vol. 40, No. 2 / 2013

e: ISSN 2068 – 2239
p: ISSN 2068 – 4215

INMATEH - AGRICULTURAL ENGINEERING

Indexed in:

ULRICHS

CABI

SCIPIO ROMANIAN EDITORIAL PLATFORM

ELSEVIER / SciVerse SCOPUS

MAY - AUGUST

Editorial

The National Institute of Research-Development for Machines and Installations designed to Agriculture and Food Industry - INMA Bucharest has the oldest and most prestigious research activity in the field of agricultural machinery and mechanizing technologies in Romania.

Short History

- In 1927, the first research **Center for Agricultural Machinery** in Agricultural Research Institute of Romania - ICAR (Establishing Law was published in O.D. no. 97/05.05.1927) was established;
- In 1930, was founded **The Testing Department of Agricultural Machinery and Tools** by transforming Agricultural Research Centre of ICAR - that founded the science of methodologies and experimental techniques in the field (Decision no. 2000/1930 of ICAR Manager - GHEORGHE IONESCU ŞIŞEŞTI);
- In 1952, was established the Research Institute for Mechanization and Electrification of Agriculture - ICMA Băneasa, by transforming the Department of Agricultural Machines and Tools Testing;
- In 1979, the Research Institute of Scientific and Technological Engineering for Agricultural Machinery and Tools – ICSITMUA was founded - subordinated to Ministry of Machine Building Industry - MICM, by unifying ICMA subordinated to MAA with ICPMA subordinated to MICM;
- In 1996 the National Institute of Research-Development for Machines and Installations designed to Agriculture and Food Industry – INMA was founded – according to G.D. no.1308/25.11.1996, by reorganizing ICSITMUA, G.D no. 1308/1996 coordinated by the Ministry of Education and Research G.D. no. 823/2004;
- In 2008 INMA has been accredited to carry out research and developing activities financed from public funds under G.D. no. 551/2007, Decision of the National Authority for Scientific Research - ANCS no. 9634/2008.

As a result of widening the spectrum of communication, dissemination and implementation of scientific research results, in 2000 was founded the institute magazine, issued under the name of SCIENTIFIC PAPERS **(INMATEH)**, ISSN 1583 – 1019.

Starting with volume 30, no. 1/2010, the magazine changed its name to **INMATEH - Agricultural Engineering**, appearing both in print format (ISSN 2068 - 4215), and online (ISSN online: 2068 - 2239). The magazine is bilingual, being published in Romanian and English, with a rhythm of three issues / year: January-April, May-August, September-December and is recognized by CNCSIS – with B category. Published articles are from the field of AGRICULTURAL ENGINEERING: technologies and technical equipment for agriculture and food industry, ecological agriculture, renewable energy, machinery testing, environment, transport in agriculture etc. and are evaluated by specialists inside the country and abroad, in mentioned domains.

Technical level and performance processes, technology and machinery for agriculture and food industry increasing, according to national requirements and European and international regulations , as well as exploitation of renewable resources in terms of efficiency, life, health and environment protection represent referential elements for the magazine „**INMATEH - Agricultural Engineering**".

We are thankful to all readers, publishers and assessors.

Editor in chief,
Ph.D. Eng. Pirnă Ion

Managing Editorial Board - INMA Bucharest

INMATEH - Agricultural Engineering
vol. **40**, no. 2 / 2013
NATIONAL INSTITUTE OF RESEARCH-DEVELOPMENT FOR MACHINES AND INSTALLATIONS DESIGNED TO AGRICULTURE AND FOOD INDUSTRY - INMA Bucharest
6 Ion Ionescu de la Brad Blvd., sector 1, Bucharest
Three issues per year,
e ISSN: 2068 – 2239
p ISSN: 2068 – 4215
Edited by: INMA Bucharest

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RESEARCHES ON VARIATION OF GRIST PARTICLE SIZE PARAMETERS ACCORDING TO CONSTRUCTIVE CHARACTERISTICS OF GRINDING ROLLS
/
CERCETĂRI ASUPRA VARIAȚIEI PARAMETRILOR GRANULOMETRICI AI MĂCINIŞURILOR CU CARACTERISTICILE CONSTRUCTIVE ALE CILINDRILOR DE MĂCINARE

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Abstract: *In the paper are presented the theoretical and experimental researches results regarding the particle size characteristics variation of grist coming from breakage phase of wheat seeds on the milling plant technological flow of 100 t / 24h capacity, along with constructive parameters of grinding rolls. For determining the workflow parameters of grinding rolls the mathematical model is presented.*

Keywords: *particle size characteristics, wheat milling, roller mill, parameters of flute, breakage*

INTRODUCTION

In milling plant, the grinding process of wheat seeds includes three main operations: crushing, screening and grinding. Wheat seeds crushing are done in mills with pairs of fluted rolls which rotate in opposite directions and have different angular speeds, in order to detach the endosperm from the bran and grinding it in flour and semolina particles.

In breakage phase, the wheat seeds grinding is influenced by physical and mechanical characteristics of seeds and grist (particle shape and size, particle size distribution, moisture content, hardness) and grinding rolls construction and operation (rolls speed, differential speed, roll disposition, flutes profile, specific number of flutes, roll gap) [2,3].

Construction and working parameters of grinding rolls must be adjusted according to wheat seed size and grist particles [7].

Study of influence of grinding rolls constructive and functional parameters on the milling process can be done by evaluating the particle size characteristics of material to be ground and grist (medium particle size, specific surface, grinding degree, surface increase), flour quality and energy consumption.

In the breakage phase, different roll disposition has resulted in different distribution of stress and, thus, in different wheat seed breakage and different size distribution obtained, [5]. Chaoying F. and Grant Cambell (2002) [5], studying the roll disposition influence on the grinding process, have shown that back to back (B/B) roll disposition is recommended to the other positions. In this case, grinding is performed, primarily, by compression (crushing), leading to fragmentation and crushing of fragile endosperm, while the bran remains relatively intact, [5,6]. This fact easies the separation of endosperm from the bran.

The relationship between grinding roll gap and grist particle size can be approximated by a linear function, [10]. Chaoying F. and Grant Cambell (2002) [6], changing the roll gap from 0.3 mm to 0.7 mm were obtained greater mass fraction of large particles.

The studies performed [1, 9] have shown that between the degree of grist extraction and speed of fast grinding roll is a direct linear dependence. The ratio of speed grinding

Rezumat: *În lucrare sunt prezentate rezultatele unor cercetări teoretice şi experimentale referitoare la variația caracteristicilor granulometrice ale măcinişurilor rezultate din faza de şrotare a semințelor de grâu de pe fluxul tehnologic al unei unități de morărit cu capacitatea de* 100 t / 24h, cu *parametrii constructivi ai cilindrilor de măcinare. Este prezentat modelul matematic pentru determinarea parametrilor procesului de lucru al cilindrilor de măcinare.*

Cuvinte cheie: *caracteristici granulometrice, măcinare grâu, moară cu cilindri, parametrii riflului, şrotare*

INTRODUCERE

În unitățile de morărit procesul de măcinare a semințelor de grâu cuprinde trei operații principale: sfărâmarea, cernerea şi mărunțirea. Sfărâmarea semințelor de grâu se realizează în mori cu perechi de cilindri riflați ce se rotesc în sensuri contrare şi au viteze unghiulare diferite, urmărind detaşarea endospermului de înveliş şi mărunțirea lui în particule de făină şi griş.

În faza de şrotare, mărunțirea semințelor de grâu este influențată de caracteristicile fizice şi mecanice ale semințelor şi produselor de măciniş (forma şi mărimea particulelor, distribuție după dimensiuni, conținut de umiditate, duritate) şi de construcția şi funcționarea cilindrilor de moară (turația cilindrilor, viteza diferențială, dispunerea cilindrilor, profilul riflurilor, numărul specific de rifluri, distanța dintre cilindri) [2,3].

Construcția şi parametrii de lucru ai cilindrilor de măcinare trebuie să fie ajustate în funcție de dimensiunile semințelor de grâu şi ale particulelor de măciniş [7].

Studiul influenței parametrilor constructivi şi funcționali ai cilindrilor de măcinare asupra procesului de măcinare se poate realiza prin evaluarea caracteristicilor granulometrice ale materialului de măruntit şi ale măcinişului (dimensiuni medii ale particulelor, suprafața specifică, grad de mărunțire, creştere de suprafață), calitatea făinii şi consumul de energie.

Dispunerea reciprocă diferită a riflurilor cilindrilor de măcinare, în faza de şrotare, are rezultate în distribuția diferită a tensiunilor şi, deci, în spargerea diferită a semințelor de grâu şi obținerea de distribuții după dimensiuni diferite, [5]. Chaoying F. şi Grant Cambell (2002) [5], studiind influența pe care o are dispunerea riflurilor cilindrilor asupra procesului de mărunțire, au demonstrat că, dispunerea riflurilor spate/spate (S/S) este de recomandat față de celelate poziții. În acest caz, mărunțirea se execută, în primul rând, prin compresiune (strivire), determinând fragmentarea şi sfărâmarea endospermului fragil, în timp ce învelişul rămâne relativ intact, [5,6]. Acest lucru facilitează procesul de separare a endospermului de înveliş.

Relația dintre distanța între cilindrii de măcinare şi dimensiunea particulelor de material măruntit poate fi aproximată printr-o funcție liniară, [10]. Chaoying F. şi Grant Cambell (2002) [6], modificând distanța între cilindrii de măcinare de la 0,3 mm la 0,7 mm au obținut fracții de măciniş cu dimensiuni şi mase din ce în ce mai mari.

În urma studiilor efectuate, [1, 9] au arătat faptul că între gradul de extracție a produselor de măciniş şi viteza periferică a cilindrului de măcinare rapid există o dependență liniară,

rolls with fluted surface, *k*, has a significant influence on the quantity of semolina, flour and bran and their particle size chracateristics, [8]. Hareland (1998) in the paper [8], changing the ratio k from 1.5:1 to 2.5:1 and 3.5:1, for the pairs of fluted rolls, obtained an increase in extraction degree of semolina from 55% to 67% and 72%, respectively, and a decrease of bran from 24% to 15% and 11%, respectively.

Flour extraction degree decreased from 8% to 5%, when the ratio k increased from 1.5:1 to 2.5:1 and remained at the 5% when the ratio k increased from 2.5:1 to 3.5:1.

In paper [11], for three ratio of grinding rolls speeds, k = 2.0; k = 2.5; k = 3.0, was shown that for the grinding of Mallaca wheat seeds variety (10.23% moisture content), the best results were obtained for k = 2.5, in terms of the optimum distribution of ground wheat products, ash content and fine particles mass.

The objective of this paper is to present the variation of particle size parameters of the material to be ground and grist in breakage phase in a mill with 100 t / 24 h capacity, in compliance with the constructive characteristics of grinding rolls.

MATERIAL AND METHOD

The constructive characteristics of grinding rolls and physical characteristics of grist were experimentally determined on the technological flow of S.C. Spicul S.A. Roşiori de Vede milling plant with capacity of 100 t / 24 h and analyzing samples of material and data processing were done in laboratories of Biotechnical Systems Department of U.P.B.

In this phase the flour milling flow sheet has five mills with fluted rolls, followed each by one compartment of plane sieve. In addition, the flow sheet includes two semolina machines and three bran finishers and a sixth plane sieve compartment for sorting by size. The flour milling flow sheet is presented in the papers [14,15].

Experimental determinations were made on particle size characteristics of the material which enters and exits from the grinding process of five roller mills of breakage phase: particle mean diameter, specific surface of material, particles number, surface increase. These were analyzed in relation with geometrical parameters of rolls: differential speed, rolls gap; geometrical parameters of flutes: total number of flutes acting on the particles in the work area between two grinding rolls, shear number of points in the grinding area, flutes depth, flutes pitch. To determine particle size characteristics were used samples of 100 g of material at the entry and exit of each grinding rolls pair, which were been sifted with VAPO classifier equipped with 5 overlapped sieves with meshes of different sizes, trained in a circular plain movement at an adjusted speed of 120 rpm for 3 minutes, [13,15]. The complete work methodology is presented in detail in paper [4].

Grinding rolls of mills from breakage phase have length of 1000 mm, diameter of 250 mm and fluted surface. Ratio of tangential speeds of grinding rolls is k = 2.5 and back-to-back roll disposition. Flute angles (α – flute sharpe angle and β – flute dull angle) have the values: for Break 1 (Gr.1) and Break 2 (Gr.2) α/β = 30/60, Break 3 (Gr.3) and Break 4 (Gr.4) - α/β = 35/65, Break 5 (Gr.5) - α/β = 40/70. Specific number of flutes (number of flutes on one centimeter from grinding rolls circumference (R/cm)) and flutes inclination (I(%)): R = 3.8 flute/cm, I = 6 (%), for Gr. 1, R = 6 flute/cm, I = 6 (%), for Gr. 2, R = 7 flute/cm, I = 8 (%), for Gr. 3, R = 8.9 flute/cm, I = 10 (%), for Gr. 4 şi R = 10 flute/cm, I = 10 (%), for Gr. 5.

directă. Raportul k, al turațiilor cilindrilor de măcinare cu suprafața riflată, are o influență semnificativă asupra cantității de grişuri, făină şi tărâțe şi asupra caracteristicilor granulometrice ale acestora, [8]. Modificând raportul k de la 1,5:1, la 2,5:1 şi 3,5:1, pentru perechile de cilindri riflați, Hareland (1998) în lucarea [8], a obținut o creştere a extracției de grişuri de la 55% la 67% şi respectiv 72% şi o scădere a cantității de tărâțe de la 24% la 15% şi respectiv 11%.

Gradul de extracție al făinii a scăzut de la 8% la 5%, când raportul k a crescut de la 1,5:1 la 2,5:1 şi a rămas la valoarea de 5% când raportul turațiilor a crescut de la 2,5:1 la 3,5:1.

În lucrarea [11], pentru trei rapoarte ale turațiilor cilindrilor de măcinare, k = 2,0;k = 2,5; k = 3,0, s-a arătat că la mărunțirea semințelor de grâu din soiul Mallaca (conținut de umiditate de 10,23%) cele mai bune rezultate au fost obținute pentru k = 2,5, în ceea ce priveşte distribuția după dimensiuni a particulelor de măciniş, conținutul de cenuşă şi masa de particule fine.

Obiectivul acestei lucrări este de a prezenta variația parametrilor granulometrici ai materialului supus mărunțirii şi ai materialului mărunțit în faza tehnologică de şrotare la o moară de 100 t / 24 h, cu caracteristicile constructive ale cilindrilor de măcinare.

MATERIAL ŞI METODĂ

Caracteristicle constructive ale cilindrilor de măcinare, precum şi caracteristicile fizice ale măcinişurilor au fost determinate experimental, pe fluxul tehnologic al unității de morărit S.C. Spicul S.A. Roşiori de Vede, cu capacitatea de 100 t / 24 h, iar analiza probelor de material şi prelucrarea datelor s-a făcut în cadrul laboratoarelor Departamentului de Sisteme Biotehnice din UPB.

În cadrul acestei faze, diagrama tehnologică a morii cuprinde cinci mori cu cilindri riflați, completate fiecare cu câte un compartiment de sită plană. Pe lângă acestea, diagrama mai cuprinde două maşini de griş şi trei finisoare de tărâțe, precum şi un al şaselea compartiment de sită plană pentru sortarea după dimensiuni. Diagrama tehnologică a fazei de şrotare a morii este prezentată în lucrările [14,15].

Au fost efectuate determinări experimentale privind caracteristicile granulometrice ale materialului care intră şi care iese din procesul de mărunțire la cele cinci mori cu cilindri ale fazei de şrotare: diametrul mediu al particulelor, suprafața specifică a materialului, numărul de particule, creşterea de suprafață. Acestea au fost analizate în corelație cu parametrii geometrici ai cilindrilor: viteza diferențială, distanța dintre cilindri; parametrii geometrici ai riflurilor: numărul total de rifluri care acționează asupra particulelor de material în zona de lucru dintre cei doi cilindri de măcinare, numărul punctelor de forfecare din zona de mărunțire, adâncimea riflurilor, pasul riflurilor. Pentru determinarea caracteristicilor granulometrice au fost folosite eşantioane de 100 grame de material de la intrarea respectiv ieşirea de la fiecare pereche de cilindri de măcinare, care au fost cernute cu clasificatorul VAPO prevăzut cu 5 site suprapuse cu orificii de mărimi diferite, antrenate într-o mişcare plană circulară la o turație reglată de 120 rot/min timp de 3 minute, [13,15]. Metodologia de lucru completă este prezentată în detaliu în lucrarea [4].

Cilindrii de măcinare ai morilor din faza de şrotare au lungimea de 1000 mm, diametrul de 250 mm şi suprafața riflată. Raportul vitezelor tangențiale ale cilindrilor de măcinare este k = 2,5, iar poziția reciprocă a riflurilor este spate/spate (S/S). Unghiurile riflurilor (α – unghiul tăişului riflului şi β – unghiul spatelui riflului) au următoarele valori: pentru Şrotul 1 (Şr.1) şi Şrotul 2 (Şr.2) – α/β = 30/60, Şrotul 3 (Şr.3) şi Şrotul 4 (Şr.4) - α/β = 35/65, iar pentru Şrotul 5 (Şr.5) - α/β = 40/70. Numărul specific de rifluri (numărul de rifluri de pe un centimetru din circumferința cilindrilor de măcinare (R/cm)) şi înclinarea riflurilor (I (%)) sunt: R = 3,8 rifl/cm, I = 6 (%), pentru Şr. 1, R = 6 rifl/cm, I = 6 (%), pentru Şr. 2, R = 7 rifl/cm, I = 8 (%), pentru Şr. 3, R = 8,9 rifl/cm, I = 10 (%), pentru Şr. 4 şi R = 10 rifl/cm, I = 10 (%), pentru Şr. 5.

Knowing geometrical characteristics of grinding rolls the geometrical parameters of flutes were calculated.

For the calculation, consider a spherical particle of material with *d* equivalent diameter, caught between two grinding rolls with smooth surface, diameter *D* and roll gap *e* (fig.1), [12].

Route length (grinding zone) covered by a particle between two grinding rolls during breaking process is the circular zone on the roll surface from the point in which particle catching occurs (ψ ≤ φ) and the highest point of rapprochement between the rolls (e distance), [12]:

Cunoscând caracteristicile geometrice ale cilindrilor de măcinare au fost calculați parametrii geometrici ai riflurilor cilindrilor.

Pentru efectuarea calculelor, se consideră o particulă de material de formă sferică cu diametrul echivalent *d*, prinsă între doi cilindri de măcinare cu suprafața netedă, cu diametrul *D* şi distanța dintre ei *e* (fig.1), [12].

Lungimea traseului (zona de mărunțire) parcurs de o particulă între cei doi cilindri de măcinare în timpul procesului de sfărâmare este reprezentată de zona circulară de pe suprafața cilindrului din punctul în care are loc prinderea particulei (ψ ≤ φ) şi punctul de cea mai mare apropiere dintre cilindri (distanța e), [12].

