitimate the environment.

If the pollutant concentrations (or only one) in the environment exceed the alert thresholds specified in the regulations on the assessment of environmental pollution, there is a significant potential pollution. Thresholds competent authorities warn about the existence, in a certain situation, a potential pollution in air, water or soil. They compared the values imposed standards lead to some sequence of processing.

MATERIALS AND METHODS

In this paper we study the flow of a biphasic mixture into the cyclone and the mechanical separation in cyclones. Cyclone is a device that is used for mechanical air purification processes. The analysis was done for a cyclone-type Stairmand 633 mm diameter. Geometric Modeling was performed using SolidWorks software in SPO 2008.

In the cyclone was performed separation of a biphasic mixture: air and fine particles of dust at a temperature of 25 ° C for purging the air.

The geometrical characteristics of the cyclone are:

1. The diameter of the barrel 633 mm
2. Mixture inlet diameter: 317 mm
3. The total length of 1899 mm cyclone
4. 379 mm diameter drain hole
5. The hole diameter of 474 mm overflow

Modelling and simulation of the separation process was done using the environment CFD (Computer Fluid Dynamics). Using computerized systems to assist the designer in the process of creation, modification, analysis and optimization project was called computer-aided design. In modern computer aided design include the most diverse applications, from drawing or computer modelling and continuing with analysis tolerances, properties has mass calculation, modelling, finite element analysis results visualization and much more basic engineering calculation.

Rezumat: *Epurarea aerului constituie ansamblul procedeelor fizico-chimice de purificare a aerului preluat de la o sursă, în vederea îmbunătățirii calității şi a caracteristicilor pentru a deveni corespunzător necesităților consumatorilor. În prezentul articol este prezentată curgerea unui amestec bifazic în ciclon şi procesul de separare mecanică în cicloane, folosind metode de modelare geometrica 3D si programul de analiză numerica a curgerii fluidelor CFD .*

Cuvinte cheie: *CFD, ciclon, curgerea fluidelor, epurare*

INTRODUCERE

Prin poluare se denumește orice concentrație de poluant în mediu ce depășește valoarea naturală, valabilă şi în prezent. Poluarea atmosferică se definește ca introducerea în atmosferă de către om, direct sau indirect, de substanțe sau energie având acțiune nocivă, care pun în pericol sănătatea omului, afectează resursele biologice, ecosistemele, deteriorează bunurile materiale, locațiile de agrement şi alte utilități legitime ale mediului înconjurător.

În cazul în care concentrațiile de poluanți per ansamblu (sau numai a unui singur poluant) în mediu depășesc pragurile de alertă, prevăzute în reglementările privind evaluarea poluării mediului, atunci există o poluare potențial semnificativă. Pragurile de alertă avertizează autoritățile competente asupra existentei, într-o anumita situație, a unei poluări potențiale în aer, apă sau sol. Acestea, comparate cu valorile impuse în standarde, conduc la o anumită succesiune a operațiilor de tratare.

MATERIALE SI METODA

In acest articol se studiază curgerea unui amestec bifazic în ciclon şi procesul de separare mecanică în cicloane. Ciclonul este un echipament care este folosit pentru procesele de epurare mecanică a aerului. Analiza s-a făcut pentru un ciclon de tip Stairmand cu diametrul de 633 mm. Modelarea geometrică s-a realizat cu ajutorul programului SolidWorks SPO 2008.

În ciclon s-a efectuat separarea unui amestec bifazic: aer şi particule fine de praf, la temperatura de 25ºC, în vederea epurării aerului.

Caracteristicile geometrice ale ciclonului sunt:

1. Diametrul corpului cilindric: 633 mm
2. Diametrul orificiului de intrare a amestecului: 317 mm
3. Lungimea totala a ciclonului 1899 mm
4. Diametrul orificiului de scurgere 379 mm
5. Diametrul orificiului de suprascurgere 474 mm

Modelarea şi simularea procesului de separare s-a făcut cu ajutorul CFD (Computer Fluid Dynamics). Procesul de proiectare asistată de calculator include aplicații dintre cele mai diverse, pornind de la desenare sau modelare computerizată şi continuând cu analiza toleranțelor, calculul proprietăților masice, modelarea cu elemente finite, vizualizarea rezultatelor analizelor şi multe alte funcții elementare de calcul ingineresc.

Using CFD analysis environment, ANSYS CFX if given within two-phase research dust-air mixture flow scrubbers, determines important parameters such as pressure distribution on the wall of the cyclone, cyclone performance appraisal; determination of the use of energy and many other parameters. This allows assessment of performance without significant expense studied object with minimum effort and maximum efficiency. Experiments were performed for the input air velocity of 50-60 m / s.

ANSYS was chosen for modelling and simulation software system because it works with a mesh and not solid model allowing parameterization of CAD models, and nonparametric geometry while containing network elements. It is also possible to read using this program to a file that contains a mesh and then create an initial configuration in order to "synthesize geometry" from the existing network of finite elements. The case study will include the analysis of the velocity and pressure distribution in the mixing bowl using finite volume method.

Equipment design using 3D systems

One of the major differences between 3D solid modeling and 2D drafting is to create three-dimensional model with perfect precision. Because existing systems currently on the market at affordable prices, these models can be viewed, analyzed and modified as real objects. For many designers is a big gain to be able to express concepts and ideas towards a model real. Designers dimensional thinking, while trying to reproduce mental 2D 3D model becomes difficult. By improving the ability to view the project is also an advantage. An assembly can be easily exploded elements and can create a very clear picture of what will be the future product.

A big advantage is the ability to automatically extract the necessary views 2D representation of the product manufacturing process required representation

Design teams need system design that meets the following objectives:

• integration capabilities of solids modeling tools for structural analysis;

• reduced development costs and time;

• increase the quality of structural analysis in order to improve the final product;

• quick response to changes in input parameters;

• optimization of design activity;

• a high level of confidence in products

All activities listed necessitated geometric shape of the product, it is necessary for programming CNC machine tools (CAM). For this reason, drawing components or geometric modelling is the most important component of the suite of CAD, programs that have this possibility being included in this category.

Geometric model can then be used in the CAE software packages to simulate and analyse product behaviour in different operating conditions. You may be assigned programs kinematics analysis, with which are determined trajectories, speeds and accelerations specific points of interest of a mechanism programs finite element analysis used in solving problems of strength, thermodynamics, fluid mechanics, distribution of magnetic fields but and other issues involving the existence of continuous fields.

Utilizarea mediilor de analiză CFD, în cazul dat ANSYS CFX, în cadrul cercetării curgerii amestecului bifazic praf-aer în instalaţia de epurare, permite determinarea parametrilor importanţi cum ar fi: distribuţia presiunii pe peretele ciclonului, aprecierea performanţei ciclonului; determinarea coeficientului de utilizare a energiei şi mulţi alţi parametri. Acest fapt permite aprecierea performanţei ciclonului studiat fără cheltuieli considerabile, cu efort minim şi maximă operativitate. Experimentele s-au realizat pentru o viteza de intrare a aerului de 50-60 m/s.

S-a ales programul ANSYS pentru modelarea şi simularea sistemului deoarece lucrează cu reţeaua de elemente finite şi nu cu modelul solid, permiţând parametrizarea modelelor CAD, şi totodată acceptă geometrii neparametrice ce conţin reţeaua de elemente. De asemenea, este posibilă citirea cu ajutorul acestui program a unui fişier ce conţine reţeaua de elemente finite şi apoi crearea unei configuraţii iniţiale in vederea “sintetizării geometriei” pornind de la reţeaua de elemente finite existentă. Studiul de caz va conţine analiza distribuţiei vitezelor şi presiunilor în vasul de omogenizare, utilizând metoda volumelor finite.

Proiectarea echipamentelor cu ajutorul sistemelor 3D

Una dintre diferenţele majore dintre modelarea solidă 3D şi desenare 2D este crearea modelului tridimensional cu o precizie desăvârşită. Datorită sistemelor existente la ora actuală pe piaţă la preţuri acceptabile, aceste modele pot fi vizualizate, analizate şi modificate ca şi cum ar fi obiecte reale. Pentru mulţi proiectanţi, este un mare câştig de a-şi putea exprima concepţiile şi ideile faţă de un model real. Proiectanţii gândesc tridimensional, pe când a încerca de a reproduce model 3D mental în 2D devine dificil. Îmbunătăţirea capacităţii de vizualizare 3D a proiectului este de asemenea un avantaj. Un ansamblu poate fi uşor explodat în elemente şi se poate crea o imagine foarte clară a ceea ce va fi viitorul produs.

Un mare avantaj este posibilitatea de a extrage automat vederile necesare reprezentării 2D a produsului, reprezentare necesară procesului de fabricaţie.

Colectivele de proiectare au nevoie de sistem de proiectare care să îndeplinească următoarele obiective:

• integrarea capabilităţilor de modelare a solidelor cu instrumente de analiza structurala;

• costuri si timp de dezvoltare reduse;

• creşterea calităţii analizei structurale în scopul îmbunătăţirii produsului final;

• răspuns rapid la schimbările parametrilor iniţiali;

• optimizarea activităţii de proiectare;

• un ridicat nivel de încredere în produse.

Toate activităţile enumerate necesită existenţa formei geometrice a produsului, ea fiind necesară şi pentru programarea maşinilor unelte cu comandă numerică (CAM). Din acest motiv, proiectarea componentelor sau modelarea geometrică este cea mai importantă din suita de componente CAD, programele care dispun de această posibilitate fiind încadrate în aceasta categorie.

Modelul geometric poate fi utilizat ulterior de pachete software din domeniul CAE, pentru a simula şi analiza comportamentul produsului în diverse condiţii de exploatare. Aici pot fi încadrate programele de analiză cinematică, cu ajutorul cărora sunt determinate traiectoriile, vitezele si accelerațiile caracteristice punctelor de interes ale unui mecanism, programe de analiză cu elemente finite utilizate în rezolvarea unor probleme de rezistenţa, termotehnică, mecanica fluidelor, distribuţia câmpurilor magnetice dar şi a altor probleme care implică existenţa unor câmpuri continue.

Based on the results, it can be executed further optimization procedure, most often focusing on reducing the weight without affecting performance product.

Computer-aided design and drafting, in the broadest sense (CAD software) is done with computer programs that can be classified into the following categories of applications:

• Applications for geometric modeling and computer-aided drawing (among which AutoCAD, Design CAD, Solid Works, etc.);

• applications for solving general problems numeracy, especially useful in CAE aided engineering (among which Matlab, MathCAD, Maple, etc.) or simulation of particular systems described by differential equations (like Spice);

• applications for numerical modeling, finite element or similar functions dedicated to solving partial differential equations used in designing integrated (the most widespread are the structural calculation as ANSYS, COSMOS);

• embedded systems applications with a degree of integration of components CAE / CAD / CAM higher or lower (among which I-DEAS, CATIA, Pro Engineer

Specialized numerical analysis of fluid flow

ANSYS® CFX. Already holds the leading position in solutions for simulating fluid flow (CFD), its performance superior being based on the combination of leading technologies embedded that make it possible to optimize all aspects of the analysis of fluid flow in the context of the cycle design - manufacturing specific to each company .

ANSYS CFX has considerable experience in studying how they can be improved performances pumps, motors flights, turbines, compressors and other rotating machinery, propelling it just that as the market leader in this field. Specialized models for combustion and radiation reactive flow, among other things help to increase productivity and improve the life of the product.

Pe baza rezultatelor obținute, poate fi executată în continuare o procedură de optimizare, axată de cele mai multe ori pe reducerea masei produsului fără a-i afecta performanțele.

Proiectarea şi desenarea asistate de calculator, în sensul cel mai larg (CAD), se realizează cu programe de calculator care se pot clasifica în următoarele categorii de aplicații informatice:

• aplicații pentru modelare geometrica si desenare asistate de calculator (dintre care menţionăm AutoCAD, Design CAD, Solid Works etc.);

• aplicații pentru rezolvarea unor probleme generale de calcul matematic, utile mai ales în ingineria asistata CAE (dintre care menționam Matlab, MathCAD, Maple etc.) sau simularea unor sisteme particulare descrise de ecuații diferențiale (precum Spice);

• aplicații destinate modelării numerice, cu element finit sau cu funcții similare dedicate rezolvării ecuațiilor cu derivate parțiale, utilizate în proiectarea integrată (cele mai răspândite sunt cele de calcul structural ca ANSYS, COSMOS);

• sisteme integrate de aplicații, cu un grad de integrare a componentelor CAE/CAD/CAM mai mare sau mai mic (dintre care menționam I-DEAS, CATIA, ProEngineer.

Programe specializate de analiză numerica a curgerii fluidelor

ANSYS® CFX . Deține deja poziția de lider în domeniul soluțiilor de simulare a curgerii fluidelor (CFD), performanța sa superioară fiind bazată pe combinația de tehnologii de vârf înglobate, care fac posibilă optimizarea tuturor aspectelor legate de analiza curgerii fluidelor în contextul ciclului proiectare – fabricație proprie fiecărei companii.

ANSYS CFX dispune de o experiență considerabilă în studierea modului în care pot fi îmbunătățite performanțele pompelor, motoarelor de avion, turbinelor, compresoarelor şi ale altor maşini rotative, tocmai acest lucru propulsându-l ca lider pe piață în acest domeniu. Modelele specializate pentru combustie, curgere reactivă şi radiație, ajută printre altele la creşterea productivității şi îmbunătățirea duratei de viață a produsului.

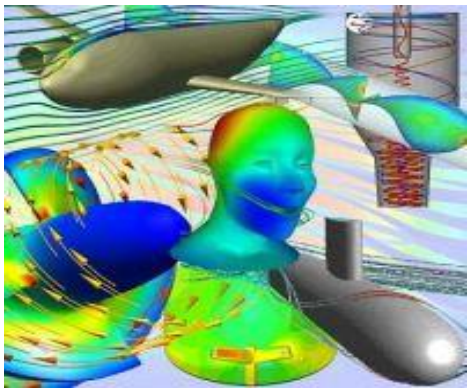

Fig. 1 - Cycle analysis of fluid flow in the context of the design – production

ANSYS® ICEM CFD Cart3D. It's a high-fidelity analysis software package used for conceptual and preliminary aerodynamic design. Allows user to perform CFD analyzes automatically very complex geometries. The package includes utilities to import geometry, modeling and surfaces intersection, meshing and flow analysis.

ANSYS® ICEM CFD Cart3D. Este un pachet software de analiză de înaltă fidelitate folosit pentru proiectare aerodinamică conceptuală şi preliminară. Permite utilizatorului să realizeze în mod automat analize CFD pe geometrii foarte complexe. Include utilitare pentru importul geometriei, modelare şi intersecție de suprafețe, discretizare precum şi analiză la curgere.

FLUENT is a complete package, very flexible and powerful used for the simulation of any complexity. It offers a full range of physical models that can be used for a wide range of applications in various industries.

FloWizard is a modeling tool that enables the rapid type flow design engineers / Process validates projects much faster and with greater accuracy, much earlier in the product development cycle.

FLUENT for CATIA V5 modeling technology fully integrates type of FLUENT rapid flow in the PLM (Product Lifecycle Management) from CATIA V5, giving engineers the ability to design, analyze and optimize the product within a single environment.

POLYFLOW advanced FE is a tool that includes a wide range of fluids viscoelastic models, ideal for analyzes of developments in polymer processing, glass forming and many other applications in materials processing

RESULTS

Numerical analysis of the flow in cyclone finite volume method

The research activities of the project, carried out in this chapter included the following aspects:

1. Choosing a cyclone proposed class representative for the study and development of CAD model, three-dimensional, using SolidWorks software in 2008.

2. CFD analysis model chosen for the study using ANSYS 10.0 software facilities put at his disposal by the company INAS SA Ro.

1. Develop CAD model three-dimensional study of the cyclone (Stairman) - SolidWorks 2008

For the study were proposed more cyclones (Stairmand, Swift, Swift Lapp-Peterson / Whitby) representative of the class to which they belong, opting for two of them:

• Lapp-Swift, product of Blocks, US;

• Stairmand, experimental model of the company, Kroibs, UK.

For these types of stations have been developed CAD models, three-dimensional, as follows.

FLUENT - este un pachet CFD complet, foarte flexibil şi puternic, folosit pentru simulări de orice complexitate. Oferă o gamă completă de modele fizice ce pot fi utilizate pentru un spectru larg de aplicații, din diverse industrii.

FloWizard este un instrument de modelare de tip rapid flow ce permite inginerilor proiectanți/de proces să valideze proiectele mult mai rapid şi cu o mai mare acuratețe, mult mai devreme în cadrul ciclului de dezvoltare al produsului.

FLUENT for CATIA V5 integrează în totalitate tehnologia de modelare de tip rapid flow din FLUENT în procesul PLM (Product Lifecycle Management) din CATIA V5, oferind inginerilor posibilitatea să proiecteze, să analizeze şi să optimizeze produsul în cadrul unui singur mediu de lucru.

POLYFLOW este un instrument FE (fluid element) avansat ce include o gamă foarte largă de modele fluide vâcoelastice, fiind ideal în cazul analizelor realizate în domeniul procesării polimerilor, formarea sticlei precum şi pentru multe alte aplicații din domeniul procesării de materiale

REZULTATE

Analiza numerică a curgerii în ciclon cu metoda volumului finit

Activitățile de cercetare teoretică cuprinse în acest articol au vizat următoarele aspecte:

1. Alegerea unui ciclon reprezentativ din clasa propusă pentru studiu şi elaborarea modelului CAD, tridimensional, cu ajutorul programului SolidWorks 2008.

2. Analiza CFD a modelului ales pentru studiu, utilizând facilitățile programului ANSYS 10.0, pus la dipoziție de firma INAS S.A. Ro.

1. Elaborarea modelului CAD, tridimensional, al ciclonului studiat (Stairmand) – SolidWorks 2008

Pentru analiză au fost propuse mai multe cicloane (Stairmand, Swift, Lapple-Swift, Peterson/Whitby), reprezentative pentru clasa din care fac parte, optându-se pentru doua dintre ele:

• Lapple-Swift, produs al firmei Blocks, US;

• Stairmand, model experimental al firmei, Kroibs, UK.

Pentru aceste tipuri de statii au fost elaborate modelele CAD, tridimensionale, după cum urmează.

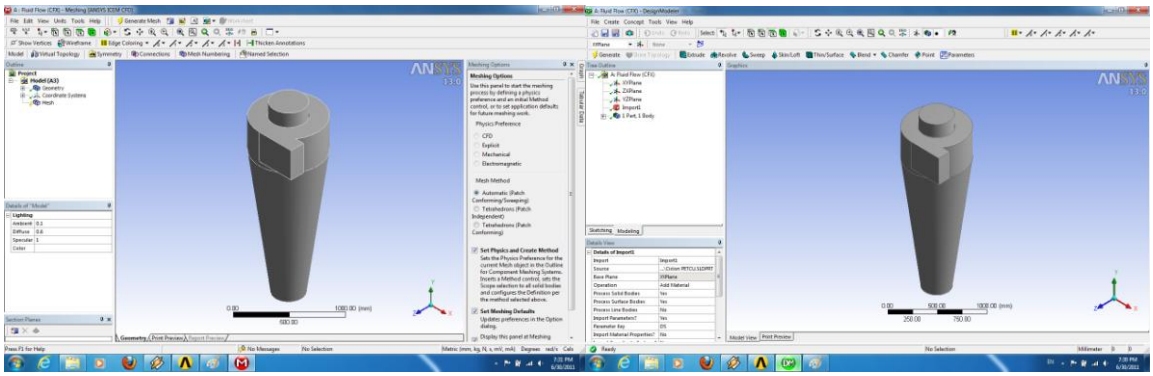

Fig. 2 - Three-dimensional models

The final was decided to continue the study on model Stairmand

Numerical Modeling - Ansys Workbench 10.0.

The main steps of numerical modeling process were:

1. Preprocessing

It is the most laborious stage in a process of numerical modeling.

The activities were:

În final s-a decis continuarea studiului pe modelul Stairmand.

Modelarea numerică - Ansys Workbench 10.0

Principalele etape au fost:

1. Preprocesare

Este cea mai laborioasă etapă dintr-un proces de modelare numerică.

Activitățile desfăşurate au fost:

Transferring of the threedimensional model of the cyclon chosen for the study of SolidWorks software ANSYS (as file type * .wbdb). As this study is primarily aimed at studying the influence of turbulence effect on the characteristics of hidrodidamice station, it gave up some of its accessories, such as pipes, pumps, valves control, their influence negligible flow.

- *Transferarea modelului tridimensional al ciclonului ales pentru studiu din programul SolidWorks în ANSYS* (ca fişier de tip *.wbdb). Deoarece prezentul studiu vizează în primul rând studiul influenței efectului turbulentei asupra caracteristicilor hidrodinamice ale stației, s-a renunțat la o parte din accesoriile acesteia, precum: conducte, pompa, ventile de reglaj, influența acestora asupra curgerii fiind neglijată.

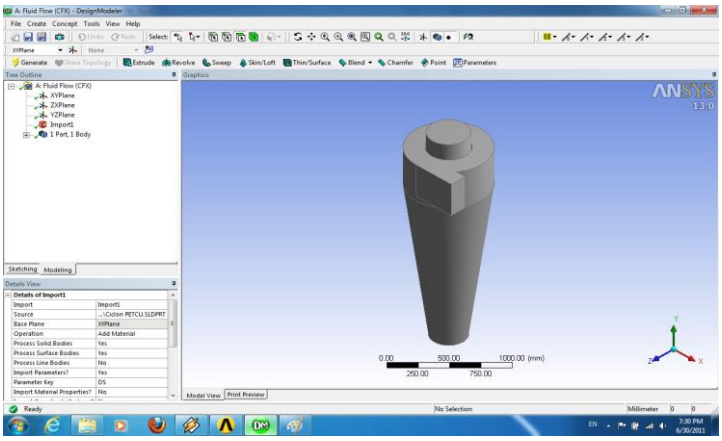

Fig. 3 - 3D model of a cyclone

Because the studied model is not symmetrically using the facilities offered by ANSYS software was chosen for its entire model analysis, thus being able to use computing resources more efficiently used machine.

Establishing field size calculation, following certain tests dimensional models and considering the complexity analysis. Reported to the main station feature size, length of 1899 mm H dimensions are analyzed domain (see Figure 4):

- Over leak diameter 0.474 m (0.25 ≅ • H);
- Diameter powder output 0.379 m (≅ 0.20 • H);
- Height cylinder 0.237 m (0.125 ≅ • H).

Datorită faptului că modelul studiat nu are plan de simetrie, utilizând facilitățile pe care le oferă programul ANSYS s-a optat pentru analiza modelului întreg al acestuia, în acest mod putându-se utiliza mai eficient resursele maşinii de calcul folosite .

- *Stabilirea dimensiunilor domeniului de calcul*, în urma efectuării unor teste pe modele bidimensionale şi ținând cont de complexitatea procesului analizat.

Raportate la principala dimensiune caracteristică a stației, lungimea acestuia H = 1899 mm, dimensiunile domeniului analizat sunt (vezi figura 4):

- Diametru suprascurgere 0.474 m (≅ 0.25•H);
- Diametru ieşire praf 0.379 m (≅ 0.20•H);
- Inaltime cilindru 0.237 m(≅ 0.125•H).

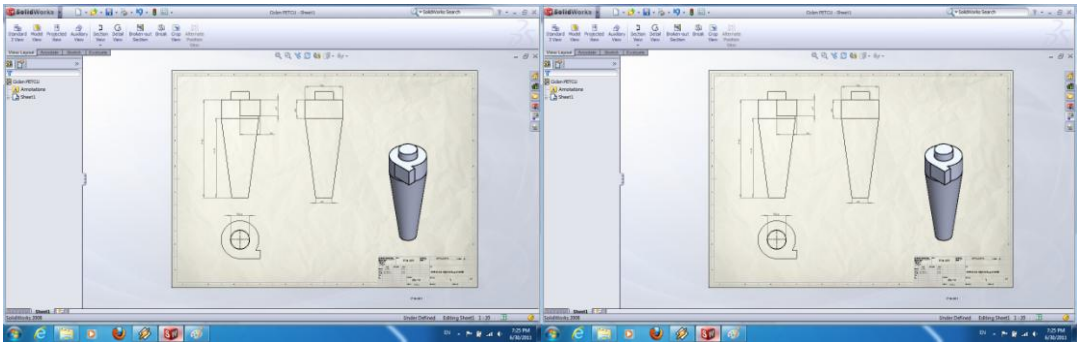

Fig 4 - Main geometric dimensions

- Meshing domain calculation was done with tetrahedral elements, 3D Design Modeler (specific program used). The grid mesh generation (multiblock) were considered the following quality criteria, in conjunction with the computer hardware resources (AMD Turion 64 processor, 1.5 GB DDRAM):

- domain profile to represent as closely meshed on the physical sciences;
- concentration nodes (calculation points) in areas where high values are estimated gradients of physical quantities involved in differential equations of the model mathematical (impact areas of flow separation

- Discretizarea domeniului de calcul, s-a făcut cu elemente tetraedale, 3D Design Modeler (specifice programului utilizat). La generarea grilei de discretizare (multibloc) s-au avut în vedere următoarele criterii de calitate, în corelație cu resursele hard ale calculatorului (procesor AMD TURION 64, 1.5 GB DDRAM):

- profilul domeniului discretizat să reprezinte cât mai fidel pe cel fizic, real;
- concentrarea nodurilor (punctelor de calcul) în zonele în care se estimează valori mari ale gradienților mărimilor fizice care intervin în ecuațiile diferențiale ale modelului matematic (zone de impact, de separare a

or recirculation);

The dimensional characteristics of the network thus generated are:

• 24 268 meshing elements

• 4607 computing nodes, of which

• 3458 computing nodes on the borders that define the model.

curgerii sau de recirculare);

Caracteristicile dimensionale ale rețelei astfel generate sunt:

• 24268 elemente de discretizare

• 4607 noduri de calcul, din care

• 3458 noduri de calcul pe frontierele ce definesc modelul.

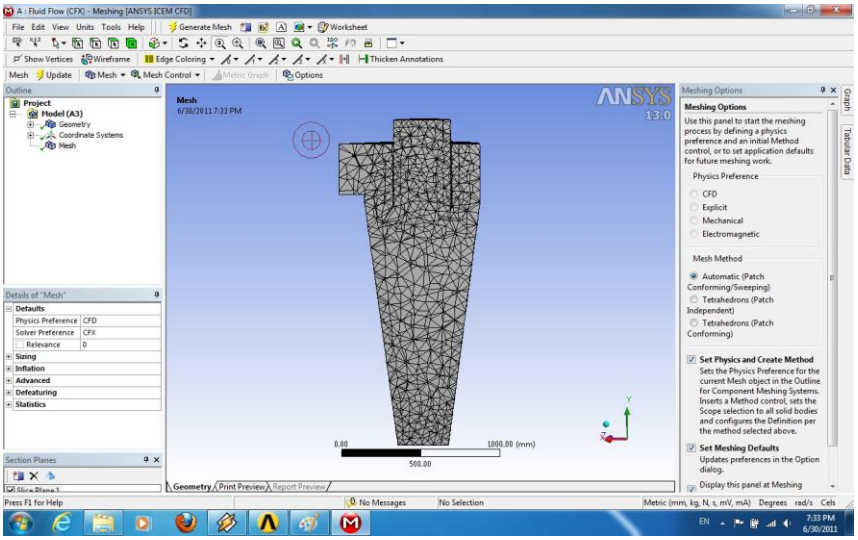

Fig. 5 - Tetrahedral finite element Network

The conditions imposed on the computational domain boundaries in accordance with the flow analysed are:

• zero speed on the solid borders - v x = v y = v z = 0, in this case nodes on the surfaces defining the intern contact surface of the cyclone ;

• uniform velocity v z = ∞ in the direction of flow v and v x = v y = 0 for the vertices of the area of entry into the calculation;

• zero speed in the direction normal to the plane of symmetry, v x = 0 for the vertices of the surface which defines the plane of symmetry of the field;

• zero pressure on remaining frontiers, p = 0, considered a sufficient distance model, where the air flow is not disturbed.

2. Numeric settlement

The stage of the differential equations defining the parameters and the equations that characterize the mathematical model studied numerically solving them.

The activities were:

Setting parameters defining the equations studied and Governance: made in accordance with the process flow analysis.

Thus they were imposed following:

• reference conditions:

- nature of the working fluid: air in the internațional system;
- fluid entry speed: $D_{mixture}$ = 46.82 [Nm^3s^{-1}];
- atmospheric pressure reference: p_{air} = 101325 N / m2;
- reference atmospheric temperature: T_{air} = 288.15 K;

• Conditions of the trial:

- turbulent flow (depending on Reynolds number Re> 5000) with variation in density of the fluid; turbulence model used was a

Condițiile impuse pe frontierele domeniului de calcul, în conformitate cu procesul de curgere analizat, sunt:

• viteze nule pe frontierele solide – v x =v y =v z = 0, în acest caz pentru nodurile de pe suprafețele care definesc suprafața interioară de contact a ciclonului;

• viteză uniformă v z =v ∞ pe direcția de curgere şi v x =v y = 0 pentru nodurile de pe suprafața de intrare în domeniul de calcul;

• viteze nule pe direcția normală pe planul de simetrie, v x = 0 pentru nodurile de pe suprafața ce defineşte planul de simetrie al domeniului;

• presiune zero pe frontierele rămase, p = 0, considerate la o distanță suficient de mare de model, acolo unde curgerea aerului nu mai este perturbată.

2. Soluționarea numerică

Este etapa în care se definesc parametrii şi ecuațiile diferențiale ale modelului matematic ce caracterizează procesul studiat şi soluționarea numerică a acestora.

Activitățile desfăşurate au fost:

Stabilirea parametrilor ce definesc procesul studiat şi ai ecuațiilor guvernante: s-a făcut în conformitate cu procesul de curgere analizat.

Astfel s-au impus următoarele:

• condiții de referință:

- natura fluidului de lucru: aer în sistemul internațional;
- viteza de intrare a fluidului: $D_{amestec}$ = 46.82 [Nm3 s^-1];
- presiune atmosferică de referință: p_{aer} = 101325 N/m2;
- temperatura atmosferică de referință:T_{aer} = 288.15 K;

• condiții de desfăşurare a procesului:

- curgere turbulentă (în funcție de numărul Reynolds, Re > 5000), cu variație a densității fluidului; modelul de turbulență folosit a fost unul de tip k −ε , modificat, " new k −ε"

type k -ε, as amended, "new k -ε"

- • dependent on the physical properties of air reference temperature.

- • proprietăți fizice ale aerului dependente de temperatura de referință.

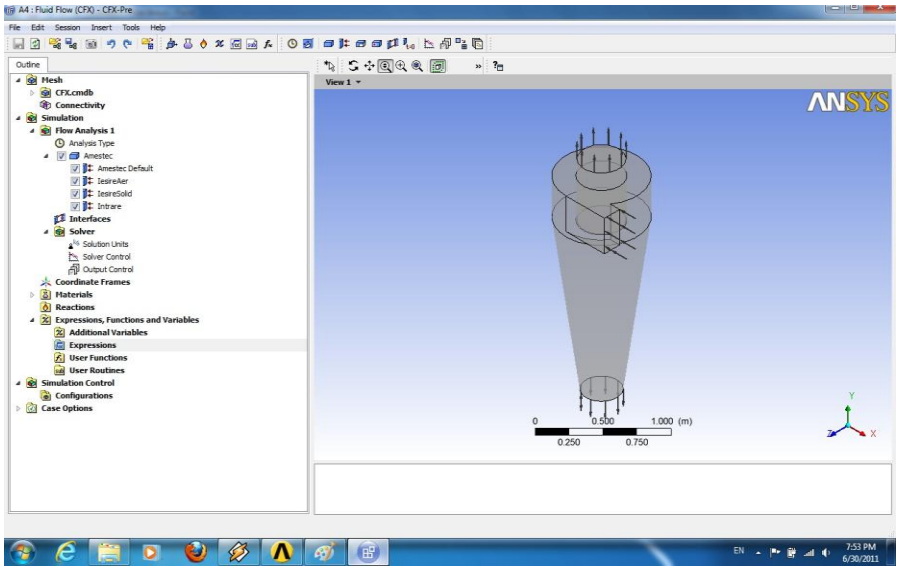

Fig. 6 - The extremes of simulation

Establishing a strategy to address the digital process, which given the complexity of the phenomena studied required a gradual approach using artificial viscosities in the early stages of relaxation and change parameters for sizes with significant variations (pressure and kinetic energy of turbulence).

The settlement was considered closed after 150 iterations, the variation in convergence parameters (rules residual pressure, velocity components and parameters of turbulence) has become insignificant over a hundred iterations consecutive order of magnitude of their falling by three units from baseline.

3. Postprocessing

It is the stage in assessing and interpreting results. To better characterize the study were analyzed as follows:

Obtained results:

• convergence of model solutions (see Figure 7,8);

Stabilirea unei strategii de soluționare a procesului numeric, care datorită complexității fenomenelor studiate a necesitat o abordare graduală, utilizându-se în primele faze vâscozități artificiale şi parametri de relaxare modificați pentru mărimile cu variații semnificative (presiune şi energie cinetică de turbulență).

Procesul de soluționare a fost considerat încheiat după 150 de iterații, când variația parametrilor de convergență (normele reziduale pentru presiune, componentele vitezei şi parametrii de turbulență) a devenit nesemnificativă pe durata a o sută de iterații consecutive, ordinul de mărime al acestora scăzând cu trei unități față de valoarea inițială.