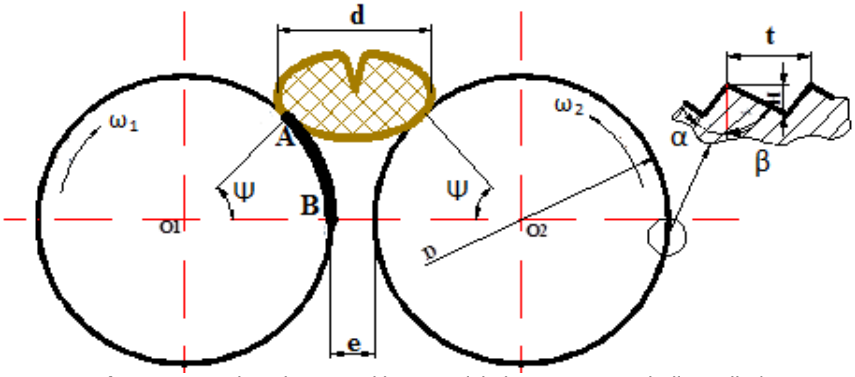


Fig. 1 – Route length covered by a particle between two grinding rolls /
Lungimea traseului parcurs de particular de material între cei doi cilindri de măcinare

$$L_{AB} = \psi \frac{D}{2}\left(\arccos\frac{D+e}{D+d}\right)\frac{D}{2}, \quad (1)$$

where: ψ is catching angle of particle between rolls;
D – grinding rolls diameter;
d – equivalent size of particle;
e – grinding rolls gap;
φ – friction angle between particle and roll.

Processing route, in grinding zone, depends on the grinding rolls diameter D, gap rolls e and average particle size of material to feeding d.

Number of flutes acting on the particle in grinding zone can be appreciated by number of futes on the fast roll. It is considered that the slow roll acts as a bulwark of particle, during grinding, and, so, its flutes serve it as supports. It depends on the length of grinding zone L_{AC}, specific number of flutes *R* and the differential *k*, [12]:

unde: ψ este unghiul de prindere al particulei între cilindri;
D – diametrul cilindrilor de măcinare;
d – dimensiunea echivalentă a particulei de material;
e – distanța dintre cilindri de măcinare;
φ – unghiul de frecare dintre particulă şi cilindru.

Traseul de prelucrare, în zona de mărunțire, depinde de diametrul cilindrilor de măcinare D, distanța dintre cilindri e şi dimensiunea medie a particulelor de material la alimentare d.

Numărul de rifluri care acționează asupra particulei de material în zona de mărunțire se poate aprecia prin numărul de rifluri de pe cilindrul rapid, în timpul mărunțirii considerând că cilindrul lent are rol de reazem al particulei şi, deci, riflurile acestuia au rol de a o susține. Acesta depinde de lungimea zonei de mărunțire L_{AC}, numărul specific de rifluri *R* şi de raportul vitezelor periferice ale celor doi cilindri de măcinare *k*, [12]:

$$n_r = L_{AB} \cdot R \cdot \frac{k-1}{k+1}, \quad (2)$$

Flutes depth of two grinding rolls is expressed as a function of flutes pitch *t* and flutes angles, *α* and *β,* [12]:

Adâncimea riflurilor de pe cei doi cilindri de măcinare se exprimă în funcție de pasul riflurilor *t* şi de unghiurile riflurilor, *α* şi *β,* [12]*:*

$$H = t \cdot \frac{\cos\alpha \cdot \cos\beta}{\sin(\alpha+\beta)}, \quad (3)$$

For an intense and progressive flutes action on the material to be ground, flutes have some inclination towards their generator. Flutes inclined position of two grinding rolls, leading to their intersection and the intersection points are points in which the particles are compressed up to the grinding. The grinding process is even more intense as the frequency of intersection points is higher, [12]. Grinding degree increases as the number of flutes intersection point's increases.

The number of intersection points $n_{p.f.}$,is equal to the square of the number of flutes of one roll on the grinding zone $L_{AC.}$

Pentru o acțiune intensă şi progresivă a riflurilor cilindrilor de măcinare asupra materialului supus mărunțirii, riflurile au o anumită înclinare față de generatoarea acestora. Poziția înclinată a riflurilor celor doi cilindri de măcinare, conduce la intersectarea lor, iar punctele de intersecție sunt puncte în care are loc comprimarea particulelor până la mărunțire. Procesul de mărunțire este cu atât mai intens cu cât frecvența punctelor de intersecție este mai mare, [12]. Gradul de mărunțire creşte pe măsură ce numărul punctelor de intersecție a riflurilor cilindrilor creşte.

Numărul punctelor de intersecție $n_{p.f.}$, a cilindrilor de măcinare este egal cu pătratul numărului de rifluri de pe un cilindru pe zona de mărunțire L_{AC}.

$$n_{p.f.} = n_r^2, \quad (4)$$

RESULTS

Performing the parameters calculation on presented relations, were obtained the values shown in table 1 (n_r, $n_{p.f.}$, v_o, H, t). Also, in table 1 the values of particle size characteristics obtained by classifier analyzing were presented. Thus, the values for ground particles mean dimension d_m, grinding index λ, specific surface S and surface increase ΔS are presented.

These characteristics are graphically presented in figure 1 – 3 for the entire breakage technological phase.

REZULTATE

Efectuând calculul parametrilor pe baza relațiilor prezentate s-au obținut valorile prezentate în tabelul 1 (n_r, $n_{p.f.}$, v_o, H, t). De asemena, în tabelul 1 sunt prezentate valorile caracteristicilor granulometrice obținute prin analiza cu clasificatorul. Astfel, sunt prezentate valorile pentru dimensiunea medie a particulelor mărunțite d_m, indicele de mărunțire λ, suprafața specifică S şi creşterea de suprafață ΔS.

Aceste caracteristici sunt prezentate grafic în figurile1 - 3 pentru întreaga fază tehnologică de şrotare.

Table 1 / *Tabelul 1*

Geometrical characteristics of breaking rolls / *Caracteristici geometrice ale cilindrilor de şrotare*						Particle size characteristics of grist / *Caracteristici granulometrice ale măcinişurilor*			
Break / *Şrot*	**Flutes number / *Numarul de rifluri* n_r**	**Shear points number / *Nr. pct. de forfecare* $n_{p.f.}$**	**Differential / *Vit.dif.* [m/s] v_o**	**Flutes depth / *Adâncimea riflurilor* [mm] H**	**Flutes pitch / *Pasul riflurilor* [mm] t**	**Mean diameter/ *Dimetrul mediu* [mm] d_m**	**Grinding index / *Indicele de mărunțire* λ**	***Specific surface / Suprafața specifică* [x10³ m²/kg] S**	**Surface increase / *Creşterea de suprafață* [x10³ m²/kg] ΔS**
Sr.1I	5.46 / *5,46*	29.76 / *29,76*	7.50 / *7,50*	1.133 / *1,133*	2.61 / *2,61*	3.763 / *3,763*	1.764 / *1,764*	1.286 / *1,286*	0.965 / *0,965*
Sr.1E						2.133 / *2,133*		2.249 / *2,249*	
Sr.2I	7.13 / *7,13*	50.76 / *50,76*	7.50 / *7,50*	0.502 / *0,502*	1.67 / *1,67*	2.222 / *2,222*	1.816 / *1,816*	2.216 / *2,216*	1.809 / *1,809*
Sr.2E						1.223 / *1,223*		4.025 / *4,025*	
Sr.3I	6.56 / *6,56*	43.03 / *43,03*	7.65 / *7,65*	0.501 / *0,501*	1.427 / *1,427*	1.514 / *1,514*	1.682 / *1,685*	3.604 / *3,604*	2.681 / *2,681*
Sr.3E						0.898 / *0,898*		6.285 / *6,285*	
Sr.4I	6.73 / *6,73*	45.36 / *45,36*	7.61 / *7,61*	0.393 / *0,393*	1.121 / *1,121*	1.065 / *1,065*	1.032 / *1,032*	5.546 / *5,546*	0.106 / *0,106*
Sr.4E						1.031 / *1,031*		5.652 / *5,652*	
Sr.5I	5.50 / *5,50*	30.25 / *30,25*	7.50 / *7,50*	0.279 / *0,279*	1.001 / *1,001*	0.652 / *0,652*	1.026 / *1,026*	8.365 / *8,365*	0.333 / *0,333*
Sr.5E						0.635 / *0,635*		8.698 / *8,698*	

Şr.1I – pasaj tehnologic Şrot 1, I – intrare; E – ieşire

The analysis of table 1 and graphs of figures 2 - 4 show that the mean dimensions of material particles entering in grinding process for the five roller mills decrease with the griound material. Also, in terms of material resulting of five passages ground, it is found that the mean dimensions of ground particles decreases along the technological route, from Gr.1 to Gr.5. But while the particles subject to grinding process, where the decrease is continuous, for the particles ground the decrease of mean dimensions chopped takes account of a polynomial law, at Gr.4 and 5, the decrease being insignificant. The explanation could be that herein particle content of bran is greater than for the first three passages and that they are ground less compared with the endosperm particles adhering to the layers of coating.

Din analiza tabelului 1 şi a graficelor din figurile 2 - 4 se constată că dimensiunile medii ale particulelor de material care intră în procesul de mărunțire la cele cinci mori cu cilindri scad pe măsură ce materialul se mărunțeşte. De asemenea, în ceea ce priveşte materialul rezultat în urma mărunțirii la cele cinci pasaje, se constată că dimensiunile medii ale particulelor mărunțite scad şi ele de-a lungul traseului tehnologic, de la Şr.1 la Şr. 5, dar spre deosebire de particulele supuse mărunțirii unde scăderea este continuă, la particulele mărunțite scăderea dimensiunilor medii urmează o lege polinomială, la Şroturile 4 şi 5, scăderea fiind nesemnificativă. Explicația ar fi aceea că aici conținutul de particule de înveliş este mai mare decât la primele 3 pasaje şi că acestea se mărunțesc mai puțin în comparație cu particulele de endosperm aderent pe foițele de înveliş.

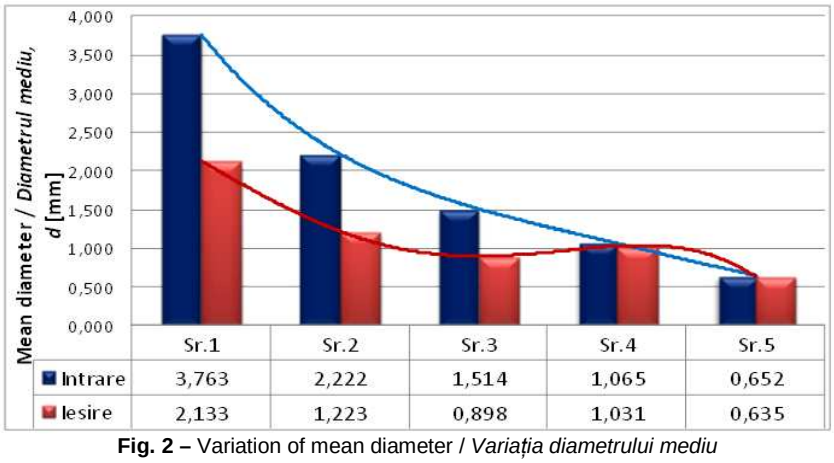


Fig. 2 – Variation of mean diameter / *Variația diametrului mediu*

Regarding the specific surface of material particles, has been found that for the material subject to grinding process, it increases from the passage of Gr.1 to the

În ceea ce priveşte suprafața specifică a particulelor de material, se constată că pentru materialul care este supus mărunțirii, acesta creşte de la pasajul Şr.1 la pasajul Şr.5,

passage of Gr.5 continuously and visibly, but the specific surface of particles resulted after grinding shows a similar increase only at the first three passages, remaining at the same value for the material processed at Gr.4 and Gr.5 respectively.

It should be noted that at the first three passages the material subjected to grinding and the material resulted from grinding consists of large particles of endosperm (grist and semolina), which makes it to be properly assessed by particle size analyzing with classifier. But to the Gr.4 and Gr.5 passages, the material particles being mainly layers of coating, they have only two of the three dimensions in correlation with mesh sizes of sieves (they are flattened) and, therefore, the calculated mean dimension have significant errors.

If the decrease of particles mean dimensions is still visible and continuous in the first three breakage passages, the index grinding *λ* shows insignificant variation in these passages (around λ ≈ 1.7) and keeps around λ ≈ 1 at the 4 and 5 passages, where the mean dimensions of particles remain in close range (layers of coating are very little ground).

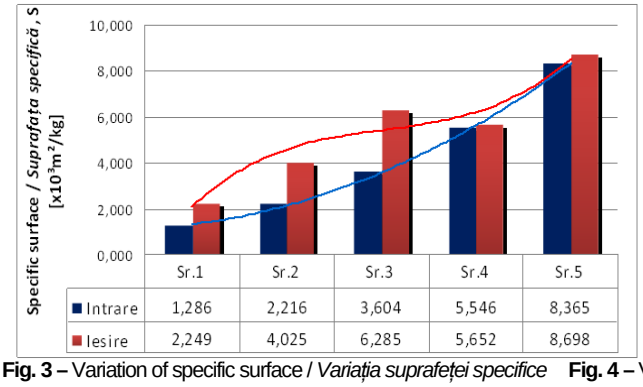
This happens, on the one hand, because the roll gap decreases from the Gr.1 to Gr.5 passage and, also, for flute depth decreases significantly from the Gr.1 to Gr.2 and Gr. 3 passages.

în mod continuu şi vizibil, dar suprafaţa specifică a particulelor rezultate după măruntire prezintă o creştere după aceeaşi alură numai la primele trei pasaje, rămânând la aceeaşi valoare pentru materialul prelucrat la Şr.4, respectiv la Şr.5

Este de reţinut faptul că la primele trei pasaje materialul supus măruntirii, respectiv materialul rezultat la măruntire este constituit din particule mari de endosperm (şroturi şi grişuri), ceea ce face ca el să poată fi apreciat corespunzător prin analiza granulometrică cu clasificatorul, dar la pasajele Şr. 4 şi Şr. 5, particulele de material fiind cu preponderenţă foiţe de înveliş, acestea au numai două din cele trei dimensiuni în corelaţie cu dimensiunile ochiurilor sitelor (sunt aplatizate) şi, deci, dimensiunea medie calculată prezintă erori însemnate.

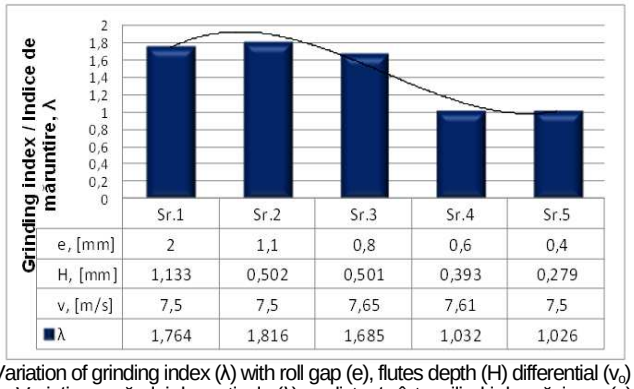
Dacă scăderea dimensiunilor medii ale particulelor este vizibilă şi continuă la primele trei pasaje de şrotare, valoarea indicelui de măruntire λ prezintă variaţii nesemnificative la aceste pasaje (în jurul valorii λ ≈ 1,7) şi se păstrează în jurul valorii λ ≈ 1, la pasajele 4 şi 5, acolo unde dimensiunile medii ale particulelor rămân în limite apropiate (foiţele de înveliş se măruntesc foarte puţin).

Acest lucru se întâmplă, pe de o parte, pentru că distanţa dintre cilindri se micşorează de la pasajul Şr.1 la Şr. 5 şi, de asemena, pentru că adâncimea riflului scade semnificativ de la Şr.1 la pasajele Şr.2 şi Şr.3.



	Sr.1	Sr.2	Sr.3	Sr.4	Sr.5
Intrare	1,286	2,216	3,604	5,546	8,365
Iesire	2,249	4,025	6,285	5,652	8,698

Fig. 3 – Variation of specific surface / *Variaţia suprafeţei specifice*



	Sr.1	Sr.2	Sr.3	Sr.4	Sr.5
e, [mm]	2	1,1	0,8	0,6	0,4
H, [mm]	1,133	0,502	0,501	0,393	0,279
v, [m/s]	7,5	7,5	7,65	7,61	7,5
λ	1,764	1,816	1,685	1,032	1,026

Fig. 4 – Variation of grinding index (λ) with roll gap (e), flutes depth (H) differential (v_o) / Variaţia numărului de particule (λ) cu distanţa între cilindri de măcinare (e), adâncime riflurilor (H), viteza diferenţială (v_o)

CONCLUSIONS

The breakage technological phase is the most important stage of the transformation of wheat in flour.

The rolls of this phase have fluted surface and flutes characteristics and rolls gap significantly influence the characteristics of ground material.

It is important to know the particle size characteristics of grist and particle size distribution of it, so that can be properly established the constructive characteristics of grinding rolls flutes for all roller mills of the technological diagram of phase.

From the analysis of this paper, it was found that the material is ground at each five passages of breakage phase of 100 t / 24 h, the material flow is controlled such that fragments of endosperm (meal and dunst) are ground to the grinding rolls pairs with roll gap increasingly less and flutes on their surface are increasingly finer.

Thus, if for Gr.1, which have the roll gap of 2 mm and number of flutes of 3.8 flutes/cm, surface increase is 0.965 m^2 for a grinding index of λ =1.764, for Gr.3 (number of flutes of 7 flutes/cm and roll gap e = 0.8 mm) surface increase is 2.681 m^2 for a grinding index of λ =1.685.

It has also found that seeds fragments and large fragments of endosperm are processed, predominantly, in the first three passages, while the last two breakage passages the processed fractions have a high content of

CONCLUZII

Faza tehnologică de şrotare este cea mai importantă etapă a procesului de transformare a grâului în făină.

Cilindrii morilor din această fază au suprafaţa rifluită, iar caracteristicile riflurilor şi distanţa dintre cilindri influenţează semnificativ caracteristicile materialului măruntit.

Este important de cunoscut caracteristicile granulometrice ale măcinişului şi distanţa după dimensiuni a acestuia, astfel încât să poată fi stabilite corespunzător caracteristicile constructive ale riflurilor cilindrilor de măcinare la toate utilajele de măruntire din diagrama tehnologică a fazei.

Din analiza efectuată în cadrul acestei lucrări, s-a constatat că pe măsură ce materialul este măruntit la fiecare din cele 5 pasaje ale fazei de şrotare 100 t / 24 h, circuitul materialului este astfel dirijat încât fragmentele de endosperm (grişuri şi dunsturi) sunt măruntite la perechile de cilindri măcinători cu distanţa din ce în ce mai mica între cilindri, iar riflurile de pe suprafaţa acestora sunt din ce în ce mai fine.

Astfel, dacă la Şr.1, care are distanţa între cilindri de 2 mm şi cu un număr de rifluri de 3,8 rifl/cm, creşterea de suprafaţă este 0,965 m^2 pentru un indice λ =1,764, la pasajul Şr.3 (cu 7 rifl/cm şi distanţa e = 0,8 mm) creşterea de suprafaţă este de 2,681 m^2, pentru un indice de măruntire λ = 1,685.

S-a constatat, de asemenea, că fragmentele de seminţe şi fragmentele mari de endosperm sunt prelucrate, preponderant, la primele trei pasaje, în timp ce la ultimele două pasaje de şrotare fracţiile prelucrate au un conţinut ridicat de înveliş şi

bran and minimally adherent endosperm.

In line with the above affirmed in Gr.4 and Gr.5 the grinding index has values very close to 1.

Acknowledgement

The work has been funded by the Sectoral Operational Programme of Human Resources Development 2007-2013 of the Romanian Ministry of Labor, Family and Social Protection through the Financial Agreement POSDRU / 88/1.5/S/61178.

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numai foarte puțin endosperm adherent pe acestea.

În corelație cu cele afirmate, la Şr.4 şi Şr.5 indicele de mărunțire are valori foarte apropiate de 1.

Mulțumiri

Rezultatele prezentate in acest articol au fost obținute cu sprijinul Ministerului Muncii, Familiei si Protecției Sociale prin Programul Operațional Sectorial Dezvoltarea Resurselor Umane 2007-2013, Contract nr. POSDRU / 88/1.5/S/61178.

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DYNAMIC MODELLING OF A CONICAL VIBRATORY THREE-POINTS SUSPENDED SIEVE / *MODELAREA DINAMICĂ A UNEI SITE CONICE VIBRATOARE SUSPENDATĂ ÎN TREI PUNCTE*

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Abstract: *The dynamical study of oscillatory motion in the horizontal plane of a conical sieve with vertical axis, suspended in three points, is presented in this paper. The sieve is suspended with three elastic cables, in three points, at the top and at the bottom. The differential equations of the sieve motion in polar coordinates have been determined with Lagrange's equations. The trajectory of the sieve joint point to the acting mechanism was graphically drawn. Analyzing the trajectory of a point on the sieve, some qualitative assessments on material motion on the sieve, in separation process, can be done.*

Keywords: *generalized coordinates, Lagrange's equations, numerical integration, oscillatory motion, conical sieve*

INTRODUCTION

A sieve with outer conical separating surface was used to clean rape seeds of large foreign bodies. The sieve is suspended with flexible elastic wires, in three equidistant points, at the top and at the bottom [8].

The steel cables diameter is ϕ 1.5 mm. The acting mechanism provides mostly an alternating circular motion of which amplitude can be measured to the edge of the sieve on both sides of the equilibrium position of oscillation. At this point an arm of length d is connected to the acting mechanism (horizontal oscillating circular saw).

The acting mechanism consists of an alternating current electric engine with a power of 710W and a worm-wheel drive with oscillating crank lever acting system. This one has the control button eccentrically disposed on the worm wheel of the transmission mechanism.

The oscillating crank lever stroke of the acting system is of 16mm. The slider arm is joined by a spherical joint on the arm stiffened with the sieve and it is laid on radial direction to the base circle of the cone.

The experimental equipment is provided with the possibility to set the oscillating motion parameters namely the oscillation frequency F, and the oscillation amplitude A_i.

Oscillation frequency can be changed from the electric motor by varying the electric current parameters. The oscillation amplitude can be modified by changing the position of acting mechanism in relation to the radial arm of the sieve, joined one to the other by a spherical joint.

By the eccentric tangential positioning of the arm joint of acting mechanism to the conical sieve, it develops almost circular oscillations towards the vertical axis of the cone. This motion is assumed to be oscillatory, because the vertical axis of the sieve (its center) was not constrained to move in the direction of the arm joined with the sieve (placed radially at the base circle of the cone).

The equipment designed and experimentally developed was used both to determine the vibratory motions of the separation surface (as an agricultural products processing element) and to estimate the material movement on the sieve and the separation and seed crops sorting process efficiency. The schematic representation of the conical suspended sieve is presented in fig.1 [7, 8].

Rezumat: *În lucrare se prezintă studiul dinamic al unei site conice cu ax vertical, cu mişcare oscilantă în plan orizontal, suspendată în trei puncte, la partea de sus şi la partea de jos, prin trei cabluri elastice. Pe baza ecuațiilor lui Lagrange au fost determinate ecuațiile diferențiale ale mişcării sitei în coordonate polare. A fost trasată grafic traiectoria punctului de articulație a sitei la mecanismul de acționare. Pe baza traiectoriei punctului de pe sită se pot face aprecieri calitative cu privire la mişcarea materialului pe sită în procesul de separare.*

Cuvinte cheie: *coordonate generalizate, ecuațiile lui Lagrange, integrare numerică, mişcare oscilantă, sită conică*

INTRODUCERE

O sită cu suprafață de separare conică exterioară, suspendată în trei puncte echidistante, atât la partea de sus, cât şi la partea de jos, cu fire elastice flexibile, a fost utilizată la curățirea semințelor de rapiță de corpuri străine mari.

Diametrul cablurilor de oțel este ϕ1,5 mm. Mecanismul de acționare al sitei a fost astfel conceput încât să asigure în principal o mişcare circulară alternativă cu o anumită amplitudine, măsurată la marginea sitei conice, de o parte şi de cealaltă a poziției neutre de oscilație în care este fixat un braț de legătură de lungime d, la mecanismul de acționare (de tip ferăstrău pendular).

Mecanismul de acționare este compus dintr-un motor electric de curent alternativ cu puterea de 710 W şi un sistem de acționare de tip melc roată melcată cu culisă oscilantă, cu butonul de acționare dispus excentric pe roata melcată a transmisiei mecanismului.

Cursa culisei oscilante a sistemului de acționare este de 16 mm, brațul culisei fiind articulat printr-o articulație sferică la brațul rigidizat cu sita dispus pe direcție radială la cercul de bază al conului.

Standul experimental este prevăzut cu posibilitatea reglării parametrilor mişcării oscilante şi anume a frecvenței de oscilație, F şi a amplitudinii oscilației, A_i.

Frecvența de oscilație se poate modifica de la motorul electric prin variația parametrilor curentului electric, iar amplitudinea oscilației se poate modifica prin schimbarea poziției de dispunere a mecanismului de acționare în raport cu brațul radial al sitei, articulate între ele printr-o articulație sferică.

Prin dispunerea excentrică, tangențială a articulației brațului mecanismului de acționare la sita conică, aceasta realizează oscilații aproximativ circulare față de axa verticală a conului, mişcarea fiind însă o mişcare presupus oscilantă deoarece axa verticală a sitei (centrul acesteia) nu a fost constrânsă să se deplaseze pe direcția brațului solidar cu sita (dispus radial la cercul de bază al conului).

Utilajul conceput şi realizat experimental a fost utilizat atât în cadrul unor determinări ale mişcărilor vibratorii ale suprafeței de separare (ca organ de prelucrare a produselor agricole), dar şi pentru estimarea mişcării materialului pe sită, precum şi a eficienței procesului de separare şi sortare a semințelor unor culturi agricole. Reprezentarea schematică a sitei conice suspendate este prezentată în fig.1 [7, 8].

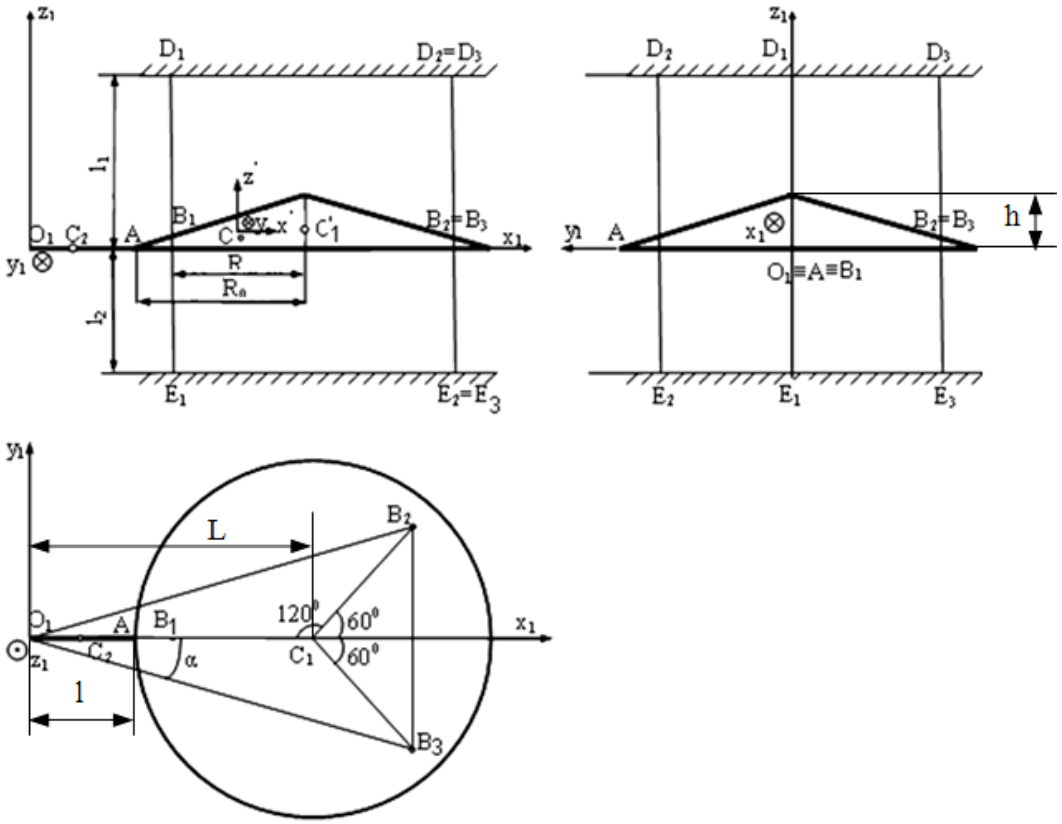

Fig. 1 – *System schematic representation of suspended conical sieve/ Reprezentarea schematica a sitei conice suspendate*

MATERIAL AND METHOD

Considering the coordinate system presented in the figure above, first the coordinates of the suspending cables clamping-in points of the static position of the sieve (D_1 E_1, D_2 E_2, D_3 E_3) and then the position vectors relative to the fixed reference system $O_1x_1y_1z_1$ (fig.1), as well as their moduli, have been written.

Thereby, these vectors have the following expressions

$$\overline{O_1B_1} = (L-R)\bar{i}\ ;\ \overline{O_1B_2} = (L+\frac{R}{2})\bar{i} + R\frac{\sqrt{3}}{2}\bar{j}\ ;\ \overline{O_1B_3} = (L+\frac{R}{2})\bar{i} - R\frac{\sqrt{3}}{2}\bar{j} \quad (1)$$

where L is the distance, in the $O_1x_1y_1$ plane, between the acting point and the mass center C_1 and R is the clamping radius of suspension cables in relation to the sieve.

There are considered as known: the length of the suspension cables at the top and bottom, l_1 respectively l_2, the radius of the sieve generator R_o; the length, l; and the mass, m_2, of the arm connected to the acting mechanism the sieve cone height h and the sieve mass m_1.

The moduli of the position vectors represented in fig.1 have the following expressions:

$$\left|\overline{O_1B_1}\right| = L-R\ ;\ \left|\overline{O_1B_2}\right| = \sqrt{R^2+L^2+RL}\ ;\ \left|\overline{O_1B_3}\right| = \sqrt{R^2+L^2+RL}\ . \quad (2)$$

Knowing the masses and dimensions of the sieve components one can determine the mass center coordinates of the whole equipment, $C\ (\xi, \eta, \zeta)$.

Any current position of the working system can be graphically represented as in fig.2.

If one neglects the vertical displacement, the sieve plane parallel movement in generalized coordinates is defined by λ and θ parameters, given by the relations (3):

$$\lambda = O_1O\ ,\ \hat{\theta} = \sphericalangle\left(Ox;\ Ox_1\right). \quad (3)$$

MATERIAL ŞI METODĂ

Pentru sistemul de coordonate prezentat în figură au fost scrise mai întâi coordonatele punctelor de prindere a cablurilor de suspendare ale sitei în poziție statică (D_1 E_1, D_2 E_2, D_3 E_3), şi apoi vectorii de poziție în raport cu sistemul de referință fix $O_1x_1y_1z_1$ (fig.1) precum şi modulul acestor vectori.

Astfel expresiile acestor vectori sunt:

în care L este distanța de la punctul de acționare la centrul de greutate al sitei C_1 în planul $O_1x_1y_1$, iar R este raza de prindere a cablurilor de suspendare în raport cu sita.

Se consideră cunoscute: lungimea cablurilor de suspendare la partea de sus şi la partea de jos l_1 respectiv l_2; raza cercului generator al sitei R_o; lungimea brațului de legătură cu mecanismul de acționare l; înălțimea conului sitei h; masa sitei m_1 şi masa brațului de legătură cu mecanismul de acționare m_2.

Pentru schema reprezentată, modulele vectorilor de poziție sunt:

Cunoscând masele şi dimensiunile elementelor componente ale sitei se pot determina coordonatele centrului de masă ale întregii instalații, $C\ (\xi, \eta, \zeta)$.

O poziție curentă, oarecare a sistemului de lucru poate fi reprezentata grafic prin schemele din fig.2.

Neglijând deplasarea pe verticală, mişcarea plan paralelă a sitei în coordonate generalizate este definită de parametrii λ şi θ, dati de relațiile (3):

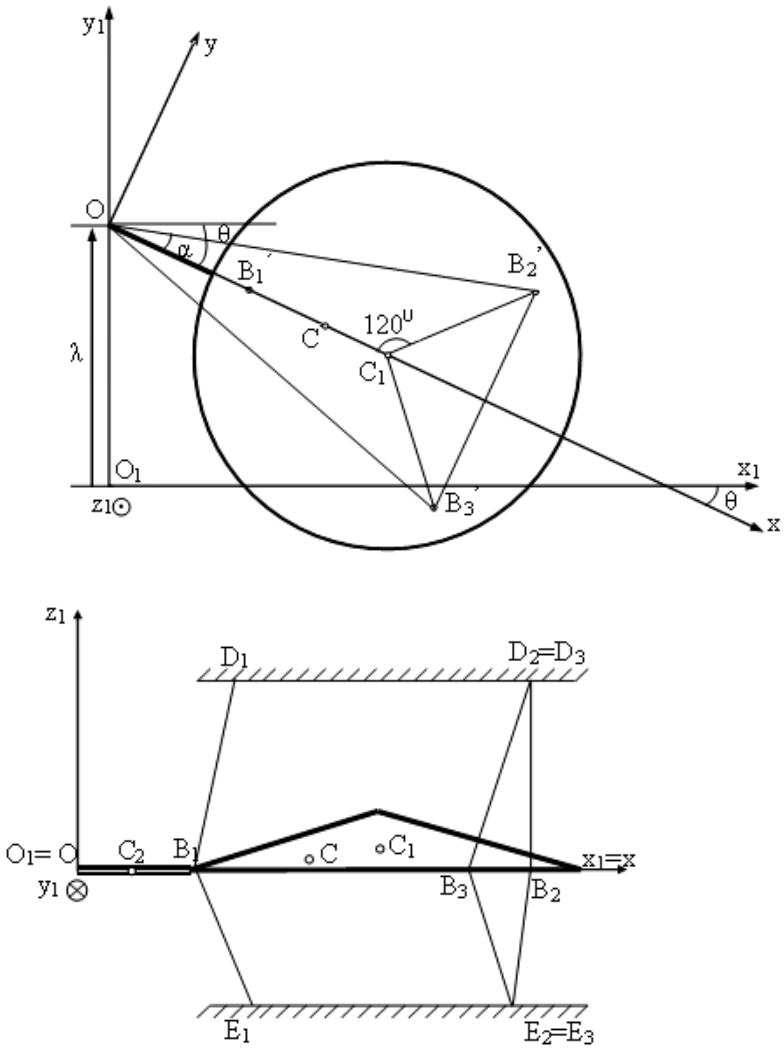

Fig. 2 – *System representation in current position / Reprezentarea schematică a sitei conice suspendate în poziție curentă*

Applying the Lagrange's equations, the differential equations of the motion of the conical suspended sieve were determined (see rel. 4):

Determinarea ecuațiilor diferențiale ale mișcării sitei conice suspendate a fost realizată aplicând ecuațiile lui Lagrange, relațiile (4):

$$\frac{d}{dt}\left(\frac{\partial E}{\partial \dot{q}_k}\right)-\frac{\partial E}{\partial q_k}=Q_k^C+Q_k^n \quad , \text{k = 1, 2,...., n} \tag{4}$$

where: E is the kinetic energy of the system composed of the conical sieve and the connecting arm, q_k – the generalized coordinates, $\dot{q}_k$ - the generalized velocities, Q_k^C are the conservative generalized forces and Q_k^n are the non conservative generalized forces.

To apply the Lagrange's equations one calculates the current position of the mass center (5), the moments of inertia tensor of the working body, the kinetic energy of the system, the function of force.

în care: E – reprezintă energia cinetică a sistemului format din sita conică şi brațului de legătură; q_k - coordonatele generalizate; $\dot{q}_k$ - vitezele generalizate; Q_k^C - forțele generalizate conservative; Q_k^n - forțele generalizate neconservative.

Pentru aplicarea ecuațiilor lui Lagrange au fost calculate: poziția curentă a centrului de masă (5), tensorul momentelor de inerție ale organului de lucru, energia cinetică a sistemului, funcția de forță.

$$C[\xi\cos\theta;(\lambda-\xi\sin\theta);\zeta] \tag{5}$$

The inertia moments tensor of the working body is obtained by summing the moments of inertia tensor of the conical sieve with the moments of inertia tensor of the connecting arm to the acting mechanism, respectively:

Tensorul momentelor de inerție ale organului de lucru se obține prin însumarea tensorului momentelor de inerție ale sitei conice cu tensorul momentelor de inerție ale brațului de legătură cu mecanismul de acționare, respective:

$$[J_c]=[J_C^1]+[J_C^2]. \tag{6}$$

The moments of inertia tensor of the conical sieve with respect to its mass center, written in matrix form, is:

Tensorul momentelor de inerție ale sitei conice în raport cu centrul său de greutate, scris sub formă matriceală, este:

$$\left[J^{1}_{C_1}\right]=\begin{bmatrix}\frac{m_1R_0^2}{4}+\frac{m_1h^2}{18} & 0 & 0\\ 0 & \frac{m_1R_0^2}{4}+\frac{m_1h^2}{18} & 0\\ 0 & 0 & \frac{m_1R_0^2}{2}\end{bmatrix} \quad (7)$$

The moments of inertia tensor of the connecting arm to the acting mechanism with respect to its mass center, is given by relation (8)

Tensorul momentelor de inerție ale brațului de legătură cu mecanismul de acționare în raport cu centrul sau de greutate, este dat de relația (8)

$$\left[J^{2}_{C_2}\right]=\begin{bmatrix}0 & 0 & 0\\ 0 & \frac{m_2\ell_2{}^2}{12} & 0\\ 0 & 0 & \frac{m_2\ell_2{}^2}{12}\end{bmatrix} \quad (8)$$

The kinetic energy of the working system (sieve-connecting arm), considering that the sieve vertical displacement is neglected, is given by relation (9)

Energia cinetică a sistemului de lucru (sita – braț de legătură) în condițiile în care se neglijează deplasarea sitei pe verticală este dată în relația (9)

$$E=\frac{1}{2}mv_C^2+\frac{1}{2}J_C\omega^2, \quad (9)$$

in which, m is the mass of the system consisting of conical sieve and connecting arm, v_C – mass center velocity, J_C – the moment of inertia, ω – the angular velocity of the system.

Deriving the mass center current position coordinates, the mass center velocity is determined. Then, the kinetic energy of the system is determined with relation (10)

în care m este masa sistemului format din sita conică şi brațul de acționare; v_C – viteza centrului de masă; J_C – moment de inerție; ω - viteza unghiulară a sistemului.