3. Postprocesarea

Este etapa în care se evaluează şi se interpretează rezultatele obținute. Pentru a caracteriza cât mai bine procesul studiat s-au analizat următoarele:

Rezultate obținute:

• convergenta solutiilor modelului (vezi figura 7,8);

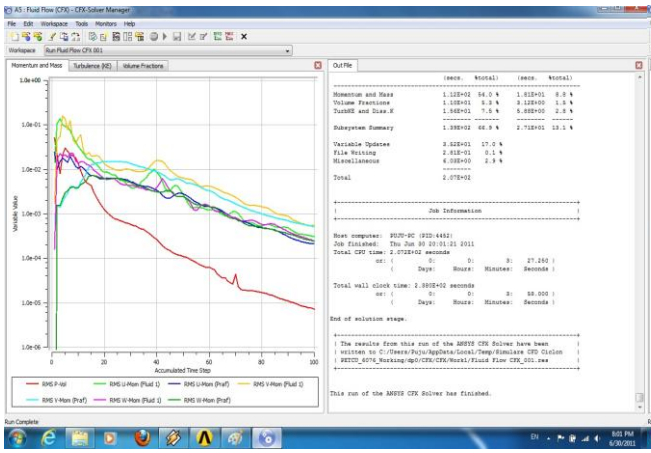

Fig.7 - Convergence equations for mass and moment

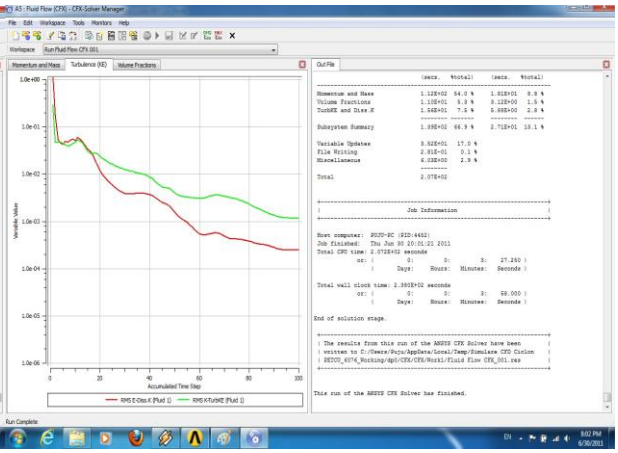

Fig. 8 - Convergence turbulence equations

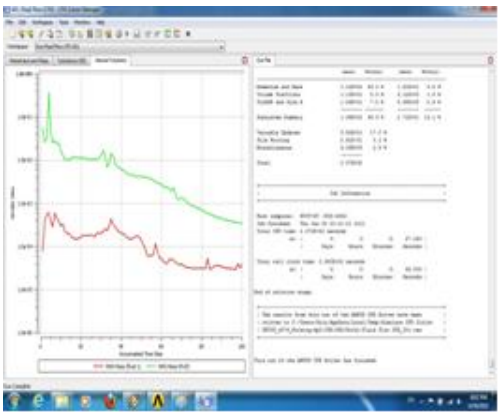

Fig. 9 - Convergence volume fraction cyclone

• velocity distribution around the model;

• distribuția vitezelor în jurul modelului;

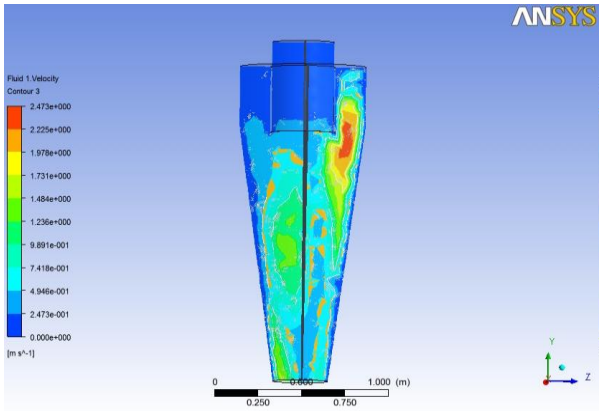

Fig.10 - Distribution of air speed YZ plane

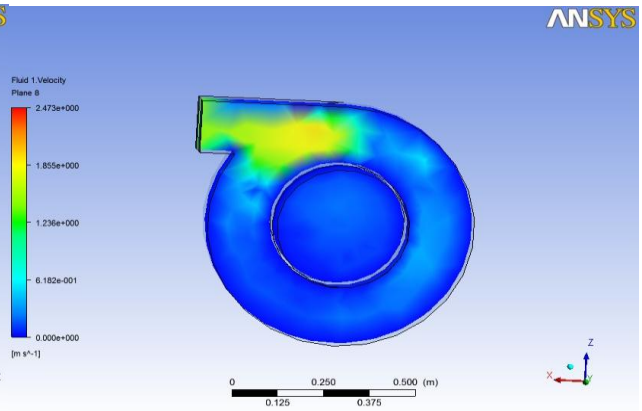

Fig. 11 - Velocity distribution - air in plane XZ

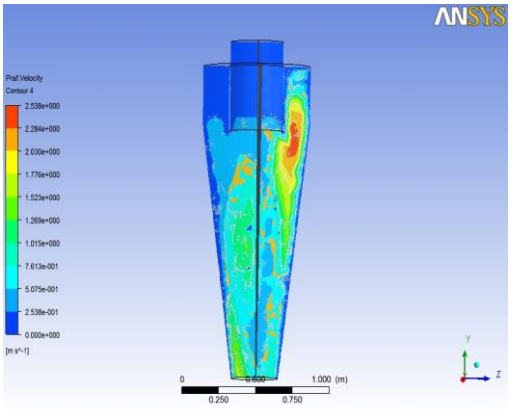

Fig.12 - Variation of dust velocity on YZ and XZ plan

• pressure distribution on the model;

• distribuția presiunii asupra modelului;

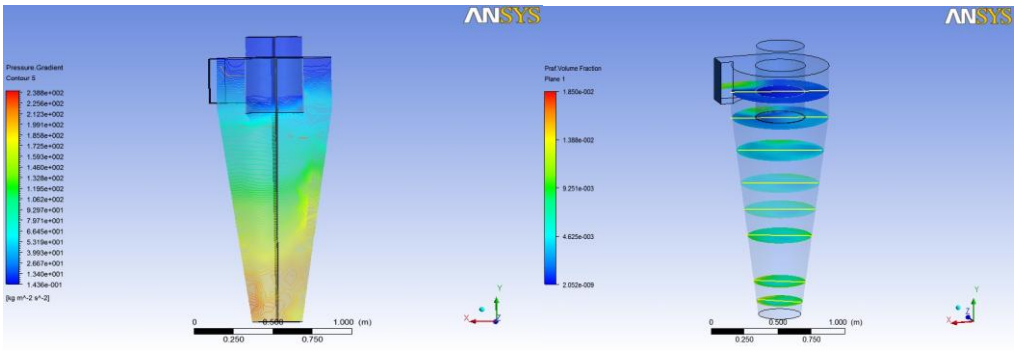

Fig. 13 - Distribution XZ pressures in plan and section plans dust on horizontal lines

• turbulent kinetic energy change.

• variația energiei cinetice turbulente .

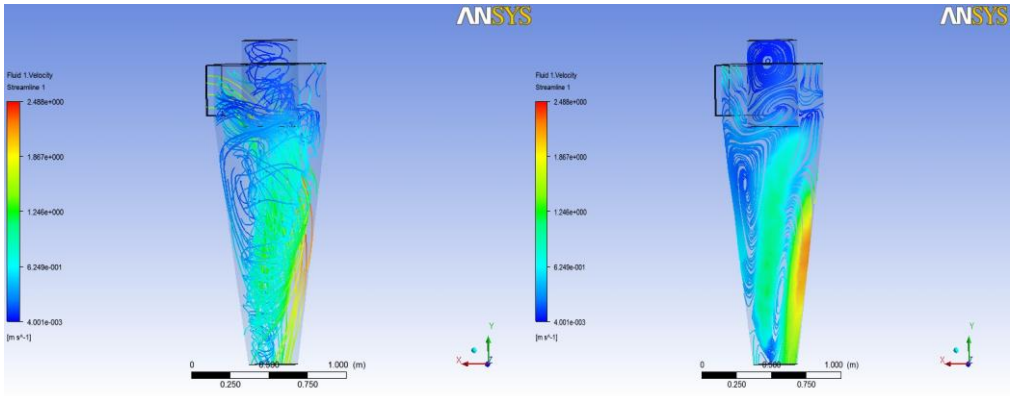

Fig. 14 - Airflow distribution lines - velocity distribution

CONCLUSIONS

Using CFD modelling involving fluid flow equipment is increasingly used, shortening the design and realization.

Simulation and modelling of the purification process determines pressure distribution and velocity field inside the cyclone; determining the flow lines of the current generated by the tangential supply; assessment of the performance of separation cyclones and many other parameters.

Models of type k -ε triggering an excess of power in the areas of stagnation which leads to excessive amounts of fluid viscosity and hence high values of the tangential friction. Therefore drag coefficient values, heavily dependent frictional forces in a turbulent flow, are much higher than in reality, being necessary corrections.

It is very important to first determine the general operating characteristics of the cyclone and pump adjustment to ensure that it will operate in steady state. General effects of changes in the most important operating parameters can thus be investigated. Finally, the experimental design methods can be used for modelling and optimization of the performance of specific material streams. These models can be used to get back at suggesting and establishing baseline running for various fluid streams subjected to separation.

Due to the complexity of the phenomenon, treatment by numerical simulation of flow through cyclones, involves the introduction of simplified assumptions. The key is choosing the simplifying assumptions leading to the construction / choice mathematical model to capture reality as faithfully as possible.

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CONCLUZII

Utilizarea CFD pentru modelarea echipamentelor care implică curgerea fluidelor este din ce în ce mai utilizată, scurtând procesul de proiectare şi realizare.

Simularea şi modelarea matematică a procesului de purificare permite determinarea distribuția presiunii si câmpului de viteze in interiorul ciclonului; determinarea liniilor de curgere ale curentului generat de alimentarea tangențială; aprecierea performanței de separare a cicloanelor şi mulți alți parametri.

Modelele de tip k −ε generează apariția unui exces de energie în zonele de stagnare, ceea ce conduce la valori excesive ale vâscozității fluidului şi implicit la valori ridicate ale tensiunilor tangențiale de frecare. Din această cauză valorile coeficienților de rezistență la înaintare, puternic dependenți de forțele de frecare într-o curgere turbulentă, sunt mult mai mari ca în realitate, fiind necesară corectarea lor.

Este foarte important să determinăm întâi caracteristicile generale de funcționare ale ciclonului şi reglajul pompei pentru a ne asigura că aceasta va funcționa în regim stabil. Efectele generale ale modificărilor celor mai importanți parametri de funcționare pot fi astfel cercetate. În final, metodele experimentale proiectate pot fi utilizate pentru modelarea şi optimizarea performanțelor unor curenți specifici de material. Aceste modele pot fi utilizate la sugerarea şi stabilirea condițiilor inițiale de funcționare pentru diferiții curenți de fluid supuşi separării.

Datorită complexității fenomenului, tratarea prin simulare numerică a curgerilor prin cicloane, implică introducerea unor ipoteze simplificatoare. Elementul cheie constă în alegerea ipotezelor simplificatoare care să conducă la construirea/alegerea modelului matematic care să surprindă cât mai fidel realitatea.

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CONSIDERATIONS ON THE CONSTRUCTION OF THE DISTRIBUTING EQUIPMENT OF SOLID ORGANIC FERTILIZERS
/
CONSIDERATII PRIVIND CONSTRUCȚIA APARATELOR DE DISTRIBUȚIE A ÎNGRĂŞĂMINTELOR ORGANICE SOLIDE

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Abstract: *Soil fertilization with animal manure is and will remain the most important way of natural nutrients sourcing, contributing to the improvement of his physical, chemical and microbiological characteristics. The major objective of this paper is to analyze the design of the existing machinery for distributing solid organic fertilizers both nationally and internationally, highlighting the advantages and disadvantages depending on agro-technical requirements.*

Keywords: *distribution, fertilization, manure, soil, spreaders.*

INTRODUCTION

The agriculture, together with the industry, could become one of the major sources of pollutants with negative impact on the environmental quality by the degradation or even the destruction of some ecosystems. Today it is practically unanimously accepted that the intensive agriculture can lead to the pollution of soil and water by the excessive use of fertilizers, pesticides, irrigation water improper qualitatively and quantitatively, especially on arable lands excessively loosened by various works.

The intake of natural organic fertilizers has a very important role in the increasing of the culture plants by the intake of nutrients brought.

In general, two methods are practiced: application by spreading on the soil surface or on plants and the localized application on seed, under the furrow and between the rows of plants.

The manure spreaders began as ground-driven units which could be pulled by a horse or team of horses. Many of these ground-driven spreaders are still produced today, mostly in the form of small units that can be pulled behind a larger garden tractor or terrain vehicle (ATV). In recent years hydraulic and PTO driven units have been developed to offer variable application rates. Several models are also designed with removable rotating mechanisms (beaters), attachable side extensions, and tailgates for hauling chopped forages, cereal grains, and other crops. A typical (modern) manure spreader consists of a trailer towed behind a tractor with a rotating mechanism driven by the tractor's power take off (PTO).

The first successful automated manure spreader was designed by Joseph Kemp in 1875. In 1903 he expanded the company to Waterloo, Iowa before selling the design to International Harvester in 1906 **[2,7].**

Joseph Oppenheim of Maria Stein, Ohio was the inventor of the first modern 'widespreading' manure

Rezumat: *Fertilizarea solului cu îngrăşăminte organice este şi va rămâne o sursa importanta de nutrienți naturali, contribuind la îmbunătățirea caracteristicilor fizice, chimice şi microbiologice ale solului. Obiectivul major al acestei lucrări este analiza constructivă a maşinilor de distribuit îngrăşăminte organice solide existente pe piață, atât pe plan național cât şi internațional, subliniind avantajele şi dezavantajele în funcție de cerințele agro-tehnice.*

Cuvinte *cheie: distribuție, fertilizare, îngrăşăminte organice, sol, distribuitoare*

INTRODUCERE

Agricultura, alături de industrie, poate deveni una dintre sursele importante de agenți poluanți cu impact negativ asupra calității mediului ambiental prin degradarea sau chiar distrugerea unor ecosisteme. Astăzi, este practic unanim acceptat că agricultura intensivă poate conduce la poluarea solului şi apei prin utilizarea excesivă a îngrăşămintelor, a pesticidelor, a apei de irigație necorespunzătoare calitativ şi cantitativ, în special pe terenurile arabile excesiv afânate prin diferite lucrări.

Aportul de îngrăşăminte organice naturale are un rol foarte important în creşterea plantelor de cultură prin aportul de nutrienți aduşi.

În general se practică două metode: aplicarea prin împrăştiere la suprafața solului sau pe plante şi aplicarea localizată, pe sămânță, sub brazdă şi între rândurile de plante.

Distribuitoarele de gunoi de grajd au început ca echipamente conduse de pe sol, care puteau fi trase de unul sau mai mulți cai. Multe dintre aceste echipamente conduse de pe sol sunt încă produse, mai ales sub forma unor echipamente mici care pot fi trase în spatele unui tractor de grădină mai mare sau a unui vehicul tot teren (ATV). În ultimii ani au fost dezvoltate echipamente acționate hidraulic sau de la priza de putere a tractorului pentru a oferi norme de aplicare variabile. Câteva modele sunt, de asemenea, proiectate cu mecanisme rotative detaşabile (tamburi rotativi cu palete), extensii laterale ataşabile şi platforme pentru tragerea prin remorcare a furajelor tocate, a boabelor de cereale şi a altor culturi. Un distribuitor de îngrăşăminte organice tipic (modern) este format din o remorcă tractată în spatele unui tractor cu un mecanism rotativ acționat de priza de putere a tractorului.

Primul echipament automatizat de succes de împrăştiat gunoi de grajd a fost proiectat de Joseph Kemp în 1875. În 1903 el a extins compania de la Waterloo, Iowa înainte de a vinde proiectul companiei International Harvester în 1906 **[2,7].**

Joseph Oppenheim din Maria Stein, Ohio a fost

spreader **[5]** and is honored as such in the Ohio Agricultural Hall of Fame. Originally manure was thrown from a wagon **[1].** Later, "manure unloaders" used a drag chain at the bottom of the wagon to pull the load of manure to the rear where it was shredded by a pair of beaters **[3].** Because the unloaders deposited manure directly behind the wagon but with very little spreading to the sides, farmers still had to take the system with peg-tooth drags or similar implements to spread the manure into the field, in order to prevent burning the soil **[6].**

inventatorul primului distribuitor modern de împrăştiat gunoi de grajd cu rază mare de acţiune **[5]** şi este onorat ca atare în Ohio Agricultural Hall of Fame. Iniţial gunoiul de grajd era aruncat dintr-o căruţă **[1]**. Mai târziu, descărcătoarele de gunoi de grajd au folosit un lanţ glisant în partea de jos a căruţei pentru a trage încărcătura de gunoi de grajd spre partea din spate unde era tocat de o pereche de tamburi rotativi cu palete **[3]** Deoarece descărcătoarele depozitau gunoiul de grajd direct în spatele căruţei dar cu foarte puţină împrăştiere în părţile laterale, fermierii au trebuit să preia totuşi sistemul cu dinţi înclinaţi de tragere sau organe similare pentru împrăştierea pe teren a gunoiului de grajd, în scopul de a preveni arderea solului **[6]**.

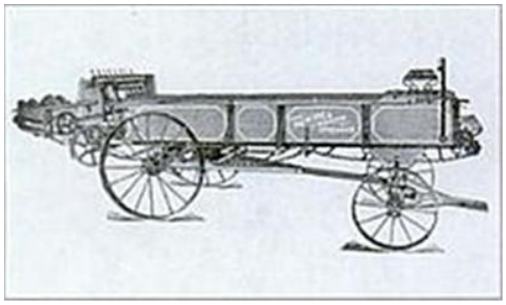


Fig.1 - The original New Idea spreader design **[7,18]**

Classification

The machines for livestock manure distribution can be classified according to several criteria, as described below.

Depending on the operations which they perform, these machines can be grouped into:

manure spreaders directly from piles;

machines conveying and livestock manure spreading.

In terms of energy source and source coupling mode, the technical equipment for distributing organic fertilizers can be: with animal traction, with mechanical traction (worn on the 3-point suspension mechanism of the tractor, semi worn or tracted).

The equipment worn on the the tractor suspension mechanism is characterized by small capacity of the bunker, which determines implicitly a low working capacity per shift, determined by the auxiliaries working times required by the movement of the manure place of storage and by the charging times. These are more rarely used, being suitable only to small individual farms.

Semi-mounted machines working in aggregate with tractors of different capacities, from 22 hp (16 kW) to 200 hp (147 kW), depending on the maximum permissible laden weight of the organic fertilizers distribution machine. These machines are characterized by the fact that part of the load is transferred to the rear axle of the tractor, which improves the aggregate behavior both in terms of transport and working conditions, by increasing the adherence of the rear axle of the tractor.

The towed machines, increasingly rare, belong to the category of the technological trailers with articulated drawbar, are equipped with steering system with peridoc bearing, have in their composition drivetrain with two axes.

Regarding the construction of the drivetrain, the machines for the distribution of organic fertilizers can be with single-axle drivetrain, with two axles or self-directed three axles.

From the point of view of the distribution device, the

Clasificare

Maşinile de administrat gunoi de grajd se pot clasifica după mai multe criterii, aşa cum este descris în continuare.

În funcţie de operaţiile pe care le execută, aceste maşini se pot grupa în:

maşini de împrăştiat gunoi de grajd direct din grămezi;

maşini de transportat şi împrăştiat gunoi de grajd.

Din punct de vedere al sursei energetice şi al modului de cuplare la sursă, echipamentele tehnice pentru administrat îngrăşăminte organice pot fi:cu tracţiune animală, cu tracţiune mecanică (purtate pe mecanismul de suspendare în 3 puncte al tractorului,semipurtate sau tractate).

Echipamentele purtate pe mecanismul de suspendare al tractorului se caracterizează prin capacitate mică a buncărului, ceea ce determină implicit o capacitate de lucru pe schimb redusă, determinată de timpii de lucru auxiliari necesitaţi de deplasarea la locul de depozitare a îngrăşământului şi de timpii de încărcare. Acestea sunt utilizate mai rar, fiind adecvate doar fermelor individuale mici.

Maşinile semipurtate lucrează în agregat cu tractoare de diverse puteri, de la 22 CP (16 kW) la 200 CP (147 kW), funcţie de masa totală maximă autorizată a maşinii de administrat îngrăşăminte. Aceste maşini se caracterizează prin faptul că o parte din sarcină se transferă pe puntea spate a tractorului, ceea ce îmbunătăţeşte comportarea agregatului atât în condiţii de transport cât şi în condiţii de lucru, prin creşterea aderenţei punţii spate a tractorului.

Maşinile tractate, din ce în ce mai rar întâlnite, fac parte din categoria remorcilor tehnologice cu proţap articulat, sunt echipate cu sistem de direcţie cu rulment peridoc, au în componenţă tren de rulare biax.

Din punct de vedere a construcţiei trenului de rulare, maşinile de administrat îngrăşăminte organice pot fi cu tren de rulare monoax, biax sau tridem autodirecţional.

machines for the administration of organic fertilizers can be:

with horizontal rotors;
with vertical rotors;
wuth shredding discs and centrifugal rotors;
with chains and weights;
turbine type with palettes type;

Regarding the direction of distribution, the solid organic fertilizers spreaders are classified in the following categories:

with distribution behind the machine (on the whole working width in strips).

with distribution in the laterally side of the machine (on one side: left / right or on the both sides).

After the mode of operation of the conveyor:

mechanical, from the tractor APP (with continuous-advance, actuation with chain transmission; with discontinuous advance, actuation with ratchet mechanism);

hydrostatic with continuous advance, actuation with hydraulic gear motor

A machine for spreading livestock manure is made from a special trailer having the conveyor (with scrapers or screw) on the bottom of the ladleand in the back / sides or in front has attached the distribution device.

Din punct de vedere al aparatului de distribuție, maşinile de administrat îngrăşăminte organice solide sunt:

cu rotoare orizontale;
cu rotoare verticale;
cu discuri centrifugale şi rotoare de mărunțire;
cu lanțuri şi greutăți;
de tip turbină cu palete;

Din punct de vedere al direcției de distribuție, maşinile de împrăştiat îngrăşăminte organice solide se clasifică în următoarele categorii:

cu distribuție în spatele maşinii (pe toată lățimea de lucru, în benzi).

cu distribuție în laterala maşinii (pe o laterală: stânga/dreapta sau pe ambele părți).

După modul de acționare a transportorului:

mecanică, de la APP al tractorului (cu avans continuu, acționare cu transmisie cu lanț; cu avans discontinuu, acționare cu mecanism cu clichet);

hidrostatică, cu avans continuu, acționare cu motoreductor hidraulic

O maşina de împrăştiat gunoi de grajd este alcătuită dintr-o remorca specială care are pe fundul benei transportorul (cu raclete sau melcat) iar în spate/laterale sau față are montat aparatul de distribuție.

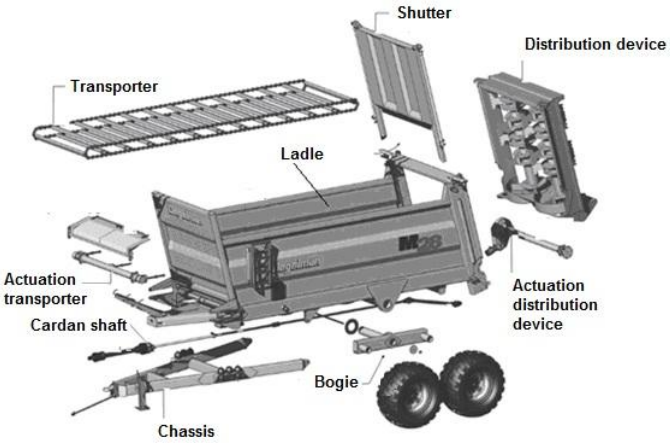


Fig 2 - Manure spreader components **[10]**

Nationally there have been concerns in the field of designing of technical equipment for administering solid organic fertilizers. Have been made machines for administering livestock manure on the soil surface in field crops (MIG-5, MIG-6A, MIG-10) and in fruit growing and viticultural sectors (MIG 2.2 and MIGV-1). These are no longer manufactured now, because over the years the organic fertilization took a secondary role in the agricultural development, their role being taken over by the mineral fertilization.

Internationally there are many manufacturers who have achieved machines for administering of solid organic fertilizers following the implementation of integrated systems for adjusting the flow rate and the working width, GPS monitoring systems of the fertilized lands. Among these companies are: Gilibert, Pichon (France), Kemper, Pöttinger, Fliegel (Germany), Westpoint, MMI International (USA), Kuhn (Canada), Corne Henri (England), Mutti Amos, Ren Mark (Italy) ş.a.

The distribution devices mounted on the spreading machines of solid organic fertilisers are of the following types: *rotor with coil, rotor with palettes, centrifugal discs, device type turbine with palettes, chains with weights.*

These are mounted on machines in various combinations and positions depending on the imagination

Pe plan național au existat preocupări în domeniul proiectării unor echipamente tehnice pentru administrarea îngrăşămintelor organice solide. Au fost realizate maşini de administrat gunoi de grajd la suprafața solului în culturile de câmp (MIG-5, MIG-6A, MIG-10) şi în sectoarele pomicol şi viticol (MIG 2,2 şi MIGV-1). Acestea nu se mai fabrică actualmente, deoarece de-a lungul anilor fertilizarea organică a ocupat un rol secundar în dezvoltarea agriculturii, rolul acestora fiind preluat de fertilizarea minerală.

Pe plan internațional sunt foarte mulți fabricanți au realizat maşini de administrat îngrăşăminte organice solide urmărind implementarea unor sisteme integrate de reglare a debitului şi a lățimii de lucru, sisteme de monitorizare GPS a terenurilor fertilizate. Printre aceste firme se numără: Gilibert, Pichon (Franța), Kemper, Pöttinger, Fliegel (Germania), Westpoint, MMI International (SUA), Kuhn (Canada), Corne Henri (Anglia), Mutti Amos, Ren Mark (Italia) ş.a.

Aparatele de distribuție montate pe maşinile de împrăştiat îngrăşăminte organice solide sunt de următoarele tipuri: *rotor cu spiră, rotor cu cuțite, discuri centrifugale, aparat tip turbină cu palete, lanțuri cu greutăți.*

Acestea se montează pe maşini în diverse combinații şi poziții în funcție de imaginația şi cercetările

and producers researches.

The distribution device type rotor with coil or with palettes

This type of distribution device can be mounted *horizontally* in number of one to three rotors. The chopping and spreading device of the livestock manure rotor type consists of a hollow axle on which there are welded the steel palettes helically arranged from the middle to the ends of the axle and extended with toothed plates shredding and spreading the livestock manure distributed. The palettes are angled half left, half right, to steer the material left and right in the distribution process (Fig.3c) **[13].** On the same principle on the hollow shaft is mounted the helical coil coiled half left and half right (Fig. 3a) **[16]** or knives type chisel (Fig.3b) **[17].**

producătorilor.

Aparatul de distribuție tip rotor cu spiră sau rotor cu palete

Acest tip de aparat de distribuție se poate monta în poziție *orizontală* în număr de unu până la trei rotoare. Dispozitivul de mărunțire şi împrăştiere a gunoiului de grajd, de tipul rotor este alcătuit dintr-un ax tubular pe care sunt sudate paletele de oțel dispuse elicoidal de la mijloc către capetele axului şi prelungite cu plăci dințate care mărunțesc şi împrăştie gunoiul de grajd distribuit. Paletele sunt înclinate jumătate-stânga, jumătate-dreapta, pentru a dirija materialul stânga-dreapta în procesul de distribuție (Fig.3c) **[13]**. Pe acelaşi principiu pe axul tubular se montează spira elicoidală cu înfăşurare jumătate stânga jumătate dreapta (Fig. 3a) **[16]** sau cuțite tip daltă (Fig.3b) **[17].**

a) b) c)

Fig 3. – Rear distribution with horizontal rotary shaft
a) one beater; b) two beaters; c) three beaters

The first generation of spreading machines had a single rotor with coil or palettes. From experiments it was found that the material is not properly shredded remaining large chunks, the fertilization being done excessively in some areas and insufficiently in others. Then it got the idea of adding another one or two rotors depending on the height of the machine hopper. These machines are used successfully even today especially for fertilizing works on small surfaces because it has the great disadvantage of a small scattering width equal to 1-1.5 from the machine width. As regards the spreading uniformity the machines with two or three rotors ensure appropriate uniformities to the norms and standards imposed.

The category of machines with horizontal rotors includes also equipment having mounted the distribution device laterally, able of distributing both liquid and solid fertilizers.

The machine has on the bottom of the ladlea hollow snail with helical palettes arranged in countersense which grinds and brings the material towards the outlet hole from where it is taken over by the distribution apparatus.

These palettes offer maximum protection against straw blocking by wrapping and provide an effective entrainment of the material over the entireladleof the machine, mixing at the same time the contained material. Another advantage given by the palettes form and their opposite arrangement is that they provide the avoidance of material agglomeration towards the front of machine and its clogging. It gives extra speed to the spreaded material, which makes that it to be thrown beyond the path of the wheels, avoiding the machine crossing over the spreaded material. The side distribution device has the active bodies disposed in cascade.

To solve the problem of the small spreading width It has been proposed to mount the rotors in a vertical plane, in even number (two or four) with the coils oriented in opposite directions.

Prima generație de maşini de împrăştiat au avut în componeță un singur rotor cu spira sau palete. Din experimentări s-a constatat ca materialul nu este mărunțit corespunzător rămânând bucăți mari, fertilizarea făcându-se exesiv în unele zone şi excedentar în altele. Atunci s-a ajuns la ideea adăugării a încă unuia sau două rotoare în funcție de înălțimea benei maşinii. Aceste maşini se folosesc cu succes şi astăzi mai ales pentru lucrări de fertilizare pe suprafețe mici întru-cât prezintă marele dezavantaj al unei lățimi mici de împrăştiere egală cu 1-1,5 din lățimea maşinii. În ceea ce priveşte uniformitatea de împrăstiere maşinile cu două sau trei rotoare asigură uniformitati corespunzătoare normelor şi standardelor impuse.

Din categoria maşinilor cu roatoare orizontale se numara şi echipametele care au montat aparatul de distributie în laterala maşinii, capabile să distribuie atât îngrăşăminte solide cât şi lichide.

Maşina are pe fundul benei un melc tubular cu palete elicoidale dispuse în contrasens care mărunțeşte şi aduce materialul către gura de evacuare de unde este preluat de aparatul de distribuție.

Aceste paletele oferă protecția maximă împotriva blocării paielor prin înfăşurare şi asigură o antrenare eficientă a materialului de-a lungul întregii bene a maşinii, amestecând totodată materialul conținut. Un alt avantaj dat de forma paletelor şi de dispunerea acestora în contrasens este că ele asigură evitarea aglomerării materialului către fața maşinii şi înfundarea acesteia. Se imprimă materialului împrăştiat un plus de viteză, fapt care face ca acesta să fie aruncat dincolo de calea de rulare a roților, evitând trecerea maşinii peste materialul împrăştiat. Aparatul de distribuție laterală are organele active dispuse în cascadă.

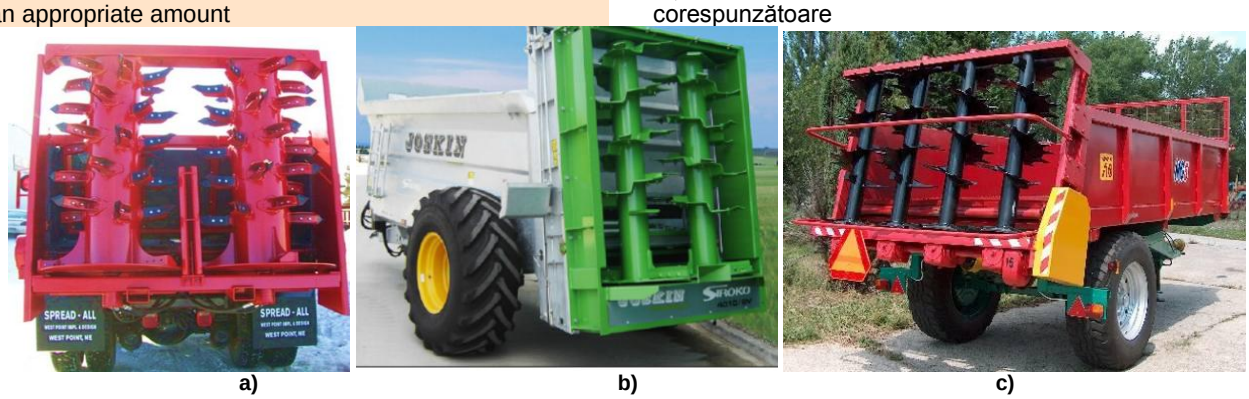
Pentru a rezolva problema lățimii mici de împrăştiere s-a propus montarea rotoarelor în plan vertical, în numar par (două sau patru) cu înfăşurarile spirelor orientate în direcții opuse.

Fig.4 - Side delivery manure spreader **[8]**

Fig.5 - Side delivery manure spreader **[15]**

It has been reached the proposed desideratum by realizing of large working width (8-22 m) but with the disadvantage of the distribution uniformity. The ends of the fertilized areas are presented in small quantities compared to the amount distributed on the machine center. This issue can be resolved at the next passing by superposing a working width so that to be able to provide an appropriate amount

S-a ajuns la dezideratul propus prin realizarea unor lățimi mari de lucru (8-22 m) dar cu dezavantajul neuniformității de distribuție. Extremitățile suprafețelor fertilizate se prezintă în cantități mici față de cât se distribuie pe centrul maşinii. Acest aspect se poate rezolva la următoarea trecere prin suprapunerea unei lățimii de lucru astfel încât să se poată asigura o cantitate corespunzătoare



a) **b)** **c)**

Fig.6 – Rear delivery vertical axis beters
a) Two vertical beaters with chisels knives **[8]** b) Two vertical beaters with coil and knives **[11]**
c) Four vertical beaters with helix and knives **[4]**

While working, the rotor palettes entraines the material with height *h* brought by transporter, fragmenting it and evacuating it from the machine. Thye spreading area width in the case of these machines represents (3…5) Bt.

Spreading screw diameter is of 450…600 mm, and the rotative speed of 300…1000 rev/min depending on the tractor from aggregate, because the spreading device is usually actuated by the PTO of the tractor.

The main advantages of these machines are: the achievement of greater distribution widths than the machines from the previous category, material is better shredded however existing the disadvantage that the uniformity of scattering is lower than in the previous case.

Distribution device type discs with palettes

The machines for the administration of solid organic fertilizers with distribution device with horizontal rotors have been improved by the addition of *centrifugal discs* at the base of the transporter (fig.2.34).

At this type of equipment the horizontal rotors purposes only shredding the material. The material thus

În timpul lucrului, paletele rotoarelor antrenează materialul de înălțime *h*, adus de transportor, îl fragmentează şi-l evacuează din maşină. Lățimea zonei de împrăştiere în cazul acestor maşini reprezintă (3…5) Bt.

Diametrul melcilor de împrăştiere este de 450…600 mm, iar turația de 300…1000 rot/min în funcție de tractorul din agregat, întrucât dispozitivul de împrăştiere este de regulă acționat de la priza de putere a tractorului.

Avantajele principale ale acestor maşini sunt: realizarea de lățimi mai mari de distribuție decat masinile din categoria precedentă, materialul este mărunțit mai bine existând totuşi dezavantajul ca uniformitatea de împrăştiere este mai redusă decât în cazul anterior.

Aparat de distribuție tip discuri cu palete

Maşinile de administrat îngrăşăminte organice silode cu dispozitiv de distribuție cu rotoare orizontale au fost îmbunătățite prin adăugarea de *discuri centrifugale* la baza transportorului (fig.2.34).

La acest tip de echipamente rotoarele orizontale având doar rol de mărunțire al materialului. Materialul

shredded falls on the discs with palettes and it is scattered by centrifugation, the disks having a speed of 400 - 700 rev/min.

With this system it observe that the distribution width increases from 2 ... 3 m to 10 ... 12m, the material being much better shredded, but scattered in a thinner cover.

The centrifugal distribution device is disposed at the bottom below the hopper, being mounted on the secondary shaft of the reducer with bevel gearing, actuated by the PTO of the tractor through the cardan drive.

The distribution device can be positioned behind the machine but also in front of it, laterally. The discs with palettes can be in number of one or two.

astfel mărunțit cade pe discurile cu palete şi este împrăştiat prin centrifugare, discurile având o turație de 400 - 700 rot/min.

Cu acest sistem se observa că lățimea de distribuție creşte de la 2...3 m la 10...12m, materialul fiind mult mai bine mărunțit, dar împrăştiat într-o peliculă mai subțire.

Aparatul de distribuție centrifugal este dispus în partea inferioară sub buncăr, fiind montat pe arborele secundar al reductorului cu angrenaj conic, acționat de la priza de putere a tractorului, prin transmisia cardanică.

Aparatrul de distribuție poate fi pozitionat în spatele maşii dar şi in față maşinii în lateral. Discurile cu palate pot fi în numar de unul sau două.

Fig.7 – Spreading disc with pallets **[14]**

Distribution device type "turbine"

The distribution device type "turbine" has a large diameter (1-1.5 m), being actuated by the tractor's PTO. By orienting the turbine outlet by changing the position of the deflector palettes may be achieved variable working widths, and by varying the transporter speed and the turbine rotative speed different norms of livestock manure can be administered per unit area.

Aparat de distribuție tip "turbină"

Aparatul de distribuție de tip turbină are diametru mare (1-1,5 m), este acționat de la priza de putere a tractorului. Prin orientarea gurii de evacuare a turbinei şi prin modificarea poziției paletelor deflectoare se pot realiza lățimi de lucru variabile, iar prin varierea vitezei transportorului şi a turației turbinei se pot administra diferite norme de gunoi de grajd pe unitatea de suprafață.

Fig.8 – Turbine spreader **[14,9]**

Distribution device type with rotary chains

Another system of distribution of organic fertilizers by centrifugation is the one composed of chains with weights.

In comparison with other machines where the manure moves to the distribution device, this machine is characterized by the fact that both the fertilizer and the distribution device do not change their position to each other. The ladle is hermetically sealed and has at the top two folding shutters serving as covers or deflectors ensuring the throw of the material in a single direction. In the center of the ladle, on the longitudinal axis, there is a rotor with chains provided at the ends with one weight exchangeable depending on the fertilizer consistency. By spinning the rotor, because of the centrifugal force, the weights extend the chains and thus becomes an active organ similar to a shaft with palettes.

Aparat de distribuție tip cu lanțuri rotative

Un alt sistem de distribuire a îngrăşămintelor organice prin centrifugare este cel format din lanțuri cu greutăți.

In comparație cu celelalte maşini în care gunoiul se deplasează către aparatul de distribuție, această maşina se caracterizează prin faptul ca atât îngrăşământul cât şi aparatul de distribuție nu-şi schimba poziția unul față de altul. Bena este perfect etanşă şi are în partea superioară două obloane rabatabile care servesc drept capace sau ca paravane ce asigură aruncarea materialului într-o singura direcție. În centrul benei, pe axa longitudinală, se află un rotor cu lanțuri prevăzute la extremități cu câte o greutate ce se poate schimba în funcție de consistența îngrăşământului. Prin învârtirea rotorului, datorită forței centrifuge, greutățile întind lanțurile şi astfel devin un organ activ similar cu un ax cu palete.

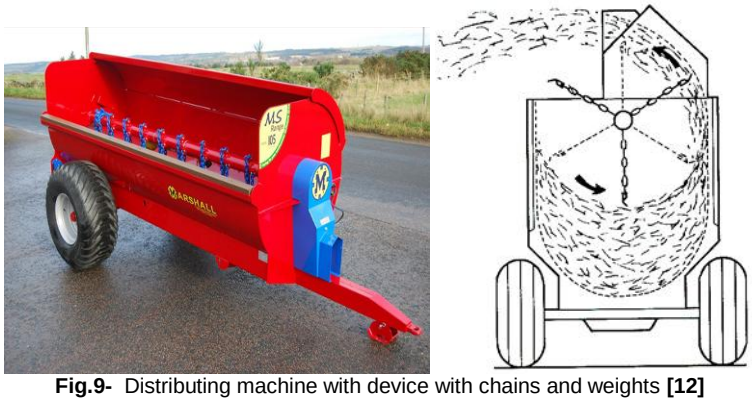


Fig.9- Distributing machine with device with chains and weights **[12]**

CONCLUSIONS

The soil fertilization with organic fertilizers has a clear role in the qualitative and quantitative increase of the yields per unit area. No other mineral fertilizer, straight or compound can not compensate the specific effects but also complex of the organic fertilizers on soils and crops.

The application of organic fertilizers is performed mechanically, by means of some machines or equipment intended for their administration, machines that are based on certain constructive principles described in the present study.

The performances of the equipment for the organic fertilizers distribution are influenced by the following physico-mechanical properties of the fertilizers: the dry matter content, density, particles sizes, the frictional characteristics and the shear properties.

The working capacity of the machines is influenced by the width of distribution, the speed of movement of the aggregate and of the net volume of the ladle.

The manure spreaders with horizontal ROTORS achieves spreading widths of about (1 ... 1.5)B_t, B_t being the machine width. The diameter of the spreading rotors is generally of 300 ... 550 mm, and the circumferential speed of 4…12 m/s (n = 300…850 rev/min), the spreading width being of 2...3.5 m.

The manure spreaders with vertical rotors achieves spreading widths of about (3…5) B_t. The largest spreading widths reach 18 m (the system provided by the company Fliegl Germany). The spreading drum diameter is of 450 ... 600 mm, and the rotation speed of 300…950 rev/min depending on the tractor in aggregate, because the spreading device is usually driven by the PTO of the tractor.

The machines with distribution device with centrifugal discs, placed at the base of the horizontal drums, achieves the greatest widths of distribution, reaching up to approx. 22 m, under a higher degree of shredding.

The necessary powers for the transporters driving varies between 5 to 6.5 HP (7-9 kW)

The powers necessary to drive the distribution devices varies between 10-15 CP (7-11 kW)

The tractor power from aggregate: 25-200 CP.

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CONCLUZII

Fertilizare solului cu îngrăşăminte organice are un rol bine definit în sporirea randamentelor calitative şi cantitative la unitatea de suprafață. Nici un alt îngrăşământ mineral, simplu sau compus nu poate suplini efectele specifice dar şi complexe ale fertilizanților organici asupra solurilor şi culturilor.

Aplicarea îngrăşămintelor organice se realizează mecanizat, cu ajutorul unor maşini sau echipamente destinate administrării acestora, maşini ce au la bază anumite principii constructive descrise în studiul de față.

Performanțele echipamentelor de distribuit îngrăşăminte organice sunt influențate de următoarele caracteristici fizico-mecanice ale îngrăşămintelor: conținutul de materie uscată, densitatea, dimensiunile particulelor, caracteristicile de frecare şi proprietățile de forfecare.

Capacitatea de lucru a maşinilor este influențată de lățimea de distribuție, de viteza de deplasare a agregatului, de volumul util al benei.

Maşinile de împrăştiat gunoi de grajd cu ROTOARE orizontale realizează lățimi de împrăştiere de cca.(1…1,5)B_t , B_t fiind lățimea maşinii. Diametrul rotoarelor de împrăştiere este, în general, de 300…550 mm, iar viteza periferică de 4…12 m/s (n = 300…850 rot/min), lățimea de împrăştiere fiind 2...3,5 m.

Maşinile de împrăştiat gunoi de grajd cu rotoare verticale realizează lățimi de împrăştiere de (3…5) B_t. Cele mai mari lățimi de împrăştiere ajung la 18 m (sistemul oferit de firma Fliegl Germania). Diametrul tobelor de împrăştiere este de 450…600 mm, iar turația de 300…950 rot/min în funcție de tractorul din agregat, întrucât dispozitivul de împrăştiere este de regulă acționat de la priza de putere a tractorului.

Maşinile cu aparat de distribuție cu discuri centrifugale, plasate la baza tobelor orizontale, realizează cele mai mari lățimi de distribuție, ajungând până la cca.22 m, în condițiile unui grad de mărunțire superior.

Puterile necesare antrenarii transportoarele variaza intre 5-6,5 CP (7-9 kW)

Puterile necesare actionarii aparatelor de diatributie variaza intre 10-15 CP (7-11 kW)

Puterea tractorul din agregat: 25-200 CP.

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EXPERIMENTAL RESEARCH OF AGRICULTURAL EQUIPMENT TYRES DESIGNED TO THEIR RATIONAL USE
/
CERCETAREA EXPERIMENTALA A PNEURILOR DE PE ECHIPAMENTELE AGRICOLE ÎN VEDEREA UTILIZĂRII RAȚIONALE ALE ACESTORA

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Abstract: *Soil compaction is one of the most important factors of anthropogenic influence on soil physical properties with immediate effect over the farms management and environment. The paper presents the results of experimental research carried out with a mobile stand designed and built for testing several types of tyres used on agricultural machinery in order to determine their influence on soil and energy parameters. Parameters measured, footprint, penetration resistance, tensile strength and tyres rational and efficient utilization contribute to reduce soil compaction and settlement.*

Keywords: *tyres, agricultural machinery, penetration resistance, soil protection*

Rezumat: *Compactarea solului este unul dintre cei mai importanți factori de influența antropică asupra proprietăților fizice ale solului cu efecte imediate asupra managementului fermelor agricole şi asupra mediului înconjurător. În lucrare sunt prezentate rezultate ale cercetărilor experimentale realizate cu un stand mobil proiectat şi realizat pentru a efectua testarea mai multor tipuri de pneuri utilizate pe echipamentele tehnice din agricultură, în vederea determinării influenței acestora asupra solului şi a parametrilor energetici. Parametrii măsurați pata de contact, rezistența la penetrare, forța de tracțiune contribuie la alegerea* si *utilizarea rațională şi eficientă a pneurilor pentru reducerea compactării şi tasării solului.*

Cuvinte cheie: *pneuri, maşini agricole, compactarea şi tasarea solului, rezistenta la penetrare, protecția solului*

INTRODUCTION

Soil artificial compaction (anthropic) is determined by aggregates passing in the field when they perform the agricultural works required by the mechanizing technologies or during transport of technological and farming products.

In Romania, most of soils are compacted, being of heavy and average structure (the clay content varying between 30-50%), low drain and often they comprise an impermeable soil layer [4].

Soil compaction also affects water dynamics in the soil, erosion, nitrogen and carbon cycle in soil, the energy necessary and efficacy of farming operations, as well as, pesticides washing, soil biology and plant cultivation technologies.

Soil compaction, determined by agricultural traffic results in soil structure damaging in its surface and depth layers, modifying the pores size, pores continuity, thus, of water and air permeability. All these may have negative effects on soil biological activity, its physico-chemical balance and production.

The direct effect of soil compaction on total porosity is manifest by reducing soil ability to retain water and air in a sustainable manner.

Soil compaction and settlement determine the appearance of deeper and more compacted strips, enhancing the surface erosion risk, water slop, inappropriate use of nutrients by plants and their leaching in depth.

Intensity and extent of artificial compaction depends on a multitude of general but also local factors, such as: climate, equipment technical characteristics and methods of implementation of different components of

INTRODUCERE

Compactarea artificială a solului (antropică) se datorează traficului efectuat de agregate pe teren pentru efectuarea diferitelor lucrări agricole impuse de tehnologiile de mecanizare sau de efectuarea unor lucrări de transport a produselor tehnologice sau agricole.

În România, majoritatea solurilor sunt compactate, cu textură mijlocie şi grea (conținutul de argilă variază între 30-50%), drenaj prost şi adesea cu un strat de sol impermeabil. [4].

Compactarea solului afectează dinamica apei în sol, eroziunea, ciclul azotului şi carbonului în sol, necesarul de energie şi eficacitatea lucrărilor agricole, spălarea pesticidelor, biologia solului, precum şi tehnologiile de cultivare a plantelor.

Compactarea solului, cauzată de traficul agricol, are ca efect deteriorarea structurii solului în straturile de suprafață şi în adâncime, modificarea distribuției porilor după mărime, continuitatea porilor şi deci a permeabilității pentru apă şi aer. Acestea pot avea efecte negative asupra activității biologice din sol, asupra echilibrului fizico-chimic şi asupra producției.

Efectul direct al tasării solului asupra porozității totale se manifestă prin reducerea capacității acestuia de a reține în mod durabil apa şi aerul.

Compactarea şi tasarea solului conduc la formarea unor benzi mai adânci şi compacte, sporind astfel riscul producerii eroziunii de suprafață, al băltirii apei, al proastei utilizări a nutrienților de către plante şi a levigării lor în adâncime.

Intensitatea şi extinderea procesului de compactare artificială depinde de o multitudine de factori având caracter general, dar şi specific local, precum: clima, caracteristicile tehnice ale echipamentelor agricole şi modalitățile de implementare în practică a diferitelor

agricultural technological systems, intrinsic features of each type of soil.[5].

Load size on running systems of farming equipment during its movement or staying on soil surface represents a very important factor especially for avoiding the deep artificial compaction of soil.

Therefore, in order to avoid the appearance and development of artificial compaction, in most countries it is recommended to limit the mass on axle to 4000...6000 kg, the wheels on axle should be increased (utilization of additional axles), and working pressure in the processed agricultural field should be limited to approx.50...60 kPa and about 80 kPa in case of running system with twinned wheels [1].

Researches have been made related to wheel-soil interaction, aiming at a rational use of tyres as a general rule and especially in terms of farming equipment when running conditions are totally different from running in highroads, researches to which generally refer the studies, their majority addressing to motor cars and tractors [1, 2,3].

Experimental researches performed with a mobile stand were designed to wheel- (tyre)-soil relation in case of tyres used with farming trailers and technical equipment, where are used especially carrying tyres instead of driving tyres, starting from tests and researches made up to now on tractors tyres [1].

MATERIAL AND METHOD

In order to study the tyre soil interaction of different types of tyres designed to agricultural machines, the *Stand for tyres testing, STP*, figure 1 was achieved as a main technical mobile equipment of uniaxial type, designed to perform different typo-dimensional tests, at different air pressure and in different types of lands; the result was to draw up a practical guide designed to be used by all the interested persons for a rational and optimum use of tyres on agricultural equipment.

componente ale sistemelor tehnologice agricole; însuşirile intrinseci specifice fiecărui tip de sol.[5].

Mărimea sarcinilor pe sistemele de rulare ale echipamentelor agricole în timpul deplasării sau staționării pe suprafața solului reprezintă un factor deosebit de importantă, îndeosebi pentru evitarea inducerii compactării artificiale a solului în adâncime.

Din acest motiv pentru evitarea apariției şi dezvoltării compactării artificiale, în majoritatea țărilor se recomandă limitarea masei pe osie la 4000...6000 kg, se încurajează creşterea numărului de roți pe osie sau a numărului de osii (utilizarea osiilor auxiliare), iar presiunea în pneuri, în timpul lucrului pe terenul agricol prelucrat, se limitează la cca.50...60 kPa şi la cca.80 kPa în cazul sistemului de rulare cu roți jumelate [1].

In domeniul abordat au fost realizate cercetări referitoare la interacțiunea roată –sol urmărind utilizarea rațională a pneurilor în general, şi pe mijloacele din agricultură în special, unde condițiile de rulare sunt cu totul diferite față de rularea pe drumurile amenajate, la care în general se referă studiile elaborate, majoritatea acestora adresându-se automobilelor şi tractoarelor [1, 2,3].

Cercetările experimentale, efectuate cu un stand mobil, au vizat relația roată (pneu) – sol în cazul pneurilor utilizate pe remorci şi pe echipamentele tehnice utilizate în agricultură, unde sunt utilizate cu precădere pneuri portante şi mai puțin motoare, plecând de la experiențele şi cercetările efectuate până în prezent pe pneurile de tractoare [1].

MATERIAL ŞI METODĂ

Pentru studierea interacțiunii pneu-sol a diverselor tipuri de pneuri destinate maşinilor agricole, s-a realizat *Standul pentru testare pneuri, STP*, figura 1, sub forma unui echipament tehnic de bază mobil, de tip monoax şi destinat efectuării testărilor pentru mai multe tipodimensiuni de pneuri, la diferite presiuni ale aerului în pneu şi pe diverse tipuri de teren în vederea elaborării unui îndrumar practic, care să fie utilizat de către toți factorii interesați, în scopul final al utilizării raționale şi optime a pneurilor pe utilajele agricole.

Fig. 1 – Stand for tyre testing, STP, equipped with tyres for testing
1. shutter; 2. assembled chassis; 3. body shell; 4. drivetrain; 5. tyre to be tested

Tests were performed with testing stand trailed by tractor NH TD 80D New Holland, of 50HP.

Body was loaded with approx.5000kg loading material, after which the aggregate Stand of testing + tractor NH TD 80D, moved forward in the testing land: asphalt, earth road, stubble field, processed field for establishing agricultural crops.

Testing stand was alternatively equipped, for testing with 5(five) types of tyres, organized in such way that conclusions should be drawn comparatively in two variants, according to table 1.

Testing load measured on tyre has maintained steady

Testările s-au efectuat cu standul de testare tractat de tractorul NH TD 80D New Holland, cu o putere de 50CP.

Bena standului s-a încărcat cu cca.5000kg material de lestare (balast), după care agregatul Stand de testare + tractorul NH TD 80D, s-a deplasat pe loturile de testare: asfalt, drum de pământ, mirişte, teren prelucrat pentru înființarea culturilor agricole.

Standul de testare a fost echipat alternativ, pentru testări, cu 5(cinci) tipuri de pneuri, organizate astfel încât concluziile să fie formulate comparativ, în două variante, conform tabel 1.

Sarcina de testare pe pneu măsurată, s-a menținut

and was of 2.63 tons.

There were made tests for five types of tyres at three air pressures, respectively: 3, 5; 3; 2.5 bar. A few aspects during the tests are shown in figure 2.

Apparata used

For performing the measurements during the experiments, the following specialized equipment was used:

-Tensiometric bar, 0-60 kN, with two channels for traction and compression;
-System of data acquisition;
- Laptop ;
- Romanian lever scale;
- TEKSCAN system with net and amplifying system of MG6 Plus, HBM type;
- Gauge tape 0-5 m, Series no. QK5529;
- Manometer, Series no. 3295;
- Penetrometer SOIL COMPACTION METER SC 900 – SPECTRUM;
- Penetrometer Penetrologger with GPS, Eijkelkamp, Series no. 29266403 with humidity sensor for soil Theta Probe, type ML2x; Delta-T Company, England.

constantă si a fost de 2,63 tone.

S-au realizat experimentări pentru cinci tipuri de pneuri: la trei presiuni ale aerului din pneu, respectiv: 3, 5; 3; 2,5 bar. Câteva aspecte din timpul experimentărilor sunt prezentate în figura 2.

Aparatura utilizată

Pentru efectuarea măsurătorilor în timpul experimentelor s-au utilizat următoarele echipamente specializate:

-Bară tensiometrică, 0-60 kN, cu două canale pentru tracțiune şi compresiune;
-Sistem achiziție date;
- Laptop ;
- Basculă ROMÂNĂ;
- Sistem TEKSCAN cu plasă şi sistem de amplificare de tip MG6 Plus, HBM;
- Ruletă de măsură 0-5 m, Seria nr. QK5529;
- Manometru, Seria nr. 3295;
- Penetrometru SOIL COMPACTION METER SC 900 – SPECTRUM;
- Penetrometru Penetrologger cu GPS, Eijkelkamp, Seria nr. 29266403 cu senzor umiditate pentru sol Theta Probe, tip ML2x; Firma Delta-T Anglia.

Table 1

Variants of tyres tested

Den.No..	Variant I		
	Approximately equal diameters and different widths		
	Tyre Code	Diameter (D)	Width (section B)
1.	Tyre 11.5-15.3	845 mm	290 mm
2.	Tyre 400-15.5	874 mm	404 mm
3.	Tyre 19.0/45-17	866 mm	491 mm
Den.No..	Variant II		
	Approximately equal width and different diameters		
	Tyre Code	Diameter (D)	Width (section B)
1.	Tyre 14.9 R24	1237 mm	392 mm
2.	Tyre 16.0/70-20	1078 mm	405 mm
3.	Tyre 400-15.5	874 mm	404 mm

Fig. 1 – Aspects during the tests (contact spot, resistance to running, settlement)

RESULTS

During the tests, a series of parameters that influence both tyres state and their action on soil, were determined. They were: pressure in tyre, running and static range, contact spot, resistance to running, humidity and penetration resistance and also the parameters allowing to estimate the mark left in soil by loaded tyres.

In this paper, we have referred to determinations of traction force (resistance to running) and penetration resistance, which clearly inform about the energy consumption and compression and compaction level.

Values of traction force determined are shown in table 2, and those of penetration resitance in table 3.

Variations of the two parameters, for tested tyres, at different pressures of air in tyre and in different types of

REZULTATE

In timpul experimentărilor s-au determinat o serie de parametri care influențează atât starea pneurilor cât şi acțiunea acestora asupra solului, precum: presiunea în pneu, razele de rulare şi statice, pata de contact, rezistența la rulare, umiditatea şi rezistența la penetrare precum şi parametri care permit aprecieri asupra urmei lăsate pe sol după trecerea pneurilor sub sarcină.

În lucrarea de față s-au făcut referiri asupra determinărilor forței de tracțiune(rezistență la rulare) şi rezistenței la penetrare care dau indicii clare asupra consumului energetic şi a gradului de tasare şi a compactării.

Valorile forței de tracțiune determinate sunt prezentate în tabelul 2, iar ale rezistenței la penetrare în tabelul 3.

Variațiile celor doi parametri, pentru pneurile testate, la diferite presiuni ale aerului în pneu şi pe diferite tipuri de suprafețe, atât individual cât si comparativ pentru cele două

land, were presented as diagrams. A few representative examples are shown in diagrams from figures 3, 4.

variante testate, au fost prezentate sub forma unor diagrame. Câteva exemple reprezentative sunt prezentate în diagramele din figurile3, 4.

Table 2

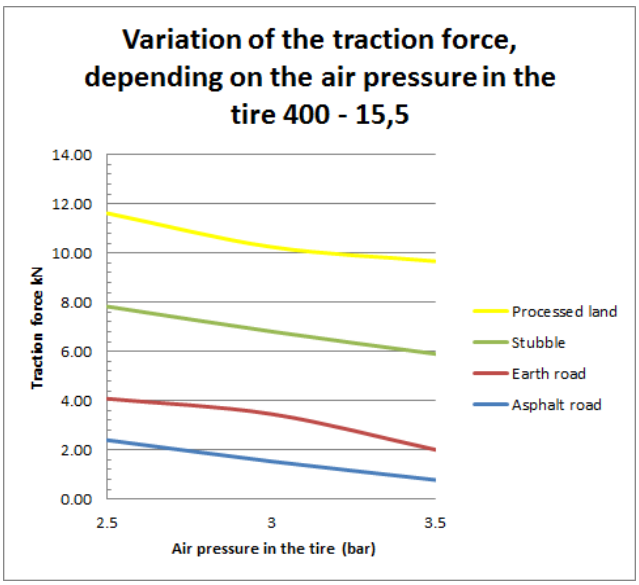
The values of the traction force (rolling resistance)

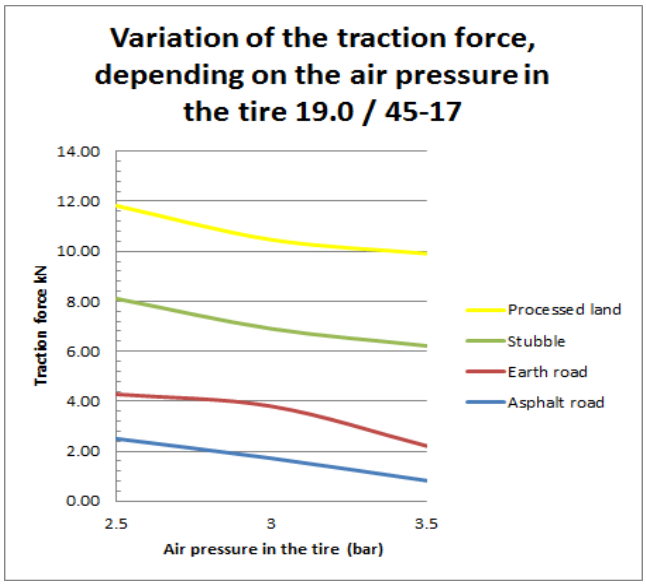
Type of tyre [code]	Pressure Bar											
	2.5	3	3.5	2.5	3	3.5	2.5	3	3.5	2.5	3	3.5
	Type of land											
	Asphalt road			Earth road			Stubble			Processed land		
	Traction force											
11,5-15,3	1.453	1.052	0.499	2.108	1.438	0.7975	5.261	4.379	3.446	10.285	9.110	8.389
400 -15,5	2.404	1.54	0.788	4.088	3.463	2.012	7.832	6.816	5.905	11.620	10.252	9.672
19.0 / 45-17	2.505	1.72	0.828	4.283	3.803	2.215	8.105	6.902	6.218	11.822	10.462	9.908
16.0 / 70-20	1.312	0.8174	0.625	5.042	2.302	1.858	6.788	4.783	4.503	9.783	8.886	8.015
14.9 R 24	1.211	0.791	0.583	4.721	2.089	1.708	6.223	4.598	4.102	9.325	8.325	7.912

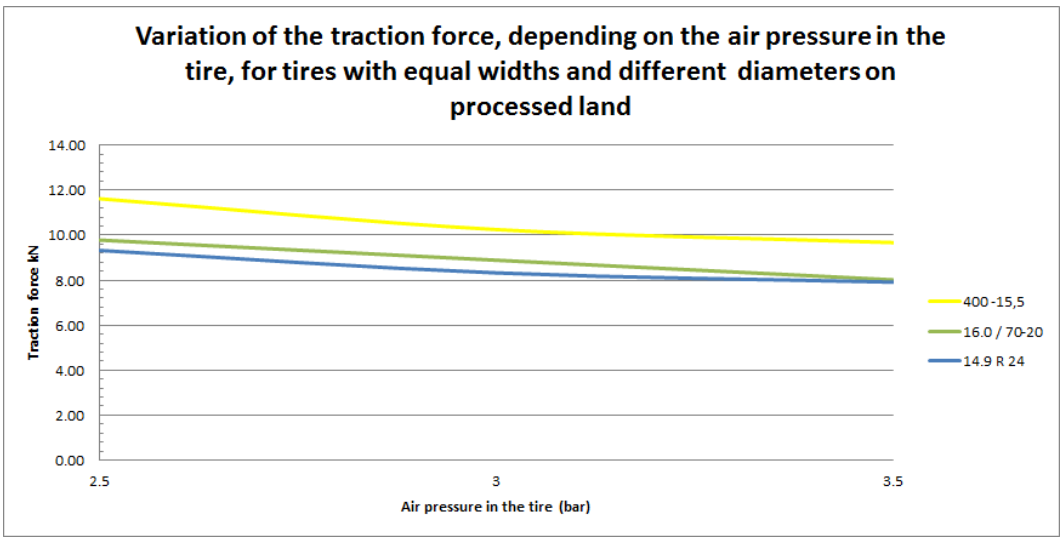
Table 3

The penetration resistance for processed land for tyre 19.0/45 R17

Penetration resistance before crossing of the tyres				After crossing								
				Tyre 19/45 17								
				Pressure in tyre 2,5 bar			Pressure in tyre 3 bar			Pressure in tyre 3,5 bar		
Depth (cm)	Point 1	Point 2	Point 3	Point 1	Point 2	Point 3	Point 1	Point 2	Point 3	Point 1	Point 2	Point 3
0	0.35	0.27	0.39	0.35	0.24	0.28	0.46	0.42	0.43	0.58	0.61	0.58
1	0.35	0.27	0.42	0.35	0.64	0.89	0.52	0.73	0.9	0.69	0.82	0.91
3	0.47	0.36	0.52	0.63	0.98	1.19	0.74	1.03	1.11	0.85	1.09	1.04
5	0.72	0.46	0.56	0.66	1.04	1.01	0.86	1.06	0.99	0.97	1.09	0.98
7	0.79	0.51	0.79	0.81	0.92	1.04	0.9	1.02	1	0.89	1.12	0.96
9	0.9	0.52	0.97	0.94	0.98	1.17	0.95	1.1	1.09	0.89	1.22	1.02
11	0.98	0.7	1.03	1.08	1.15	1.28	0.95	1.3	1.19	1.09	1.45	1.1
13	1.11	1.12	1.11	1.25	1.36	1.34	1.2	1.44	1.38	1.09	1.53	1.42
15	1.12	1.38	1.11	1.39	1.41	1.37	1.1	1.47	1.48	1.12	1.53	1.6
17	1.2	1.76	1.15	1.45	1.47	1.65	1.12	1.61	1.66	1.22	1.76	1.67
19	1.16	1.94	1.42	1.56	2.02	1.85	1.4			1.25		
21	1.3	2.44	1.78	1.94	2.31	2.03	1.68			1.43		







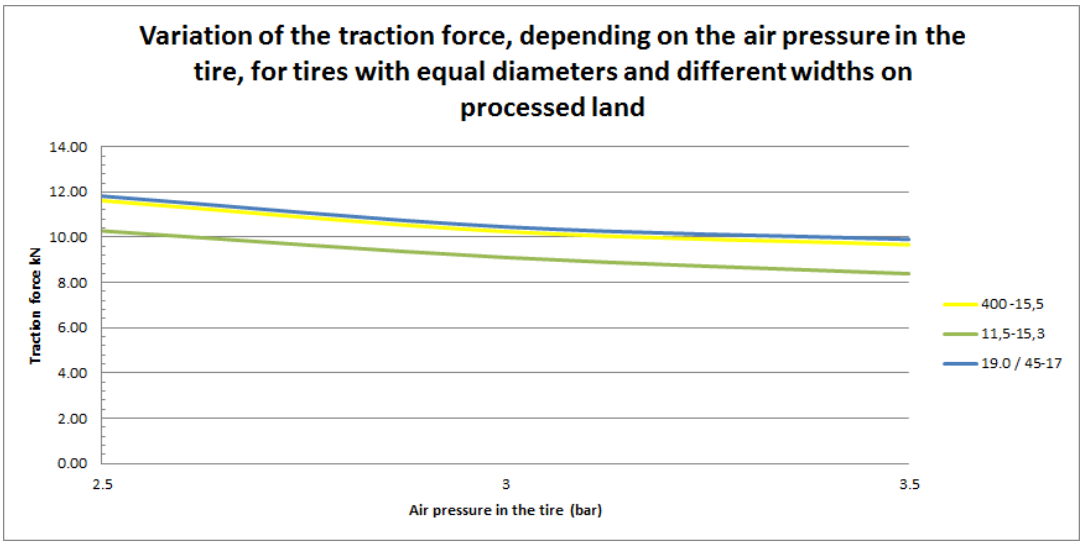


Fig. 3 – A few diagrams of traction force variation

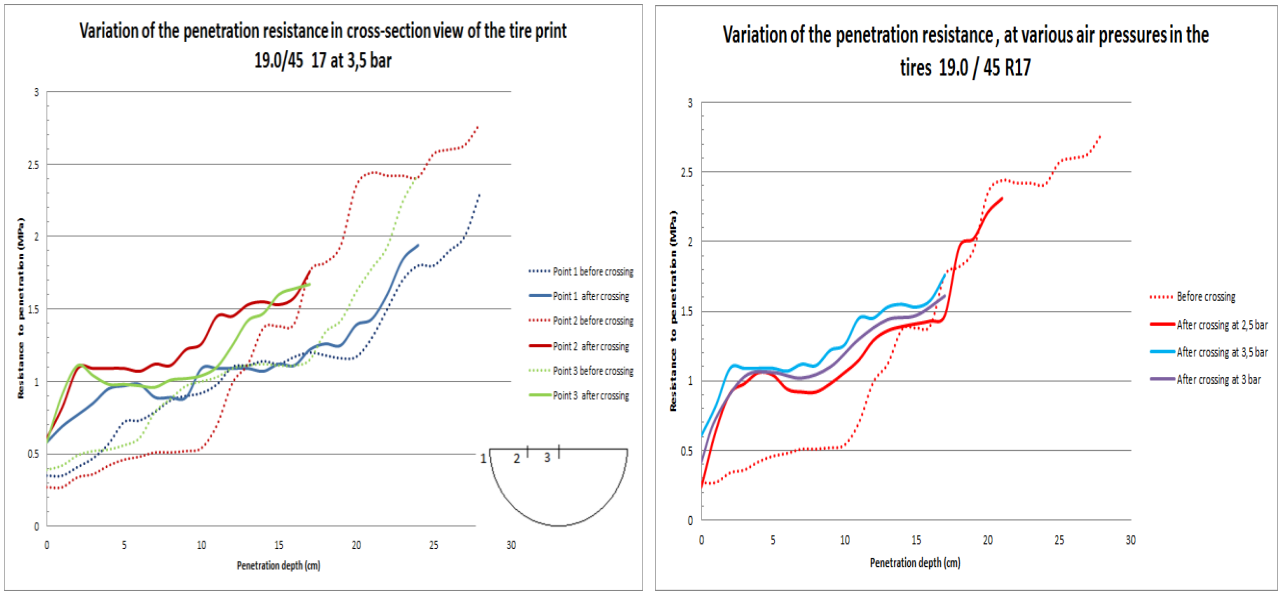


Fig.4 – Variation of resistance to penetration of tyre 19.0/45-17

CONCLUSIONS

- tyre resistance to running has increased along with air

CONCLUZII

- rezistenta la rulare a pneului creste odată cu scăderea

pressure decrease, fig. 3;
- for tyre having the same width, resistance to running is higher at smaller diameter tyres, fig. 3;
- running resistance increases when the equipment runs in uneven field, fig. 3;
- in the cross section of the tyre track in soil, the compaction degree has increased from the exterior to interior of the track, fig. 4.
- soil compaction after tyre displacement increases along with air pressure from tyre growth, fig. 4.