După derivarea coordonatelor centrului de masă în poziția curentă se determină viteza centrului de masă al sistemului, după care se determină energia cinetică a sistemului.

$$E=\frac{1}{2}m\dot{\lambda}^2+\frac{1}{2}\left(J_C+m\xi^2\right)\dot{\theta}^2-m\xi\dot{\lambda}\dot{\theta}\cos\theta. \quad (10)$$

Following the mathematical model known for applying Lagrange's equations, the kinetic energy derivatives with respect to the coordinates λ and θ, the velocities $\dot{\lambda}$, $\dot{\theta}$ and the time t, were determined (11):

Urmărind modelul matematic cunoscut pentru aplicarea ecuațiilor lui Lagrange, au fost determinate derivatele energiei cinetice în raport cu coordonatele λ şi θ, vitezele $\dot{\lambda}$, $\dot{\theta}$ şi cu timpul t, care sunt date de relațiile (11).

$$\frac{\partial E}{\partial\lambda}=0;\ \frac{\partial E}{\partial\dot{\lambda}}=m\dot{\lambda}-m\xi\dot{\theta}\cos\theta;\qquad \frac{d}{dt}\left(\frac{\partial E}{\partial\dot{\lambda}}\right)=m\ddot{\lambda}-m\xi\ddot{\theta}\cos\theta+m\xi\dot{\theta}^2\sin\theta;$$

$$\frac{\partial E}{\partial\theta}=m\xi\dot{\lambda}\dot{\theta}\sin\theta;\qquad \frac{\partial E}{\partial\dot{\theta}}=\left(J_C+m\xi^2\right)\dot{\theta}-m\xi\dot{\lambda}\sin\theta; \quad (11)$$

$$\frac{d}{dt}\left(\frac{\partial E}{\partial\dot{\theta}}\right)=\left(J_C+m\xi^2\right)\ddot{\theta}-m\xi\ddot{\lambda}\sin\theta-m\xi\dot{\lambda}\dot{\theta}\cos\theta.$$

For the acting mechanism that generates an harmonic motion, the vibration generating force is defined by function:

Pentru mecanismul de acționare care imprimă o mişcare oscilatorie armonică, forța generatoare de vibrații este definită de funcția:

$$F=F_0\sin\Omega t. \quad (12)$$

The non-conservative generalized forces were determined, as follows, with relations (13). Using the expression (14) of the force function, the conservative generalized forces were determined too, by noting:

Au fost determinate în continuare forțele generalizate neconservative date de relațiile (13) precum şi cele conservative utilizând expresia funcției de forță (14)

$$Q_k^n=Q_\lambda=\frac{\delta L_\lambda}{\delta\lambda}=\frac{F_o\sin\Omega t\cdot\delta\lambda}{\delta\lambda}=F_o\sin\Omega t;\ Q_k^n=Q_\theta=0 \quad (13)$$

$$U=-\frac{1}{2}k_1\left[\left(\Delta\ell_{B_1D_1}\right)^2+\left(\Delta\ell_{B_2D_2}\right)^2+\left(\Delta\ell_{B_3D_3}\right)^2\right]-\frac{1}{2}k_2\left[\left(\Delta\ell_{B_1E_1}\right)^2+\left(\Delta\ell_{B_2E_2}\right)^2+\left(\Delta\ell_{B_3E_3}\right)^2\right], \quad (14)$$

$\Delta\ell_{B_iD_i}$ is the suspending cables elongation on the top of the sieve, $\Delta\ell_{B_iE_i}$ is the suspending cables elongation on the bottom of the sieve and k_1 and k_2 are the suspending cables stiffness on the top and on the bottom of the sieve. Using the expressions of the vectors corresponding to the length of the undistorted wires, the expressions of vectors corresponding to a distorted position, at the top and at the bottom of the sieve, resulted, so that the suspending cables elongations were calculated. It resulted the following expression of the force function:

unde: $\Delta\ell_{B_iD_i}$ este alungirea cablurilor de suspendare a sitei la partea superioară, $\Delta\ell_{B_iE_i}$ este alungirea cablurilor de suspendare a sitei la partea inferioară iar k_1 şi k_2 sunt rigiditățile cablurilor de suspendare ale sitei la partea superioară şi respective la partea inferioară. În continuare au fost calculate alungirile cablurilor de suspendare folosind expresiile vectorilor ataşați lungimii firelor din poziția nedeformată din care au rezultat vectorii corespunzători firelor în poziția deformată, atât la partea de sus cât şi la partea de jos a sitei. Expresia funcției de forță a sistemului de lucru este următoarea:

$$U = -\frac{1}{2}k_1\left[a_{11} + \lambda^2 - a_{12}\cos\theta - a_{13}\lambda\sin\theta + l_1^2 - 2\ell_1\sqrt{a_{11} + \lambda^2 - a_{12}\cos\theta - a_{13}\lambda\sin\theta}\right] -$$

$$-\frac{1}{2}k_1[\lambda^2 + \ell_1^2 + a_{21} - a_{22}\cos(\alpha-\theta) - a_{23}\sin(\alpha-\theta) - \lambda a_{24} - \lambda a_{25}\sin(\alpha-\theta) -$$

$$-2\ell_1\sqrt{a_{21} - a_{22}\cos(\alpha-\theta) - a_{23}\sin(\alpha-\theta) - \lambda a_{24} - a_{25}\lambda\sin(\alpha-\theta)}] -$$

$$-\frac{1}{2}k_1[\lambda^2 + \ell_1^2 + a_{31} - a_{32}\cos(\theta+\alpha) + a_{33}\sin(\alpha+\theta) - \lambda a_{34} - \lambda a_{35}\sin(\alpha+\theta) -$$

$$-2\ell\sqrt{a_{31} - a_{32}\cos(\alpha+\theta) - a_{33}\sin(\alpha+\theta) - \lambda a_{34} - a_{35}\lambda\sin(\alpha+\theta)}] -$$

$$-\frac{1}{2}k_2[b_{11} + \lambda^2 - b_{12}\cos\theta + b_{13}\lambda\sin\theta + \ell_2^2 - 2\ell_2\sqrt{b_{11} + \lambda^2 - b_{12}\cos\theta + b_{13}\lambda\sin\theta}] \quad (15)$$

$$-\frac{1}{2}k_2[\lambda^2 + \ell_2^2 + b_{21} - b_{22}\cos(\alpha-\theta) - b_{23}\sin(\alpha-\theta) - \lambda b_{24} - \lambda b_{25}\sin(\alpha-\theta) -$$

$$-2\ell_2\sqrt{b_{21} - b_{22}\cos(\alpha-\theta) - b_{23}\sin(\alpha-\theta) - \lambda b_{24} - b_{25}\lambda\sin(\alpha-\theta)}] -$$

$$-\frac{1}{2}k_2[\lambda^2 + \ell_2^2 + b_{31} - b_{32}\cos(\theta+\alpha) + b_{33}\sin(\alpha+\theta) - \lambda b_{34} - \lambda b_{35}\sin(\alpha+\theta) -$$

$$-2\ell_2\sqrt{b_{31} - b_{32}\cos(\alpha+\theta) + b_{33}\sin(\alpha+\theta) - \lambda b_{34} - b_{35}\lambda\sin(\alpha+\theta)}]$$

where one noted:

în care s-au facut notatiile:

$$a_{11} = 2(L-R)^2 + \ell_1^2 \qquad a_{12} = 2(L-R)^2 \qquad a_{13} = 2(L-R)$$

$$a_{21} = \left(L + \frac{R}{2}\right)^2 + 2OB_2^2 + \left(R\frac{\sqrt{3}}{2}\right)^2 + \ell_1^2;\ a_{22} = 2\left(L + \frac{R}{2}\right)OB_2;\ a_{23} = 2\left(R\frac{\sqrt{3}}{2}\right)OB_2;\ a_{24} = 2R\frac{\sqrt{3}}{2};$$

$$a_{25} = 2OB_2 = 2\sqrt{L^2 + R^2 + LR};\ a_{31} = \left(L + \frac{R}{2}\right)^2 + OB_3^2 + \left(-R\frac{\sqrt{3}}{2}\right)^2 + \ell_1^2;\ a_{32} = 2\left(L + \frac{R}{2}\right)OB_3;$$

$$a_{33} = 2\left(-R\frac{\sqrt{3}}{2}\right)OB_3;\ a_{34} = 2R\frac{\sqrt{3}}{2};\ a_{35} = 2OB_3;\ b_{11} = 2(L-R)^2 + \ell_2^2;$$

$$b_{12} = 2(L-R)^2;\ b_{13} = 2(L-R); \quad (16)$$

$$b_{21} = \left(L + \frac{R}{2}\right)^2 + 2OB_2^2 + \left(R\frac{\sqrt{3}}{2}\right)^2 + \ell_2^2;\ b_{22} = 2\left(L + \frac{R}{2}\right)OB_2;\ b_{23} = 2\left(R\frac{\sqrt{3}}{2}\right)OB_2;\ b_{24} = 2R\frac{\sqrt{3}}{2};$$

$$b_{25} = 2OB_2 = 2\sqrt{L^2 + R^2 + LR};\ b_{31} = \left(L + \frac{R}{2}\right)^2 + OB_3^2 + \left(-R\frac{\sqrt{3}}{2}\right)^2 + \ell_2^2$$

$$b_{32} = 2\left(L + \frac{R}{2}\right)OB_3;\ b_{33} = 2\left(-R\frac{\sqrt{3}}{2}\right)OB_3;\ b_{34} = 2R\frac{\sqrt{3}}{2};\ b_{35} = 2OB_3.$$

RESULTS

Using the force function given by relation (17), the conservative generalized forces [3,4] were calculated,

REZULTATE

Cu ajutorul funcției de forță dată de relația (17) au fost calculate forțele generalizate conservative [3,4],

$$Q_\lambda^c = \frac{\partial U}{\partial \lambda},\ Q_\theta^c = \frac{\partial U}{\partial \theta}. \tag{17}$$

By replacing in Lagrange's equations, a system of two differential equations of second order in λ and θ was obtained. These equations represent the motion equations system of the oscillating system with conical sieve.

Înlocuind în ecuațiile lui Lagrange s-au obținut sistemul de ecuații diferențiale de ordinul al doilea în λ şi θ care exprimă mişcarea sistemului oscilant cu sită conică.

$$\begin{aligned}
&m\ddot{\lambda} - m\xi\ddot{\theta}\cos\theta + m\xi\dot{\theta}^2\sin\theta = F_o\sin\Omega t - \frac{1}{2}k_1[2\lambda - a_{13}\sin\theta - \frac{2\ell_1(2\lambda - a_{13}\sin\theta)}{2\sqrt{a_{11}+\lambda^2 - a_{12}\cos\theta - a_{13}\lambda\sin\theta}}] - \\
&-\frac{1}{2}k_1\{2\lambda - a_{24} - a_{25}\sin(\alpha-\theta) - \frac{2\ell_1[-a_{24} - a_{25}\sin(\alpha-\theta)]}{2\sqrt{a_{21}+a_{22}\cos(\alpha-\theta) - a_{23}\sin(\alpha-\theta) - \lambda a_{24} - a_{25}\lambda\sin(\alpha-\theta)}}\} - \\
&-\frac{1}{2}k_1\{2\lambda - a_{33} - a_{35}\sin(\alpha+\theta) - \frac{2\ell_1[-a_{34} - a_{35}\sin(\alpha+\theta)]}{2\sqrt{a_{31}+a_{32}\cos(\alpha+\theta) - a_{33}\sin(\alpha+\theta) - \lambda a_{34} - a_{35}\lambda\sin(\alpha+\theta)}}\} - \\
&-\frac{1}{2}k_2[2\lambda + b_{13}\sin\theta - \frac{2\ell_2(2\lambda + b_{13}\sin\theta)}{2\sqrt{b_{11}+\lambda^2 - b_{12}\cos\theta + b_{13}\lambda\sin\theta}}] - \frac{1}{2}k_2\{2\lambda - b_{24} - b_{25}\sin(\alpha-\theta) - \\
&-\frac{2\ell_2[-b_{24} - b_{25}\sin(\alpha-\theta)]}{2\sqrt{b_{21}+b_{22}\cos(\alpha-\theta) - b_{23}\sin(\alpha-\theta) - \lambda b_{24} - b_{25}\lambda\sin(\alpha-\theta)}}\} - \frac{1}{2}k_2\{2\lambda - b_{34} - b_{35}\sin(\alpha+\theta) - \\
&-\frac{2\ell_2[-b_{34} - b_{35}\sin(\alpha+\theta)]}{2\sqrt{b_{31}+b_{32}\cos(\alpha+\theta) - b_{33}\sin(\alpha+\theta) - \lambda b_{34} - b_{35}\lambda\sin(\alpha+\theta)}}\}.
\end{aligned} \tag{18}$$

$$\begin{aligned}
&\left(J_C + m\xi^2\right)\ddot{\theta} - m\xi\ddot{\lambda}\sin\theta - m\xi\dot{\lambda}\dot{\theta}\cos\theta - m\xi\dot{\lambda}\dot{\theta}\sin\theta = \\
&-\frac{1}{2}k_1\left[a_{12}\sin\theta - a_{13}\lambda\cos\theta - \frac{2\ell_1(a_{12}\sin\theta - a_{13}\lambda\cos\theta)}{2\sqrt{a_{11}+\lambda^2 - a_{12}\cos\theta - a_{13}\lambda\sin\theta}}\right] - \\
&-\frac{1}{2}k_1\left[-a_{22}\sin(\alpha-\theta) + a_{23}\cos(\alpha-\theta) + a_{25}\lambda\cos(\alpha-\theta) - \frac{2\ell_1[a_{22}\sin(\alpha-\theta) + a_{23}\cos(\alpha-\theta) + a_{25}\lambda\cos(\alpha-\theta)]}{2\sqrt{a_{21}+a_{22}\cos(\alpha-\theta) - a_{23}\sin(\alpha-\theta) - \lambda a_{24} - a_{25}\lambda\sin(\alpha-\theta)}}\right] - \\
&-\frac{1}{2}k_1\left[a_{32}\sin(\theta+\alpha) + a_{33}\cos(\alpha+\theta) - a_{35}\lambda\cos(\alpha+\theta) - \frac{2\ell_1[a_{32}\sin(\alpha+\theta) - a_{33}\cos(\alpha+\theta) - a_{35}\lambda\cos(\alpha+\theta)]}{2\sqrt{a_{31}+a_{32}\cos(\alpha+\theta) - a_{33}\sin(\alpha+\theta) - \lambda a_{34} - a_{35}\lambda\sin(\alpha+\theta)}}\right] - \\
&-\frac{1}{2}k_2\left[b_{12}\sin\theta + b_{13}\lambda\cos\theta - \frac{2\ell_2[b_{12}\sin\theta + b_{13}\lambda\cos\theta]}{2\sqrt{b_{11}+\lambda^2 - b_{12}\cos\theta + b_{13}\lambda\sin\theta}}\right] - \\
&-\frac{1}{2}k_2\left[-b_{22}\sin(\alpha-\theta) + b_{23}\cos(\alpha-\theta) + \lambda b_{25}\cos(\alpha-\theta) - \frac{2\ell_2[b_{22}\sin(\alpha-\theta) + b_{23}\cos(\alpha-\theta) + b_{25}\lambda\sin(\alpha-\theta)]}{2\sqrt{b_{21}+b_{22}\cos(\alpha-\theta) - b_{23}\sin(\alpha-\theta) - \lambda b_{24} - b_{25}\lambda\sin(\alpha-\theta)}}\right] - \\
&-\frac{1}{2}k_2\left[b_{32}\sin(\theta+\alpha) + b_{33}\cos(\alpha+\theta) - \lambda b_{35}\cos(\alpha+\theta) - \frac{2\ell_2[-b_{32}\sin(\alpha+\theta) - b_{33}\cos(\alpha+\theta) - b_{35}\lambda\sin(\alpha+\theta)]}{2\sqrt{b_{31}+b_{32}\cos(\alpha+\theta) - b_{33}\sin(\alpha+\theta) - \lambda b_{34} - b_{35}\lambda\sin(\alpha+\theta)}}\right]
\end{aligned}$$

For an experimental equipment with conical sieve with circular holes, with known constructive parameters, respectively,

Pentru o instalație experimentală cu sită conică cu orificii circulare, cu parametrii constructivi cunoscuți, respectiv,

$l_1 = 0{,}24$ m; $l_2 = 0{,}18$; $d = 0{,}0015$ m; $R_o = 0{,}215$ m; $l = 0{,}205$ m;

$L = 0{,}420$ m; $R = 0{,}2$ m; $h = 0{,}015$m; $m_1 = 0{,}8$ kg; $m_2 = 0{,}4$ kg

the stiffness coefficients, k_1 and k_2 [1], of the suspending cables on the top and on the bottom of the sieve, were first

au fost calculate mai întâi constantele de rigiditate ale cablurilor de legătură la partea de sus, respectiv la partea

calculated as follows:

In relations (19), *E* represents the elastic modulus and *A* is the area of cables section.

Using numerical integration of differential equations Runge Kutta fourth order, with Turbo Pascal programming language [5,6], the numerical integration of the system (18) has been done.

With the obtained values, the trajectory of the sieve joint point to the acting mechanism arm was graphically drawn (fig.3).

de jos k_1 şi k_2 [1]:

$$k_1 = \frac{EA}{\ell_1},\ k_2 = \frac{EA}{\ell_2} \tag{19}$$

în care: *E* reprezintă modulul de elasticitate, iar *A* este aria secțiunii transversale a cablurilor.

Utilizând metoda de integrare numerică a ecuațiilor diferențiale Runge Kutta de ordinul IV, cu ajutorul limbajului de programare Turbo Pascal [5,6], s-a făcut integrarea numerică a sistemului (18).

Cu valorile obținute a fost trasată grafic traiectoria punctului de legătură a sitei cu brațul mecanismului de acționare, (fig.3).

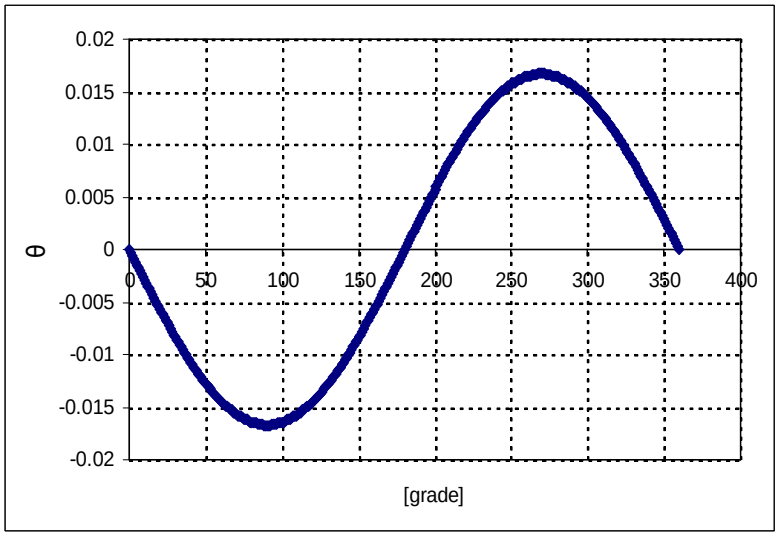

Fig. 3 - The trajectory of the sieve joint point to the acting mechanism arm / *Traiectoria punctului de legătură a sitei cu brațul mecanismului de acționare*

CONCLUSIONS

Suspended oscillating conical sieves are used to separate foreign bodies in mixed grain.

The dynamic analysis of the oscillating system with conical sieve is quite difficult, and the motion differential equations system of a point on the sieve is very complex.

This system can not be solved mathematically. Therefore, if the constructive parameters of the mechanical system are known, the numerical integration is necessary.

However, our numerical calculations and our observations have shown that the system has a harmonic motion that was graphically drawn in fig.3.

The mathematical model presented can be the basis for the design and construction of grain cleaning systems that have integrated such a sieve.

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CONCLUZII

Sitele conice oscilante suspendate sunt utilizate pentru separarea corpurilor străine din amestecurile de cereale.

Analiza dinamică a sistemului oscilant cu sită conică este destul de dificilă, iar sistemul de ecuații diferențiale ale mişcării unui punct de pe sită este deosebit de complex.

El nu poate fi rezolvat matematic şi de aceea este necesară integrarea numerică cunoscând parametrii constructivi ai sistemului mecanic.

Din calculele şi observațiile noastre rezultă totuşi o mişcare oscilatorie armonică a sistemului reprezentată grafic prin figura 3.

Modelul matematic prezentat poate sta la baza proiectării şi construcției sistemelor de curățire a cerealelor care au integrate o astfel de sită.

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RESEARCH OF FACTORS AFFECTING THE AGRO PRODUCTS LOGISTICS BASED ON THE AHP- GREY CORRELATION ANALYSIS
/
基于 AHP-灰关联分析法的农产品物流发展对策研究

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Abstract: *The long-standing problem of agricultural product logistics process heavy loss and high cost has seriously constrained the development of rural economy and the improvement of the living standard of farmers. In order to identify the main factors which influence the development of agricultural products logistics, six aspects, i.e. the rural logistics support level, the level of economic development, social attention, logistics supply and demand level, the level of modernization and logistics technical levels with 20 factors were selected to establish evaluation index system. The combination of analytic hierarchy process and Grey correlation analysis method is applied to calculate the indicators at all levels. And the results were analyzed meticulously with a view to China's modern agricultural product logistics development planning and provide scientific basis.*

Keywords: *agro products logistics, index system, AHP, Grey correlation analysis.*

INTRODUCTION

After years of development, the supply and output capacity of agricultural products in China has made great improvement. But compared to the United States and other developed countries, there is still a large gap. A prominent problem is the process of agricultural logistics losses and the high cost of circulation. According to the data, the loss rate of fruits, vegetables and other agricultural products in developed countries in the harvesting, transport and storage process is less than 5%, while China's loss rate is about 35%, even in the developed areas in China, the loss rate can also reach 20% to 30%[1]. At the same time, as a large agricultural country, the liquidity of China's agricultural products, food, oil, vegetables, fruit, meat, eggs and other products ranked first for many years, in the world. The high loss rate as well as a huge base led to a serious waste of China's agricultural intermediate links. In view of this, the domestic scholars have carried out extensive research around the impact of China's agricultural products logistics problem. Yang Jun, et.al[2] measured the logistics efficiency of agricultural products of China's major provinces over the years with distance function and non-parametric linear programming method, proving that rural urbanization in China has a significant role to enhance the efficiency of agricultural logistics. Li Qingfang[3] identified the six key factors like the total power of agricultural machinery, the state of financial expenditure for agriculture that affect the demand for agricultural products logistics with multiple linear regression and principal component analysis method, and established a linear regression model. Taking vegetables liquidity for instance, Tang Bulong[4] analyzed the effect of roads, the level of information, brokers, facilities, and education level on logistics development, and came to the level of significance of each factor. It is not difficult to find that the studies above are more in-depth studies selecting only one aspect of China's agricultural products logistics. A comprehensive analysis of the influencing factors of China's agricultural products logistics is

摘要: *为了找出影响农产品物流发展的主要因素，选取了农村物流支持水平、经济发展水平、社会关注度、物流供需水平、现代化水平和物流技术水平等几个方面建立评价指标体系，运用层次分析与灰关联分析相结合的方法，计算出了各级指标的最终权重。计算结果表明我国的物流技术水平、基础设施建设、社会对农产品物流的关注度、农村机械化水平以及互联网的普及程度等仍然偏低，并针对这些问题提出了相应的对策与建议。*

关键词: *农产品物流, 指标体系, 层次分析法, 灰关联分析法*

引言

经过多年的发展，我国的农产品供给及输出能力取得了较大的提高，但是相较于美国等发达国家，仍存在较大的差距。其中一个突出的问题就是农产品物流过程损耗大、流通成本高。数据显示，发达国家水果蔬菜等农副产品在采摘、运输、储存的过程中损失率不到 5%，而我国农产品在物流中的损耗率达到 35%左右，即使在发达地区，其损耗率也达到了 20% ~ 30%[1]。与此同时，作为一个农业大国，我国农产品流通量大，粮食、油料、蔬菜、水果、肉蛋等产品产量连续多年居世界第一，较高的损失率以及巨大的基数导致了我国农产品中间环节浪费严重。鉴于此，国内学者围绕影响我国农产品物流的相关问题展开了广泛的研究。杨军、王厚俊[2]等采用距离函数和非参数线性规划的方法测量了我国主要省份历年的农产品物流效率，通过实证研究发现我国农村城镇化对农产品物流效率的提升具有明显的促进作用。李庆芳[3]通过多元线性回归及主成分分析等方法找出了影响农产品物流需求的农业机械总动力、农林牧渔业总产值、国家财政用于农业的支出等 6 个关键因素，并建立了一次线性回归模型。唐步龙[4]以蔬菜流通量为例，在对淮安、宿迁等 13 个县区面板数据进行搜集整理的基础上，分析了道路、信息化水平、经纪人队伍、设施及教育水平对物流发展的影响，并得出了各影响因素的显著性水平。不难发现，以上研究都较深入，但选取的研究对象都只反映了我国农产品物流的某个方面，尚未开始全面地分析我国农产品物流的影响因素。因此，对影响农产

still in short. Therefore, a comprehensive analysis to identify the key and targeted factors to improve them is with practical significance.

The main factors affecting the agricultural product logistics

There are many factors affecting agricultural products logistics. Yang, Tang as well as Li gave a detailed study from the agricultural logistics point of view. In addition, Feng Dan[5] carried out a detailed analysis by selecting the four aspects of a total of 17 factors from the perspective of the logistics industry as a whole. After earnestly drawing, six aspects including rural logistics support level, the level of economic development, social attention, supply and demand level of logistics, the level of modernization and logistics technology of a total of 20 factors affecting the agricultural product logistics are filtered on this basis, combined with expert advice.

品物流的主要因素进行分析，找出其中的关键因素，并进行针对性地改善就具有较大的现实意义。

影响农产品物流的主要因素

影响农产品物流的因素众多，杨军、唐步龙以及李庆芳等都从农产品物流角度给出了详细的研究，此外冯丹[5]等人还从物流业整体发展的角度选取了四个方面的共 17 个因素进行了详细的分析。本文经过认真汲取，结合专家意见，在此基础上经过筛选，认为影响农产品物流的主要因素包括农村物流支持水平、经济发展水平、社会关注度、物流供需水平、现代化水平和物流技术水平等六个方面共 20 个因素，建立评价指标体系如表 1 所示：

Table 1 / *表 1*

Agri-product logistics development level evaluation index system / 农产品物流发展评价指标体系

The first grade indexes(A) / 一级指标 A	The second grade indexes (B) / 二级指标 B	Weights / 权重	The third grade indexes(C) / 三级指标 C	General ranking / 总排序
Agricultural Product Logistics / 农产品物流	The rural logistics support level / 农村物流支持水平	0.1373	The length of rural postal line / 农村邮递线路长度	0.0318
			The number of employees of the transportation and warehousing industry / 交通运输仓储业从业人员数	0.0319
			The total power of agricultural machinery / 农业机械总动力	0.0379
			National fiscal expenditure for agriculture / 国家财政用于农业的支出	0.0305
			The original value of fixed assets for production of rural households(transportation, post and telecommunications) / 农村家庭生产性固定资产原值（交通运输邮电业）	0.0422
			Fixed asset investment in rural areas / 农村固定资产投资	0.0337
	The level of economic development / 经济发展水平	0.2452	Per capita net income in rural areas / 农村人均纯收入	0.0818
			Retail sales in rural areas / 农村社会消费品零售总额	0.0646
			Per capita gross domestic product / 人均 GDP	0.0761
			Urbanization rate / 城镇化率	0.0595
	Social attention / 社会关注度	0.0314	The number of articles of the rural logistics phase in CNKI / CNKI 中农产品物流相关文章数量	0.0071
	Logistics supply and demand levels / 物流供需水平	0.2345	The number of import and export of agricultural products / 进出口农产品数量	0.0553
			Agriculture, forestry, animal husbandry and fishery 农林牧渔业总产值	0.0801
	The level of modernization / 现代化水平	0.1130	Overall netizens / 总体网民规模	0.0232
			Internet penetration in rural areas / 农村互联网普及率	0.0188
			The extent of resident education / 居民受教育程度	0.0347
	The level of logistics technology / 物流技术水平	0.2385	The level of storage technology / 仓储技术水平	0.0712
			The technical level of the fresh frozen technology / 冷冻保鲜技术水平	0.0649
			The level of packaging technology / 包装技术水平	0.0661
			The level of picking technology / 采摘技术水平	0.0655

MATERIAL AND METHOD

Calculation of qualitative indicators

As the level of development of the agricultural product logistics evaluation is a complex multi-factor integrated decision with incomplete information, which contains both qualitative indicators and quantitative indicators. Among the index factor is essentially a gray relationship. So it is to be calculated with the combined method of AHP and gray relational analysis. Analytic Hierarchy Process is a method that decomposes decision-making related elements and combines each attribute on a qualitative judgment and quantitative analysis by constructing a hierarchy and ratio analysis. It can be divided into six steps, such as define the problem, establish hierarchy, build judgments matrix, hierarchy single ranking and its uniformity inspection, hierarchy general ranking, uniformity inspection. According to the judgment matrix, A B layer level single-sort results are calculated as follows. In Table 2, $\lambda_{\max}=6.1269$, $CI=0.0254$, $RI=1.24$, the mean random consistency index $CR=0.0205<0.10$.

计算方法

定性指标的计算

由于农产品物流发展水平评价是一个信息不完全的复杂多因素综合决策问题，评价指标中既有定性指标，也包含定量指标，各指标因素之间本质上是一种灰色关系，故采用 AHP 与灰关联分析相结合的方法进行计算。其中，层次分析法是将与决策有关的元素分解，通过构造层次结构和比率分析将各属性上的定性判断与定量分析结合起来[6]。大体分为六个步骤，即明确问题；建立层次结构；构造判断矩阵；层次单排序及其一致性检验；层次总排序；最后做出相应决策。根据专家填写的判断矩阵，计算出 A 对 B 层的层次单排序结果为表 2 所示。其中 $\lambda_{\max}=6.1269$，$CI=0.0254$，$RI=1.24$，平均随机一致性指标 $CR=0.0205<0.10$。

Table 2 /*表 2*

Secondary indicators of single-level sequencing / *二级指标层次单排序*

The second grade indexes / *二级指标 B*	Weights(b_i) / *重要度 b_i*
The rural logistics support level / *农村物流支持水平*	0.1373
The level of economic development / *经济发展水平*	0.2452
Social attention / *社会关注度*	0.0314
Logistics supply and demand levels / *物流供需水平*	0.2345
The level of modernization / *现代化水平*	0.1130
The level of logistics technology / *物流技术水平*	0.2385

Calculation of quantitative indicators

Professor Deng Julong's system theory is a mathematical method used to solve the system of uncertain information. The basic idea of the theory is analyzing the degree of association or similarity between various elements in the system and upon which the system is sorted. The advantage of this method is a comparison of the geometric relationship of the system within the time sequence statistics can be conducted for multiple indicators by a quantitative analysis of the development trend of the dynamic process. And thus the gray relational degree between the reference series and comparing columns can be obtained. It avoids accidental impact of a given year data, and the data requirements are not demanding. During the Grey correlation calculations, expert opinion method is used to rate the qualitative indicators. Then associate the B layer index with the C layer index calculated by multiplying the weights and its correlation. The impact of the second indicators can also be taken into account in the calculation of gray relational analysis with the combination of AHP and Grey Relational Analysis, so that the computing is closer to reality. The specific calculation steps

定量指标的计算.

邓聚龙教授所提出的灰色系统理论是用来解决信息不确定系统的一种数学方法，其基本思想是通过分析系统中各元素之间的关联程度或相似程度，依据关联度对系统排序。该方法的优点就是可以针对多个指标，通过对动态过程发展态势的量化分析，完成对系统内时间序列有关统计数据几何关系的比较，从而求出参考数列与各比较数列之间的灰关联度，避免了某一年数据的偶然性影响，对数据要求不苛刻。在进行灰关联计算时，采用专家意见法对定性指标进行评分。然后将 B 层指标的权重与灰关联计算出的 C 层指标关联度相乘。将 AHP 法与灰关联分析相结合可以将二级指标的影响程度也考虑到灰关联分析的计算中，从而使计算更加接近现实，其具体计算步骤为：

are as follows:

- Determine the analysis of the number of columns. Setting the reference sequence is $Y=\{Y(k)\mid k=1,2,\Lambda,n\}$; the comparative sequence is $X_i=\{X_i(k)\mid k=1,2,\Lambda,n\},i=1,2,\Lambda,m$. The amount of agricultural product logistics from the year 2005 to 2010 is selected as the reference sequence, which is regarded as a substitute for the overall level of development of the agricultural products logistics.
- Standardized processing of the index value. In this paper, the mean law is used to regulate the treatment, and eliminate the dimensionless impact of different indicators to get a matrix $x=x_i(k),k=1,2,\Lambda,n;i=1,2,\Lambda,m$;
- The calculation of the correlation coefficient. For the reference sequence and comparative sequence, the points to the interval distance method are used to obtain the correlation coefficient of the $Y(k)$ and $x_i(k)$:

- 确定分析数列，设参考序列 $Y=\{Y(k)\mid k=1,2,\Lambda,n\}$; 比较序列 $X_i=\{X_i(k)\mid k=1,2,\Lambda,n\},i=1,2,\Lambda,m$。文中选择的参考序列为 2005-2010 年的农产品物流量，以此代替农产品物流发展的总体水平。
- 指标值的规范化处理。本文采用均值法进行规范处理，消除不同指标之间的量纲影响，得到矩阵 $x=x_i(k),k=1,2,\Lambda,n;i=1,2,\Lambda,m$；
- 计算关联系数。对于参考序列和比较序列，采用点到区间距离的方法求得 $Y(k)$ 与 $x_i(k)$ 的关联系数：

$$\xi_i^{\,k}=\frac{\min\limits_i\min\limits_j|Y_i(k)-x_i(k)|+\rho\max\limits_i\max\limits_j|Y(k)-x_i(k)|}{|Y(k)-x_i(k)|+\rho\max\limits_i\max\limits_j|Y(k)-x_i(k)|} \tag{1}$$

In the formula, ρ is the distinguishing coefficient. The smaller the ρ whose argument is in the interval (0, 1), the greater the resolution is. Usually ρ=0.5. As the degree of correlation between the comparative sequence and the reference sequence, the associated formula of the k factor is:

式（1）中，ρ 为分辨系数。ρ 越小，分辨力越大，一般其取值区间为（0,1），通常取 ρ=0.5。则作为比较数列与参考数列间关联程度的数量表示，第 k 个因素关联度公式为：

$$C_i(k)=\frac{\xi_i^{\,k}}{\sum_{k=1}^{n}\xi_i^{\,k}} \tag{2}$$

The general ranking $W=\sum_{j=1}^{3}b_jc_i(k)\,i=1,2,3,4,5,6)$. The calculation results are shown in Table 4 for the quantitative indicators.

计算总排序结果。总排序 The general ranking $W=\sum_{j=1}^{3}b_jc_i(k)\,i=1,2,3,4,5,6)$.对于上述定量指标的计算结果见表 3。

Table 3 /表 3

The Grey relational sort results / *灰关联排序结果*

The third grade indexes / *三级指标*	**correlation degree(c_{ij}) / *关联度***
The length of rural postal line / *农村邮递线路长度*	0.0913
The number of employees of the transportation and warehousing industry / *交通运输仓储业从业人员数*	0.0915
The total power of agricultural machinery / *农业机械总动力*	0.1087
National fiscal expenditure for agriculture / *国家财政用于农业的支出*	0.0874
The original value of fixed assets for production of rural households(transportation, post and telecommunications) / *农村家庭生产性固定资产原值（交通运输邮电业）*	0.1211
Fixed asset investment in rural areas / *农村固定资产投资*	0.0967
Per capita net income in rural areas / *农村人均纯收入*	0.2348
Retail sales in rural areas / *农村社会消费品零售总额*	0.1853
Per capita gross domestic product / *人均GDP*	0.2184

Urbanization rate / *城镇化率*	0.1706
The number of articles of the rural logistics phase in CNKI / *CNKI 中农产品物流相关文章数量*	0.0205
The number of import and export of agricultural products / *进出口农产品数量*	0.1587
Agriculture, forestry, animal husbandry and fishery / *农林牧渔业总产值*	0.2299
Overall netizens / *总体网民规模*	0.0665
Internet penetration in rural areas / *农村互联网普及率*	0.0540
The extent of resident education / *居民受教育程度*	0.0995
The level of storage technology / *仓储技术水平*	0.2044
The technical level of the fresh frozen / *冷冻保鲜技术水平*	0.1863
The level of packaging technology / *包装技术水平*	0.1897
The level of picking technology / *采摘技术水平*	0.1878

In the difference sequence Min=0.0007, Max=0.6062.

RESULTS

After calculation, the final result for each index is shown in Table 1, from which we can see the macro-economic indicators such as per capita net income in rural areas, per capita GDP, has a greater impact on the agricultural products logistics of the year 2005 to 2010. Then , the retail sales in rural areas, The level of logistics technology, urbanization rate, the number of import and export of agricultural products etc, which can be regarded as factors affecting the consumption. Followed again , the technical level of the fresh froze, the original value of fixed assets for production of rural households, the total power of agricultural machinery, fixed asset investment in rural areas etc, which can be viewed as agricultural impact factors and key technical factors. Finally, other factors are considered, the effect of which in the years 2005-2010 on China's total agricultural product logistics is very small.

CONCLUSIONS

It can be seen that with the national increase of agricultural inputs and financial support to the agriculture, forestry, animal husbandry and fishery output value constraints to the amount of agricultural products logistics has been gradually reduced, based on the analysis above, combined with the current situation of China's agricultural products logistics. In order to improve the overall level of development of the agricultural product logistics, the government should focus on improving the level of infrastructure and agricultural mechanization, level of modernization of rural logistics information, as well as agricultural products logistics technology and other related aspects.