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presiunii aerului din pneu, fig. 3;
- la pneuri cu aceeaşi lățime, rezistenta la rulare este mai mare la pneurile cu diametru mai mic, fig. 3;
- rezistenta la rulare creste la deplasarea pe terenuri deformabile, fig. 3;
- in secțiunea transversala a urmei lăsate pe sol după trecerea pneului, gradul de compactare creste de la exteriorul spre interiorul urmei, fig. 4.
- compactarea solului in urma deplasării pneului creşte odată cu creşterea presiunii aerului din pneu, fig. 4.

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EXPERIMENTATION METHODOLOGY FOR SEEDS TREATMENT EQUIPMENT WITH BRUSH SCREW CONVEYOR
/
METODOLOGIE DE EXPERIMENTARE LA UN ECHIPAMENT DE TRATAT SEMINTE CU TRANSPORTOR ELICOIDAL CU PERII

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Abstract: *Establishing a suitable seed and grain crops coating technology involves a thorough analysis of all the factors involved in the coating seed process, as: seed quality, destination, special characteristics depending on the variety of seed conditioning, etc. By "seed treatment" it is means any process that they have undergone before sowing in order to obtain high and stable yields. The worldwide research conducted in this field, highlighted a series of aspects relating to the need for further research of these coating technologies.*
This paper presents the testing methodology for the seeds treatment equipment with screw conveyor with brush in order to determine coverage degree with the treated substance.

Keywords: *cereal seed, chemical treatment coverage degree, screw conveyor with brush*

INTRODUCTION

The use of high physiologic quality seeds, is essential for the highest yields of the crops. These seeds are more likely to get high performance when exposed to different environmental conditions, high speed germination and a good initial seedling development and final production growth[5]. During seed production are adopted several strategies to ensure high-quality seed.

After sowing, the seeds are still exposed to environmental factors biotic and abiotic [1] and agricultural soils have many pathogenic microorganisms that can interact with seeds and seedlings results [3] and may reduce their performance causing rotting of seeds, death seedlings or root rot [4]. Phytophagous insects in the soil can also affect planting and significantly reduces plant population [2].

Modern seed treatment products provides control target pests and diseases and ensure healthy plants and viguros.Formularea creating their applications on an industrial scale also helps growers improve safety and protect the environment. [6]

Seed Treatment is a term that describes both products and processes. The usage of specific products and specific techniques can improve the growth environment for the seed, seedling, and young plant. Seed Treatment complexity ranges from a basic dressing, to coatings and pelleting:

Seed Dressing: The most common method of Seed Treatment. The seed is dressed with either a dry formulation or wet treated with a slurry or liquid formulation. Dressings are applied both on-farm and industrially.

Seed Coating: A special binder is used with a

Rezumat: *Realizarea unei tehnologii adecvate de acoperire a semințelor de cereale şi plante tehnice presupune o analiză aprofundată a tuturor factorilor care participă la procesul de tratare chimică a semințelor, precum: calitatea semințelor, destinația acestora, particularitățile condiționării semințelor în funcție de soi etc. Prin „tratamentul semințelor" se înțelege orice proces la care sunt supuse semințele înainte de semănat, cu scopul obținerii unor producții mari și stabile. Cercetările realizate pe plan mondial în acest domeniu au scos în evidența o serie de aspect referitoare la necesitatea aprofundării cercetării acestor tehnologii de acoperire. Lucrarea prezintă metodologia de experimentare pentru un echipament de tratat semințe cu transportor elicoidal cu perii in vederea determinării gradului de acoperire a semințelor cu substanța de tratat.*

Cuvinte cheie: *semințe de cereale, tratare chimica, grad de acoperire, transportor elicoidal cu perii*

INTRODUCERE

Utilizarea de semințe de înaltă calitate fiziologica, este esentiala pentru obținerea de randamente maxime a culturilor. Aceste semințe sunt mult mai probabil a obține o înaltă performanță atunci când sunt expuse la condiții de mediu diferite, o viteză de răsărire ridicata şi, o buna dezvoltare inițială a răsadului şi creşterea producției finale.[5] În timpul producției de semințe sunt adoptate mai multe strategii pentru a asigura o calitate înaltă a semințelor.

După însămânțare, semintele sunt încă expuse la factorii de mediu biotici și abiotici[1] si solurile agricole au multe microorganismele patogene care pot interacționa cu semințele și răsadurile rezultate [3], și pot reduce performanțele lor cauzand putrezirea semințelor, moartea răsadurilor sau putregaiul rădăcinei [4]. Insectele fitofage din sol poate afecta, de asemenea răsadurile şi de a reduce în mod semnificativ populația de plante[2].

Produsele moderne de tratare a semințelor oferă controlul dăunătorilor țintă și a bolilor și să asigure crearea de plante sănătoase și viguros.Formularea lor și aplicațiile pe scara industriala, de asemenea, contribuie la îmbunătățirea sigurantei cultivatorilor si protectiei asupra mediului. [6]

Tratamentul semințelor' este un termen care se refera atât la produse cat si la procese. Utilizarea de produse specifice şi tehnici specifice pot îmbunătăți ediul de creştere pentru semințele, răsaduri, şi tinerele plante. Complexitatea tratarii semințelor variază de la o simpla stropire a semintelor, pana la acoperire și drajare completa.

Stropirea semințelor: Cea mai comună metodă de tratament al seminței. Semințele sunt stropite fie cu o suspensie uscata gen mocirlire sau substanta lichida. Aceasta metoda este aplicata atât la fermă cat și

formulation to enhance adherence to the seed. Coatings require advanced treatment technology. Seed Pelleting: The most sophisticated seed treatment technology, resulting in changing the physical shape of a seed to enhance plantability and handling. Pelleting requires specialized application machinery and techniques and is the most expensive of the applications.

Simple equipment, only for a basic dressing, and for small quantities is the screw conveyor type machine used in cereals. The more complex the treatment, the more cost is involved. Many modern treatment machines can provide specific formulation and dosing by way of a direct injection process.The most sophisticated treatment machines can provide the various formulations and additives as layers on the seed, which allows precise placement of the active ingredient.[7]

MATERIAL AND METHOD

A simple equipment with screw conveyors brush is IMTS-2. This equipment is intended for treatment of cereal and technical plant seeds before packaging, wet with insecticide-fungicide solutions. It can be used both in seed conditioning stations and in private households.

IMTS-2 structure is composed of: framework one (construction steel profiles, joined together by welding. Holds directly or indirectly, other components of the system); the hopper 2 (welded construction, provided at the bottom with a sybarite who ensure uniform seed flow) provided at the bottom with a sybarite which ensures uniformity of seed flow; 3 drum with spray (in his interior is mounted the spreading disc, who is connected to an electric motor, and provides a speed of 3000 rev / min, ensures atomisation of the liquid to be treated, at the surface of the seeds) in that is mounted the spreading disk; 4 is liquid dispenser (constructive device is a metal (welded pipe placed in a vat of metal sheet) which is provided for delivering a dose of the liquid in the tank with adjustable level in the drum for spraying), the carrier mixer 5 (which is a sub-assembly is provided for delivering a dose of the liquid in the tank with adjustable level in the drum for spraying), the homogenizer conveyor 5 (It is a subset that includes gutter, construction welded metal provided with two holes bag dischargers product auger conveyor brushes yarn rayon pump carrying liquids from tank to dispenser of liquid, brushes screw conveyor serve to transport the product to the mouth of the bag but realized at the same time homogeneous liquid wetting treat this reservoir fluid 6 (galvanized steel frame fitted with level indicator and valves and agitator driven electromagnetic force and control wiring 7 (realizes the engines used on the installation and electromagnetic elements)

industrial. Acoperirea semințelor: un liant special este utilizat cu o formula pentru a spori aderenta la semințele. Acoperirea necesită tehnologii avansate de tratament. Drajarea este cea mai sofisticata tehnologie de tratare a semințelor, care rezultă în schimbarea formei fizice a unei semințe pentru a usura plantarea şi manipularea.Drajarea necesita utilaje si tehnologii complexe si este cea mai costisitoare operatie.

Un utilaj simplu, doar pentru o acoperire de baza, şi pentru cantități mici este echipamentul de tratat cu melc folosită în sectorul cerealelor. Cu cât este mai complex tratamentul, costul este mai ridicat. Multe maşini moderne de tratament pot oferi formulare şi de dozare specifice printr-un proces de injecție directă. Maşinile de tratament mai sofisticate pot furniza diverse formulări şi aditivi ca straturi pe sămânța, care permit plasarea exactă a ingredientului activ.[7]

MATERIAL ŞI METODĂ

Un echipament simplu cu transportor elicoidal cu perii este IMTS2-2. Acest echipament este destinata tratării semințelor de cereale si plantelor tehnice înainte de ambalare, pe cale umeda cu soluții insecto-fungicide. Se poate utiliza atât in cadrul stațiilor de condiționat semințe, cat si in gospodăriile particulare.

Structura IMTS-2 este compusa din: cadrul 1 (constructie din profile de otel, îmbinate prin sudura. Susține, direct sau indirect, celelalte componente ale instalației); buncărul de alimentare 2 (construcție de table sudata, prevăzuta la partea inferioara cu un şibăr care asigura uniformitatea curgerii semințelor) prevăzut la partea inferioară cu un şibăr care asigură uniformitatea curgerii semințelor; toba cu pulverizator 3(in interiorul sau este montat discul de împrăștiere, cuplat la un motor electric ce-i asigura o turație de 3000 rot/min; asigura pulverizarea lichidului de tratat, pe suprafața semințelor) în interiorul căreia este montat discul de împrăştiere; dozatorul de lichid 4 (este un dispozitiv de constructive metalica (ţevi sudate amplasate intr-o cuva din tabla) care are rolul de a trimite doza de lichid din vasul cu nivel reglabil in toba de pulverizare);transportorul omogenizator 5 (este un subansamblu ce include: Jgheabul, construcție metalica sudata, prevăzut cu doua guri de sac pentru evacuarea produsului, melcul transportor cu perii din fire de relon, pompa care realizează transportul lichidului de la rezervor la dozatorul de lichid, periile melcului transportor au rolul de a transporta produsul spre gurile de sac dar realizează in acelaşi timp si umectarea omogena cu lichid de tratat a acestui, rezervorul cu lichid 6 (realizat din tabla zincata, prevăzut cu indicator de nivel, agitator acționat electromagnetic si robinete şi instalația electrică de forță şi comandă 7 (realizează acționarea motoarelor folosite pe instalație cat si a elementelor electromagnetice)

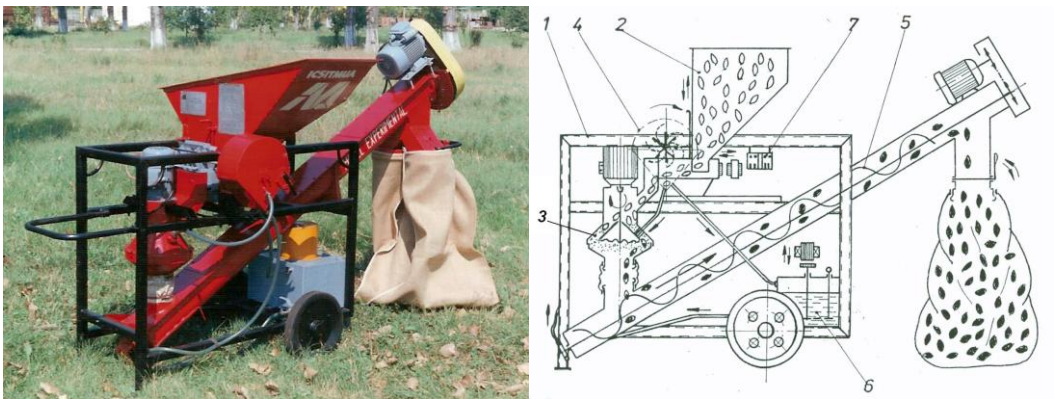

Fig. 1 – Mobile installation for treat seeds and components of IMST 2

Grains cleaned, sorted and graded arrive by gravity into the hopper. Under the hopper is fitted with a vibrating feeder role for maintaining constant working capacity of the plant. Seed treated, outgoing feeder vibrator, is dispersed on the outer surface of the drum inner cone spray. Inside the cone, the liquid is sprayed with a fine spreading disc with a speed of 3000 rev / min. The liquid used for seed treatment vessel is sent pump with adjustable level, where using a special dispenser spray reaches the drum. Excess liquid is returned to the dispenser fluid reservoir where it is taken back and recycled pump. Pump exercise is simultaneous with the operation screw conveyor brush. These brushes yarn ers are designed to even out the treated liquid film formed on the surface of the grain, and to transport the product to the top of the tray where it is drained through the two holes of the bag working alternately

To determine coverage seed testing methodology should be made to take into account the parameters that influence this. For this type of equipment parameters to be taken into account in drawing up the methodology for testing are:

Boabele curățate, sortate sau calibrate ajung prin cădere liberă în buncărul de alimentare. Sub buncărul de alimentare este montat un alimentator vibrator cu rol de menținere constantă a capacității de lucru a instalației. Sămânța de tratat, la ieşire din alimentatorul vibrator, este dispersată pe suprafața exterioară a conului interior al tobei cu pulverizator. Din interiorul conului, lichidul este fin pulverizat cu ajutorul unui disc de împrăştiere, având o turație de 3000 rot/min. Lichidul folosit pentru tratarea semințelor este trimis de pompă în vasul cu nivel reglabil, de unde cu ajutorul unui dozator special ajunge în toba de pulverizare. Surplusul de lichid din dozator este returnat în rezervorul de lichid de unde este preluat din nou de pompă şi recirculat. Acționarea pompei este simultană cu acționarea melcului transportor cu perii. Aceste perii din fire de relor au rolul de a uniformiza pelicula de lichid de tratat, formată pe suprafața bobului şi de a transporta produsul spre capătul superior al jgheabului unde, este evacuat prin două guri de sac care lucrează alternativ.

Pentru determinarea gradului de acoperire a semintelor trebuie realizata o metodologie de experimentare care sa tine cont de parametrii ce influenteaza acest lucru. Pentru acest tip de echipament parametrii ce trebuie luati in considerare la intocmirea metodologiei de experimentare sunt urmatorii:

$$P = f\,(Q,\ n_1,\ n_2,\ q_{dl},\ j,\ \rho,\ p_s,\ mat_{spira}) \qquad (1)$$

where: Q - feed rate, kg / h;
n1- speed of relon screw conveyor, rev / min;
n2 – speed of scattering liquid drum, rev / min;
qdl - substance flow metering device, l;
j - game of wit and gutter mm;
ρ - material density;
ps - raw material properties;
mat_{spira} - the type of material the coil conveyor homogenizer.

Because not all parameters have an influence as great in the experiments were conducted measurements for only a few of them

unde: Q - debitul de alimentare, kg/h;
n1- turaţie transportor elicoidal cu şnec relon, rot/min;
n2 - turaţie toba de imprastiere lichid, rot/min;
qdl - debitul dispozitivului de dozare substanța, l;
j - jocul dintre spira si jgheab, mm;
ρ - densitatea materialului;
ps - proprietati materie prima;
mat_{spira} – tipul de material al spirei transportorului omogenizator.

Deoarece nu toți parametrii au o influență la fel de mare, în cadrul experimentelor se vor efectua determinări doar pentru câțiva dintre ei.

RESULTS

Before using the equipment to give seeds treatment must be carried out several functional checks:

- constructive completeness check of the equipment;
- tighten all the screws;
- correct lubrication of bearings;
- checking the alignment of wheel chain providing transmission of motion from the electric motor to the

REZULTATE

Înainte da a se utiliza echipamentul de tratat seminte trebuiesc efectuate câteva verificări funcționale:

- verificarea integralității constructive a echipamentului;
- strângerea tuturor şuruburilor;
- ungerea corectă a lagărelor;
-verificarea alinierii roților de lanț ce asigură transmiterea mişcării de la motorul electric la melcul cu

screw conveyor;

-checking the possibility of regulating the supply of product of the plant;

-appropriate dosing system installation;

-checking all records (including connecting water pumps) and hydraulic seals,

- checking electrical connections at both central propane machine control as well as auxiliary devices needed in experimenting.

-checking apparatus for measurement of the mechanical, electrical and thermal.

Before starting the pump has been primed first.

It performs three starts, of 5 minutes, the machine to identify possible beatings, shocks, vibrations and noises in order to ensure correct operation of the machine

Once these checks are made run-in goal 6 hours into the used water instead of suspension. During running it will check:

- normal operation of electrical systems for command and control;

it watch the bearings and electric warming does not exceed by more than 30 ° C ambient temperature;

-checks mentainning the blacklesh and correct distances of moving parts;

-also check any loosening of the removable connectors (bolts, nuts, tension devices, etc.) as well as permanent joints.

Idling adjustment of installation

Functional verification is done with the whole running in idling adjustment. Such adjustments must be carried out relevant installation verificâdu the operation manually.

It will make repeated starting and stopping the machine, in order to identify possible beatings, shocks, vibrations and noises.

After this round will achieve break-in blank for a running 8 hours to be used to treat water without substance. Shall be observed when running:

- normal operation of electrical systems for command and control;

- bearings and electric heating, so they do not exceed more than 300 C ambient temperature;

-check maintaining normal game and distances bodies in motion,

-check the joints mobile (bolts, nuts, tension devices, etc.) as well as the permanent joining.

After installation is adjustment in idle it will will adjust in loaded states

The adjustment of installation in loaded states

In order to achieve the technological process of seed treatment or coverage is necessary to make the following adjustments

- adjusting the flow rate from the hopper which must be uniform and not exceed 2t / h (maximum capacity specifications as outlined in equipment);

- adjust the position liquid dosing system for a correlation between raw material supply system (hopper and vibrating table)

spiră;

- verificarea posibilității de reglare a alimentării cu produs a instalației;

- montajul corespunzător al sistemului de dozare;

- verificarea tuturor racordurilor (inclusiv racord apa la pompa) și etanșărilor hidraulice,

- verificarea conexiunilor electrice atât la panul central de comanda a mașinii precum si la dispozitivele auxiliare necesare în faza de experimentare.

- verificarea aparaturii pentru măsurarea mărimilor de natură mecanică, electrică, termică.

Înainte de prima pornire pompa a fost amorsata.

Se efectueaza 3 porniri, a cate 5 minute, a utilajului pentru a se identifica eventualele bătăi, șocuri, vibrații si zgomote suspecte in vederea asigurării funcționarii corecte a utilajului

După aceste verificări se realizeaza rodajul in gol de 6 ore in care s-a folosit apa in loc de suspensie. In timpul rodajului se verifica :

- funcționarea normala a sistemelor electrice de comanda si control;

-se urmăreste ca încălzirea lagărelor si a electromotoarelor sa nu depaseasca cu mai mult de 30°C temperatura mediului ambiant;

- se verifica păstrarea jocurilor si a distantelor normale ale organelor in mișcare;

- de asemenea se verifica eventualelor slăbiri ale îmbinărilor demontabile (bolțuri, piulițe, dispozitive de întindere, etc.) precum și a îmbinărilor nedemontabile.

Reglarea instalatiei in gol

Verificarea funcțională în ansamblu se face odată cu efectuarea rodajului în gol. Astfel se efectuaza reglajele corespunzătoare instalației, verificâdu-se funcționarea în regim manual.

Se vor efectua porniri si opriri repetate ale utilajului, in vederea identificării eventualelor bătăi, șocuri, vibrații si zgomote suspecte.

După aceasta etapa se va realiza rodajul in gol, pentru o perioada de funcționare de 8 ore in care se va folosi apa fără substanța de tratat. In timpul rodajului se vor urmării:

- funcționarea normala a sistemelor electrice de comanda si control;

- încălzirea lagărelor si a electromotoarelor, astfel încât acestea sa nu depaseasca cu mai mult de 30^0 C temperatura mediului ambiant;

- se va verifica păstrarea jocurilor si a distantelor normale ale organelor in mișcare,

- se va verifica îmbinările demontabile (bolțuri, piulițe, dispozitive de întindere, etc.) precum și a îmbinările nedemontabile.

După reglarea mașinii in gol se va regla mașina in sarcina

Reglarea instalației in sarcina

In vederea realizării procesului tehnologic de tratare a semințelor, respectiv gradul de acoperire este necesar sa se efectueze următoarelor reglaje

- reglarea debitului la buncărul de alimentare care trebuie sa fie uniform si sa nu depaseasca 2t/h (capacitate maxima de lucru prezentata in specificațiile utilajului);

- reglarea poziției sistemului de dozare lichid pentru o corelare intre sistemul de alimentare cu materie prima(buncăr si masa vibratoare)

- reglarea cantității de soluție de tratat care trebuie sa fie in conformitate cu specificațiile soluției utilizate

- adjusting the amount of solution that must be treated in accordance with the specifications of the solution used
- control for conveyor speed optimal functioning.

Methodology for determining seed flow

After the initial technical expertise in load and load operation will move to the determination of the seed and the different grading scale capacity sybarite.

Grading scale hopper sybarite from facet is given the position (D1) in the hopper flow is minimal and the maximal opening position sybarite (D3). D2 intermediate gradation was chosen at equal intervals between D1 and D3 two values

To determine the amount of material used in the determination of the supply system the scale used is brought to 0

- choose the amount of material used
- the plant will start from the control panel then will feed hopper with the product.
- lifts the lappet at the lowest mark (D1) and at the same time starts the timer which switches off completely when the material left bunker
- the values will go up sheet measurements.

These steps will follow to determine flow and D2, D3.

Methodology for determining the flow of liquid used to treat

Methodology for determining the flow metering system must take into account the geometry of the dosing system piping and mechanical system design dosage and liquid dosage adjusting, which is performed using the lever.

- adjust the position of the master controller to the minimum dosing system;
- start the machine;
- adjust the voltage of the dosing system;
- during operation flow is taken from the feed drum to the spray for 60 seconds amount of solution fed into a container;
- this amount is measured using a beaker.
- the value is then note in the table.

These steps are repeated for each speed separately for each position of the lever flow metering system.

Determination of speed rotation of drum at the centrifugal disc

These measures were necessary to determine the rotational speed of the disc spreader, which in part centrifugal drum assembly. The disc spreader is mounted directly on the motor shaft it can be determined dismantled jacket. In order to determine the rotational speed of a speed may be used.

To determine the speed screw conveyor can also use a tachometer.

CONCLUSIONS

Experimental researches in the field of seeds treatment equipment with inclined screw conveyor brush is quite small and in literature not found enough data influence constructive elements for the quality of work, this paper aims at completing data experiments and it wish to make an important contribution on the

- reglarea turaţiei transportorului pentru o funcţionare optima.

Metodologie de determinarea a debitului de seminţe

După expertiza tehnica iniţiala la funcţionarea in gol si in sarcina se va trece la determinarea debitului de seminţe si gradare a scalei sibarului la diverse capacităţii.

Gradarea scalei sibarului de la buncărul de alimentare se facet ţinând cont de poziţia iniţiala (D1) in care debitul buncărului de alimentare este minima si de poziţia maxima de deschidere a sibarului (D3). Gradaţia intermediara D2 a fost aleasa la interval egal intre cele doua valori D1 si D3

Pentru a determina cantitatea de material folosita la determinarea debitului sistemului de alimentare se aduce la 0 cantarul folosit

- Se va alege cantitatea de material folosita la
- Instalaţia se va porni de la panoul de comanda după care se va alimenta buncărul de alimentare cu produs.
- Se ridica sibarul la gradaţia cea mai mica (D1) si in acelaşi timp se porneşte procesul de cronometrare care se opreşte atunci când materialul a parasit complet buncărul
- Valorile obţinute se vor trece in fisa de măsurători.

Aceşti paşi se vor urmării si pentru determinarea debitelor D2,D3.

Metodologie de determinare a debitului de lichid folosit la tratare

- Metodologia de determinare a debitului sistemului de dozare trebuie sa tina cont de construcţia geometrica a sistemului de dozare cu ţevi si construcţia sistemului mecanic de dozare si pentru reglarea dozajului de lichid, care se realizează cu ajutorul manetei.
- Se reglează poziţia manetei a sistemului de dozare la poziţia minima;
- Se porneşte utilajul;
- Se reglează tensiunea de alimentare a sistemului de dozare;
- In timpul fluxului de funcţionare se prelevează din circuitul de alimentare a tobei cu pulverizator timp de 60 s cantitatea de soluţie alimentata intr-un recipient, ;
- Aceasta cantitate se măsoară cu ajutorul unui vas gradat.
- Valoarea este apoi nota in tabel.

Aceşti paşi se repeta pentru fiecare turaţie in parte pentru fiecare poziţie a manetei de reglare a debitului a sistemului de dozare.

Determinarea vitezei de rotaţie a discului de la toba centrifugala

Aceste măsurători au fost necesare pentru determinarea vitezei de rotaţie a discului de împrăştiere, aflat in componenta ansamblului tobei centrifugale. Discul de împrăştiere fiind montat direct pe axul motorului aceasta poate fi determinata demontând carcasa de protecţie. Pentru determinarea vitezei de rotaţie se poate folosi un turometru.

Pentru determinarea turatiei transportorului elicoidal se poate folosi de asemenea un turometru.

CONCLUZII

Cercetarile experimentale de specialitate in domeniul tratarii semintelor cu echipament de tratat cu transportor elicoidal inclinat cu perii sunt destul de limitate cu privire la influenta partilor constructive asupra procesului de tratare si de accea aceasta lucrare isi propune sa aduca

interdependence of its working qualitative indices, constructive and functional and how to work with this type of machine seeds treatment.

All working parameters have influence on the final level of seed treatment, and they must be optimized very accurate depending on the nature of the treatment for more precision

The information presented may be important for all professionals and workers in the processing and conditioning of seeds, referring especialy to the operation of the technological process of seed treatment.

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o contributie importanta asupra indicilor calitativi, constructivi si functionali si modul de lucru cu tipul acesta de utilaj de tratat seminte.

Toti parametrii de lucru au o influenta asupra gradului final de acoperire si ei trebuiesc optimizati foare exact in functie de natura tratamentului folosit pentru o tratare de cat mai buna precizie.

Informatile prezentate pot fi importante pentru toti profesionistii si pentru toti lucratorii in procesarea si conditionarea semintelor referindu-se in special operatorilor ce lucreaza in domeniul tratarii semintelor.

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DETERMINATION OF THE RELAXATION PERIOD AT STATIC COMPRESSION OF GOLDEN DELICIOS APPLES VARIETY
/
DETERMINAREA PERIOADEI DE RELAXARE LA COMPRESIUNEA STATICĂ A MERELOR DIN SOIUL GOLDEN DELICIOS

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Abstract: *The paper presents the Golden Delicious apples experimental researches, that aimed to emphasize apples behaviour at mechanical static or quasi-static compression stress and mechanical and rheological characteristics of fruits correlated to deficiencies (contusions, form distorsion) determined in order to anticipate their conduct in different practical situations.*

Keywords: apples, storage, static compression

INTRODUCTION

During the long term storage the compression stress of apples located in the package bottom rows in boxes or containers should not be neglected, especially when the packages are not appropriate, determining the fruits defects, especially geometrical shape modifications (visible changes), which make them non marketable, thus leading to losses [5,6] .

Experimental researches performed aimed to emphasize the Golden Delicious apple behaviour at mechanical static or quasi-static compression stress and rheological characteristics of fruits correlated to deficiencies (contusions, form modifications) determined in order to anticipate their conduct in different practical situations [1, 2].

The apple compression resistance has determined as bio-flowing compression force and appropriate deformation and, at the same time, the specific hysteresis energy per cycle when loading-unloading, elasticity level (respectively plasticity level) to compression, Mayer hardness test (a measure of structure and tissue hardness) completed by resistance to penetration of a cylindrical rod and a suitable cone of shearing strain limit of flow (τc) of epicarp-pulp of whole fruits [3,4] have found out.

It has aimed to find the rheological behaviour at compression between plane parallel rigid surfaces and a cylindrical punch, at constant load, followed by total unloading of fresh Golden Delicious apples, after harvesting [8].

MATERIAL AND METHOD

In order to perform the compression tests, The Golden Delicious apples were used, the fruits being grouped by three in each ripening class and coded as: A_1, A_2, A_3 representing the green apples; A_4, A_5, A_6 represent average ripe level apples and A_7, A_8, A_9 represent mature apples.

It has aimed to choose geoid shape fruits to be as close as possible to the spherical shape. Before being subjected to compression, the fruits were weighed, and their geometrical dimensions and radius of spherical surfaces in contact points with stress surfaces (by means of spherical shape meter) were measured, being shown

Rezumat: *Lucrarea prezintă cercetările experimentale efectuate pe soiul de mere Golden Delicious ce au urmărit să pună în evidență comportarea lor la solicitările mecanice de compresiune statică sau cvasistatică şi caracteristicile mecanice şi reologice ale fructelor în corelație cu defectele (contuzii, distorsionări ale formei) cauzate pentru a le putea anticipa în diferite situații practice.*

Cuvinte cheie: mere, depozitare, compresiune statică

INTRODUCERE

Pe durata păstrării de lungă durată solicitarea la compresiune la care sunt supuse merele din rândurile de pe fundul ambalajelor de tip lăzi sau containere, nu este deloc de neglijat, mai ales atunci când alegerea ambalajelor nu este adecvată, ajungând ca acestea să capete defecte, mai ales distorsiuni ale formei geometrice (deformări vizibile) care le pot face necomerciabile cauzând pierderi [5,6] .

Cercetările experimentale efectuate au urmărit să pună în evidență comportarea la solicitările mecanice de compresiune statică sau cvasistatică a merelor Golden Delicious şi caracteristicile mecanice şi reologice ale fructelor în corelație cu defectele (contuzii, distorsionări ale formei) cauzate fructelor pentru a le putea anticipa în diferite situații practice [1,2].

S-a determinat rezistența la compresiune a merelor, sub forma forței de compresiune la biocurgere şi a deformației corespunzătoare, de asemenea s-a detrminat energia specifică de histerezis pe ciclu la încărcare-descărcare, gradul de elasticitate (respectiv de plasticitate) la compresiune, duritatea Mayer (o măsură a fermității structuro-texturale) completată cu rezistența la penetrare a unei tije cilindrice şi a unui con şi corespunzător acesteia a tensiunii limită de forfecare la curgere (τc) a ansamblului epicarp-pulpă a fructelor întregi [3,4].

S-a urmărit comportarea reologică la compresiune între suprafețe rigide plane paralele şi cu un puanson cilindric, la sarcină constantă urmată de descărcare totală, pentru merele Golden Delicious proaspete, imediat după recoltare[8].

MATERIAL ŞI METODĂ

Pentru efectuarea experimentărilor la compresiune s-au utilizat mere Golden Delicious, fructele fiind grupate câte trei în fiecare grupă de coacere şi codificate astfel: A_1, A_2, A_3 reprezentând merele verzi; A_4, A_5, A_6 reprezentând mere cu grad de coacere mediu şi A_7, A_8, A_9 reprezentând mere coapte.

S-a căutat să se aleagă fructe cu forma geometrică de geoid cât mai apropiată de forma sferică. Inainte de a fi supuse la compresiune, fructele au fost cântărite, măsurate dimensiunile lor geometrice şi razele suprafețelor sferice în punctele de contact cu suprafețele de solicitare (cu ajutorul sferometrului) valorile fiind redate în tab. 1.

in tab. 1..

Table 1

Physical characteristics of fruits studied

Code	Ripe level	Mass m (g)	Height H(mm)	D_e (mm) diam. ec		Point 1	Point 2
				$D_{e\ max}$	$D_{e\ min}$	R_1 (mm)	R_2 (mm)
A1	green	140.3	66.54	71.13	65.47	41.76	48.46
A2		154.3	72.8	71.24	65.5	38.20	35.85
A3		153.1	68.41	70.32	66.63	42.26	44.40
A4	average	146.8	68.79	70.45	66.28	30.60	39.72
A5		145.8	67.58	72.87	69.68	33.66	38.62
A6		149.1	66.70	71.79	68.60	39.79	32.87
A7	ripe	177.3	71.75	74.49	71.18	31.84	39.53
A8		142.9	64.62	69.69	68.34	28.25	28.05
A9		154.4	75.80	69.53	67.67	34.72	39.05

Fruits were subjected to compression at a load rating between plane parallel rigid plates, using the universal apparatus of mechanical tests Hounsfield H25 KT.

After the compression, it aimed to test the firmness of fruit texture, sometimes called texture ,rigidity" by using the method named « method of Magnes –Taylor pressing test", measuring the pressing force of a cylindrical rod calibrated of Φ 11.1 mm that penetrates into the fruit pulp to a certain depth, named ,,penetration resistance". Measurements were made with the Penetrometer FT 327 with a precision of 0.01 mm [9].

The fruit pulp texture resistance was determined in 12 points of each fruit, 4 points on every diameter (equatorial, apical and peduncle), according to fig. 1, in tab.2 being shown the data for the average penetration resistance between the 4 points on equatorial diameter.

Fructele au fost supuse apoi la compresiune la sarcină de încărcare între plăci rigide plane paralele utilizându-se aparatul universal de încercări mecanice Hounsfield H25 KT.

După solicitările la compresiune, s-a căutat determinarea fermității ("firmness") texturii fructelor asimilată uneori prin ,,rigiditatea" texturii utilizând metoda cunoscută sub numele de ,,metoda testului de apăsare Magnes –Taylor" măsurând forța de apăsare a unei tije cilindrice cu Φ 11,1 mm calibrate care pătrunde în pulpa fructului pe o anumită adâncime, forța denumită,,rezistență la penetrare". Măsurătorile au fost efectuate cu penetrometrul Penetrometer FT 327 cu o precizie de 0,01 mm [9].

S-a determinat rezistenței texturii pulpei fructelor, în 12 puncte pe fiecare fruct, câte 4 puncte pe fiecare diametru (ecuatorial, apical şi peduncular), conform fig. 1, în tab.2 fiind redate datele pentru media rezistenței la penetrare între cele 4 puncte de pe diametrul ecuatorial.

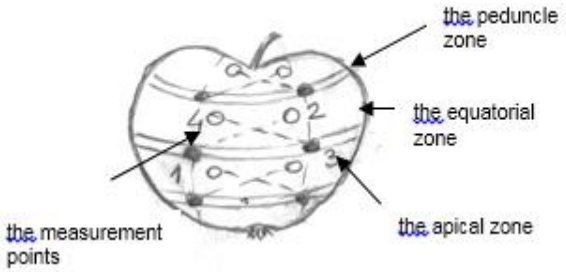


Fig.1 - Areas on fruit surface and points of measuring the penetration resistance [3]

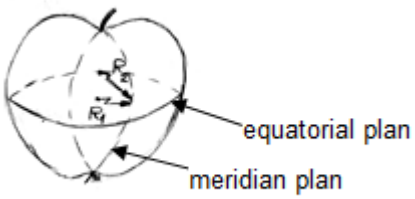


Fig. 2 - Representaion of radius measured in the two plans

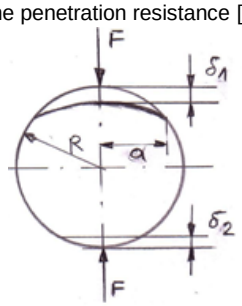


Fig. 3 - Schema de calcul a razei (a) urmei

There were calculated the elasticity module Young, E corresponding to bio-flow point and maximum normal tension $\sigma_{c\ max}$ of bio-flow, using the relations from the theory of of elastic contact Hertz, [7], ec. (1)

Au fost determinate prin calcul modulul de elasticitate Young, E corespunzător punctului de biocurgere şi a tensiunii normale maxime $\sigma_{c\ max}$ de biocurgere, utilizându-se relațiile din teoria contactului elastic Hertz, [7], ec. (1)

$$E = 0,749 \frac{F \ 1-\upsilon^2}{\delta^{3/2}} \left(\frac{1}{R_1^{1/3}} + \frac{1}{R_2^{1/3}} \right)^{3/2} \quad (1)$$

For the apples, it was considered υ=0,35; R_1 and R_2 representing the radius of curvature between the two contact points (fig.2), δ represents the total deformation (according to table 2), and F representing the force corresponding to bio-flow point (F_1 according to table. 1).

After performing the calculations, the values from table 2 resulted.

Bio-flow tension was calculated by relation (2), where it represents the radius of track, in compliance with fig.3 [7]:

Pentru mere s-a considerat υ=0,35; R_1 şi R_2 reprezintă razele de curbură în cele două puncte de contact (fig.2), δ reprezintă deformaţia totală (conform tab. 2), iar F reprezintă forţa corespunzătoare punctului de biocurgere (F_1 conform tab. 1).

In urma efectuării calculelor au rezultat valorile redate în tab.2.

Tensiunea de biocurgere s-a calculat cu relaţia (2), unde a reprezintă raza urmei, conform fig. 3 [7]:

$$\sigma_c = \frac{3}{2} \frac{F}{\pi a^2} \quad (2)$$

RESULTS AND DISCUSSIONS

Based on data obtained in tests one has aimed to research the possibility of establishing the correlations between the mechanical values measured and their compliance with the theoretical relations proposed for achieving the calculations.

After performing the compression tests with the apparatus Hounsfield H25 KT at 5mm/min speed, using the cell of 1000 N, by processing the data gathered with Hounsfield Microsoft Windows Based program, graphics with force-deformation curves were obtained, from which were extracted the force and deformation values corresponding to the bio-flow point. These bio-flow point values are presented in table1.

From graphics and tables was extracted the value of force (F_1) corresponding to point C of bio-flow, displacement (total deformation up to bio-flow point) and slope corresponding to bio-flow point (table 2) and Figures 5-13 representing the force-deformation curve for each apple.

Data obtained from tests designed to determining fruit pulp texture resistance with Penetrometer FT 327 are given in table 3.

REZULTATE SI DISCUTII

Cu datele obţinute la experimentări s-a cercetat posibilitatea stabilirii unor corelaţii între diferitele mărimi mecanice măsurate şi concordanţa acestora cu relaţiile teoretice propuse pentru efectuarea de calcule.

După efectuarea experimentelor de supunere a fructelor la compresiune cu aparatul Hounsfield H25 KT la viteza de 5mm/min, utilizând celula de 1000 N, prin prelucrarea datelor captate de placa de achiziţie a datelor şi prelucrate cu programul Hounsfield Microsoft Windows Based s-au obţinut grafice conţinând curbe forţă-deformaţie din care s-au extras valorile forţei şi ale deformaţiei corespunzătoare punctului de biocurgere. Aceste valori ale punctului de biocurgere sunt prezentate în tab.1.

Din grafice şi tabele s-a extras valoarea forţei (F_1) corespunzătoare punctului C de biocurgere, deplasarea (deformaţia totală până la punctul de biocurgere) şi panta corespunzătoare punctului de biocurgere (tab. 2) şi Figurile 5-13 ce reprezintă curba forţă – deformaţie pentru fiecare măr.

Datele obţinute din experimentările pentru determinarea rezistenţei texturii pulpei fructelor cu apenetrometrului Penetrometer FT 327 sunt redate în tab.3.

Table 2

Characteristics corresponding to bio-flow point (Hounsfield apparatus)

Code	F_1 (N)	Displacement (deformation) δ (mm)	Slope (N/mm)
A1	119,3	4,176	28,48
A2	64	2,616	24,43
A3	78	2,632	29,51
A4	42	2,120	19,69
A5	63,6	4,128	16,85
A6	120,4	5,30	22,72
A7	75,5	3,224	23,37
A8	35	2,392	14,6
A9	77,3	3,192	24,22

Noticing from graphics made by Hounsfield apparatus that deformation is delayed by certain quota, the correction of deformation δ, given in table 2 was made, using it in calculations

Observându-se din graficele efectuate de programul aparatului Hounsfield că deformaţia este întârziată cu anumite cote s-a făcut corecţia deformaţiei δ, dată în tab.2, utilizându-se aceasta în calcule.

Table 3

Data of equatorial area referring to la R_{pmed}, E, E_{med}, σ_c, σ_{cmed}

Fruit	Force F (N)	Deformation δ corrected (mm)	$R_{p\ med}$ (N)	R_{pmed} (N)	E (Pa)	E_{med} (Pa)	σ_c (Pa)	σ_{cmed} (Pa)
A1	119.3	3.976	44.145	44.73	$4.19*10^6$	$5.426*10^6$	$0.352*10^6$	$0,374*10^6$
A2	64	2.276	44.120		$5.72*10^6$		$0.381*10^6$	
A3	78	2.292	45.91		$6.37*10^6$		$0.390*10^6$	
A4	42	1.72	47.995		$5.89*10^6$	$4.56*10^6$	$0.387*10^6$	$0.34*10^6$

A5	69.6	3.858	37.817	42.66	$2.85*10^6$		$0.264*10^6$	
A6	120.4	4.9	42.158		$3.44*10^6$		$0.371*10^6$	
A7	75.5	2.954	45.224		$4.66*10^6$		$0.393*10^6$	
A8	35	2.052	39.534	42.31	$4.19*10^6$	$4.15*10^6$	$0.296*10^6$	$0.31*10^6$
A9	77.3	2.792	42.183		$5.1*10^6$		$0.389*10^6$	

Graphically representing penetration resistance depending on the elasticity module in bio-flow point and penetration resistance depending on bio-flow resistance, the following graphics were obtained, fig. 4

Reprezentând grafic rezistența la penetrare în fucție de modulul de elasticitate în punctul de biocurgere şi rezistența la penetrare în fucție de tensiunea de biocurgere s-au obținut următoarele grafice, fig. 4

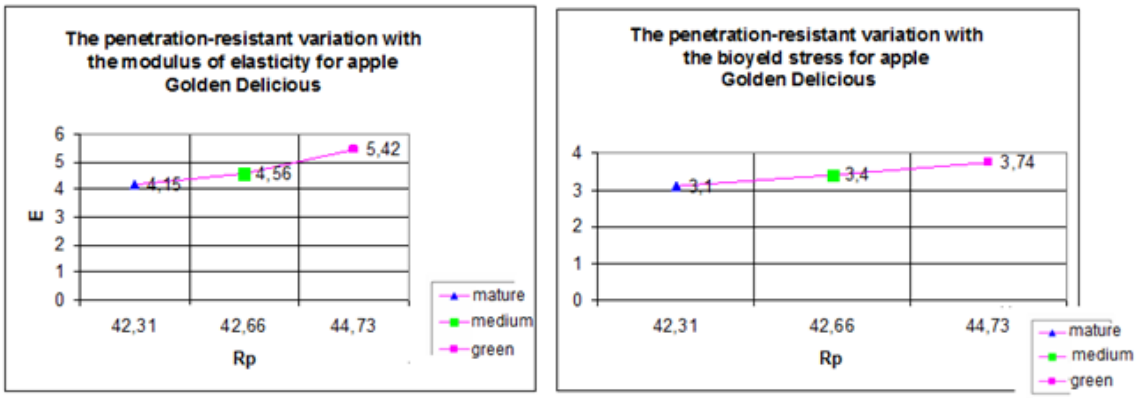


Fig. 4 - Corelația (E, R_p) şi (σ_c, R_p) pentru cele 3 grade de coacere ale soiului de mere Golden Delicious

From fig. 4 of correlations (E, R_p) and (σ_c, R_p) for Golden Delicious variety could be coralete with ripening level of apples.

Din fig. 4 ale corelațiilor (E, R_p) şi (σ_c, R_p) pentru soiul Golden Delicious pot fi puse în corelație cu gradul de coacere al merelor.

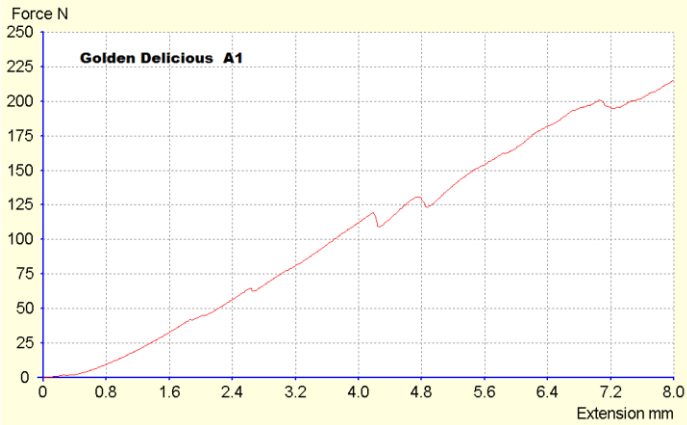


Fig.5 - Variation force – deformation for Delicious A1

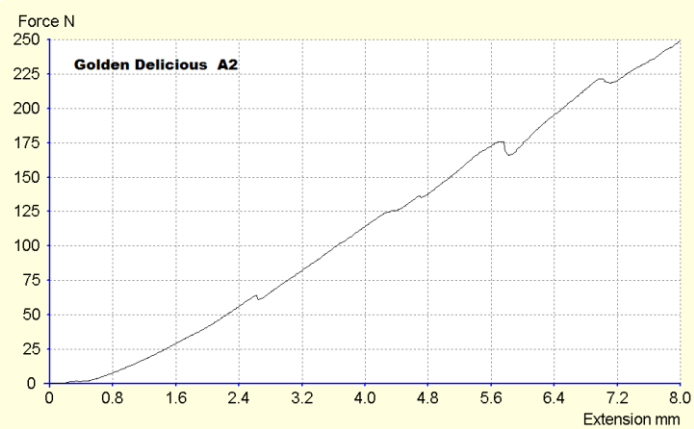


Fig.6 - Variation force – deformation for Delicious A2

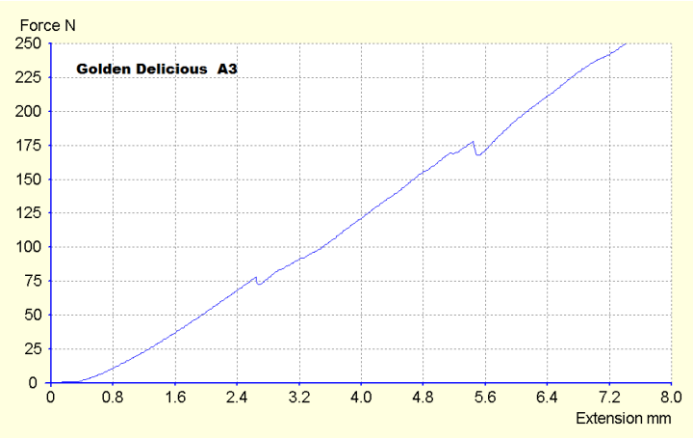


Fig.7 - Variation force – deformation for Delicious A3

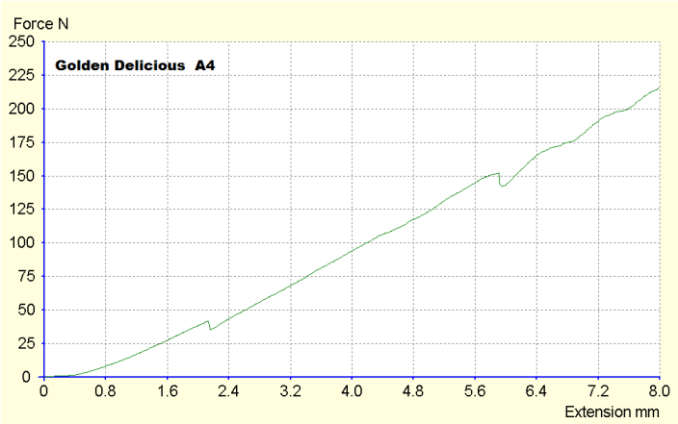
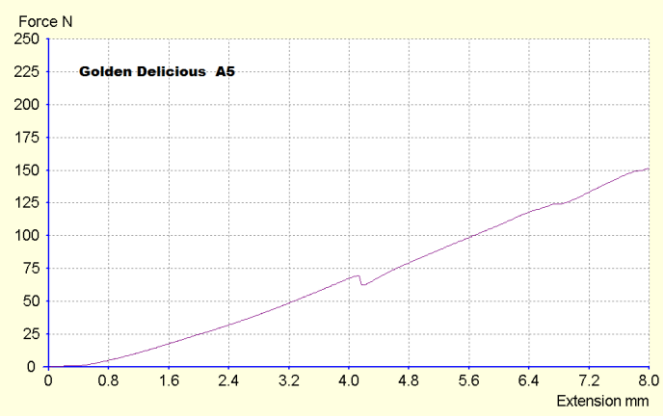


Fig.8 - Variation force – deformation for Delicious A4



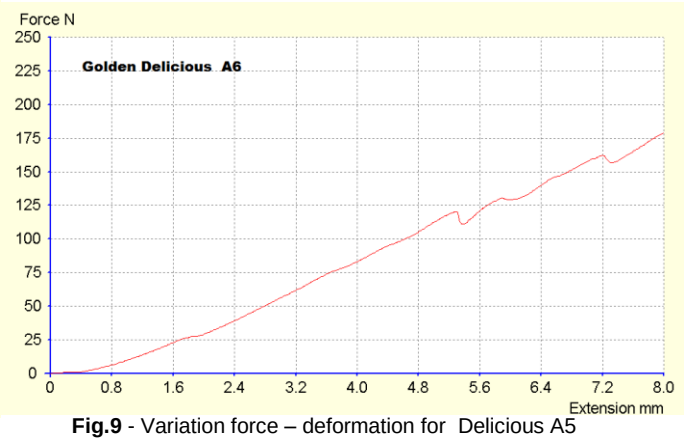
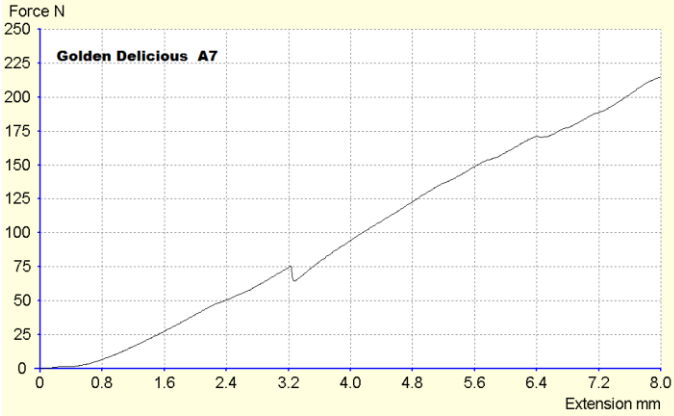


Fig.9 - Variation force – deformation for Delicious A5

Fig.10 - Variation force – deformation for Delicious A6



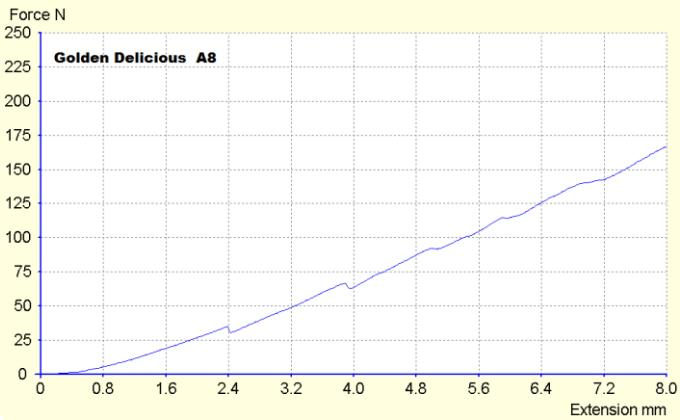


Fig.11 - Variation force – deformation for Delicious A7

Fig.12 - Variation force – deformation for Delicious A8

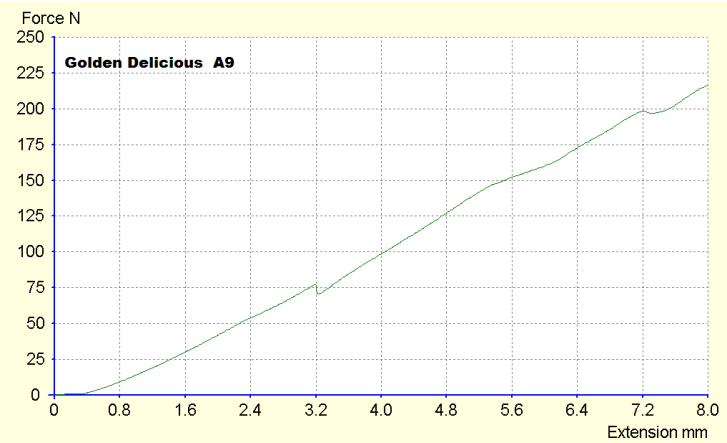


Fig.13 - Variation force-deformation for Delicious A9

CONCLUSIONS

Following the analysis of apple varieties existing in Romania, we have oriented towards the Golden Delicious study, because this variety is most demanded by market and presents technological features for a long storage period.

Losses and damages appearing during apples conservation are caused by static and quasi-static stress as well as, metabolic processes and diseases. [27].

Considering the fruit as a viscous-elastic body, knowing the rheological parameters such as elasticity modules, viscosity parameters, relaxing time, etc allows to anticipate the fruit behaviour when is subjected to

CONCLUZII

In urma analizei soiurilor de mere existente în România, ne-am orientat spre studiul soiului Golden Delicious, deoarece sunt printre cele mai cerute pe piață și prezintă însușiri tehnologice pentru păstrarea de lungă durată.

Pierderile şi declasările care apar în timpul păstrării merelor se datoresc solicitărilor statice şi cvasistatice la care sunt supuse urmate de procesele metabolice şi boli [27].

Considerând fructul un corp vâscoelastic, cunoaşterea parametrilor reologici precum module de elasticitate, coeficienți de vâscozitate, timpi de relaxare etc. permit anticiparea comportării acestor materiale biologice (fructe) în cazul supunerii lor la diverse tipuri de solicitări

mechanical strain.

Experimental researches performed aimed to emphasize the apples behaviour at static and quasi-static compression and their mechanical characteristics related to their faults (contusions, modifications of shape) in order to anticipate their conduct in different practical situations.

The compression resistance was determined as bio-flow force and related deformation, between two plane parallel plates, the elasticity module Young and penetration resistance, a measure of firmness.

Elasticity module and penetration resistance, as well as bio-flow tension may be put into correlation with ripening level of Golden Delicious apples (these values increasing along with apple ripening degree).

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mecanice.

Cercetările experimentale efectuate au urmărit să pună în evidență comportarea la solicitările mecanice de compresiune statică sau cvasistatică a merelor şi caracteristicile mecanice ale lor în corelație cu defectele (contuzii, distorsionări ale formei) cauzate fructelor pentru a le putea anticipa în diferite situații practice.

S-a determinat rezistența la compresiune, sub forma forței de biocurgere şi a deformației corespunzătoare, la compresiune între plăci plane rigide paralele, modulul de elasticitate Young şi rezistența de penetrare, o măsură a fermității.

Modulul de elasticitate şi Rezistența la penetrare precum şi tensiunea de biocurgere şi rezistența la penetrare pot fi puse în corelație cu gradul de coacere al merelor Golden Delicious (ele crescând odata cu creşterea gradului de coacere).

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RESEARCH ON INFLUENCE OF ENVIRONMENTAL PARAMETERS OVER THE PROCESS OF DRYING OF VOLUME FODDER
/
CERCETĂRI PRIVIND INFLUENȚA PARAMETRILOR MEDIULUI ASUPRA PROCESULUI DE USCARE A FURAJELOR DE VOLUM

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Abstract: *In modern agriculture, sustainable farming plays an important role because they provide much of the food people, but development of this field of agriculture is dependent on providing the necessary feed. Fodder plants have the essential characteristic full use of plant mass, which imprints a number of advantages related primarily to more efficient use of sunlight, wind and environmental conditions, which place them among the cultures most intensive. This paper addresses some theoretical and experimental aspects of how the environment influences the drying volume fodder plants for preservation, storage and maintaining the nutritional qualities. In the research of the environment parameters were analyzed: the speed of the wind, solar radiation, humidity, pressure, yielding information about their influence on the drying time.*
Keywords: *hay, fodder volume, drying, humidity, temperature and duration of drying.*

INTRODUCTION

In order to produce green fodder and the one preserved in various forms (hay loose and round, semi silo or silage) particular importance presents fodder of high productivity (feed volume) rich in nutrients, among them a few: Lucerne, red or white clover, sainfoin, canola, lupine, sorghum, Sudan grass, [7].

The hay has an important share in the balance of forage during winter, especially in regions where there are large hill and mountain grasslands large. In the plain regions, hay produced on agricultural land planted with annual or perennial fodder plants, natural grasslands occupying the smaller areas. Hay importance consists not only of the large share that it has in animal feed, but also by high nutritional value, containing increased nutrients and vitamins.

In temperate countries to provide fodder for grazing livestock on winter drying of fodder crops is frequently used especially in countries where the weather conditions permit. Hay remains mainly in sheep and cattle farms, [3].

The hay is needed and recommended to feed animals due to their characteristics:
- have a physical structure corresponding to good health and milk production, rumen positively influencing mobility, rumination, salivary secretion, growth of microorganisms and digestion;
- it provides a good sensation of satiation;
- have a stabilizing effect on rumen fermentation processes;
- high digestibility;
- high biological value;
- it can be used all year round.

Increased nutrient quantity of hay depends primarily on the chemical composition and nutritional value of

Rezumat: *Într-o agricultura modernă, durabilă, creșterea animalelor ocupă un loc important, deoarece acestea asigură o mare parte din hrana oamenilor, însă dezvoltarea acestui domeniu al agriculturii este dependent de asigurarea necesarului de furaje. Plantele furajere au drept caracteristică esențială utilizarea integrală a masei vegetale, ceea ce imprimă o serie de avantaje, referitoare în primul rând, la valorificarea mai eficientă a luminii solare, a vântului și a condițiilor de mediu, fapt ce le situează printre culturile cele mai intensive. Lucrarea de față abordează unele aspecte teoretice și experimentale ale modului cum influențează mediul procesului de uscare a plantelor furajere de volum, în vederea conservării, depozitării și menținerii calităților nutritive. În cadrul cercetărilor au fost analizați parametrii mediului ambiant: viteza vântului, radiația solară, umiditatea, presiunea, obținându-se informații privind influența acestora asupra duratei de uscare.*

Cuvinte cheie: *fân, furaj de volum, uscare, umiditate, temperatura, durata de uscare.*

INTRODUCERE

În vederea producerii furajului verde, cât şi a celui conservat sub diferite forme (fân vrac şi balotat, semi siloz sau siloz) o importanţă deosebită o prezintă plantele furajere de mare productivitate (furaje de volum) bogate în substanţe nutritive, dintre care enumeră câteva: lucernă, trifoiul roşu sau alb, sparceta, rapiţa, lupinul, sorgul, iarba de Sudan, [7].

Fânurile au o pondere importantă în balanţa furajeră pe perioada de iarnă, mai ales în regiunile colinare şi montane unde există suprafeţe mari de pajişti. În regiunile de câmpie, fânul se produce pe terenurile agricole cultivate cu plante furajere anuale sau perene, pajiştile naturale ocupând suprafeţe mai mici. Importanţa fânului constă nu numai în ponderea mare pe care o are în hrana animalelor, ci şi prin valoarea nutritivă ridicată, având un conţinut sporit în substanţe nutritive şi vitamine.

În ţările cu climat temperat pentru asigurarea furajelor destinate erbivorelor pe timpul iernii, uscarea culturilor furajere este frecvent utilizată în special în ţările în care condiţiile meteorologice permit acest lucru. Fânul rămâne preponderent în fermele de ovine şi bovine, [3].

Fânurile sunt necesare şi recomandate în alimentaţia animalelor datorită caracteristicilor lor:
- au o structură fizică corespunzătoare unei bune sănătăţi şi producţii de lapte, influenţând pozitiv mobilitatea rumenului, rumegarea, secreţia salivară, dezvoltarea microorganismelor şi digestia;
- realizează o bună senzaţie de saţietate;
- au efect stabilizator asupra proceselor fermentative din rumen;
- digestibilitate mare;
- valoare biologică superioară;
- se poate folosi pe tot parcursul anului.

Cantitatea sporită în elemente nutritive a fânului depinde, în primul rând de compoziţia chimică şi valoarea nutritivă a furajelor verzi din care provin, corespunzătoare momentului recoltării şi în al doilea rând de condiţiile de

green fodder from which corresponding time of harvest and secondly of harvesting, handling and storage. The conditions of our country following types of cultivated hay: hay of alfalfa, hay of clover, hay of vetch, hay of sainfoin, hay of Sudan grass, but extending crop mixtures of grasses and legumes or grasses only in pure culture. Hay of alfalfa has a higher percentage of protein and minerals than grass. It is most often used in feeding dairy cows because it has high productivity and high nutritional value. The optimum time for harvesting alfalfa and clover corresponds with the beginning of flowering, the protein content is maximum and the plant corresponds to a humidity of about 75 ... 80%, and the yield per hectare is satisfactory, [3].

The best harvesting moment and conservation feed module are determined by the specific weather conditions of the execution period. Based on experiments found to be better in terms of quality and quantity of forage harvesting technology to modify and plants, [4].

MATERIAL AND METHOD

The conditions in our country the cultivation of a wide range of fodder plants and establishing modern technologies and their maintenance will produce considerable yields with higher nutritional qualities.

The main fodders plants are grown on large areas in our country in 2003 (according to statistical) are presented in Table 1.

recoltare, manipulare şi conservare. În condiţiile din ţara noastră se disting următoarele tipuri de fân cultivat: fân de lucernă, de trifoi, de borceag, de sparcetă, de iarbă de Sudan, dar se extind culturile de amestecuri dintre graminee şi leguminoase sau numai de graminee în cultură pură. Fânul de lucernă are un procent mai ridicat de proteine şi substanţe minerale decât cel de graminee. Acesta este cel mai frecvent folosit în hrana vacilor de lapte întrucât are productivitate mare şi valoare nutritivă ridicată. Perioada optimă de recoltare în cazul lucernei şi trifoiului corespunde fazei de început de înflorire, când conţinutul de proteină este maxim şi corespunde unei umidităţi a plantei de cca 75...80% iar producţia la hectar este satisfăcătoare, [3].

Momentul optim de recoltare şi modul de conservare a furajelor sunt determinate de condiţiile atmosferice specifice perioadei executării acestor lucrări. Pe baza experimentărilor s-a constatat că este mai bine sub aspectul calităţii şi cantităţii furajului să se modifice tehnologia de recoltare şi conservare a plantelor, [4].

MATERIAL ŞI METODĂ

Condiţiile din ţara noastră favorizează cultivarea unei game variate de plante furajere, iar tehnologiile moderne de înfiinţare şi întreţinere ale acestora permit obţinerea unor producţii însemnate cu calităţi nutritive superioare.

Principalele plante furajere care se cultivă pe suprafeţe mari în ţara noastră la nivelul anului 2003 (conform anuarului statistic) sunt prezentate în tabelul 1.

Table 1

The main fodder crops grown in Romania, [1]

Specification	Cultivated area [thousand ha]	Average annual production [t/ha]
Lucerne	350	35
Clover	150	30
Annual hay and green mass	250	25
Corn for silage	50	30

The main objective in the collection, preparation and preservation as hay to feed the volume on grasslands and fodder crops is to achieve a final product with nutritional value, Table 2, as close to the original green fodder, bowing on the premise that he fulfils a feed of high quality, both in terms of botanical composition (balanced mix of perennial grasses with leguminous plants) and in the on phenophase of harvest, [5].

Principalul obiectiv în recoltarea, pregătirea şi conservarea sub formă de fân a furajelor de volum de pe pajişti şi din culturile furajere constă în realizarea unui produs final cu o valoare nutritivă, tabelul 2, cât mai apropiată de cea iniţială a furajului verde, plecându-se de la premisa că acesta îndeplineşte condiţiile unui furaj de foarte bună calitate, atât în ceea ce priveşte compoziţia botanică (amestec echilibrat de graminee cu leguminoase perene), cât şi în cea referitoare la fenofaza de recoltare, [5].

Table 2

The nutritional value of fodder plants, [1]

Culture	The average yield [kg/ha]	UN/ha	Kg PD/ha
Hay of Lucerne	5.000	2.400	610
Hay of borceag	4.000	2.040	268
Corn silage	30.000	6.600	330
Fodder beet	45.000	5.850	450

Green fodder, the freshly mowing contains a large amount of water, generally between 70 and 85%. Shorten the harvest, preparation and conservation of feed as hay is possible by rapidly reducing the initial

Furajul verde, cel proaspăt cosit, conţine o cantitate mare de apa, cuprinsă în general între 70 şi 85%. Scurtarea duratei de recoltare, pregătire şi conservare a furajelor sub formă de fân este posibilă prin reducerea

moisture (from mowing) feed, so ultimately it reaches below 18%.

The actual amount of water to be removed from the feed and [6], to obtain a fan with moisture preservation of 18% is calculated from the relation 1:

rapidă a umidității inițiale (de la cosire) a furajului, astfel ca aceasta să ajungă în final sub 18 %.

Cantitatea reală de apă care trebuie eliminată din furaj, [6] pentru a se obține un fân cu umiditatea de păstrare sub 18% se calculează cu relația 1:

$$Q_a = P_i \frac{U_i - U_f}{100 - U_f}, \text{ [kg]} \quad (1)$$

Where:

Q_a - is the amount of water to be removed from the fodder in [kg];

U_i - is the initial moisture (from mowing) to feed [%];

U_f - final moisture content of the hay storage (less than 18%) in [%];

P_f - initial mass of green forage harvesting in [kg].

P_i - dry weight of the product [kg].

To calculate the weight should be so dry hay, based on the moisture content at harvest and reaching up to the moisture content suitable for storing it at can use the formula 1 or formula 2:

Unde:

Q_a – reprezintă cantitatea de apă care trebuie eliminată din furaj în [kg];

U_i – reprezintă umiditatea inițială (la cosire) a furajului în [%];

U_f – umiditatea finală de păstrare a fânului (mai mică de 18%) în [%];

P_f – masa inițială la recoltare a furajului verde în [kg].

P_i – masa produsului uscat în [kg].

Pentru a calcula greutatea care ar trebui s-o aibă fânul uscat, plecând de la conținutul în umiditate în momentul recoltării şi ajungând până la conținutul de umiditate recomandat pentru păstrarea lui se poate utiliza formula 1 sau formula 2:

$$P_f = P_i \frac{100 - U_i}{100 - U_i}, \text{ [kg]} \quad (2)$$

Drying hay can be done naturally or artificially. Natural drying directly in the field, due to which it is subject hay handling after drying, is accompanied by the losses. By manipulating the nutritional value is lost parts highest (leaves, flowers). In regions with high moisture hay losses are greater, unable to provide hay drying in a short period [6].

Through artificially drying hay is producing a quality and minimal loss of nutrients. Artificial hay dryers can be hot air with cold air, and most have installations spread a dry cold air, Figure 1.