Continuous increasing of rural logistics infrastructure

For a long time, China's road infrastructure, means of transport were relatively undevelopped[7], which demonstrates mainly in the small scale of road network, low homeland coverage and road grade, as well as poor capacity. The volume of rural transport is small. Part of the

在求差序列中， Min=0.0007，Max=0.6062。

计算结果

经过计算，各指标的最终结果如表 1 所示，从表 1 中可以看出，在各影响因素中农民人均纯收入、农林牧渔业总产值以及人均国内生产总值等描述宏观经济总框的指标对 2005-2010 年的农产品物流总额影响最大；其次是农村社会消费品零售总额、农产品物流技术水平、城镇化率、进出口农产品数量等，可视为消费影响因素；再次是农产品冷冻保鲜技术水平、交通运输邮电业农村家庭生产性固定资产原值、农业机械总动力、农村固定资产投资、交通运输仓储业从业人员数、农村邮递线路长度、国家财政用于农业的支出等，可视为农业影响因素及关键技术因素；最后是其他因素，在 2005-2010 年我国农产品物流总额的影响中所占比重甚轻。

结论与建议

根据以上分析，结合我国的农产品物流现状可以看出，随着国家对农业投入及财政支持力度的加大，农林牧渔业总产值等因素对农产品物流量的制约已经逐渐减小。为了提高农产品物流的总体发展水平，应着重从提高基础设施水平和农业机械化水平、农村物流信息现代化水平、以及农产品物流技术水平等相关方面着手。

继续加大农村物流基础设施建设

长期以来，我国的道路基础设施、运输工具都比较落后[7]，主要表现在公路网规模小、国土覆盖率低、公路等级低、通行能力差等几个方面。农村的运输工具运量小、集约

backward areas still maintain the traditional rough mode of transport as the main means of transport, such as agricultural vehicles or small and medium-sized trucks, even with the help of human or animal power, which contributes to transportation inefficiencies, high energy consumption and heavy pollution. Therefore, to promote the development of agricultural product logistics, we must continue to increase the logistics infrastructure in rural areas, improve the level and coverage of rural roads, and increase the investment in fixed assets of the transportation of Posts and Telecommunications industry for production of rural households.

Gradually increase the rate of agricultural mechanization

It is an important indicator of agricultural mechanization to measure a country's level of agricultural development. In the early 1940s, the United States took the lead in realizing the mechanization of food production. Since the 1990s, food, crops and some vegetables of developed countries led by the United States have achieved a high degree of mechanization from planting to harvest. The substantial decline in the proportion of the agricultural labor force, accounts for only 2% to 8% of the country's total labor force. Although many developing countries, including China, have accelerated the pace of agricultural mechanization, overall it is still only equivalent to the level of economically developed countries in the early 1950s to 1960s. It is also very important for the promotion of agricultural development and agricultural logistics to increase the level of agricultural mechanization, and vigorously raise cropland efficiency as well as labor transfer.

Promote the construction of agricultural information

At present, information of agricultural products is mainly released through radio, television and other traditional media in China. With the rapid development of information technology, the information center of rural economy and agricultural professional websites have been built[9]. There are some rural agricultural leading enterprises which establish a specialized agricultural products page website publishing market information and gaining agricultural publicity. But overall, the level of information construction in rural areas is still rather backward with low Internet penetration and poor information flow. The level of agricultural e-commerce has yet to be enhanced.

Increasing the degree of social wide concern

In recent years, with the concern of three rural issues, agricultural products logistics began to attract attention of the community. More and more in-depth studies are carried out by experts and scholars in this field. However, these are still far unable to meet the needs of the development of rural logistics. First, it is the lack of professional logistics of company stationed in the logistics market of agricultural products. Second, the lack of government attention and great support for agricultural products logistics enterprises. As a result, it needs not only the government, the media, the attention of the relevant agencies, but also the 3PL enterprises and strong preferential policies to increase social concern ai a wide range.

Developing modern logistics technology

Because of the fresh and perishable nature of some agricultural products, their preservation time is short with demanding storage environment and conditions, which makes such agricultural products logistics cost, low efficiency, and lack of profitability point[10,11]. Therefore, in

性差，部分落后地区仍保持传统粗犷的运输方式，以农用车辆或中小型卡车作为主要运输工具甚至借助人力或畜力，运输效率低下、能耗高且污染重。因此，促进农产品物流的发展，必须继续加大农村物流基础设施建设，提高农村道路等级及覆盖率，增加交通运输邮电业农村家庭生产性固定资产投资。

逐步提高农业机械化率

农业机械化水平是衡量一个国家农业发展水平的重要标志。20 世纪 40 年代初，美国率先实现了粮食生产的机械化。从 90 年代开始，以美国为首的发达国家粮食、经济作物以及部分蔬菜从种植到收获都实现了高度的机械化，农业劳动力的比例大幅下降，只占到全国总劳动人口的 2%-8%。而虽然包括中国在内的许多发展中国家也一直在加快农业机械化步伐，但总体看来，仍只相当于经济发达国家 50-60 年代初期的水平[8]，农机化水平远远落后与发达国家。提高农业机械化水平，大力提高耕地效率以及劳动力转移，对于促进农业发展、农产品物流的进步也十分重要。

促进农业信息化建设

目前，我国主要通过广播、电视等传统媒体发布农产品信息，随着信息化的迅速发展，各种农村经济信息中心和农业专业性网站相继建成[9]，也有一些农村农业龙头企业建立了专门的农产品网页网站，发布市场信息以及进行农产品的宣传等。但是总体看来，农村信息化建设水平仍然相当落后，互联网的普及率低、信息流通度差，农产品电子商务水平仍有待增强。

广泛增加社会关注度

近年来，随着国家对三农问题的重视，农产品物流也开始逐渐受到社会各界的关注，不少专家学者对该领域的研究也越来越深入，但是这些仍远远无法满足农村物流发展的需要。首先是缺乏专业的物流公司进驻农产品物流市场，其次是缺乏政府对农产品物流企业的关注与大力扶持。因此，广泛增加社会关注度，不仅需要政府、媒体、相关机构的重视，更需要 3PL 企业以及强有力的优惠吸引政策。

发展现代物流技术

由于部分农产品具有鲜活与易腐特性，保鲜时间短，储存环境与条件要求苛刻，使得该类农产品的物流配送成本高、效率低，缺乏盈利点[10，11]。因此在农产品生产、运

the entire chain of agricultural production, transportation and sales, technological innovation has become an important support and motivation of the development of agricultural products logistics industry[12]. The United States with developed agricultural logistics has formed a modern logistics technology system with IT having as core, storage and transportation technology , packaging technology and other professional technology as the support[7,13]. While in China's agricultural technology research and development emphasis is generally placed on the technology of the production processes in the fields, such as seed and plant protection, then gradually starting to focus on the aspects of technical research of the processing of agricultural products. Also, technology research of agricultural products logistics chain has not been taken seriously[14]. Backward logistics technology seriously hindered the development of China's agricultural products logistics, causing waste and loss of agricultural custody and transit. Therefore, to develop modern agricultural products logistics technology, including picking, warehousing and packaging, to guide agricultural products logistics standardization have an important significance to promote the progress of agricultural products logistics, develop rural economic and increase farmers' income.

Aknowlegement

This work was supported by Graduate Innovation Project fund of Jiangsu Province –CXLX12_0681

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输、销售的整个链条上，技术创新就成为了农产品物流产业发展的重要支撑和动力[12]。农产品物流发达的美国已经形成了以信息技术为核心、以储运技术和包装技术等专业技术为支撑的现代化物流技术体系[7,13]。而在我国以往的农业技术研发中，一般比较重视良种、植保等田间地头生产环节的技术研究，后来逐渐开始重视农产品加工环节的技术研究，而农产品物流环节的技术研究却一直没有受到重视[14]。物流技术的落后严重束缚了我国农产品物流的发展[15]，造成了农产品保管以及运输途中的浪费和损耗。因此，发展包括采摘、仓储、包装等在内的现代农产品物流技术，引导农产品物流标准化对于促进农产品物流的进步、农村经济发展以及农民增收具有重要意义。

Aknowlegement

江苏省研究生创新项目（CXLX12_0681）

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RESEARCH ON SUPPLY CHAIN DEMAND PREDICTION BASED ON BP NEURAL NETWORK ALGORITHM
/
基于神经网络的供应链需求预测研究

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Abstract: *Demand prediction is a hot research field in markets management, especially for fresh agricultural products prediction based on supply chain management. Based on BP neural network, a new demand prediction algorithm for fresh agricultural products is presented in the paper. First, the structure and data indicators of BP neural network algorithm are redesigned and the training function is selected for the fresh agricultural products prediction algorithm. Second, the improvement of excitation function, (including trigonometric function and sigmoid function) and orthogonalizable design, are presented and analyzed to speed up the calculation and improve the prediction accuracy of ordinary BP algorithm. Finally, data from certain fresh agricultural product corporations are taken for example and the simulation results show that not only the problem of convergence speed has been solved, but also the prediction accuracy is ensured when the improved algorithm is used in demand prediction for fresh agricultural products .*

Keywords: *supply chain management, demand prediction, BP neural network algorithm, fresh agricultural products.*

摘要: *需求预测是市场管理（尤其是农鲜产品的供应链管理）的研究热点之一。本文在改进 BP 神经网络的基础上，提出了一个新的农鲜产品供应链需求预测模型。首先，本文为农鲜产品供应链需求预测模型设计了 BP 神经网络模型的网络结构、数据指标和训练函数；其次，通过改进 BP 神经网络的激励函数（包括 trigonometric 和 sigmoid 函数）和正交选择以优化提升原算法的运算效率、收敛速度和需求预测的精度；最后选用某农鲜产品供应链的数据为例进行了实验仿真预测，实验结果表明，本文算法不仅解决了 BP 神经网络在供应链需求预测时的收敛速度问题，也提高了预测精度。*

关键字: *供应链管理，需求预测，BP 神经网络，农鲜产品。*

INTRODUCTION

Supply chain management plays an important role in today's society. The study and application of supply chain of fresh agricultural products have also obtained remarkable achievement in recent years. Application study on "organizing supply of goods according to customers' orders" is growing vigorously, and the most basic job to achieve this is to establish prediction system of market demand on fresh agricultural products, which is the important factor driving the entire supply chain. Reasonable and effective prediction method can lower the inventory cost, provide basis for making production plan and improve the overall efficiency of supply chain. However, as the demand prediction of fresh agricultural products has not only common characteristics of general demand prediction, i.e. derivation, complexity, timeliness, spatiality, but also some unique ones, for example: ① prediction demand of fresh agricultural products is wide in range, great in scale, mainly reflected in the demand prediction of fresh agricultural products involving in lots of departments, including agricultural sector, industrial department, circulation department, consumers, and etc.; ② demand prediction of fresh agricultural products is high in complexity, mainly because fresh agricultural products has numerous kinds, which leads to various and variable specific applications; ③ fresh agricultural products, due to high perishability, random life cycle and continuous physical deterioration, are affected not only by human factors, but also by natural factors. It is due to the above specific features of prediction of fresh agricultural products as well as the bullwhip effect in supply chain management that the effects of traditional prediction methods are not that satisfactory. Therefore, it is urgent to explore the demand prediction

引言

在当今社会供应链管理具有越来越重要的作用，而且最近国内外学者在农鲜产品的供应链管理理论研究和实践应用方面都取得了显著成就。按客户订单组织货源更是供应链管理实践中的研究热点之一。按客户订单组织货源的研究前提就是要构建实际有效的农鲜产品供应链需求预测系统。供应链需求预测也是推动整个供应链合理运转的关键要素。准确合理的预测模型，能够帮助企业降低库存，为企业制定合理的生产计划提供依据，从而提高企业供应链管理综合效率。但是农鲜产品的供应链需求预测不仅具有空间性、派生性、时间性、复杂性等普通需求预测的共同特点，还具有农鲜产品的个性化的特征，如（1）农鲜产品供应链需求预测涉及的规模大、范围广，且需求预测所涉及的行业部门众多，包括农业部门、流通部门、工业部门、消费者等。（2）农鲜产品供应链需求预测实现难度大，因为农鲜产品品目众多，其在各行业的具体用途也同样复杂多变。（3）由于生鲜农产品具有易损性、易腐性和生命周期随机性等特点，这些特点不仅受到人为主观因素的影响，还受到众多自然因素的影响。由于农鲜产品供应链预测的以上复杂特点，又由于供应链管理中存在的牛鞭效应，一般预测模型的实际应用效果难以让人满意，因此针对

method of fresh agricultural products based on supply chain, so as to improve prediction accuracy, reduce storage and production cost, enhance the overall efficiency of supply chain of fresh agricultural products market [1,2].

As for demand prediction of agricultural products at home and abroad, this paper will mainly carry out the analysis from the following two aspects. ① traditional methods are moving average, exponential smoothing, linear regression, time series decomposition, time series forecasting, grey prediction and other methods[3.4,5], all of which adopt historical demand data to carry out prediction, not considering the change factors influencing specific demand. While in fact, factors influencing logistics demand are very complex, not only closely related to society, economic consumption and price, but also to natural resources and geographical conditions; relations among these factors are very complicated and all of them are non-linear relations, thus the prediction results of these models are not that ideal [3-5]; ② demand prediction method based on artificial intelligence; in recent years, with the continuous maturity of artificial intelligence technology, neural network with non-linear predictive ability is applied to logistics demand prediction, having broadened the space for logistics demand prediction, and obtained decent achievement. Neural network is a prediction method based on empirical risk minimization principle, the prediction performance of which is greatly related to the size of logistics sample set. If the quantity is too small, it is easy to be over-fitting; meanwhile, there are lots of neural network parameters and complex network structure, such defects exist as low rate of convergence and local optimization, causing not high prediction accuracy of small sample logistics [6-7].

Neural network has the capacities like non-linear, curve fitting, learning and anti-interference, which is a generally-used non-linear function approximation tool. Through the training of BP neural network algorithm, especially applicable to construct non-linear forecasting function and the accuracy can reach preconcerted requirements. The features of logistics demand of fresh agricultural products just adapt to the performance of neural network. Therefore, theoretically, if such defects of neural network as local optimization and low rate of convergence can be conquered, the method is a relatively superior analysis method of demand prediction of fresh agricultural products. So the trigonometric function , sigmoid function and orthogonalizable design of BP neural network algorithm is improved in the paper to speed up its calculation and convergence of original BP algorithm, and then presents a new demand prediction algorithm of supply chain for fresh agricultural products based on BP neural network algorithm.

MATERIAL AND METHOD

Structure design for BP neural network

According to the characteristics of logistics demand of fresh agricultural products, while applying neural network to predict logistics demand of fresh agricultural products, it needs to establish three-layer (input layer, hidden layer, output layer) BP neural network algorithm prediction model based on logistics quantity prediction of agricultural products (sees Fig. 1) [8].

Input Layer: the input layer neurons take gross retail sales of fresh agricultural products, output value, yield, resident income and fresh agricultural products expenditure of enterprise as reference inputs, 5 in total.

农鲜产品供应链需求预测模型研究成为业内的研究热点之一[1,2]。

目前国内外农鲜产品供应链需求预测的主要方法可以分为传统预测方法和基于人工智能的预测方法。（1）传统预测方法：线性回归预测法、移动平均法、时间序列预测法、时间序列分解法、指数平滑法、灰色预测等方法等。传统预测方法主要是根据企业历史的需求量数据进行未来需求预测，这种方法很难考虑需求在实践中的变化性，又由于影响供应链需求的因素非常的复杂，并且个因素之间存在复杂的非线性关系，这使得传统的供应链预测精度差强人意[3-5]。（2）人工智能的供应链需求预测方法，随着人工智能技术近年来的不断发展，具有非线性模拟和预测能力的人工智能技术广泛应用于供应链需求预测中，这大大拓宽了供应链需求预测空间，研究也取得了较好的研究成果。人工智能技术方法（这里以神经网络技术为代表）基于历史预测经验风险最小化的原理，预测精度和性能与供应链样本数量和质量有较大关系。如果供应链样本数量选择过小，则可能会出现过拟合现象，又由于神经网络的拓扑结构比较复杂、模型参数众多，使得该模型存在局部最优和收敛速度慢的缺点，这使得这类算法对数量较少的样本供应链预测精度不高[6-7]。

考虑到神经网络具有强大的非线性曲线拟合能力、学习能力和抗干扰能力，因此神经网络是一种强大的非线性函数模拟工具。因此BP神经网络非常适用于构造非线性预测函数，而且曲线拟合的精度能达够工程实践的具体要求。因此在理论上，如果能够克服神经网络的收敛速度慢和局部最优的模型缺点时，神经网络完全可以成为较好的农鲜产品供应链需求预测分析方法。本文就是利用神经网络的这些优点，并通过改进原模型的激励函数和正交选择方法，力图克服原始模型的缺点，从而提出一个符合实践预测精度需求和算法效率的农鲜产品供应链需求预测模型。

材料与方法

BP 神经网络的结构设计

根据农鲜产品供应链需求预测的实际特点，在应用BP神经网络预测农鲜产品供应链需求时，需要重新构建基于农产品供应链流量预测的三层拓扑层结构，即输入层、隐含层、输出层的 BP神经网络预测模型，具体网络结构设计见图1 [8]。输入层：该层神经元由农鲜产品的产值、零售总额、产量、企业的农鲜产品支出和居民收入为基准输入，共有5个输入变量。

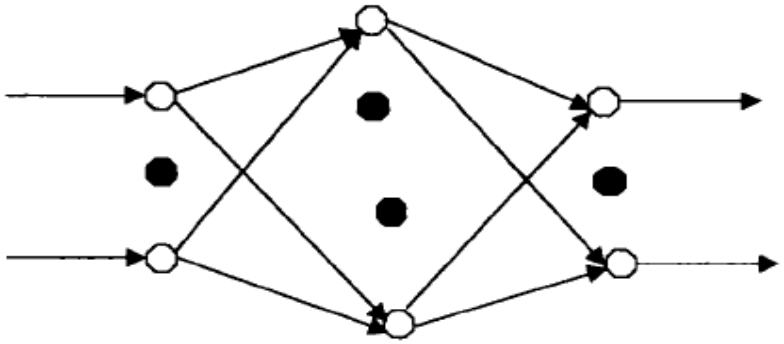

Fig. 1 - Basic structure of BP neural network / *BP 神经网络的基本结构*

Hidden Layer: the determination of hidden layer in this paper is to make use of the empirical equation of the three-layer neural network of trained linear basic function, in which s means the number of nodes of hidden layer; m,n indicate the number of input nodes and output nodes, the conversion relation among which is as shown in equation 1 [9].

隐含层：本文利用线性基本函数的三层神经网络的经验方程来确定隐含层。在该层中 s 表示隐含层中节点的个数；m,n 则分别表示输入节点和输出节点的个数，如式2表示他们之间的换算关系。

$$s = m(n+1)+1 \quad (1)$$

Through the equation 1, it can be temporarily determined that the number of hidden layers is 16, increasing or decreasing several nodes of hidden layer in this interval to finally determine that the unit interval of hidden layer is 10~19, adjusting according to error analysis after adjustment and training. Output Layer: the output layer neurons are only to predict single variable, and the obtained node of output layer of neural network prediction model shall be 1. Hence, as for the prediction result of this paper, as prediction is only carried out on logistics demand of fresh agricultural products, there is only one output layer. Propagate the input vectors $(X_1^{(t)}, X_2^{(t)}, X_3^{(t)}, X_4^{(t)}, X_5^{(t)})$ forward to the hidden layer through transfer function of input layer tan- sigmoid. Upon the effect of transfer function tan- sigmoid through hidden layer, transfer the output vector of node of hidden layer to output node to obtain the results. BP neural network algorithm, in the process of learning, has the characteristics of forward propagation of working signal and back propagation of error signal. If there is error between actual output and expected output (i.e. set output vector) of network and the error is beyond permitted range, it turns to back propagation, returning the error signal layer by layer along with the original propagation route, and network weights shall be adjusted by error feedback. Make the actual output of network more approximate to expected output through continuous amendment of weights [10].