Uscarea fânul se poate face pe cale naturală sau pe cale artificială. Uscarea naturală direct în câmp, datorită manipulării la care este supus fânul după uscare, este însoțită de pierderi. Prin manipulare se pierd părțile cu valoare nutritivă cea mai mare (frunze, flori). În cazul regiunilor cu umiditate ridicată pierderile de fân sunt şi mai mari, neputându-se asigura uscarea fânului într-o perioadă scurtă, [6].

Prin uscarea artificială a fânului se asigură obținerea unui fân de calitate, iar pierderile de substanțe hrănitoare sunt minime. Instalațiile de uscare artificială a fânului pot fi cu aer rece sau aer cald, iar cea mai mare răspândire o au instalațiile de uscat cu aer rece, figura 1.

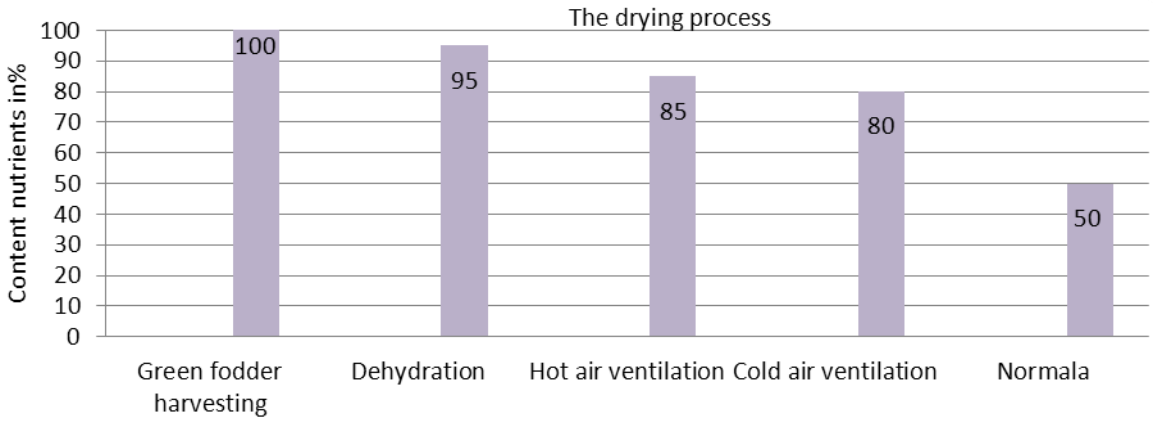

Fig. 1 - Content nutrients by various methods of drying hay, [1]

The principle performance of individual installations of cold dry air is based on properties of unsaturated air is charged with water vapour. To this end, the air is forced to pass through the layer of hay using a ventilation system. Installations of hay drying with cold air assure the continuation from storage.

Principiul de funcționare a instalațiilor de uscat cu aer rece se bazează pe proprietățile aerului nesaturat de a se încărca cu vapori de apă. În acest scop, aerul este forțat să treacă prin stratul de fân, folosind un sistem de ventilare. Instalațiile de uscat fân cu aer rece asigură continuarea uscării fânului la locul de depozitare.

RESULTS

Biggest losses of nutrients are obtained with traditional drying hay stubble. These losses reach, in case of bad

REZULTATE

Pierderile cele mai mari de substanțe nutritive se obțin la uscarea tradițională pe mirişte a fânului. Aceste

weather or even 50 ... 60%, the drying time increased to over 6 ... 8 days. The smallest losses, 4 ... 5% Figure 1 are obtained when green fodder dehydration in drying and briquetting special stations, [1].

Execution of certain works in accordance with agro-technical and technological requirements contribute to the high production of fodder, and top quality hay. High productions are obtained by reducing losses of fodder harvesting and harvesting cycles increase through a reduction in the harvest period. Hay quality is improved by reducing the duration for keeping the feed ground after mowing and quality execution of works, [8].

The influence of weather on drying high stubble hay, in a first stage and is given a warm day, with low humidity, hay dries faster than in a cold day with high air humidity. During the weather is hot and dry summer hay can be obtained by drying the soil in two days, while in the cold and wet winter, drying time traditional soil increases to 6…8 days, and atmospheric humidity play a role importantly, as can be seen in Figure 2.

Under such weather conditions must give up on traditional preparation by drying hay on the ground, because long periods of drying greatly increase nutrient losses, resulting in lower quality hay.

pierderi ajung, în caz de vreme nefavorabilă, chiar la 50…60%, timpul de uscare crescând la peste 6…8 zile. Cele mai mici pierderi, de 4…5%, figura 1, se obţin în cazul deshidratării furajelor verzi în staţii speciale de uscare şi brichetare [1].

Executarea unor lucrări conforme cu cerinţele agrotehnice şi tehnologice contribuie la obţinerea de producţii înalte de furaje, şi unui fân de calitate superioară. Producţiile ridicate se obţin prin reducerea pierderilor de furaje la recoltare şi prin creşterea numărului ciclurilor de recoltare ca urmare a diminuării perioadei de recoltare. Calitatea fânului se îmbunătăţeşte prin reducerea duratei de menţinere pe sol a furajului după cosire şi prin executarea unor lucrări de calitate, [8].

Influenţa ridicată a condiţiile meteo asupra uscării pe mirişte a fânului, într-o primă etapă este dată şi de o zi caldă, cu umiditatea aerului scăzută, fânul se usucă mai repede decât într-o zi rece cu umiditatea aerului ridicată. În timpul vremii fierbinţi şi uscate de vară fânul poate fi obţinut prin uscare pe sol în două zile, pe când, în perioada rece şi umedă de toamnă, timpul de uscare tradiţională pe sol creşte la 6…8 zile, iar umiditatea atmosferica având un rol important, cum se poate vedea în fig. 2.

În astfel de condiţii meteo trebuie să se renunţe la pregătirea fânului prin uscarea tradiţională pe sol, deoarece în perioade de uscare lungi cresc foarte mult pierderile de substanţe nutritive, rezultând un fân de calitate inferioară.

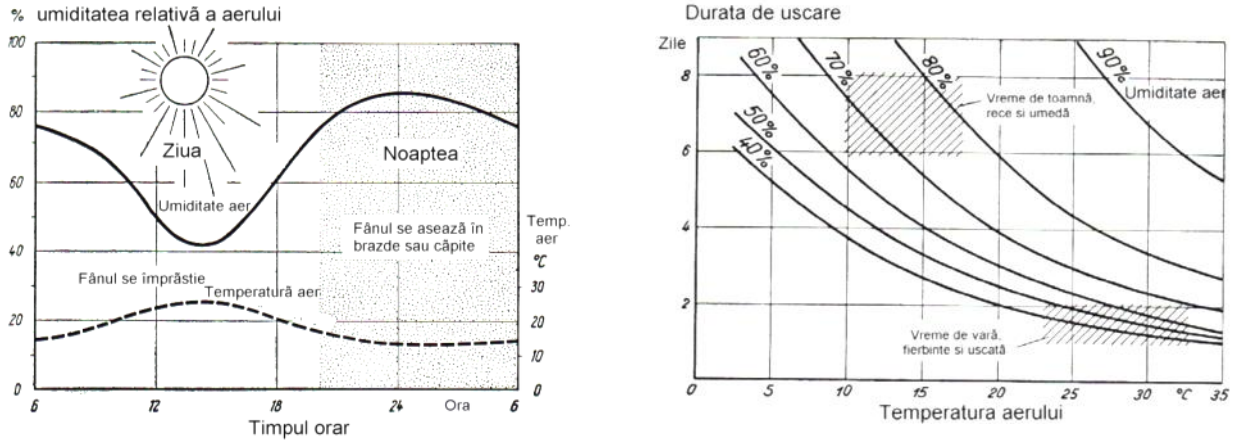

Fig. 2 - The evolution of the humidity of the ambient air temperature during the day and night, and during the natural drying of the hay under different weather, [3]

The data in Table 3 on the moisture content of the atmosphere, g water to 1 kg of dry air in function of temperature and relative humidity give us a clear view about the efficiency of drying in atmospheric conditions.

Datele din tabelul 3 cu privire la conţinutul de umiditate al aerului atmosferic, g de apa la 1 kg de aer uscat, în funcţiei de temperatură şi de umiditatea relativă ne dau o vedere clară despre eficienţa uscării în condiţiile atmosferice.

Table 3

The moisture content of the air in grams of water depending on the temperature and relative humidity, data sources [2]

Air temperature [ºC]	Relative humidity[%]					
	40	50	60	70	80	90
0	1,53	1,92	2,30	2,69	3,07	3,46
5	2,19	2,75	3,20	3,85	4,40	4,95
10	3,09	3,87	4,65	5,43	6,21	7,00
15	4,30	5,38	6,47	7,56	8,66	9,76
20	5,91	7,41	8,91	10,42	11,94	13,46
25	8,01	10,08	12,14	14,21	16,20	18,39
30	10,32	13,59	16,37	19,19	22,03	24,89
35	14,43	18,14	21,90	25,70	29,54	33,43
40	19,07	24,03	25,03	34,16	39,35	44,62
45	25,03	31,30	38,31	45,15	59,28	59,28

For example, in the case of atmospheric air drying to a moisture content of 40% and a temperature of 30°C to moisture content equal to 10.32 g/kg. In these conditions

Spre exemplu, în cazul uscării cu aer atmosferic cu o umiditate de 40% şi cu o temperatură de 30ºC conţinutul în umiditate este egală cu 10,32 g/kg. În

when air passes through a layer of humidity fodder subjected to drying up because it adds humidity and temperature taken from material decreases because part of the heat to the evaporation of water.

Obviously, the duration of drying is inversely proportional to the amount of evaporated water per kg air to be accepted when a constant amount of air per hour. Consequently, drying time under unfavourable conditions will be approximately 5...20 times longer than favourable weather conditions, increase energy consumption for drying and productivity will decrease in inverse proportion dryers.

The influence of the structure and nature the forage The drying rate of drying is reduced with increasing concentration of solids in addition, the leaves dry more quickly than stems, and besides these items biological drying process is influenced by features the furrows.

In the case thick and dense furrows, normally obtained from harvesting grassland and forage crops, with high output, airflow and heat occurs with difficulty, the lower layers dries harder. The furrow surface reflects about 20% of solar radiation, the remaining energy is rapidly absorbed from the surface, and so that 2 cm inside penetrates only half, and only based on 10%. At the same time airflow into the furrow is quite low. For example, at a wind speed of 2 m/s to 10 cm above the ground current of air does not exceed 0.2 m/s.

In addition, air humidity falls below 80% rarely furrow in the early stages of drying. As a result hay preparatory work must aim to create the conditions needed to accelerate rate uniform drying, and so reduce the nutrient losses through breathing, shaking the leaves and wash when precipitation [3].

CONCLUSIONS

Green forage feed contains a large amount of water, generally between 70...85%. For storage the winter it must be subjected the drying process, so that's humidity is reduced below 18% as result storage will be achieved under optimal conditions, without causing undesirable phenomena.

The condition for the drying of feed varies from species to species, depending on their further destination. These terms refer to the atmospheric air temperature is a drying agent, and during the process humidity was determined by drying it.

Following the research and previous study we can draw some advantages of using the drying process within the appropriate facilities to lessen possible influence and reduce dependence on weather conditions during harvest, allowing a hay quality (with high nutritional value, fragrant, pale grass close of origin) due to shortening for keeping stubble feed after mowing.

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aceste condiţii când aerul trece printr-un strat de furaj supus uscării umiditatea lui creşte, deoarece se adaugă umiditatea preluata din material şi temperatura scade deoarece o parte din căldură se consumă pentru evaporarea apei.

Evident că durata uscării este invers proporţională cu cantitatea de apă evaporată de fiecare kg de aer atunci când se admite o cantitate constantă de aer pe oră. Prin urmare, durata uscării în condiţii nefavorabile va fi de cca 5…20 ori mai lungă decât în condiţii atmosferice favorabile, va creşte şi consumul de energie pentru uscare şi va scădea invers proporţional productivitatea instalaţiei de uscare.

Influenţa structurii şi a naturii furajului asupra uscării Ritmul de uscare se reduce pe măsură ce creşte concentraţia de substanţă uscată, în plus, frunzele se usucă mult mai rapid decât tulpinile, iar pe lângă aceste elemente de natură biologică, procesul de uscare este influenţat şi de caracteristicile brazdelor.

În cazul brazdelor groase şi dense, obţinute în mod normal la recoltarea pajiştilor şi culturilor furajere cu producţie ridicată, circulaţia aerului şi a căldurii are loc cu dificultate, straturile inferioare uscându-se mult mai greu. Suprafaţa brazdei reflectă cca 20% din radiaţia solară, energia rămasă fiind absorbită rapid la suprafaţă, astfel că la 2 cm în interior pătrunde numai jumătate, iar la bază doar 10%. Totodată circulaţia aerului în interiorul brazdei este destul de redusă. Spre exemplu la o viteză a vântului de 2 m/s, la 10 cm deasupra solului curentul de aer nu depăşeşte 0,2 m/s.

În plus, umiditatea aerului din brazdă rareori scade sub 80% în primele faze ale uscării. Drept urmare lucrările de pregătire a fânului trebuie să urmărească crearea condiţiilor necesare accelerării ritmului de uscare uniformă, reducându-se astfel pierderile de substanţe nutritive prin respiraţie, scuturarea frunzelor şi spălarea în cazul precipitaţiilor, [3].

CONCLUZII

Furajul verde la cosire conţine o cantitate mare de apă, cuprinsă în general între 70%...85%. Pentru păstrarea peste iarnă el trebuie supus procesului de uscare, astfel ca umiditatea lui să fie redusă sub 18%, drept urmare depozitarea se va realiza în condiţii optime, fără apariţia fenomenelor nedorite.

Condiţiile pentru uscare furajelor diferă de la o specie la alta, în funcţie de destinaţia ulterioară a acestora. Aceste condiţii se referă la temperatura aerului atmosferic care devine agent de uscare, umiditatea sa şi durata procesului de uscare determinat de acesta.

În urma cercetărilor şi a studiului anterior se pot trasa câteva avantaje ale folosirii procesului de uscare în cadrul instalaţiilor adecvate pentru a diminua pe cât posibil influenţa şi a se reduce dependenţa faţă de condiţiile meteorologice din timpul recoltării, permiţând obţinerea unui fân de calitate superioară (cu valoare nutritivă ridicată, cu miros plăcut, de culoare apropiată de iarba de provenienţă) datorită scurtării duratei de menţinere pe mirişte a furajului după cosire.

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THE MODEL OF THE AGGREGATE TRACTOR - SEMITOWED MACHINE
/
MODELAREA AGREGATULUI TRACTOR - MASINA SEMIPURTATA

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Abstract: *This paper presents modeling tractor - semi-mounted machine. The tractor is a complex mechanical system in which, while moving produces vibrations which are transmitted to the driver of the tractor from the rolling track. Using a modeling program studied: field of variation of the real speed of the aggregate when cruising on the two lands; field of variation of maximum driving force at the movement of the mobile agricultural unit on the two lands; field of variation of the effective driving force at the movement of the aggregate tractor - semi-mounted machine on the two lands; the variation of the driving power of the mobile agricultural aggregate when cruising on the two lands; variation of hourly fuel consumption at the movement of the aggregate tractor - semi-mounted machine on the two lands; variation of specific fuel consumption at the movement of the aggregate tractor - semi-mounted machine on the two lands.*

Keywords: *semi-mounted machine, mathematical model tractor*

Rezumat: *Lucrarea prezintă modelarea tractorului-masina semipurtata. Tractorul reprezintă un sistem mecanic complex în care, în timpul deplasării, se produc vibrații care se transmit de la calea de rulare la conducătorul tractorului. Cu ajutorul unui program de modelare s-a studiat: domeniul de variație al vitezei reale a agregatului la deplasarea pe cele două terenuri; domeniul de variație al forței motoare maxime la deplasarea agregatului agricol mobil pe cele două terenuri; domeniul de variație al forței motoare efective la deplasarea agregatului tractor – maşină semipurtată la deplasarea pe cele două terenuri; variația puterii motoare a agregatului agricol mobil la deplasarea pe cele două terenuri; variația consumului orar de combustibil la deplasarea agregatului tractor – maşină semipurtată pe cele două terenuri; variația consumului specific de combustibil la deplasarea agregatului tractor – maşină semipurtată pe cele două terenuri.*

Cuvinte cheie: *masina semipurtata, model matematic, tractor.*

INTRODUCTION

Based on the tractor dynamics a modeling software was made in order to study the dynamics of the mobile agricultural unit [1].

The program of modeling the dynamics of the tractor using a model with four degrees of freedom is complemented with data on the machine working in aggregate with the tractor U-650M [5].

Because of the machine that is attached to the tractor, the dynamic weight distribution on the tractor axels will be different as against the tractor without machine. The coefficient of the dynamic weight distribution on the tractor driven axle is [7[:

- in the case of semi-mounted machine:

INTRODUCERE

Bazându-se pe dinamica tractorului s-a făcut un program de modelare a acestuia pentru a se putea studia dinamica agregatului agricol mobil [1].

Programul de modelare a dinamicii tractorului utilizând un model cu patru grade de libertate este completat cu date referitoare la maşina cu care lucrează în agregat tractorul U-650M [5].

Datorită maşinii, care este cuplată la tractor, repartizarea dinamică a greutății pe punțile tractorului va fi diferită față de cazul tractorului fără maşină. Coeficientul de repartizare dinamică a greutății pe puntea motoare a tractorului este [7]:

- în cazul maşinii semipurtate:

$$\lambda_{din} = \lambda_s + \frac{R(L+c) + F_t h_c}{M_t g L} \quad (1)$$

where:

λ_s - the coefficient of the tractor static weight distribution on the driving axle;

R - semi-mounted machine weight distributed on the driven axle of the tractor;

unde:

λ_s - coeficientul de repartizare statică a greutății tractorului pe puntea motoare;

R - greutatea maşinii semipurtate repartizată pe puntea motoare a tractorului;

$$R = 0{,}15(M_m + M_u)g \quad (2)$$

and:

M_m - machine mass;

M_u - mass of load;

M_t - tractor mass.

iar:

M_m - masa maşinii;

M_u - masa încărcăturii;

M_t - masa tractorului.

MATERIAL AND METHODE

MATERIAL ŞI METODĂ

The mobile agricultural unit for which was run the modeling program was formed from U-650M tractor and the tank trailer RC-1.8 designed for the transportation of fuel (diesel and petrol) [2], [3]. The tank trailer RC-1.8 is a single-axle trailer and has the following characteristics:

- trailer mass, $M_m = 1200$ kg;
- useful mass, $M_u = 2000$ kg.

Taking into account that some of the trailer weight is distributed on the driving axle of the tractor, the coefficient of the dynamic weight distribution on the tractor driving axle is $\lambda_{din} = 0{,}861$. After running the modeling program were obtained datas from Tables 1 and 2.

Agregatul agricol mobil, pentru care a fost rulat programul de modelare, a fost format din tractorul U-650M şi remorca cisternă RC-1,8 destinată transportului combustibilului (motorină şi benzină) [2], [3]. Remorca cisternă RC-1,8 este o remorcă monoaxă şi are următoarele caracteristici:

- masa remorcii, $M_m = 1200$ kg;
- masa utilă, $M_u = 2000$ kg.

Având în vedere că o parte din greutatea remorcii este repartizată pe puntea motoare a tractorului, coeficientul de repartizare dinamică a greutății este $\lambda_{din} = 0{,}861$. În urma rulării programului de modelare s-au obținut datele din tabelele 1 şi 2.

Table 1

Real speed, effective and maximum driving force at the movement of aggregate tractor - semi-mounted machine on the agricultural land

Engaged gear	Real speed [km/h]			The effective driving force [N]			Maximum driving force [N]		
	min	max	Δv	min	max	ΔF_m	min	max	ΔF_{max}
1	3.74325	3.7437	0.00045	6844	6856	12	14725	14790	65
2	5.67	5.6718	0.0018	6842	6859	17	14710	14810	100
3	7.8588	7.862	0.0032	6840	6860	20	14700	14820	120
4	9.6058	9.613	0.0072	6838	6864	24	14690	14830	140

Table 2

Real speed, effective and maximum driving force at the movement of aggregate tractor - semi-mounted machine on country road

Engaged gear	Real speed [km/h]			The effective driving force [N]			Maximum driving force [N]		
	min	max	Δv	min	max	ΔF_m	min	max	ΔF_{max}
1	3.7426	3.7443	0.0017	6829	6871	42	14640	14880	240
2	5.667	5.6745	0.0075	6820	6882	62	14580	14920	340
3	7.854	7.867	0.013	6810	6892	82	14520	14980	460
4	9.594	9.626	0.032	6795	6897	102	14500	15120	620

The slipping coefficient was $\delta = 5{,}742 - 5{,}762$ % when cruising on the farmland and $\delta = 5{,}69 - 5{,}81$ % when cruising on the country road [4].

Figure 1 shows the real speed variation of the mobile agricultural aggregate when cruising on the two lands.

Coeficientul de patinare a fost $\delta = 5{,}742 - 5{,}762$ % la deplasarea pe terenul agricol şi $\delta = 5{,}69 - 5{,}81$ % la deplasarea pe terenul de țară [4].

În figura 1 se prezintă variația vitezei reale a agregatului agricol mobil la deplasarea pe cele două terenuri.

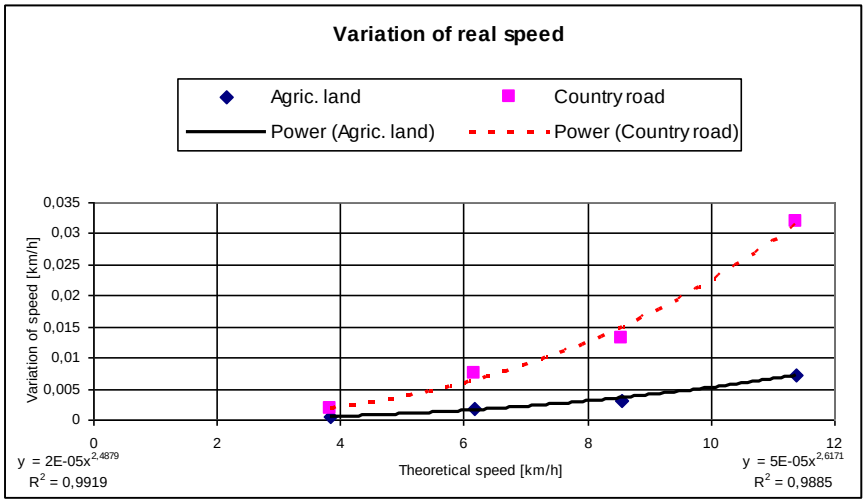

Fig. 1 – Range of variation of real speed of the aggregate when moving on the two lands

It is observed just like at the aggregate tractor - trailed machine that the range of variation of the real speed is directly proportional to the speed of the aggregate and greater when cruising on the country road.

Variation of the maximum driving force (ΔF_{max}) depending on the speed of movement of the aggregate on the two lands is shown in Figure 2.

Se observă, la fel ca la agregatul tractor – maşină tractată, că domeniul de variație al vitezei reale este direct proporțional cu viteza agregatului şi mai mare la deplasarea pe drumul de țară.

Variația forței motoare maxime (ΔF_{max}) în funcție de viteza de deplasare a agregatului, pe cele două terenuri este prezentată în figura 2.

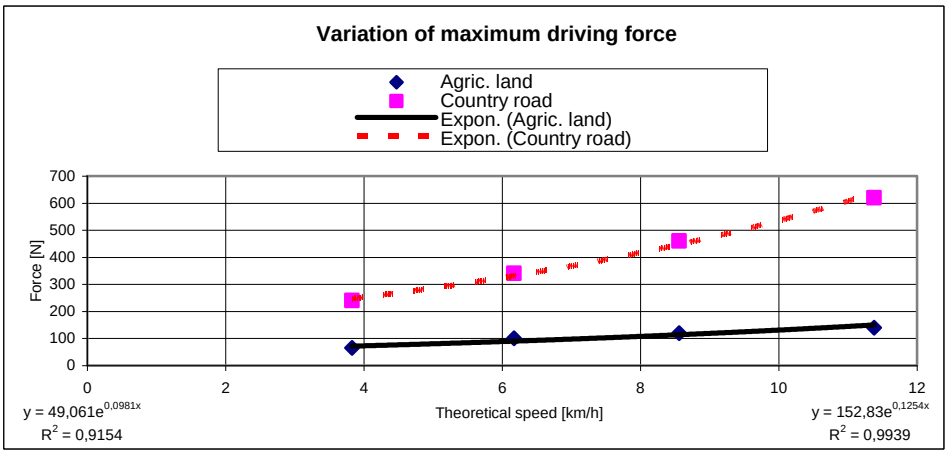

Fig. 2 – The range of variation of the maximum driving force at the movement of the mobile agricultural aggregate on the two lands

Range of variation of the maximum driving force depending on the moving speed of the aggregate tractor - semi-mounted trailer is higher at than traveling on the country road when riding on the farmland. Is kept approximately the same range of variation as in the case of the aggregate tractor - trailed machine [6].

Variation of effective driving force at the displacement of the mobile agricultural aggregate on the two lands is shown in Figure 3.

Domeniul de variație al forței motoare maxime în funcție de viteza de deplasare a agregatului tractor – remorcă semipurtată este mai mare la deplasarea pe drumul de țară față de cazul deplasării pe terenul agricol. Se menține aproximativ acelaşi domeniu de variație ca în cazul agregatului tractor – maşină tractată [6].

Variația forței motoare efective la deplasarea agregatului agricol mobil pe cele două terenuri este prezentată în figura 3.

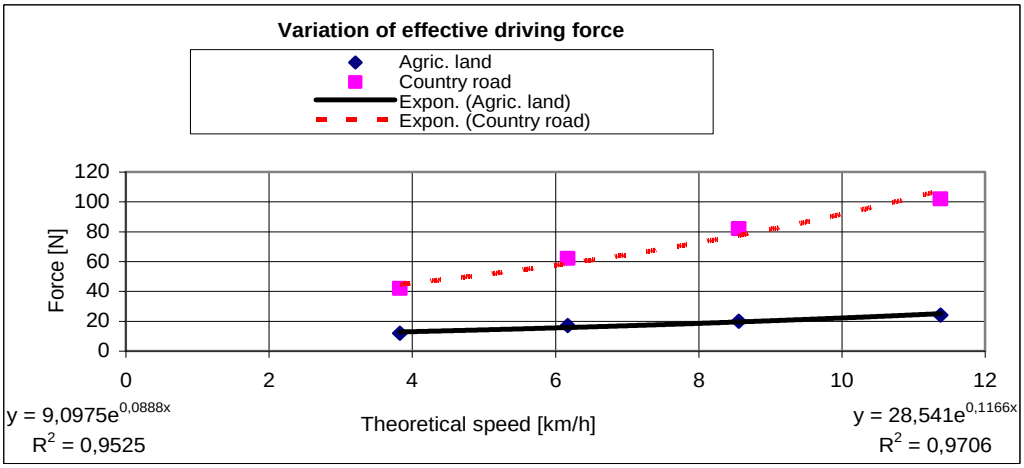

Fig. 3 – Range of variation of the effective driving force at the displacement of the aggregate tractor - semi-mounted machine on the two lands

The range of variation of the effective driving force depending on the moving speed of the mobile agricultural aggregate is higher when cruising on the country road than on the agricultural land.

Variation of the traction power, of the hourly consumption and of that specific of fuel for different moving speeds of the mobile agricultural aggregate tractor - semi-mounted machine is shown in Tables 3 and 4.

Domeniul de variație al forței motoare efective în funcție de viteza de deplasare a agregatului agricol mobil este mai mare la deplasarea pe drumul de țară față de deplasarea pe terenul agricol.

Variația puterii de tracțiune, a consumului orar şi a celui specific de combustibil pentru diferite viteze de deplasare ale agregatului agricol mobil tractor – maşină semipurtată este prezentată în tabelele 3 şi 4.

Table 3

Traction power, consumption per hour and specific of fuel at the mobile agricultural aggregate

movement on the agricultural field

Engaged gear	Traction power [kW]			Hourly fuel consumption [kg/h]			Specific fuel consumption [g/kWh]		
	min	max	ΔP	min	max	ΔC_h	min	max	Δc
1	7.8678	7.881	0.0132	5.4636	5.4658	0.0022	743.65	744.45	0.8
2	12.042	12.065	0.023	6.5471	6.552	0.0049	563.32	536.9	0.58
3	14.575	14.611	0.036	7.7915	7.7998	0.0083	517.96	518.24	0.28
4	20.138	20.198	0.06	8.93	8.942	0.012	448.85	449.17	0.32

Table 4

Traction power, consumption per hour and specific of fuel at the mobile agricultural aggregate movement on the country road

Engaged gear	Traction power [kW]			Hourly fuel consumption [kg/h]			Specific fuel consumption [g/kWh]		
	min	max	ΔP	min	max	ΔC_h	min	max	Δc
1	7.852	7.894	0.042	5.465	5.469	0.005	742.5	745.6	3.1
2	12.01	12.1	0.09	6.54	6.5525	0.0185	535.5	537.7	2.2
3	14.52	14.66	0.14	7.778	7.812	0.034	517.6	518.6	1
4	20.04	20.3	0.26	8.9	8.964	0.064	448.4	449.7	1.3

The range of variation of the driving power for the moving speeds of the mobile agricultural aggregate tractor U-650M, RC -1.8 trailer, on the two lands is shown in Figure 4.

Domeniul de variație al puterii motoare, pentru vitezele de deplasare ale agregatului agricol mobil tractor U -650M, remorcă RC -1,8, pe cele două terenuri este prezentat în figura 4.

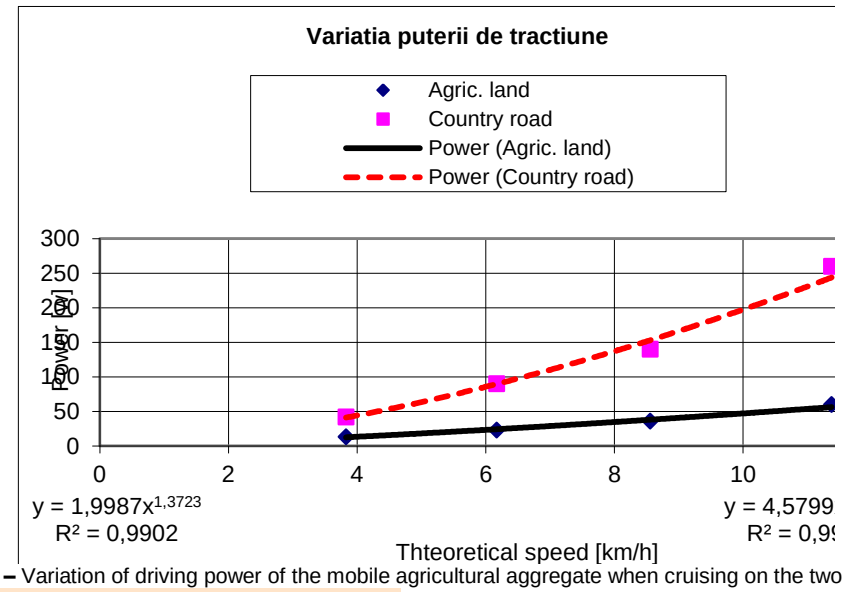

Fig. 4 – Variation of driving power of the mobile agricultural aggregate when cruising on the two lands

It keeps the same driving power variation as for the aggregate tractor - trailed machine but the variation at the displacement is higher ($\Delta P = 50 - 250$ W at the aggregate tractor - semi-mounted machine compared to $\Delta P = 20 - 160$ W for the aggregate tractor - trailed machine).

Variation of the hourly fuel consumption depending on the moving speed of the aggregate on the two lands is shown in Figure 5.

Variation of the specific fuel consumption at the mobile aggregate displacement on the the two agricultural lands is shown in Figure 6.

Variation of the specific fuel consumption depending on the speed of the mobile agricultural aggregate has minimum value for the speed of $v = 10$ km/h. In the case of the movement on the country road, the variation of specific fuel consumption is higher than in the case of movement on the agricultural land.

Se păstrează aceeaşi variație a puterii motoare ca şi în cazul agregatului tractor – maşină tractată însă domeniul de variație la deplasare este mai mare ($\Delta P = 50 - 250$ W la agregatul tractor – maşină semipurtată față de $\Delta P = 20 - 160$ W în cazul agregatului tractor – maşină tractată).

Variația consumului orar de combustibil în funcție de viteza de deplasare a agregatului pe cele două terenuri este prezentată în figura 5.

Variația consumului specific de combustibil la deplasarea agregatului agricol mobil pe cele două terenuri este prezentată în figura 6.

Variația consumului specific de combustibil în funcție de viteza agregatului agricol mobil are valoarea minimă pentru viteza $v = 10$ km/h. În cazul deplasării pe drumul de țară variația consumului specific de combustibil este mai mare față de cazul deplasării pe terenul agricol.