根据以上方程暂定16为隐含层的节点取，实际计算中可以在此区间上适当增减此数字，最终确定的隐含层单元数目将落在10~19取值区间，该取值区间可以在模型运算中根据计算误差分析进行适当调整。

输出层：在该层神经元仅仅预测单一变量，该层得到的输出层节点理论取值应为1。因此输出层只有1层。

随后通过输入层的tan-sigmoid传递函数将输入向量 $(X_1^{(t)}, X_2^{(t)}, X_3^{(t)}, X_4^{(t)}, X_5^{(t)})$ 向前逐步传播至隐含层。再经由隐含层的log- sigmoid传递函数计算后，把输出向量（隐含层节点的）传递到输出节点上，就可以得到最终的计算结果。考虑到BP神经网络在训练过程中工作信号向正向传播、误差信号则向反向传播。因此假如模型的期望输出与实际输出之间存在较大误差，则模型转入反向传播机制，从而能够将误差信号沿传播路线逐层返回，网络节点的权值通过误差反馈进行调整。模型通过权值的反复调节，最终使模型的实际输出与期望输出之间的误差符合要求。

Determination of data indicators of BP neural network algorithm

As it is very difficult to collect logistics demand data of fresh agricultural products in actual work, indirect indicator method is adopted in the model, i.e. adopting relevant economic indicators besides logistics demand of fresh agricultural products to establish economic indicator system of logistics demand of fresh agricultural products, carrying out induction and derivation through mathematical methods so as to determine logistics demand type of agricultural products.

As logistics demand of fresh agricultural products is a derivative demand, the size of logistics demand of fresh agricultural products is closely related to its self demand. In a macro perspective, it mainly includes internal and external

BP 模型中数据指标的确定

考虑到农鲜产品供应链需求的仿真数据收集的难度较大，本文采用间接指标法进行模型计算。就是借用与农鲜产品供应链需求之外的、但与之相关的一些经济学指标构建农鲜产品供应链需求预测的经济学指标体系，通过数学模型进行相应的归纳与推导，从而确定农鲜产品的供应链需求预测模型。

由于农鲜产品供应链需求预测并不是模型本身所具备的能力，因此农鲜产品供应链需求数量与其具体的真实需求有

factors: production capacity of agricultural products, external economic environment and regulating influence. Basically, the production capacity of fresh agricultural products is the key factor of logistics demand of agricultural products. The higher the output value and yield of fresh agricultural products are, the faster the logistics demand increases; if the output value and yield of fresh agricultural products reduce, the logistics demand of fresh agricultural products will be insufficient and reduce. Therefore, this paper adopts certain output value and yield of fresh agricultural products as the indicators for predicting logistics demand of fresh agricultural products. Secondly, another key factor influencing logistics demand of fresh agricultural products comes from external economic environment and national policy orientation. Gross retail sales of products consumption, per-capita income of rural residents and expenditures governments using for agriculture influence the demand function of logistics of agricultural products and the scale of logistics demand; better economic environment and more support from the nation on agriculture have, to a large extent, exerted an impact on the size of logistics demand scale of agricultural products. Therefore, these relevant economic indicators can be served as the influencing factors of demand logistics scale of fresh agricultural products in the model, i.e. 5 indicators of input layer neurons. Suppose that $X_1^{(t)}$, $X_2^{(t)}$, $X_3^{(t)}$, $X_4^{(t)}$, $X_5^{(t)}$ indicate relevant economic indicator systems in different period respectively, $Y^{(t)}$ indicates logistics demand scale of agricultural products determined under the influence of relevant economic indicators, it can be expressed as Equation 1 with an equation. In equation 2, $y(t)$ is the output vector of BP neural network algorithm; $f()$ is the decision function for connection weight and threshold of neural network [9].

着紧密的关联。这需要从宏观层面上考虑内外两部分因素，即外部经济环境和调控政策的影响和农产品自身的产能情况。从本质上说，农鲜产品的自身产能是农产品供应链需求的关键因素。农鲜产品产量和产值越高，它对供应链的需求增长也就增快； 反之将导致农鲜产品供应链需求不足和下降。对此本文选取某农鲜产品产量、产值作为预测农鲜产品供应链需求的经济指标。其次影响农鲜产品供应链需求的另一个要素是外部经济环境和国家政策调控。农鲜产品的消费零售总额、政府对农业的支出、农民的人均收入、农鲜产品供应链的需求规模等都在较大程度上会影响农产品供应链需求量和需求规模。因此在模型具体计算中可以以上述经济指标作为农鲜产品供应链需求预测的影响因素，即作为模型输入层的5个输入值。

假设 $X_1^{(t)}$，$X_2^{(t)}$，$X_3^{(t)}$，$X_4^{(t)}$，$X_5^{(t)}$ 表示不同时期的相关经济指标，$Y^{(t)}$ 则代表输出，即农鲜产品供应链需求量，具体可以用方程2表示。在方程2中，$y(t)$ 表示网络模型的实际输出，$f()$ 表示模型的阈值和连接权的决定函数。

$$y() = f(X_1^{(t)}, X_2^{(t)}, X_3^{(t)}, X_4^{(t)}, X_5^{(t)}) \quad (2)$$

Training function selection for BP algorithm

There are various kinds of training functions of BP neural network algorithm; the training function used in prediction model of logistics demand of agricultural products based on neural network is BFGS Quasi-Newton BP algorithm function which is able to train neural network in any form, as long as its transfer function is derivable towards weights and input. In this regard, available transfer functions are tansig and logsig, meeting the premise for the training of train bfg [10].

Take the determined macroeconomic indicators as the input sample of logistics demand model of agricultural products, train function train bfg with input sample, make use of different input vectors to obtain corresponding output vectors, so as to establish prediction model. Through continuous test, after reaching relatively small error, the network can be used for logistics demand prediction of agricultural products, thus obtaining final prediction results.

Excitation function improvement of BP algorithm

Theoretically, functions differentiable in any order and non-constant can be served as the excitation function of H. Generally, BP neural network adopts sigmoid function as excitation function; however, it is found in research that S type function often causes low rate of convergence of network, low learning efficiency, and network easy to fall into local minimum instead of global minimum, and other shortcomings. Thus, to improve excitation function becomes one of the concepts to improve BP neural network model [6].

-Improvement of trigonometric function: This paper proposes to adopt trigonometric function to substitute sigmoid function, as shown in equation 3.

BP神经网络训练函数的选取

有众多函数可以作为BP神经网络的训练函数，本文采用BFGS准牛顿BP算法函数为BP模型的训练函数，只要该网络的传递函数对于输入和节点权值可导，BFGS准牛顿BP算法函数就能够训练任意形式的网络，因此本文使用的传递函数分别为logsig和tansig函数，完全满足模型的训练前提。

以确定好的宏观经济指标为农产品供应链需求量模型的输入， 运用输入train bfg样本训练函数, 输入不同的输入向量就可以得到不同的输出向量，从而建立起需求预测模型。经过模型不断的调整，最终达到误差最小，就得到了农鲜产品供应链需求预测模型，经过该模型就可以得到合理的预测结果。

改进 BP 神经网络的激励函数

在理论上讲，非常数的且任意阶可导的函数均可作为 BP 网络模型的激励函数，一般 BP 网络均选用 sigmoid 函数为激励函数。许多研究发现，sigmoid 函数常会导致 BP 模型局部最优、算法效率低、模型运算收敛速度慢等缺陷，因此通过改进 BP 模型的激励函数而提升 BP 模型算法性能成为主要的模型改进思路之一。

-采用三角函数的激励函数改进: 本文尝试采用三角函数取代 sigmoid 函数作为 BP 模型的激励函数，具体如式 3 所示。

$$f(x) = 0.5\sin(\lambda x) + 0.5 \quad (3)$$

In which, according to the experience, the value of λ is among [1.2, 1.8]; and the simulation result in this thesis shows that adopting the trigonometric function to be the excitation function of BP neural network achieves remarkable results on the global optimization, but not that obvious in the improvement of learning rate of network. Through further analysis and test, it is found that the reason why learning rate is not obviously enhanced is that there is no connection between two parameters in the above equation: 0.5 and λ; thus if change equation 3 into equation 4 [10].

在公式 3 中，根据经验一般 λ 的取值落在在 [1.2, 1.8] 取值区间。仿真结果也表明：以三角函数作为 BP 模型的激励函数，会使得模型在全局最优化上的改进效果显著，但是对模型算法效率提升效果不是很理想。经过深入仿真实验可以找到模型算法效率不高是由于公式 3 中参数 0.5 和 λ 不发生联系，因此尝试将公式 3 改进为公式 4 [10]。

$$f(x) = (0.5/\lambda)\sin(\lambda x) + 0.5/\lambda \quad (4)$$

In this way, while the period of function $f(x)$ is changed, the amplitude can be changed with the change of function period, thus changing the excitement degree of two connected neurons in layers, i.e. changing corresponding link weight values, in which the value of λ is still among [1.2, 1.8]; as a result, it can both guarantee global optimization of network and obviously enhance learning rate.

- Improvement of sigmoid function for BP algorithm: Traditional BP neural network adopts sigmoid function as shown in equation 5. As action function is fixed in shape, influencing the rate of convergence of network, the rate of convergence of network shall be accelerated through increasing its steepness, i.e. adding steepness factor (also called shape factor) λ. The improved excitation functions in this paper are as shown in equation 6, equation 7 and equation 8.

通过公式 4，$f(x)$ 的函数周期改变发生变化，同时函数的幅值也能随之发生相应的变化，使不同层间两个相连的神经元之间的兴奋程度发生关联，也就改变了相应节点的连接权值，参数 λ 的取值仍然落在[1.2, 1.8]区间，这样不仅可以保证 BP 模型的全局最优，同时模型的算法效率也明显提高。

-采用 sigmoid 函数的激励函数改进: 一般的 BP 模型采用的 sigmoid 函数如式 5 所示。由于该函数的作用形状一般保持不变，这大大限制了算法模型的收敛速度，通过加大 sigmoid 函数的陡峭度来可以加快 BP 模型的收敛速度，即在模型中加入形态因子 λ。改进后的激励函数可以用公式 6、公式 7 和公式 8 表示。

$$f(x) = \frac{1}{1+e^{-x}} \quad (5)$$

$$f(x) = \frac{1}{1+e^{-\lambda x}} \quad (6)$$

$$x = u_j \quad (7)$$

$$f(u_j) = \frac{1}{1+e^{-\lambda * u_j}} = \frac{1}{1+e^{-\lambda * (\sum_l w_{ij} x_i - \theta_j)}} \quad (8)$$

In which u_j is the status value of the j th neuron, s is shape factor, w_{ij} is the weight from pre-input x_{ij} to the j th neuron, θ_j is the threshold of the neuron; due to the introduction of shape factor λ, sigmoid function, as for input, is able to freely stretch out and draw back as well as translational transformation.

- Improvement of Orthogonalizable Design: In order to further optimize BP neural network algorithm, this thesis adopts orthogonalizable design method to optimize relevant parameters of BP neural network. Variables intended to be chosen are nodes of hidden layers, accuracy requirements and transfer function. Each

上述公式中，第 j 个神经元的取值用 u_j 表示，形态因子用 s 表示，x_{ij} 前级输入至第 j 个神经元的权重取值用参数 w_{ij} 表示，该神经元的阈值用参数 θ_j 表示，由于引入了 λ 形态因子，使得 sigmoid 函数的伸缩和平移变换可以自由地进行。

-正交化设计优化 BP 神经网络: 为了能够进一步改进 BP 模型，本文尝试采用正交设计方法优化 BP 模型的相关参数。本文拟选择传递函数、精度要求、隐含层节点数等三个变量，每个变量均可以选择两个层级取值，采用梯度下

variable can choose two levels. Training function adopts gradient descent and LM method; the number of neurons of hidden layers can also be chosen between two levels, less than 7 or more than 7; accuracy required by training can be high accuracy or low accuracy.

This paper, while making use of orthogonalizable design to optimize BP neural network algorithm, adopts 7 nodes, algorithm accuracy as $\varepsilon \le 0.001$, transfer function as traingdx function. First, BP neural network learning input adopts n evaluation indicators, thus preliminarily determining n indicators used for establishing system model. Also adopt m in effective sample M as training samples ($M \succ m$), $M-m$ as test sample. The algorithm process is designed as below.[1] Randomly divide sample data into two groups; [2] Respectively establish two groups of C analysis programs; [3] Carry out simulation with original data; [4] Analyze simulated results; [5] Compare simulated results of the test with actual results, make a judgment on whether needs to rebuild model; if yes, turn to the 3rd step; if no, the simulation process finishes.

RESULTS

Data acquisition and pre-processing

The data from a certain fresh agricultural product corporation were taken as experimental sample and the data include 12 years from 2003-2013 of the corporation. As BP neural network prediction model is the most sensitive to data among 0 ~ 1 while training, in order to improve the learning speed of BP neural network algorithm, we shall firstly carry out normalization processing on influencing factors of logistics demand; see equation 9 for details, in which x_i is original data, $x_i^{'}$ is normalized data, $x_{\max}$ and $x_{\min}$ indicate the maximum and minimum values of each variable.

降法和 LM 法为模型训练函数，隐含层神经元的节点个数也可以有两个层级取值（大于 7 个或小于 7 个），训练的期望精度值也定义为两个，即高精度期望和低精度期望。

在正交化设计优化 BP 模型时本文采用 $\varepsilon \le 0.001$ 的算法精度、7 个节点数、traingdx 传递函数。首先 BP 模型输入学习时使用 的评价指标数为 n ，并以此初步确定系统模型构建的 n 个指标。具体计算时采用 M 个样本中的 m 个做为训练样本（ $M \succ m$ ），检测样本为 $M-m$ 个。优化后的算法流程设计如下。[1] 将样本数据随机分为两组；[2] 构建两组 Matlab 分析程序；[3] 对经过预处理的数据进行模拟；[4] 仔细分析仿真模拟结果；[5] 比较实验仿真结果与实际预测效果的差异，判断是否需要继续重建模型，如果需要的话转入第 3 步进行计算，否则算法运算结束。

实验结果

数据采集与预处理

经验表明BP神经网络预测模型，对在0～1 之间的数据训练时最为敏感，因此为提高模型的学习效率，本文首先对供应链个影响要素的采集数据进行归一化预处理，具体形式见公式9，公式9中 x_i 表示原始数据， $x_i^{'}$ 表示是归一化运算后的数据， $x_{\max}$ 和 $x_{\min}$ 则表示各个变量的最大取值和最小取值。

$$x_i^{'} = \frac{x_i - x_{\min}}{x_{\max} - x_{\min}} \tag{9}$$

Experimental results and analysis

The paper realized the demand prediction for fresh agricultural products with improved BP neural network algorithm. Table 1 and table 2 are the realization results of the paper, in which Table 1 shows some experimental results realized by the improved model presented in the paper and table 2 shows the experimental results of prediction performance (including prediction accuracy and time consumption) of different algorithms, including traditional methods (taking exponential smoothing prediction for example)[7], original BP algorithm[9] and improved BP algorithm in the paper. As for the time consuming, calculation time needed by the model presented in the paper is 8 seconds and calculation time for the original BP neural and network is 278 seconds with the calculation platform as follows: hardware is Dell Poweredge R710, in which processor is E5506, memory 2G, hard disk 160G; software platform is Windows XP operating system, C programming language environment.

实验结果与分析

本文采用某农鲜产品供应链的数据实现了本文改进模型。表1和表2是本文的实现结果，其中表1为本文改进算法的实现结果，表2则为传统算法[7]（这里以指数平滑算法为例）、改进前的BP神经网络算法[9]、本文算法的的预测性能（包括预测精度和时间消耗）。至于时间消耗本文改进算法为8秒，普通BP神经网络则为278秒，采用的计算平台如下，硬件平台：Dell Poweredge R710，E5506，2G，160G；软件平台：Windows XP, C 语言。

Table 1 / *表 1*

The prediction results of the improved algorithm / *本文改进算法的预测结果*

Year / *年份*	Quarter/*季节*	Actual demand / *实际需求*	Prediction demand / *预测需求*	Prediction error / *预测错误率*
2003	2	6034 unit / *单位*	6098unit / *单位*	1.1%
2004	3	6567 unit / *单位*	6771 unit / *单位*	3.1%
2005	4	6882 unit / *单位*	6975 unit / *单位*	1.4%
2006	1	7135 unit / *单位*	7265 unit / *单位*	1.8%/
2007	2	7689 unit / *单位*	7765 unit / *单位*	1.0%
2008	3	7999 unit / *单位*	8201 unit / *单位*	2.5%
2009	4	8699unit / *单位*	8787 unit / *单位*	1.0%
2010	1	8567unit / *单位*	8689 unit / *单位*	1.4%
2011	2	9335 unit / *单位*	9596unit / *单位*	2.8%
2012	3	9795 unit / *单位*	9921unit / *单位*	1.3%

Table 2 / *表 2*

The prediction performance of different algorithms / *各算法的预测性能*

	Exponential smoothing algorithm / *指数平滑算法*	Original BP algorithm / *原始BP算法*	Improved BP algorithm / *改进算法*
The overall prediction error / *总体预测错误率*	15.41%	4.79%	1.65%
The prediction error of the first quarter / *第一季度预测差错率*	14.22%	4.23%	1.45%
The prediction error of the second quarter / *第二季度预测差错率*	14.56%	4.91%	1.87%
The Prediction error of the third quarter / *第三季度预测差错率*	14.33%	4.78%	3.11%
The prediction error of the forth quarter / *第四季度预测差错率*	16.87%	6.08%	1.39%
Time consumption (S) / *时间消耗（秒）*	7	278	8

From table 1 and table 2, we can see clearly that the improved BP neural network algorithm in the paper can realize the demand prediction for fresh agricultural products for corporations in practice and the improved BP neural network algorithm has more advantages in prediction accuracy and time consumption compared with exponential smoothing prediction and original BP algorithm.

CONCLUSIONS

Prediction based on logistics demand of BP neural network algorithm provides a brand-new research approach. In allusion to the characteristics of logistics demand of fresh agricultural products, this thesis applies BP neural network algorithm to the demand prediction of fresh agricultural products, and the test results show that as BP neural network algorithm is the prediction method specially for multi-dimensional and non-linear data with better generalization ability, the accuracy of demand prediction of fresh agricultural products is higher than other models, having a broad application and theory prospect in logistics demand prediction.

通过表 1 和表 2，可以清楚的看到本文改进算法能够在实际应用中实现农鲜产品供应链需求预测，并且与传统预测方法和普通 BP 神经网络相比，本文算法在预测精度和时间消耗上具有较大的优势。

结论

将BP神经网络应用于供应链需求预测，为供应链管理提供了广阔的应用前景。本文针对农鲜产品供应链需求的个性化特征，通过改进BP神经网络的激励函数，将其应用于农鲜产品供应链需求预测，实验表明由于BP模型本身所具备的非线性曲线拟合能力、多维数据处理能力和泛化能力，改进BP神经网络模型应用于农鲜产品供应链的需求时具有预测精度高、时间消耗少等优点，在理论和实践上具有广阔的前景。

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RESERCH ON SUPPLY CHAIN PERFORMANCE EVALUATION OF FRESH AGRICULTURAL PRODUCTS
/
农鲜产品的供应链绩效评价研究

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Abstract: *Supply chain performance evaluation for fresh agricultural products is one of the key techniques and a research hotspot in supply chain management and in fields related. In order to overcome the deficiencies of traditional models，a new fuzzy neural network algorithm for supply chain performance evaluation of fresh agricultural products is presented based on the analysis of present literatures in the field. First the model structure of the presented algorithm is designed and simplified combining the advantages of BP neural network model and fuzzy comprehensive evaluation model; secondly the presented algorithm is improved through improving its calculation procedures and learning methods. Finally the model is performed with the data from certain supply chains of fresh agricultural products enterprises and the experimental results show that the algorithm can improve calculation efficiency and evaluation accuracy when used for supply chain performance evaluation of fresh agricultural products, practically.*

Keywords: *supply chain management, performance evaluation, fuzzy neural network algorithm, fresh agricultural products*

INTRODUCTION

Because fresh agricultural products are perishable and difficult to store, during transportation and storage they are often damaged and unable to achieve their value function for all kinds of reasons, so that the enterprises participated in the fresh agricultural product supply chain pay attention to supply chain and its management model. They try to use the minimal cost to optimize the process of production to meet customers' demand. Supply chain performance evaluation (SCPE) is used to evaluate and assess the benefit and effect of supply chain implementation, which is one of the key components of supply chain management. Building a completed set of fresh agricultural product supply chain performance evaluation metrics is conducive to assess the competitiveness of fresh agricultural product supply chain member enterprises as well as the advantages and shortages of supply chain management. So the supply chain performance evaluation has become a research hotspot for researchers and enterprises related [1].