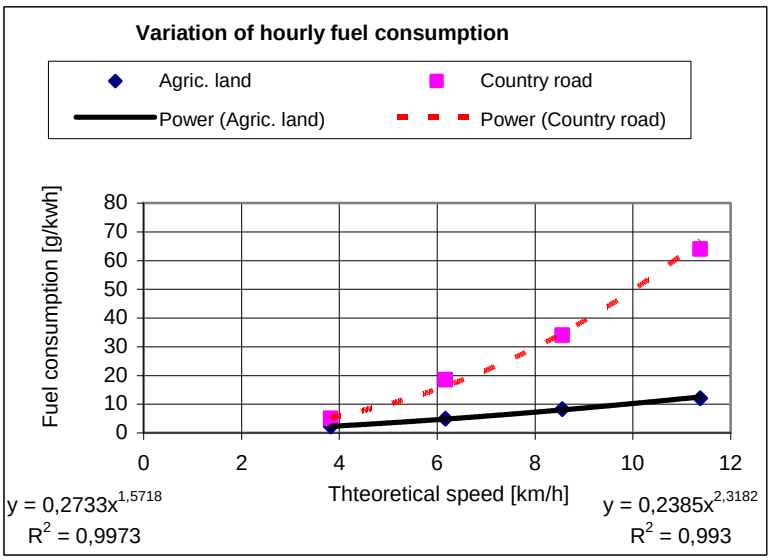

Fig.5 – Variation of the hourly fuel consumption at the displacement of the aggregate tractor - semi-mounted machine on the two lands

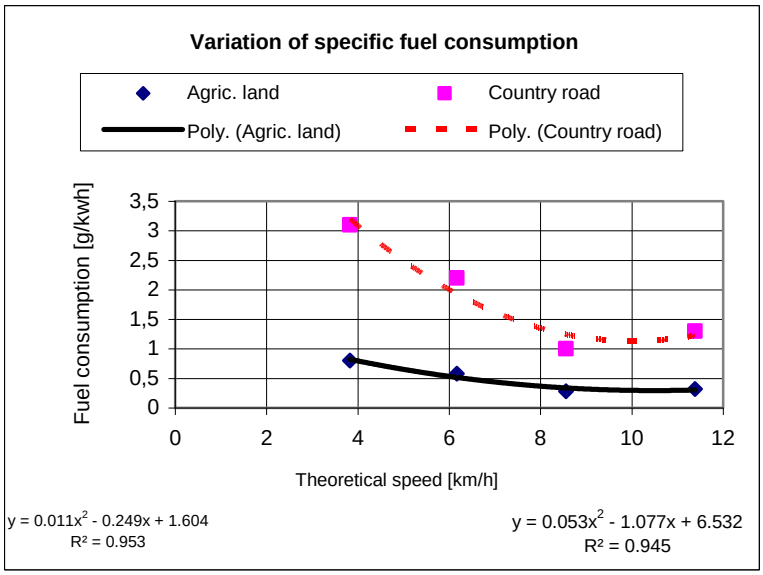

Fig. 6 – Variation of the specific fuel consumption at the displacement of the aggregate tractor - semi-mounted machine on the two lands

CONCLUSIONS

1. The modeling program of the mobile agricultural aggregate is based on the model with four degrees of freedom of the tractor completed with the machine parameters working in aggregate with the tractor and the actual feature of traction of the tractor.
2. The operational and dynamic parameters of the mobile agricultural aggregate which can be determined with the modeling program are:
   - amplitude of the oscillation of the tractor wheels and of the center of mass of the tractor for the movement of the aggregate on any terrain;
   - pitching and rolling angle of the tractor;
   - slipping coefficient of the tractor wheels;
   - the effective driving force variation and maximum at the tractor driving wheel;
   - variation of the traction power;
   - variation of the hourly consumption and specific fuel consumption at the movement of the aggregate on various terrains.
3. Thed range of variation of the real movement speed of the mobile agricultural aggregate increases with the speed of

CONCLUZII

1. Programul de modelare a agregatului agricol mobil are la bază modelul cu patru grade de libertate al tractorului completat cu parametrii maşinii care lucrează în agregat cu tractorul şi caracteristica reală de tracțiune a tractorului.
2. Parametrii funcționali şi dinamici ai agregatului agricol mobil care pot fi determinați cu programul de modelare sunt:
   - amplitudinea oscilației roților tractorului şi a centrului de masă al tractorului pentru deplasarea agregatului pe orice teren;
   - unghiul de tangaj şi de ruliu al tractorului;
   - coeficientul de patinare a roților tractorului;
   - variația forței motoare efective şi maxime la roata motoare a tractorului;
   - variația puterii de tracțiune;
   - variația consumului orar şi a consumului specific de combustibil la deplasarea agregatului pe diferite terenuri.
3. Domeniul de variație al vitezei reale de deplasare a agregatului agricol mobil creşte cu viteza agregatului,

the aggregate, the growth being more significantly when moving on country road compared to the displacement on the agricultural land.

4. the range of variation of the maximum driving force at the displacement of the aggregate on the agricultural land has the same variation for all the three aggregates studied. At the displacement of the aggregate on the country road the growth of the maximum driving force is more emphasized.

5. Variation of the effective driving force depending on the movement speed of the aggregate is more emphasized at the movement on the country road compared to the displacement on the agricultural land and has closer variations in the case tractor - trailed machine and tractor - mounted machine. In the case of the aggregate tractor - semi-mounted machine is approximately five times higher at the displacement on the country road.

6. The range of variation of the traction power is greater in the case of displacement of the mobile agricultural aggregate on the country road compared to the movement on the agricultural land and increases with the moving speed. the range of variation of the driving power at the displacement on the country road is almost two times lower in the case of the aggregate tractor - trailed machine compared to the other two aggregates analyzed.

7. The range of variation of the hourly fuel consumption is greater in the case of the movement of the aggregate on the country road compared to the displacement on the agricultural land. The range of variation is lower in the case of the aggregate tractor - trailed machine.

8. The range of variation of the specific fuel consumption is greater at the movement of the mobile agricultural aggregate on the country road compared to the displacement on the agricultural land and increases in inverse proportion with the moving speed. This has a minimum for the speed of $v = 8 \div 10$ km/h in the case of the aggregate tractor - machine trailed or semi-mounted and at the maximum speed for the aggregate tractor - mounted machine.

creşterea fiind mult mai accentuată în cazul deplasării pe drumul de țară față de deplasarea pe terenul agricol.

4. Domeniul de variație al forței motoare maxime la deplasarea agregatului pe terenul agricol are aceeaşi variație pentru toate cele trei agregate studiate. La deplasarea agregatului pe drumul de țară creşterea forței motoare maxime este mai accentuată.

5. Variația forței motoare efective în funcție de viteza de deplasare a agregatului este mai accentuată la deplasarea pe drumul de țară față de deplasarea pe terenul agricol şi are variații mai apropiate în cazul tractor - maşină tractată şi tractor - maşină purtată. În cazul agregatului tractor – maşină semipurtată este de aproximativ cinci ori mai mare la deplasarea pe drumul de țară.

6. Domeniul de variație al puterii de tracțiune este mai mare în cazul deplasării agregatului agricol mobil pe drumul de țară [față de deplasarea] pe terenul agricol şi creşte cu viteza de deplasare. Domeniul de variație al puterii motoare, la deplasarea pe drumul de țară, este aproape de două ori mai mică în cazul agregatului tractor – maşină tractată față de cazul celorlalte două agregate analizate.

7. Domeniul de variație al consumului orar de combustibil este mai mare în cazul deplasării agregatului pe drumul de țară față de deplasarea pe terenul agricol. Domeniul de variație este mai mic în cazul agregatului tractor – maşină tractată.

8. Domeniul de variație al consumului specific de combustibil este mai mare la deplasarea agregatului agricol mobil pe drumul de țară față de deplasarea pe terenul agricol şi creşte invers proporțional cu viteza de deplasare. Aceasta are un minim pentru viteza de $v = 8 \div 10$ km/h în cazul agregatului tractor – maşină tractată sau semipurtată, şi la viteza maximă pentru agregatul tractor – maşină purtată.

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OPTIMIZATION OF A VEGETABLE SEED SOWING PNEUMATIC EQUIPMENT IN PLUGS TRAYS AND NOURISHING LAYER
/
OPTIMIZAREA UNUI ECHIPAMENT PNEUMATIC DE SEMĂNAT SEMINȚE LEGUMICOLE ÎN TĂVI ALVEOLARE ŞI STRAT NUTRITIV

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Abstract: *The vegetable seed sowing pneumatic equipments in plugs trays and nourishing layer have a well defined place within superior capitalization technology of the seeding material with small dimensions, by seeding them in alveolar stand, respectively plugs trays, which are covered with nourishing layer (mixture of different soil types, minerals, elements to maintain the moisture at a constant level, nutrient grains or substances, etc.). Thus, the seed sown with this technology, benefits from germination and growth optimal conditions until it reaches the subculturing or planting stage in pots, greenhouses, solariums and in the field. By optimizing this equipment, it is aimed to implement performant command and control systems that improve the operating parameters, such as: to be suitable for a wide variety of vegetable seeds; to adjust to several types of alveolar trays and to increase productivity.*

Keywords: *equipment optimization, pneumatic sowing, vegetable seeds, plug trays.*

INTRODUCTION

The research directions in modern agriculture are directed to solve pressing problems of horticulture and to stimulate the rural development, at the European level, namely the small producers which cultivate local varieties and species of plants with high nutritional value that are grown according to organic farming requirements. Due to these considerations it became necessary an efficient seeding equipment how can be adapted to the seed characteristics.

The technologies made by the greatest manufacturers of agricultural machinery [1, 2, 3 and 5], have in mind to fight the next issue, the lack of performance and competitiveness of small horticultural producers, which is generated by the following factors: low crop production; low labor productivity, inadequate technologies and implementation methods; low quality of primary and secondary food products.

Mainly, in this moment, all these factors are conditioned by environmental conditions and climate change, which are becoming more unpredictable.

The plugs and the alveolar seedlings are ever more present on the European market and are promoted at international and national fairs with agricultural profile, such as INDAGRA - “International trade fair of equipment and products in agriculture, horticulture, viticulture and animal husbandry”.

Rezumat: *Echipamentele pneumatice de semănat seminţe legumicole în tăvi alveolare şi în strat nutritiv au un rol bine definit în cadrul tehnologiei de valorificare superioară a materialului semincer cu dimensiuni mici, prin semănarea acestora în suporturi alveolare, respectiv cuiburi, ce sunt acoperite cu strat nutritiv (amestec de diferite tipuri pământ, minerale, elemente de păstrare a umidităţii la valori constante, substanţe sau granule nutritive, etc.). Astfel, sămânţa semănată cu această tehnologie beneficiază de condiţii optime de germinare şi dezvoltare până în momentul când aceasta atinge stadiul de repicare sau de plantare în răsadniţe, seră, solarii sau în câmp. Prin optimizarea acestui echipament, se urmăreşte implementarea unor sisteme de comandă şi control pentru îmbunătăţirea parametrilor de lucru, astfel încât: să fie adaptată la o varietate largă de seminţe legumicole; să fie adaptabilă unor tipuri de tăvi alveolare şi să se mărească productivitatea.*

Cuvinte cheie: *optimizarea echipamentului, semănare pneumatică, seminţe de legume, tăvi alveolare.*

INTRODUCERE

Direcţiile de cercetare in agricultura modernă se îndreptă spre soluţionarea problemelor acute ale horticulturii şi pentru stimularea dezvoltării rurale, la nivel european, respectiv a micilor producători care cultivă soiuri şi specii de plante autohtone cu valoare nutritivă ridicată, care sunt cultivate conform cerinţelor agriculturii ecologice. Din aceste considerente a apărut necesitatea unor echipamente de semănat performante şi adaptabile la caracteristicile seminţelor.

Tehnologiile realizate de marii producătorii de maşini agricole [1, 2, 3 si 5], au ca scop combaterea următoarei probleme, lipsa de performanţă şi competitivitate a micilor producătorii horticoli, care este generată de următorii factori: producţie vegetală mică; productivitate redusă a muncii; tehnologiilor inadecvate şi a metodelor de implementare;calitatea scăzută a produselor alimentare primare şi secundare.

În mare parte, în acest moment, toţi aceşti factori sunt condiţionaţi de condiţiile de mediu şi cele schimbările climaterice, care sunt din ce în ce mai imprevizibile.

Micro-răsadurile sau răsadurile din tăvile alveolare, sunt din ce în ce mai prezente pe piaţa europeană şi sunt promovate la târgurile internaţionale şi naţionale cu profil agricol, cum ar fi INDAGRA – “Târgul internaţional de echipamente şi produse agricole, horticole, viticole şi creşterea animalelor”.

At these fairs are displayed a wide range of plug seedlings, mostly from vegetable sector but also in the floricultural - Fig.1, and also a large variety of alveolar trays made from a wide range of materials (plastics even the biodegradable) - Figure 2 and 3.

În cadrul acestor târguri sunt expuse o gamă largă de micro-răsaduri, majoritatea din sectorul legumicol dar şi din cel floricol - Fig.1, precum şi o varietate mare de tăvi alveolare realizate dintr-o gamă largă de materiale (mase plastice până la cele biodegradabile) - Fig.2 şi 3.

Fig. 1 – Horticultural plugs/ seedlings growth in alveolar trays showed at INDAGRA.

Fig. 2 – Plug trays typo dimension made from plastics and biodegradable materials.[3]

In Romania, several projects were financed to develop this kind of agriculture, especially to develop biodegradable materials that can be used to make alveolar structures. Those mostly are made from peat and cellulose fibbers, but also in its composition are integrated protection substances and biostimulators used in horticulture. [3]

By implementing certain biodegradable supports it is aimed to:

- reduction of environmental pollution by creating an alternative to plastic alveolar structures;
- increasing the use of secondary biodegradable materials from wood and agriculture industry;
- increasing the seedling and root system protection default, which can be safely transplanted in greenhouses and hotbeds, with the whole plug cell in which was grown;
- provides organic matter and substances for optimal protection and mitigation of environmental factors that can slow the seedlings development;
- alignment with the European directive requirements regarding prevention and pollution integrated control (IPPC) and the directive on packaging and packaging waste (94/62/EC);[3]

În România s-au finanțat proiecte pentru dezvoltarea acestui timp de agricultură şi mai ales pentru dezvoltarea de materiale biodegradabile care să fie utilizat pentru crearea de suporturile alveolare. Acestea, în mare parte, au ca baza turba şi fibre celulozice, dar în compoziția lui sunt integrate materiale protective si biostimulative ce sunt utilizate in horticultură. [3]

Prin implementarea unor suporturi biodegradabile se urmăreşte:

- reducerea poluării mediului prin crearea unui sistem alternativ pentru structurile alveolare din material plastic;
- creşterea gradului de utilizare a materialelor biodegradabile secundare din industria lemnului şi agricultură;
- creşterea gradului de protecție a răsadului şi a sistemului radicular, care poate fi transplantat în siguranță în sere şi răsadnițe cu tot cu celula în care s-a dezvoltat;
- asigură materie organică şi substanțe protective pentru o dezvoltare optimă şi diminuarea factorilor de mediu care pot încetini dezvoltarea răsadului;
- alinierea la cerințele directivei europene privind prevenirea şi controlul integrat al poluării (IPPC) şi ale directivei privind ambalajele şi deşeurile de ambalaje (94/62/EC); [3]

- improve the management practices concerning the agricultural seeding material production in order to optimize the existing technologies in terms of technical, economic and environmental;
- transferability of technological, managerial and educational practices, for sustainable agriculture practiced by horticultural producers and business entities form the plug production and trading. [3]

MATERIAL AND METHOD

Given the fact that the machinery used to sow seeds in alveolar structures, are almost unknown and unstudied nationally, INMA Bucharest has proposed a research project to develop a plug sowing equipment, equipped with a performing command and control system in which are incorporated latest components.

As a result of the research activity on current state of development of technologies and machines for sowing small and very small seeds in nutrient layer, was found that, the majority of equipments use pneumatic actuators and the most advanced models in this field have monitor and control integrated systems connected to: programmable electronic interfaces. Thus, are successfully embedded the ***pneutronic*** control and command systems that grants a high adaptability to the working conditions and user requirements, the seeds type, plug tray characteristics and also a high precision regarding the work parameters.

- îmbunătățirea practicilor manageriale privind producerea materialului agricol săditor în scopul optimizării tehnologiilor existente din punct de vedere tehnic, economic şi al protecției mediului; [http://www.ceprohart.ro/biosun.php]
- transferabilitatea practicilor tehnologice, manageriale şi educaționale, pentru o agricultură sustenabilă practicata de către producătorii din sectorul horticulturii şi agenților economici din domeniile producerii şi comercializării răsadurilor de plante. [3]

MATERIAL ŞI METODĂ

Având în vedere faptul că echipamentele tehnice utilizate pentru semănarea materialului semincer în structuri alveolare este aproape necunoscut şi studiat pe plan național, INMA Bucureşti a propus un proiect de cercetare pentru dezvoltarea unui echipamentele de semănat în alveole care să fie dotat cu un sistem de comandă şi control performant în care sa fie incorporate componente de ultimă oră.

În urma activității de cercetare privind stadiul actual de dezvoltare a tehnologiilor şi maşinilor de semănat seminţe mici şi foarte mici în strat nutritiv, s-a constat că, majoritatea folosesc sisteme de acționare pneumatice, iar cele mai avansate modele din domeniu au integrate sisteme de monitorizate şi control, conectate la interfețe electronice programabile. Astfel sunt implementate cu succes sisteme de comandă şi control ***pneutronice*** care conferă echipamentului tehnologic o adaptabilitate ridicată la condițiile de lucru şi la cerințele utilizatorului, la tipul materialului semincer, la caracteristicile tăvii alveolare dar şi o precizie ridicată a parametrilor de lucru.

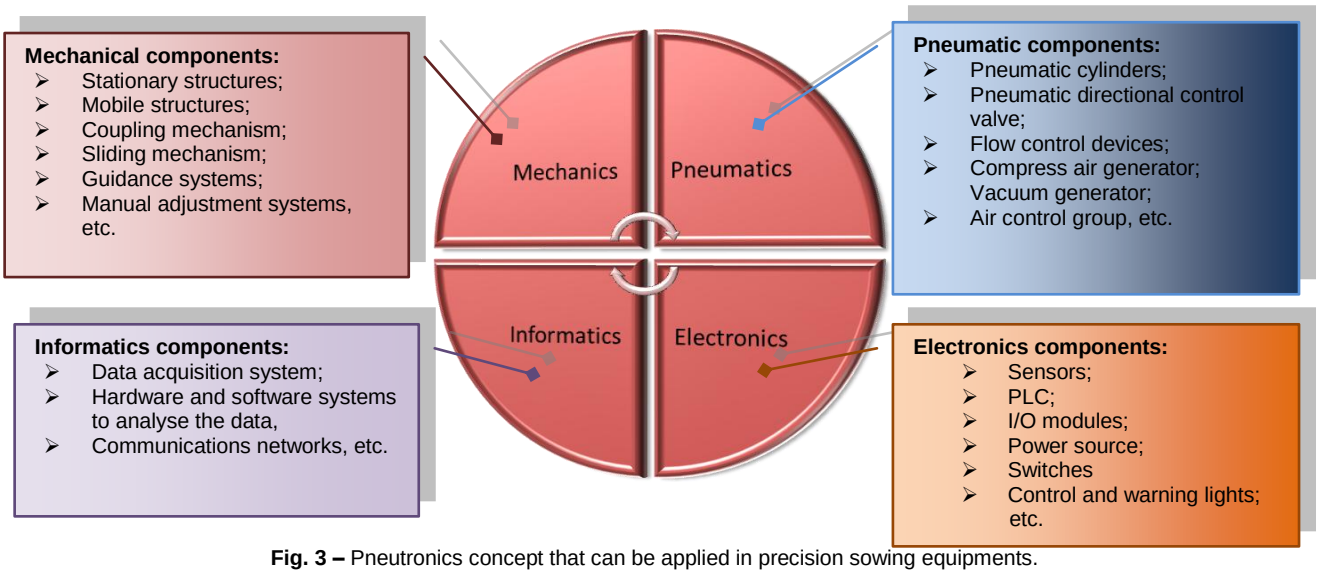

Fig. 3 – Pneutronics concept that can be applied in precision sowing equipments.

Pneutronics, is a relatively new field, which was introduced in precision mechanics to be applied in pneumatic actuation systems, command and controlled by the latest automation components in the field which can be connected to a programmable environment, respectively to mechatronics elements. Concept that can be successfully embedded also to equipments for sowing small and very small seeds in alveolar structures.

Form this point of view, the sowing equipment of small

Pneutronica este un domeniu relativ nou, ce a fost introdus în mecanica de precizie pentru a fi aplicată în cadrul sistemelor de acționare pneumatice comandate şi controlate cu ajutorul celor mai noi componente din domeniul automatizării ce pot fi conectate la un mediu programabil, respectiv elemente mecatronice. Concept care poate fi implementat cu succes şi la echipamentele de semănat seminţe mici şi foarte mici în structuri alveolare.

Din aceste punct de vedere, echipamentul de

and very small seeds SF it was optimized, which gives it a high level of interdisciplinarity.

RESULTS

The SF 13 model it was manufactured by Urbinati company from New Zealand horticulturists and it is one of the most accessible equipments that can be operated by one person and has a low level of complexity, but it is efficiency in exploitation. This model has proven to be the most popular model for greenhouses growers, because they have an automatic tray indexing mechanism and a seed planting mechanism provided with interchangeable nozzles.

Equipment optimization was made from structural point of view, so that to increase the operator safety, the equipment level of manoeuvrability and to improve operating mode.

semănat semințe mici şi foarte mici SF a fost optimizat, fapt care îi conferă şi cu un grad ridicat de interdisciplinaritate.

REZULTATE

Modelul SF 13, a fost create de firma Urbinati pentru horticultorii din Noua Zeelanda şi este unul din cele mai accesibile echipamente ce poate fi deservit de o singură persoană şi prezintă un grad de complexitate redus, dar este eficientă în exploatare. Acest model s-a dovedit a fi cele mai popular model pentru cultivatorii din sere, deoarece au un sistem automat de indexare a tăvii şi un mecanism de plantare a semințelor prevăzut cu interschimbabile duze.

Optimizarea echipamentului s-a realizat din punct de vedere constructiv astfel încât să crească gradul de siguranța a operatorului, gradul de manevrabilitate a echipamentului si de a îmbunătății regimul de funcționare.

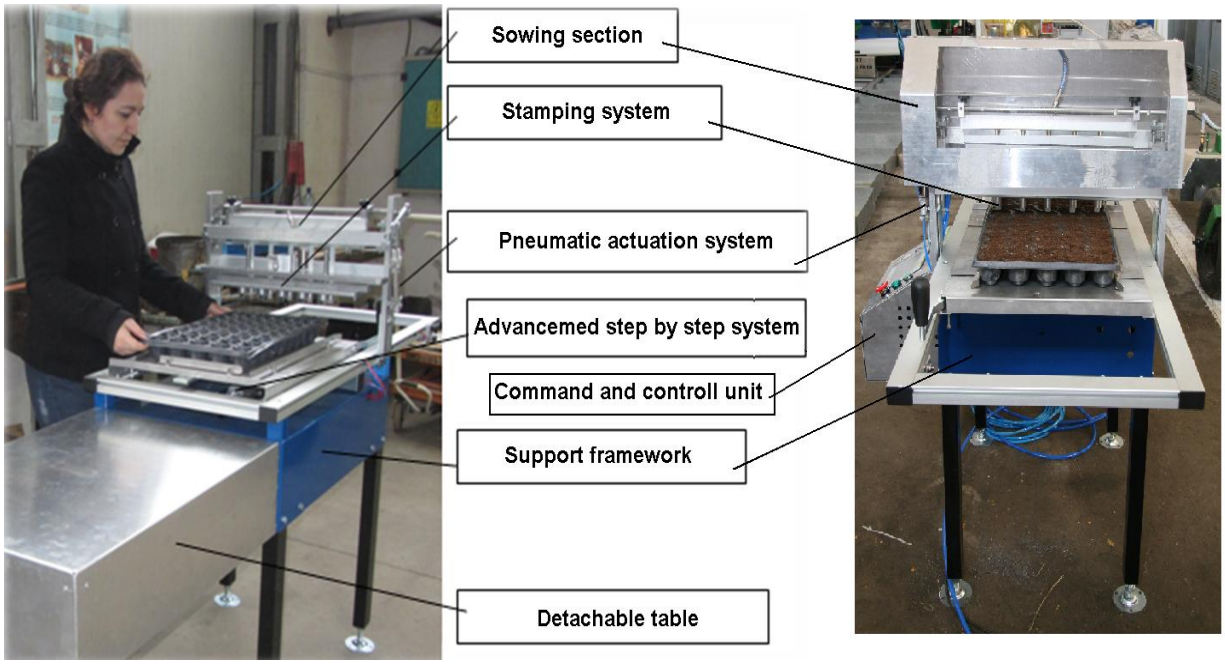

Fig. 4 – Small and very small seed pneutronic sowing equipment – ESAM.

Adding a detachable table was needed in order to increase the equipment workspace and to improve the sowing process by including the plug tray filling operation and the coverage with nourishing layer of alveoli sown, Fig.3

From the structural point of view, the EASM has also been optimized the protecting case of the seeding unit which is fitted with a hinged lid, so that it is possible to supply the vibrating tray with seeds and to secure the working area when the machine is working.

The lid has a monitoring window of sowing unit covered with Plexiglas and thus, can be adjusted vacuum generator operating mode, that depend on the seed characteristics and to indentify the inoperative or obstructed nozzles.

With this change, has increased seeding material category used in the sowing process by including the

Adăugarea unei mese detaşabile a fost necesară pentru a creşte spațiul de lucru al echipamentului şi pentru a îmbunătății procesul de semănare, prin includerea operaților de umplere a tăvii alveolare cu strat nutritiv şi de acoperire a alveolelor semănate, Fig.3.

Din punct de vedere constructiv a fost optimizată şi carcasa de protecție a unității de semănare, care este prevăzută cu un capac rabatabil astfel încât să fie posibilă alimentarea tăvii vibratoare cu semințe dar şi pentru securizarea spațiului de lucru, atunci când echipamentul este în regim de funcționare.

Capacul prezintă o fereastră de monitorizare a secției de semănare acoperită cu plexiglas şi astfel poate fi reglat regimul de funcționare a generatorului vacuum în funcție de caracteristicile seminței şi de detectare a duzelor nefuncționale sau obturate.

Datorită acestei modificări, s-a mărit gama de semințe care poate fi utilizată în procesul de semănare prin includerea semințelor tratate cu

treated seeds with chemical substances, thereby limiting the contamination of the environment with toxic substances and particles.

Having in view that, this equipment has been designed to be operated by a single operator, it was necessary to achieve a compact unity of command and control - UCC, so to integrate the all control and command components, such as: the compress air supply gauge, the adjustment and display side of vacuum/pressure generator OVEM for the sowing unit, the man-machine interface FED 770 provided by display with touch screen used to command and control the equipment operating mode, the on/off switch, the emergency button and power supply light, Fig.5.

substanțe chimice, limitând astfel contaminarea mediului înconjurător cu particule şi substanțe toxice.

Având în vedere faptul că acest echipament a fost este proiectat pentru a fi deservit de un singur operator, a fost necesar realizarea unei unității de comandă şi control compacte - UCC, astfel încât fie să includă toate componentele de reglare şi monitorizare, precum: manometru de la priza de aer comprimat, partea de reglare şi vizualizare generatorului de vacuum/ presiune OVEM a secției de semănare, interfața om-maşina FED 770 asigurată de un display-ului cu touchscreen utilizată pentru a controla si controla regimul de funcționare a echipamentului, butonul de oprire/ pornire, butonul de urgenta şi indicatorul de alimentare cu curent electric, Fig.5.

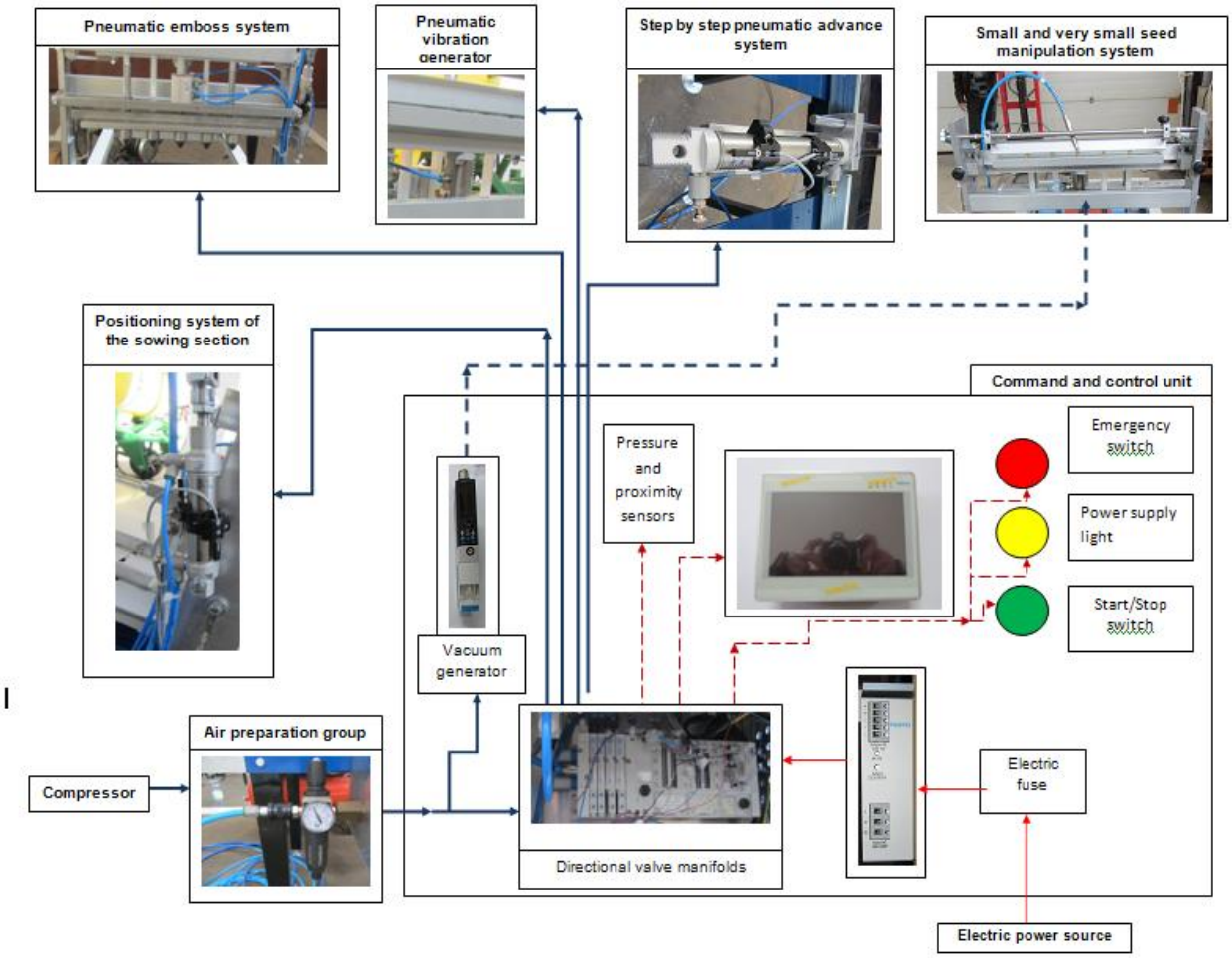

Fig. 5 – The working principle of the pneutronic equipment for seeding small and very small seeds.

In UCC also mounted the most advanced pneutronics components such as: directional valve manifolds control valve provided with terminals MPA provided with analogue and digital modular electrical terminal CPX, the control and memory module and the generator vacuum/pressure generator OVEM.

The advantages of this configuration are:

- unitary placement of all command and control components in a compact structure which is easily reconfigured in case in which is desired to increase automation and implementation of other sensors/transducers, to increase equipment performance

În UCC, de asemenea, sunt montate cel mai performante componentele pneutronice precum: insula de ventile prevăzută cu electrovalve MPA, cu module de intrare/ieşire analogice şi digitale CPX, controller-ul, modul de memorare şi generatorul de vacuum/presiune OVEM.

Avantajele acestei configurații sunt:

- amplasarea unitară a tuturor componentelor de comandă şi control în cadrul unei structuri compacte care poare fi uşor reconfigurată în cazul în care se doreşte creşterea gradului de automatizare şi implementarea altor senzori/traductori, pentru a creşte performanțele şi

and productivity;

- connecting other necessary equipments for the sowing process, such as: nutrient layer processing equipment, watering equipment, coating equipment, labelling and packaging equipment;
- development of command and control program which can be reconfigured depending on user requirements and the sowing process accuracy.

The step by step pneumatic actuation system of the plug tray, was modified because were placed inductive sensors that transmit the signals directly to UCC, to the input module of the directional valve manifolds, to the controller that command the start/stop of the seeding cycle, that can be easily positioned depending on the alveolar trays length.

Also, the proximity sensors positioned on the pneumatic imprinting system of the nutritional layer, phase that is realized previous to seeding operation, made by the emboss element, that must be synchronized with the seed sampling and evacuation operation of the sowing unit and also with plug tray displacement.

The importance of imprinting operation of nutrient layer is very important because it influences the seed positioning and the sowing depth, parameters that can be different on the crop type and its access to the nutrients resources for germination and growth in optimal conditions.

On the pneumatic cylinders of the positioning system of mobile table and seeding station, were placed electromagnetic sensors that have the role to synchronize the sowing process and to reduce the dead times.

The vacuum generator OVEM has integrated in its construction a pressure/vacuum transducer and an impurity filter (filter that collect the impurities from the seeding chamber or from seed material). This filter can be used to collect the undersized seeds that can be absorbed from the seeding material and can enter the pneumatic circuit, generating blockings and failures of command and control elements. This phenomenon has been noticed in specialized literature and it is indicated that the filter to be supervised. [5]

Thanks to the pressure transducer incorporated in the circuit vacuum generating line, it can be made a control loop of the compressed air pressure for the seeds absorption or evacuation in to the guidance system. This parameter is very important because it depends on equipment productivity and integrity sowed seeds.

The OVEM can also provide the necessary vacuum to remove the seeds for the seed vibrating tray when the sowing process is complete, by connecting the vacuum pipe line to the collection container. It can also be used to remove impurities blocked in the seed material sampling nozzles.

CONCLUSIONES

Optimizing the pneumatic sowing equipment for vegetable seeds in alveolar trays nutrient layer- ESAM, was made of the constructive and functionalpoint of view, in order to increase the competitiveness of equipment

productivitatea echipamentului;

- conectarea altor echipamente necesare procesului de semănare, precum: echipament de procesare strat nutritiv, echipament de udare, echipament de acoperire, echipament de etichetare şi împachetare;
- realizarea unui program de comandă şi control ce poate fi reconfigurabil în funcție de cerințele utilizatorului şi de precizia procesului de semănare.

Sistemul de avans pneumatic pas cu pas a tăvii alveolare, a fost modificat deoarece au fost amplasați senzori de proximitate inductivii care transmit seminalele direct la UCC, respectiv in modului de intrare a insulei de ventile către controller ce comanda începerea/ oprirea ciclului ce semănare, care pot fi poziționați în funcție de lungimea tăvi alveolare.

De asemenea, senzori de proximitate au fost montați la sistemul de amprentare a stratul nutritiv, fază care se realizează anterior operațiunii de semănare, realizată de către elementul de poansonare, ce trebuie sincronizată cu operațiunea de prelevare şi evacuare sămânță a unității de semănare şi cea de avans al tăvii alveolare.

Importanța operație de amprentare a stratului nutritiv este foarte importantă deoarece, influențează poziționarea sămânței în cadrul alveolei şi adâncimea de semănare, parametrii care poate diferi în funcție de tipul de cultură, şi accesul acesteia la toate resursele nutritive pentru a germina şi de a se dezvolta în condiții optime.

Pe cilindri pneumatici a sistemului de poziționare a mesei mobile şi a secției de semănare, au fost montați senzori electromagnetici care au rolul de a sincroniza procesul de semănare şi a reduce timpi morți.

Generatorul de vacuum OVEM are integrant în construcția sa un traductor de presiune/depresiune şi un filtru de impurității (filtru în care sunt colectate impuritățiile din incinta de prelevare sau din materialul semincer). Acest filtru mai poate fi utilizat la colectarea semințelor subdimensionale ce pot fi absorvite din materialul semincer şi pot pătrunde în circuitul pneumatic, generând blocaje şi defecțiuni ale elementelor de comandă şi control. Aceast fenomen a mai fost sesizat în literatura de specialitate şi este indicat ca filtru să fie monitorizat.[5]

Datorită traducătorului de presiune incorporart in circuitul de generare a vacumului, se poate realiza o buclă de comandă a presiunii aerului comprimat pentru absorbția sau evacuarea semințelor în sistemul de ghidare. Acest parametru este foarte important deoarece de el determină productivitatetea echipamentului şi integritatea materialului semincer semănat.

OVEM-ului de asemenea asigură vacuumul necesar pentru prelevare semințelor rămase în tava vibratoare la finalizarea procesului de semănare, prin conectarea linei de vacuum la un recipient de colectare, de asemenea acesta mai poate fi utilizat şi pentru îndepărtarea impurităților blocate în duzele de prelevare material semincer.

CONCLUZII

Optimizarea echipamentului pneumatic de semănat semințe legumicole în tăvi alveolare şi strat nutritiv - ESAM, a fost realizată din punct de vedere constructiv şi

serving the horticultural sector, respectively the vegetable sector, because these technologies have a high impact in technology, food and also economically terms and also encourages seedlings producers to break into national and international markets with competitive products, in the shortest time possible and capitalization of native seeding material.

The changes made led to:

- Increase operator safety through secure workspace, when the equipment is under operation by improving protective casing of seeding section;
- widening the seeds categories which can be used in the seeding process, by including chemical treated seeds,
- incensement of the equipment manoeuvrability, by positioning all command and control components in a single module;
- operating mode improvement, using FED 770 man-machine interface provided by a touchscreen display which can be easily used to identify the possible malfunction;
- improvement of the sowing process, by incorporating the plug tray filling operation with nutrient layer and the sown tray coating;
- ensuring equipment modularity, so that the packaging, transport, assembly and servicing activities to be easily carried out;
- increasement of the retechnologization level, using the most compact and performing pneutronics components in order to increase the control of functional parameters;
- increasement of the pneutronic system adaptability by using the modular valve manifold and analogue and digital input/output modules type CPX, so that could be integrated also other equipment or systems, in order to improve the sowing process.

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funcțional pentru a creşte gradul de competitivitate a echipamentelor care deservesc sectorul horticol, respectiv al celui legumicol, deoarece aceste tehnologii au un impact ridicat din punct de vedere tehnologic, alimentar dar şi economic şi încurajează producătorii de răsaduri ca să pătrundă pe piața internă şi internațională cu produse competitive, în cel mai scurt timp posibil, precum şi valorificarea materialului semincer autohton.

Modificările realizate au condus la:

- creşterea gradului de siguranță a operatorului, prin securizarea spațiului de lucru, atunci când echipamentul este în regim de funcționare prin îmbunătățirea carcasei de protecție a secției de semănare;
- lărgirea categoriilor de semințe care pot fi utilizate în procesul de semănare, prin includerea semințelor tratate cu substanțe chimice;
- creşterea gradului de manevrabilitate a echipamentului, prin poziționarea tuturor componentelor de comandă şi control în cadrul unui singur modul;
- îmbunătățirea regimul de funcționare, prin utilizarea interfața om-maşina FED 770 asigurată de un display-ului cu touchscreen unde pot fi identificate cu uşurință eventualele disfuncționalității;
- îmbunătățirea procesului de semănare, prin includerea operaților de umplere a tăvii alveolare cu strat nutritiv şi de acoperire a tăvilor semănate;
- asigurarea modularității echipamentului astfel încât activitățile de ambalarea, transportul, asamblarea, şi deservirea să fie realizată cu uşurință;
- creşterea gradului de retehnologizare prin utilizarea celor mai compacte şi performante componente pneutronice utilizate în scopul creşterii controlului parametrilor funcționali;
- creşterea gradului de adaptabilitate a sistemului pneutronic, prin utilizarea sistemelor modulare a insulei de ventile şi a modulelor de intrare/ieşire analogice şi digitale de tip CPX, asfel încât să poată fi integrate şi alte echipamente sau sisteme, pentru îmbunătățirea procesului de semănare.

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CONSIDERATIONS ON THE SUSPENSION SYSTEM COMPONENTS OF AGRICULTURAL TRACTORS
/
CONSIDERAȚII ASUPRA COMPONENTELOR SISTEMULUI DE SUSPENSIE AL TRACTOARELOR AGRICOLE

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Abstract: *Drivers of agricultural tractors are subjected to a high level of mechanical vibrations caused by the working conditions specific for agricultural works. Sometimes, in the peak season, due too many hours spent driving the tractor on the agricultural field, drivers experience health related issues - usually back pain, lumbar discomfort and acute fatigue. To reduce the overall effects of tractor's vibrations on the driver's side, manufacturers use active, passive or hybrid suspension systems for the tractor's chassis only or in combination with seat and cabin suspensions.*

Keywords: *suspension system, agricultural tractor, closed loop control*

INTRODUCTION

Suspension systems generally used on agricultural tractors structure offer an increased comfort degree to the driver, improving in the same time vehicle's stability especially when turning. Tractor's stability depends on suspension system characteristics, main important aspects being the capacity to maintain a permanent contact between road's surface and tractor's wheels and to protect road's surface against damages caused by excessive forces exerted by tires.

Suspension systems for agricultural tractors consist of four suspension modules placed at each one of tractor's corners, connecting tractor's chassis to its wheels. Every suspension module is made of a spring-damper unit, connected in parallel – also known as a passive suspension system. This type of module can be simulated numerically using the Kelvin-Voigt model. There is known and used the concept of active suspension systems that consists of the same two parallel spring-damper elements, but some of their working parameters can be adjusted through electronic, hydraulic or pneumatic driving signals. Although active suspension systems can be programmed to function as passive ones (similar characteristics), the issue is to achieve better comfort and handling of the agricultural tractor using closed loop control.

Passive suspension systems use steel springs and hydraulic dampers, but due to mechanical wear, in normal working cycles, their functional parameters vary in time leading to poor driver comfort and vehicle stability. In fact, an ideal suspension system must provide at the same time both maximal comfort and stability, but in practice a good suspension system is a compromise between comfort and stability. Driver comfort is left on a second side when designing a suspension system because vehicle's stability is a critical safety issue and the manufacturers always put it first.

When dealing with vehicle stability we are dealing

Rezumat: *Conducătorii auto de tractoare agricole sunt* supuși unui nivel ridicat *de vibrații mecanice cauzate de condițiile de lucru specifice pentru lucrări agricole. Uneori, în sezonul de vârf, din cauza prea multor ore petrecute conducând tractorul pe teren agricol, șoferii pot experimenta probleme de sanatate legate de - de obicei dureri de spate, disconforturi lombare si oboseală acută. Pentru a reduce efectele globale ale vibrațiilor tractor privind partea șoferului, producătorii folosesc sisteme active, pasive sau hibride de suspendare numai pentru sau în combinație cu scaune și cabină suspensii șasiul tractorului.*

Cuvinte cheie: *sistem de suspensie, tractor agricol, de control în buclă închisă*

INTRODUCERE

Sistemele de suspensie, în general, sunt utilizate pe structura tractoarelor agricole pentru a oferi un grad sporit de confort pentru conducătorul auto, îmbunătățirea stabilității în același vehicul timp în special de la pornirea acestuia. Stabilitatea tractorului depinde de caracteristicile sistemului de suspensie, principalele aspecte importante fiind capacitatea de a menține un contact permanent între suprafața drumului și roțile tractorului și de a proteja suprafața drumului împotriva daunelor cauzate de forțele excesive exercitate de anvelope.

Sistemele de suspensie pentru tractoarele agricole formate din patru module de suspendare plasate la fiecare dintre colțurile tractor lui, conectate de șasiul de tractor la roți. Fiecare modul de suspendare este fabricat dintr-o unitate de arc-amortizor, conectate în paralel - de asemenea, cunoscut ca un sistem de suspensie pasiv. Acest tip de modul pot fi simulate cu ajutorul modelului numeric Kelvin-Voigt. Nu este cunoscut și utilizat conceptul de sisteme de suspensie activă, care constă din aceleași două elemente de arc-amortizor paralele, dar unele dintre parametrii de lucru ale acestora pot fi ajustate prin semnale electronice, hidraulice sau pneumatice de conducere. Deși sistemele de suspensie activă poate fi programat sa functioneze ca cele pasive (caracteristici similare), problema este de a realiza o mai bună stare de confort si manevrabilitate a tractorului agricol folosind controlul în buclă închisă.

Sisteme de suspensie pasive folosesc arcuri din oțel și amortizoare hidraulice, dar din cauza uzurii mecanice, în cicluri normale de lucru, parametrii lor funcționale variază în timp ceea ce duce la confortul săracit al șoferului și stabilitatea vehiculului. De fapt, un sistem ideal de suspensie trebuie să asigure, în același timp, atât de confort maxim și stabilitate, dar, în practică, un sistem de suspensie bun este un compromis între confort și stabilitate. Confortul șoferului este lăsat pe o a doua parte la proiectarea unui sistem de suspensie pentru că stabilitatea vehiculului este o problemă critică de siguranță și producătorii a pus întotdeauna pe primul loc.

Atunci când se ocupă de stabilitatea vehiculului avem

with a sum of variables, most important being: resistance forces against chassis movements, weight transfer factor from back to front of the chassis, amplitude of tires vibrations in vertical plane, road's surface unevenness, centrifugal forces when turning and tire-road contact forces. Taking into consideration designing a passive suspension system for agricultural tractors, we encounter another issue because of the higher center of gravity, total weight and hard accelerations transmitted (through chassis) to the driver. Another aspect to take into consideration is that agricultural works need sometimes a constant high speed, which adds another variable to suspension system design. All these conduct, in the first place, to lower vehicle stability.

Some agricultural tractor manufacturers consider that the rear tires are enough when dealing with suspension systems (because of their size), others have mounted a (relatively) stiff suspension on the front axle and some others use cabin active suspension in combination with driver seat suspension. Active suspension systems imply using electrohydraulic closed loop control, which – with the help of new technologies in electronics – can substantially improve driver comfort and vehicle's stability.

MATERIAL AND METHOD

Modern agricultural tractors manufacturers have adapted to their need some concepts already used in automotive industry, related to active suspensions. Classic parallel spring-damper structure has been upgraded to a similar structure using electronic controlled hydraulic actuators. This imply redesigning some of vehicle's components and linkage system.

A simple model of a passive suspension must take into consideration that the spring will store vibration energy and the damper will dissipate it, mechanical characteristics of the linkage system with vehicle's chassis, the unsprung weight (which is total weight of the suspension, wheel and components connected but not supported by the suspension) and the fact that the tire itself can be considered as a spring.

de a face cu o sumă de variabile, cele mai importante fiind: forţele de rezistenţă împotriva mişcărilor şasiului, factor de transfer de greutate de la spate în faţă a şasiului, amplitudinea de anvelope vibraţii în plan vertical, denivelările suprafeţei drumului, forţele centrifuge atunci când este la cotitură şi forţele de contact ale anvelopelor de teren. Luând în considerare proiectarea unui sistem de suspensie pasiv pentru tractoare agricole, întâlnim o altă problemă, din cauza centrului de greutate, greutatea totală şi acceleraţii mari transmise (prin şasiu) de conducătorul auto. Un alt aspect de luat în considerare este faptul că lucrările agricole au uneori mare nevoie de o viteză constantă, ceea ce adaugă o altă variabilă a proiectarea sistemului de suspensie. Toate acestea conduită, în primul rând, la stabilitatea vehiculului mai mici.

Unii producători de tractoare agricole consideră că pneurile din spate sunt suficiente atunci când este vorba de sisteme de suspensie (din cauza dimensiunii lor), altii au montat un sistem suspendat rigid (relativ) pe puntea faţă şi altele folosesc in cabină suspensie activă în combinaţie cu suspensie scaunul şoferului. Sistemele de suspensie active presupun utilizarea de control în buclă închisă electrohidraulic, care - cu ajutorul noilor tehnologii in electronica - poate îmbunătăţi în mod substanţial confortul şoferului şi stabilitatea vehiculului.

MATERIAL ŞI METODĂ

Producătorii de tractoare agricole moderne au adaptat la nevoia lor unele concepte deja utilizate în industria auto, referitoare la suspensii active. Classic paralel structura arc-amortizor a fost actualizat la o structură similară, folosind elemente de acţionare hidraulice controlate electronic. Acest lucru implică reproiectarea unora dintre componentele vehiculului şi sistemul de legătură.

Un model simplu de suspensie pasivă trebuie să ia în considerare faptul că arcul va stoca energie din vibraţii şi clapeta o va disipa, caracteristicile mecanice ale sistemului de legătură cu sasiu vehiculului, greutatea nesuspendată (care este greutatea totală a suspendării, roata şi a componentelor conectate dar nu sunt suportate de suspensie) şi faptul că pneul în sine poate fi considerat ca un arc.

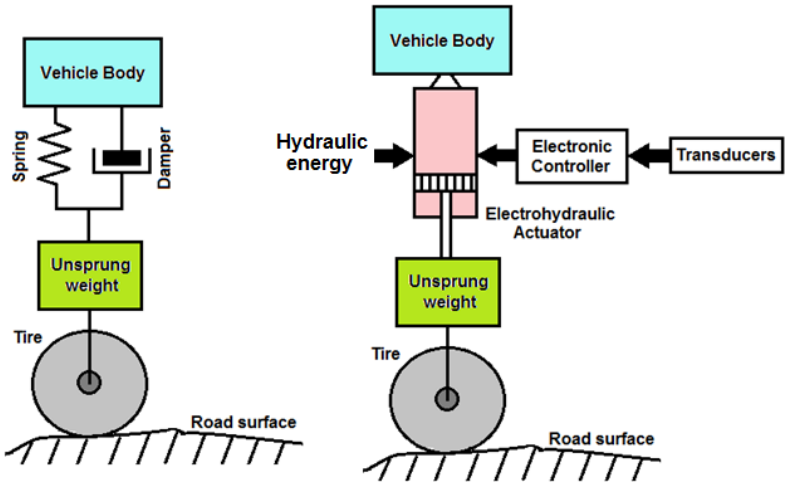


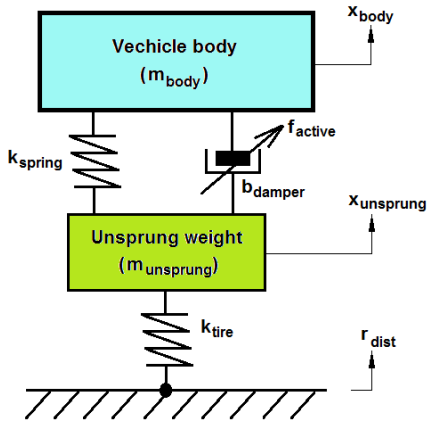
Fig. 1 – Schematic comparison between classic suspension system and active suspension system

As it can be seen in Figure 1, classic parallel spring-damper module has been replaced by an electronic controlled electrohydraulic actuator

După cum se poate observa în figura 1, în modul clasic paralel arc-amortizor a fost înlocuit cu un dispozitiv de acţionare electrohidraulic controlat electronic

(directional and auxiliary equipment have not been figured here). This new configuration offers programmable functional characteristics, having – in theory – unlimited performances in terms of vehicle stability and driver comfort, but – in real life – there are limited by mechanical constrains. Active suspension systems use closed loop control.

(echipamente de direcție și auxiliar nu au fost gândite aici). Această nouă configurație oferă caracteristici funcționale programabile, având - în teorie - performante nelimitate în ceea ce privește stabilitatea vehiculului și confortul șoferului, dar - în viața reală - sunt limitate de constrângeri mecanice. Sisteme de suspensie active utilizează controlul în buclă închisă.



m_{body} – vehicle's body mass;
$m_{unsprung}$ – unsprung mass (including tire weight);
k_{spring} – spring compressibility;
b_{damper} – damper rigidity;
f_{active} – active component (actuator) force;
k_{tire} – pneumatic tire compressibility;
r_{dist} – road disturbance;
x_{body} – travel of vehicle's body;
$x_{unsprung}$ – travel of the unsprung mass.

Fig. 2 – Equivalent model of an active suspension system

First, we assume that:

În primul rând, vom presupune că:

$$x = 0 \text{ and } y = 0 \tag{1}$$

meaning that the system is in static equilibrium, allowing that gravity can be neglected. Let consider that the springs and the damper have linear characteristics (considering that f_{active} is constant) and the damping coefficient of the tire is negligible. Therefore, the tire is represented in the model given in Figure 2 as a spring.

ceea ce înseamnă că sistemul este în echilibru static, permițând că gravitația să poată fi neglijată. Să considerăm că arcurile și amortizorul au caracteristici liniare (având în vedere că F_{active} este constantă) și coeficientul de amortizare a anvelopei este neglijabil. Prin urmare, anvelopa este reprezentat în modelul prezentat în figura 2 ca un arc.

a. b.

Fig. 3 – Suspension system model breakdown

Considering Figure 3.a, mass m_{body} has a displacement of x_{body}; it must be defined two forces given by the spring and the damper:

Având în vedere figura 3.a, m_{body} masa are o deplasare de x_{body}; acesta trebuie să fie definit două forțe date de arc și clapetă:

$$F_{damper} = b(\dot{x}_{body} - \dot{x}_{unsprung}) \tag{2}$$

$$F_{spring} = k_{spring}(x_{body} - x_{unsprung}) \tag{3}$$

In Figure 3.b, mass $m_{unsprung}$ has a displacement of $x_{unsprung}$; it must be define one force given by the tire:

În figura 3.b, $m_{unsprung}$ masa are o deplasare de $x_{unsprung}$; și trebuie să fie definiți ca o forță dată de anvelopa:

$$F_{tire} = k_{tire}(x_{unsprung} - r_{dist}) \tag{4}$$

It is a given fact that:

Este dat fiind faptul că:

$$\sum F = m \cdot a \tag{5}$$

therefore, writing equation (5) for masses m_{body} and $m_{unsprung}$ we have:

Prin urmare, scris ecuația (5) pentru mase m_{body} și $m_{unsprung}$ avem:

$$\sum F_1 = -F_{spring} - F_{damper} = m_{body} \cdot \ddot{x}_{body} \quad (6)$$

$$\sum F_1 = -k_{spring}(x_{body} - x_{unsprung}) - b_{damper}(\dot{x}_{body} - \dot{x}_{unsprung}) = m_{body} \cdot \ddot{x}_{body} \quad (7)$$

$$\sum F_2 = F_{spring} + F_{damper} - F_{tire} = m_1 \cdot \ddot{x}_{unsprung} \quad (8)$$

$$\sum F_2 = k_{spring}(x_{body} - x_{unsprung}) + b_{damper}(\dot{x}_{body} - \dot{x}_{unsprung}) = m_{unsprung} \cdot \ddot{x}_{unsprung} \quad (9)$$

Considering the equations above (6) … (9), we have:

Având în vedere ecuaţiile de mai sus (6) ... (9), avem:

$$m_{unsprung} \cdot \ddot{x}_{unsprung} + b_{damper} \cdot \dot{x}_{unsprung} + (k_{tire} + k_{body}) \cdot x_{unsprung} = \\ = b_{damper} \cdot \dot{x}_{body} + k_{spring} \cdot x_{body} + k_{tire} \cdot r_{dist} \quad (10)$$

and:

Şi:

$$m_{body} \cdot \ddot{x}_{body} + b_{damper} \cdot \dot{x}_{body} + k_{spring} \cdot x_{body} = b_{damper} \cdot \dot{x}_{unsprung} + k_{spring} \cdot x_{unsprung} \quad (11)$$

RESULTS

Classic suspension system can only store and dissipate (when needed) vibration energy, while active suspensions have one more capability: to inject energy (when needed) into the system. Computing the injected energy amount and its opportunity is done usually by a microcontroller programme having as primary data the electronic signals given by system's transducers. The command computed by the microcontroller is applied to an electronic signal amplifier and afterwards applied (usually) to an electrohydraulic actuator.

The electronic controller used to regulate active suspension's behavior has a microcontroller as central processing unit, signal conditioning modules and signal amplifiers. The microcontroller is chosen according to hardware needs of a specific control algorithm, number of transducer inputs and number of driven actuators. In active suspension system control, the electronic controller algorithm has to take into account the entire range of frequencies of the system, trying to obtain an optimal control of mechanical vibrations providing in the same time driver comfort and vehicle stability. These all are leading to overall improved functionality, but it requires much more power than a classic suspension system, thus leading to increased fuel consumption and running costs.

Furthermore, active suspension systems require accurate control of working parameters and therefore needs fast electrohydraulic actuators and electro-valves. Active suspension's high degree of structural complexity require specialized personnel to undertake installation and maintenance procedures. Total running costs and maintenance costs in the case of active suspension systems are significantly higher than a classic suspension, which recommends them to be used only in special applications.

As active suspension systems have as main driving equipment an electrohydraulic actuator, it must be taken into consideration specific critical failure situations of the actuator itself, of the electronic controller board or even unexpected programming errors. In particular cases, all these can lead to dangerous or potential life-threatening situations. A mechanical spring and in some cases a parallel damper, is mounted in series with an active suspension system that can overcome this drawback.

Rezultate

Sistemele de suspensie clasice pot numai stoca şi disipa (când este cazul) a energiei vibratorii, în timp ce suspensiile active mai au o capacitate: pentru a introduce energie (când este necesar) în sistem. Calcul cantitatea de energie introdusă şi oportunitate sa se face, de obicei, de un program de tipul microcontroler având ca date primare semnalele electronice date de traductoare sistemului. Comanda calculata de către microcontroler este aplicata la un amplificator de semnal electronic şi aplicate ulterior (de obicei) la un element de acţionare electrohidraulic.

Regulatorul electronic folosit pentru a reglementa comportamentul de suspensie activă are un microcontroler ca unitate centrală de prelucrare, modulele de semnal condiţionat şi amplificatoare de semnal. Microcontrolerul este ales în funcţie de nevoile hardware ale unui algoritm de control specific, numărul de intrări în traductor şi numărul de servomotoare acţionate. În sistemul de control suspensie activă, algoritmul controlat electronic trebuie să ia în considerare întreaga gamă de frecvenţe ale sistemului, încercând să obţină un control optim al vibraţiilor mecanice care oferă în acelaşi timp şi confortul şoferului vehiculului stabilitatea. Toate acestea conduc la funcţionalitatea generală îmbunătăţită, dar este nevoie de mult mai multă putere decât un sistem clasic de suspensie, conducând astfel la creşterea consumului de combustibil şi cheltuielile de funcţionare.

În plus, sisteme de suspensie activă necesită un control precis al parametrilor de lucru şi, prin urmare, are nevoie de elemente de acţionare electrohidraulice rapide şi electro-valve. Grad ridicat de complexitate structural suspensie activă necesită personal pentru a întreprinde procedurile de instalare şi întreţinere de specialitate. Costuri totale de funcţionare şi costurile de întreţinere, în cazul sistemelor de suspensie active sunt semnificativ mai mari decât o suspensie clasic, care le recomandă să fie utilizate numai în aplicaţii speciale.

Ca sisteme de suspensie active au ca echipamente motrice un element de acţionare electrohidraulic, trebuie să fie luate în considerare situaţii specifice de eşec critice ale actuatorului în sine, de controler de bord electronic sau chiar erori de programare neaşteptate. În anumite cazuri, toate acestea pot duce la situaţii periculoase sau potenţiale ce pot pune viata in pericol. Un arc mecanic şi, în unele cazuri, un amortizor paralel, este montat în serie cu un sistem de suspensie activă care poate depăşi acest dezavantaj. Sistem de suspensie pasiv va funcţiona ca

Passive suspension system will work as a “safety-buffer” when active suspension system encounters a failure, thus reducing the risk of potential dangerous functioning conditions. General response of the series (passive-active) suspension system it is designated to improve the dynamic response in the range of natural frequencies of vehicle’s chassis.

Passive suspension systems proved to have good stability during braking, accelerating and turning of the vehicle, but the major gain over active suspension systems is lower energy use and that are known to reduce critical failure modes encountered in active suspension systems. Active suspensions have very good dynamic performances when referring to driver comfort and vehicle stability, but in general practice are not recommended to be used in heavy weight vehicle construction due to their high energy consumption.

CONCLUSIONS

Active suspension systems used in the field of agricultural tractors are in theory the best solution for compensating mechanical vibrations caused by agricultural road surface unevenness and normal functioning regime of a tractor: braking, accelerating and turning.

The major drawbacks of active suspension systems are high energy consumption, high running and maintenance costs, complexity of the suspension system with all the auxiliary equipment and high installation costs.

As a general guideline, hybrid solutions comprising an active and a passive suspension system are more likely to be used.

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un "tampon de siguranţă" atunci când sistemul de suspensie activă întâlneşte un eşec, reducând astfel riscul de potenţiale condiţii periculoase de funcţionare. Răspuns general al seriei (pasiv-activ) sistemul de suspensie este desemnat pentru a îmbunătăţi răspunsul dinamic în domeniul de frecvenţe naturale ale sasiului vehiculului.

Sisteme de suspensie pasive s-au dovedit a avea o stabilitate bună în timpul frânării, accelerarea şi de cotitură a vehiculului, dar au un câştig major asupra sistemelor de suspensie activă este consumul de energie mai mic şi care sunt cunoscute pentru a reduce defecţiunile critice apărute în sistemele de suspensie activă. Suspensii active au performanţe dinamice foarte bune atunci când se referă la confortul şoferului şi de stabilitate a vehiculului, dar in practica generala nu sunt recomandate pentru a fi utilizate în construcţii grele vehicul greutate din cauza consumului lor de energie înaltă.

CONCLUZII

Sisteme de suspensie active utilizate în domeniul tractoarelor agricole sunt, teoretic, cea mai bună soluţie pentru compensarea vibraţiilor mecanice cauzate de planeitatea suprafeţei de drum agricol şi regim normal de funcţionare a unui tractor: frânare, accelerare şi de cotitură.

Dezavantajele majore ale sistemelor de suspensie active sunt consum mare de energie, de funcţionare mare şi de întreţinere a costurilor, complexitatea sistemului de suspensie, cu toate echipamentele auxiliare şi costurile ridicate de instalare.

Ca regulă generală, soluţiile hibride care cuprind un un sistem de suspensie pasiv activ si sunt mai susceptibile de a fi utilizate.

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INSTRUCTIONS FOR AUTHORS

Article Types

Three types of manuscripts may be submitted:

1. **Regular articles:** These should describe new and carefully confirmed findings, and experimental procedures should be given in sufficient detail for others to verify the work. The length of a full paper should be the minimum required to describe and interpret the work clearly (max. 8 pages, even number);
2. **Short Communications:** A Short Communication is suitable for recording the results of complete small investigations or giving details of new models or hypotheses, innovative methods, techniques or apparatus. The style of main sections has not necessarily to be in accordance with that of full-length papers (max. 6 pages, even number);
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All manuscripts are reviewed by the 2 members of the Scientifically Review. Decisions will be made as rapidly as possible, and the journal strives to return reviewers' comments to authors in approx. 3 weeks. The editorial board will re-review manuscripts that are accepted pending revision.

NOTE:

Submission of a manuscript implies: that the work described has not been published before (excepting as an abstract or as part of a published lecture, or thesis) that it is not under consideration for publication elsewhere.

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- Text paper will be written in two equal columns of 8.3 cm, 0.4 cm space between them, except the title, authors and their affiliations, tables, figures, graphs and equations to be entered once.
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- The chapter titles are written Uppercase (eg: INTRODUCTION, MATERIAL AND METHODS), between chapters is left a space for 9 pt. At the beginning of each paragraph to leave a tab of 0.5 cm.
- The paper will be written in Word, "Justify" alignment;
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- There are allowed 2 papers by each first author.

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Title should be short, specific and informative. Avoid long titles; a running title of no more than 100 characters is encouraged (without spaces).

The ***Abstract*** should be informative and completely self-explanatory, briefly present the topic, state the scope of the experiments, indicate significant data, and point out major findings and conclusions. The Abstract should be 100 to 300 words in length. Complete sentences, active verbs, and the third person should be used, and the abstract should be written in the past tense. Standard nomenclature should be used and abbreviations should be avoided. No literature should be cited (font: 9 pt., the title - *bold italic*; the text of abstract: *italic*).

Following the abstract, about 3 to 10 ***Keywords*** that will provide indexing references should be listed (font: 9, bold italic - the title and 9 pt., *italic* - the text).

A list of non-standard **Abbreviations** should be added. In general, non-standard abbreviations should be used only when the full term is very long and used often. Each abbreviation should be spelled out and

introduced in parentheses the first time it is used in the text. Only recommended SI units should be used. Authors should use the Solidus presentation (mg/ml). Standard abbreviations (such as ATP and DNA) need not to be defined.

The **INTRODUCTION** should provide a clear statement of the problem, the relevant literature on the subject, and the proposed approach or solution. It should be understandable to colleagues from a broad range of scientific subjects. We should refer to the current stage of researches performed in the field of the paper to be published, by quoting up-to-date specialty studies, preferably published after 2000, excepting certain referential specialty books/studies, especially papers issued in magazines/journals/conferences/ISI quoted symposia or in other international data bases, which are well known and available.

MATERIALS AND METHODS should be complete enough to allow experiments to be reproduced. However, only truly new procedures should be described in detail; previously published procedures should be cited, and important modifications of published procedures should be mentioned briefly. Capitalize trade names and include the manufacturer's name and address. Subheadings should be used. Methods in general use need not be described in detail.

RESULTS should be presented with clarity and precision. The results should be written in the past tense when describing findings in the authors' experiments. Results should be explained, but largely without referring to the literature. Discussion, speculation and detailed interpretation of data should not be included in the Results but should be put into the Conclusions section. Subheadings should be used.

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The **Acknowledgments** of people, grants, funds, etc should be brief (if necessarily).

Tables should be kept to a minimum and be designed to be as simple as possible. Tables are to be typed single-spaced throughout, including headings and footnotes. Each table must be written on the entire width of the page, into the text where reference is made, the columns are broken - one column (see attached sample). Tables should be self-explanatory without reference to the text. The details of the methods used in the experiments should preferably be described in the legend instead of in the text. The same data should not be presented in both table and graph form or repeated in the text. Table's title will be centered bold (in English). In the table, each row will be written in English (Arial, regular, size: 9 pt.). The table and its number is written right justified, bold - in English.

Figure legends should be typed in numerical order. Graphics should be prepared using applications capable of generating high resolution JPEG before to introducing in the Microsoft Word manuscript file (Insert - From File - ...jpeg). Use Arabic numerals to designate figures and upper case letters for their parts (Fig. 1). Begin each legend with a title and include sufficient description so that the figure is understandable without reading the text of the manuscript. Information given in legends should not be repeated in the text. Each figure must be inserted on the entire width of the page, into the text where reference is made, single columns (see attached sample). Leave a space between the figure and the text of figure, size: 3 pt., figure number is written in **Arial bold**, size: 8 pt., followed by what represent the figure or graph, written with Arial, regular, 8 pt. Eg:

Fig 1 - Test stand

The figures should be "*In line with text*" - Center, not "*Square*"; "*Tight*"; "*Behind text*" or "*In front of text*" (from "*Format picture*" - right mouse button on picture and then "*Layout*".

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Authors must provide instructions on how symbols and equations should be set. Equations should be numbered sequentially in the right-hand side and in parenthesis. They should be referred to in the text as Equation (4) or Eg. (4). Each equation must be written on the entire width of the page, into the text where reference is made, the columns are broken (see attached sample).

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Example:

[1], [2], [3], ..., [n]

References should be listed at the end of the paper in alphabetical order. Certain current papers, preferably published after 2000, (excepting some specialty books/studies), especially papers issued in magazines/journals/conferences/ISI quoted symposia or in other international data bases, which are well known and available should be quoted. Making personal quotations (one, at most) should not be allowed, unless the paper proposed to be published is a sequel of the cited paper. Articles in preparation or articles submitted for publication, unpublished observations, personal communications, etc. should not be included in the reference list but should only be mentioned in the article text (e.g., A. Danciu, University of Bucharest, Romania, personal communication). Authors are fully responsible for the accuracy of the references.

Examples:

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[1]. Nicolescu MA (2007) - *Relevant characteristics of alternative liquid fuels aimed at diesel engines exploitation in polycarburation duty*. INMATEH - Agricultural Engineering, vol. 27, no. 1/2009, ISSN 1583-1019, pg. 50-55.

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Conference or Symposium:

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Book:

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Book Chapter:

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- Units should be metric, generally SI, and expressed in standard abbreviated form.
- Acronyms may be acceptable, but must be defined at first usage.

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Short Communications are limited to a maximum of two figures and one table. They should present a complete study that is more limited in scope than is found in full-length papers. The items of manuscript preparation listed above apply to Short Communications with the following differences: (1) Abstracts are limited to 100 words; (2) instead of a separate Materials and Methods section, experimental procedures may be incorporated into Figure Legends and Table footnotes; (3) Results and Conclusions should be combined into a single section.

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Summaries, reviews and perspectives covering topics of current interest in the field, are encouraged and accepted for publication. Reviews should be concise (max. 8 pages). All the other conditions are similar with regular articles.

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