There are mainly following methods used for the overall evaluation of the performance of supply chain.① Multi-hierarchy comprehensive evaluation of fuzzy mathematics, its principle is to firstly evaluate various kinds of factors of the same thing, dividing into several big factors according to certain attribute; Then carry out initial hierarchical comprehensive evaluation on certain big factors, and carry out high hierarchical comprehensive evaluation on the result of initial hierarchical comprehensive evaluation based on that. The key of successful application lies in correctly specifying the factor set of fuzzy evaluation and reasonably form fuzzy evaluation matrix, obtaining evaluation result according to matrix calculation result. Make use of fuzzy

摘要：*农产品的供应链绩效评价是供应链管理中的一个关键技术，也是相关领域的研究热点之一。为了克服传统绩效评价模型的缺陷，在分析现有研究文献的基础上，本文提出了一个农产品供应链绩效评价的模糊神经网络。首先在结合 BP 神经网络和模糊多级评判的优势，本文设计并简化了模糊神经网络的网络结构；其次通过改进模糊神经网络的运算步骤和学习方法，以达到改进本文模型的目的。最后利用某农产品企业的供应链数据，实现了本文模型，实验结果表明本文算法应用于农产品供应链管理绩效评价时，能够提升算法效率和评价精度。*

关键字: *供应链管理, 绩效评价，模糊神经网，农产品*

前言

由于生鲜农产品容易腐烂变质、贮存难度大，因此生鲜农产品在长途运输和存贮过程中经常会因各种原因而出现各种损坏，无法使农鲜产品实现保值和增值，因此农鲜产品相关企业为此需要承担相当的市场风险。为了实现农鲜产品的保值和增值，并降低市场风险，农鲜产品企业将采用了供应链及其管理模式，企业通过供应链管理实现用最少的成本实现产品从生产到销售的整个过程达到利益最优化。供应链绩效评价就是对企业供应链实施的结果和成效进行评估考核，这也是现代供应链管理的关键组成部分之一。农鲜产品企业构建一套合理的供应链绩效评价指标体系不仅有利于提升企业供应链管理绩效，也有利于评价企业竞争力，从而引导企业采取针对性措施，提升产品供应链绩效。因此供应链绩效管理和评价研究已经成为业内研究者企业的研究热点之一[1]。

目前用于供应链绩效综合评价的方法主要有以下种。① 模糊多层次评价法，该方法原理是首先根据评价对象的各个评价指标的具体特征进行单个评价，随后对不同层级的评价根据前面评价结果逐层进行不同层级的评价指标进行评价，根据模糊矩阵的计算结果获得最终的绩效评价结果。该方法的成功应用的关键在于正确确立一套模糊评价因子和建立模糊评价隶属矩阵。该方法能够获得评价对象的各个指标之间权值梯度的相互关系，方法简单易行，但是该方法需要为评价对象构建合理的评价矩阵，而由于不

comprehensive evaluation method can obtain the value grade of evaluated object or mutual precedence relationship; however, the method requires to establish appropriate evaluation matrix of evaluation object, which will obtain different evaluation matrixes due to the non-conformity of different experts, leading to the non-conformity of final evaluation results[2]. ② Data envelopment analysis (DEA), starting from the perspective of relative efficiency, evaluates each decision-making unit, and the indicators selected are only relied on input and output. As it doesn't rely on specific production function, it is effective for dealing with the evaluation with various kinds of input and output indicators, suitable for the analysis of benefit, scale economy and industry dynamics. But it is complicated in computational method, subject to certain limitations in application[3]. ③ Grey correlation analysis is a multi-factor statistical analysis method, which takes the sample data of each factor as basis to describe the strength, size and order of relationship among factors with Grey correlation; If the situation of change of two factors reflected by sample data is relatively consistent, they have relatively large correlation; otherwise, the correlation is relatively small. The merits of this method lie in that that it is intellectually clear, able to reduce the loss caused by information asymmetry to a great extent and less requires for data with less workload; however, its main demerits are that it requires for human determination of the optimal values of each indicator, it has strong subjectivity and it is difficult to determine the optimal values of some indicators[4].④ Analytic hierarchy process (AHP) effectively combines qualitative analysis with quantitative analysis, not only able to guarantee the systematics and rationality of model, but also able to let decision makers make full use of valuable experience and judgment, so as to provide powerful decision-making support for lots of regulatory decision making problems. The method has such strengths as clear structure and simple computation, but due to its strong subjective judgment, the method also has shortcomings like low evaluation accuracy[5]；⑤BP neural network method, the method is adopted in the processing of uncertain information. If the input mode is close to training sample, the evaluation system is able to provide correct reasoning conclusion. The method has such advantages as wide applicability and high evaluation accuracy, but it also has some disadvantages like easy to fall into local minimum in the computation, low rate of convergence, and etc [6].

Supply chain performance evaluation is a dynamic process and there are lots of factors influencing its quality, and the influences of these factors are different; therefore, it is difficult to express the evaluation results only with a mathematical formula, which actually is a complicated, non-linear comprehensive decision-making problem. Hence, there is irrationality to adopt the above five methods to carry out comprehensive evaluation of its quality. So the paper tries to integrate the BP neural network model and fuzzy comprehensive evaluation model and advances a new fuzzy BP neural network algorithm which can achieve the advantages and overcome the deficiencies of the two models.

MATERIAL AND METHOD

Establishment of evaluation indicator system

As the supply chain of fresh agricultural products needs to focus on quality safety and circulation efficiency, meanwhile, trying to reduce the loss in the logistics process, which is a special and complicated supply chain, the similarity of general supply chain and the specialty of

同专家评价的不一致，从而使得评价矩阵的合理构建难度较大，这也容易导致最终评价结果的不完整性和评价精度不高[2]；② 数据包络分析法(DEA)，数据包络分析法评价时的出发点是从相对有效性的角度，对各个评价对象的各个单元进行逐一评价，选取的评价指标依赖于投入和产出。该方法在处理多投入、多产出指标时的供应链绩效评价时比较有效，比较适用于企业的效益分析、规模经济分析、产业动态分析。同时该方法计算上较为复杂，使得他的应用价值受到很大的局限[3]。③ 灰色关联度分析法，该方法是一种多因素的统计分析方法，它依据各因素的样本数据，描述各因素间关系式时采用灰色关联度，如果样本数据的变化趋势与某两因素变化态势基本保持一致，则可以认为它们之间的关联度较大；反之则认为其关联度较小。灰关联评价法的评价思路明晰，可以大大减少由于信息不对称所导致的评价误差，该算法对样本数据的要求也不高，计算方法的工作量也不多；但是该方法需要对确定各项指标的最优值，而这个过程的主观性太强，甚至有些指标最优值根本就无法确定[4]。④ 层析分析法，该方法结合了定性分析和定量分析的各自优势，能确保算法运用中的合理性和系统性，也能能让批判者运用其有自己的评判经验，为大量规则决策的评判问题提供决策支持。层次分析法具有计算简单、模型结构结构清晰、易于理解等许多优点，同时该方法也由于是基于平均专家的主观判断的原因，导致该方法的评价精度不高[5]；⑤BP 神经网络法，该方法主要采用了梯度搜索技术，使得模型结构的期望输出值与实际输出值之间的误差最小，该模型具有强大的非线性信息处理能力，假如训练样本与输人模式比较接近，很容易就可以得到就正确的评价结果。该方法的优点是适用性广，有较高评价精度，但是该方法也具有在计算中收敛速度慢、算法效率低等缺点[6]。

供应链绩效管理评价是一个动态的过程，其中的涉及到的许多因素会影响评价的质量，因此仅仅用一个数学方法难以进行精确有效的评价，因为这些方法确实也存在复杂的、非线性的综合决策问题。本文试图整合模糊综合评价和 BP 神经网络评价的优势，并力图克服两方法的缺陷，从而提出一种的新的模糊神经网络模型，并使之能够应用于农鲜产品企业的供应链绩效评价。

材料与方法

评价指标系统构建

如前述，生鲜农产品的企业产品供应链需要高度注重产品的质量安全和供应链的流通效率，同时还应该尽量减少物流运转中的各种损耗，农鲜产品供应链是一个复杂且特殊的

cold chain of fresh agricultural products shall be combined to establish evaluation indicator system of performance. Integrating the general idea of performance evaluation of supply chain and performance evaluation of logistics system, combining existing research literature, this paper will, from such two aspects as evaluation of internal and external performance, establish the evaluation indicator system of the performance of supply chain of fresh agricultural products, which includes 4 hierarchies, 2 categories, 6 second-grade indicators, 16 third-grade indicators; see table 1 for details [7,8,9].

供应链，因此构建农鲜产品供应链绩效评价指标体系时既要考虑普通供应链的公共特点，更要考虑生鲜农产品供应链的个性化特性。结合农鲜产品供应链绩效评价和物流系统绩效评价的思想，参阅大量现有研究文献，本文将从内部绩效和外部绩效评价两个角度构建生鲜农产品供应链绩效评价指标体系， 该体系包括四层，其中 2 个一级指标，一个二级指标，16 个三级指标，具体见表 1 [7, 8, 9]。

Table 1 / *表 1*

Evaluation indicator system of supply chain performance /*供应链绩效评价指标系统*

Target Hierarchy / *目标层*	First-class Indicator / *一级指标*	Second-class Indicator / *二级指标*	Third-class Indicator/ *三级指标*
Performance of Supply Chain of Fresh Agricultural Products / *农鲜产品供应链绩效*	External Performance / *外部绩效*	Customer Service Level / *顾客服务水平*	Timeliness of Delivery /*运输及时性*
			Accuracy of Delivery /*运输准确性*
			Security / *安全性*
			Customer Dissatisfaction Rate /*顾客不满意率*
		Adaptability of Logistics Service /*物流服务可行性*	Applicability of Products /*产品适用性*
			Applicability of Time /*时间适用性*
			Applicability of Quantity /*质量适用性*
		Integration of Logistics Service /*物流服务集成性*	Integration Level of Service /*服务集成度*
			Intimacy of Cohesion /*凝聚力*
	Internal Performance / *内部绩效*	Enterprise Input / *企业投入*	Assets Input / 财产投入
			Personnel Expenditure /个人支出
			Logistics Cost /物流成本
		Internal Operation / *内部运作*	Informational Level /信息水平
			Resource Utilization /资源利用率
			Logistics Operation / 物流运作
		Enterprise Income / *企业收入*	Cost Benefit /成本收益
			Business Growth Rate/业务增长率
			Profit Growth Rate/利润增长率

Derivation of supply chain evaluation algorithm

- Network structure design of fuzzy neural network: The fuzzy neural network structure adopted by this paper is based on Takagi-Sugeno model, and the network consists of antecedent network and consequent network, in which the former is used to match the antecedent of fuzzy rule and the latter is used to realize the consequent of fuzzy rule. Network structure is as shown in picture 1.

供应链评价模型

***-网络结构设计和模糊神经网络*：**基于 Takagi-Sugeno 算法结构，本文设计了一种新的模糊神经网络结构，该模型的网络结构主要由前件网络和后件网络构成，其中模糊规则的前件匹配工作由前件网络来完成，模糊规则年工作则由后件网络来完成，模糊神经网络的结构图如图 1 所示[9]。

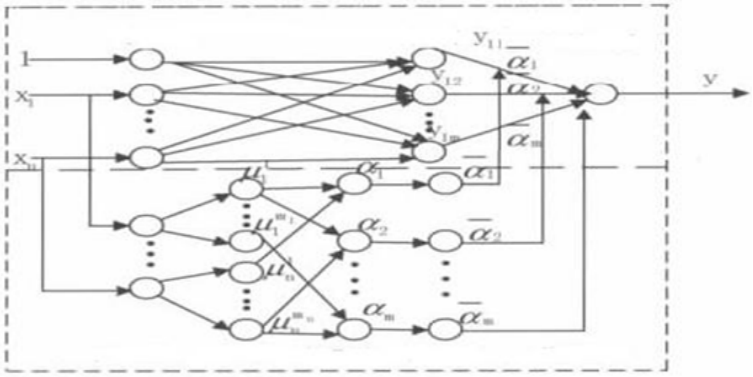

Fig. 1 - The structure of the improved fuzzy BP neural network algorithm / *改进模糊神经网络结构图*

(1) Antecedent Network: Antecedent network is comprised of 4 layers. The first one is the input layer, each node of which is directly connected to each component of input vector, playing a role of directly propagating input value $x=(x_1,x_2,...x_n)^T$ to the next layer. The number of nodes of the layer is $N_1=n$. The second layer is the fuzzification layer, and each node represents one linguistic variable value; this paper chooses 4 linguistic variables (excellent, good, medium and poor). The function of the layer is to compute the membership degree μ_i^j of each input component subordinating to each fuzzy set of linguistic value, which meets formula 1[10].

（1）前件网络

前件网络由4 层组成。第一层为输入层。它的每个节点直接与输入向量的各个分量连接，它起着直接将输入值 $x=(x_1,x_2,...x_n)^T$ 传送到下一层的作用。该层的节点数为 $N_1=n$。

第二层是模糊化层。每一个节点代表一个语言变量值，本文选择4个语言变量(优、良、中、差) 。该层的作用是计算各输入分量属于各语言值模糊集合的隶属度 μ_i^j，其满足式1[10]。

$$\mu_i^j=\mu_{Ai}^j(x_i),i=1,2,...n,\ j=1,2,...m_j,m_i=4 \tag{1}$$

In formula 1, n is the dimension of input, and the fuzzy partition of x_i is 4. The membership functions in this paper adopt Gaussian function, as shown in formula 2.

n 表示输入量的维数，x_i 的模糊分割数是4。高斯函数是本文采用的函数，形式如式2所示。

$$\mu_i^j=e^{\frac{-(x_i-c_{ij^2})}{\delta_{ij}^2}} \tag{2}$$

In formula (2), c_{ij^2} and δ_{ij}^2 indicate the center and width of membership function respectively. The total number of nodes of the layer is formula 3.

在公式(2)中，c_{ij^2} 表示隶属函数的中心，δ_{ij}^2 表示宽度，第二层的节点总数可以通过公式3计算得到。

$$N_2=4n \tag{3}$$

The third layer is the rule-based reasoning layer, each node of which represents a fuzzy rule, the role of which is to match the antecedent of fuzzy rule and compute the fitness of each rule, i.e. formula 4.

本文网络结构的第三层为规则推理层。规则推理层中的每个节点均对应于计算中的一条模糊规则，其作用主要是匹配模糊规则的前件，并据此计算得出每条规则的具体应用适用度，具体如公式4所示。

$$\alpha_j=\mu_1^{i1}\mu_2^{i2}...\mu_n^{in} \tag{4}$$

In formula (4), $i_1\in\{1,2,3,4\},...i_n\in\{1,2,3,4\}$, , $j=1,2,...m.m=4$, The total number of nodes of the layer $N_3=m$. As for the given input, only those linguistic variable values close to input point have relatively large membership degree, and the membership degree of those linguistic variable values far away from input point is either too small or 0. If the membership degree is too small (such as less than 0.05), it can be approximately valued as 0.

The fourth layer is the normalization layer, the number of nodes of which is the same as that of the third layer, i.e. $N_4=N_3=m$; what it realizes is the normalization computing, i.e. Formula 5.

在公式(4)中，$i_1\in\{1,2,3,4\},...i_n\in\{1,2,3,4\}$, $j=1,2,...m.m=4$。在这一层中的节点总和为 $N_3=m$。对于实际计算中给定的某个输入值，只有权值接近输入点的那些输入变量值，其隶属度才有较大权值，远离输入点的输入变量值的隶属度一般很小，甚至为0。当隶属度权值较小时(本文定义为小于0.05) 时，可将其值视为0。

本文算法结构中的第四层为归一化层。归一化层的节点总数与上层相同，也是 $N_4=N_3=m$，归一化层是实现归一化计算的层级，如公式5所示。

$$\overline{\alpha_j}=\frac{\alpha_j}{\sum_{i=1}^{m}\alpha_i},\qquad j=1,2,...,m \tag{5}$$

(2) Consequent Network: The first layer of consequent network is the input layer, which propagates the input variable to the second layer. The input value of the 0th node in the input layer $x_0=1$, the function of which is to provide the constant term in the consequent of fuzzy rule. There are m nodes in the second layer, and each node represents one rule; the function of the layer is to compute the consequent of each rule, i.e. formula 6. The third layer is the output layer, the evaluation result value of which is formula 7.

（2） 后件网络 输入层是后件网络的第一层，输入层将输入变量传输到第二层。第一层（输入层）中第0个节点的输入值为规定为 $x_0=1$，这样的规定可以为后继计算提供模糊规则运算后的常数项。在第二层总共有 m 个节点，他们分别代表 m 条不同的规则，第二层的作用主要是计算各条规则的后件值，可以通过公式6计算求得。本文模型的第三层为输出层，该层的评价值可以通过公式7计算求得。

$$y_{ij} = p_{j0}^1 + p_{j1}^1 x_1 + p_{j2}^1 x_2 + p_{j3}^1 x_3 + ... + + p_{jn}^1 x_n, \qquad j = 1,2,...m \tag{6}$$

$$y_1 = \sum_{j=1}^{m} y_{1j} \alpha_j \tag{7}$$

In formula 7 y_1 is the weighted sum of consequent of each rule; weighting coefficient is the fitness $\overline{\alpha_j}$ after normalization of each fuzzy rule, i.e. the output of antecedent network serves as the link weight of the third layer of consequent network. The simplified network structure is as shown in picture 2.

y_1 是各个规则后件的加权和，加权系数为各模糊规则经归一化后的适用度 $\overline{\alpha_j}$ ，即前件网络的输出用作后件网络第三层的连接权值。简化的网络结构如图2 所示。

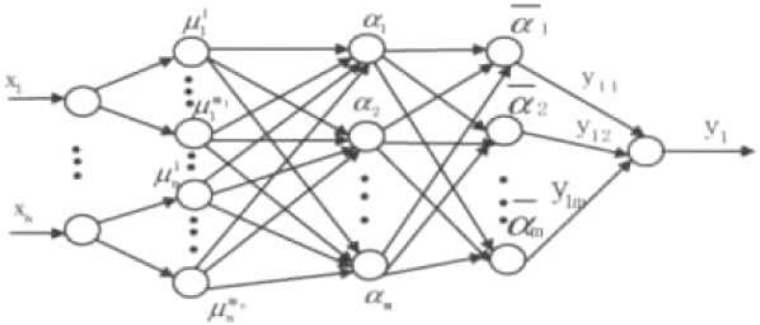

Fig. 2 - The simplified network structure of the improved algorithm/简化后的改进模型结构图

Improvement of learning methods

The fuzzy neural network provided in this paper is actually a kind of multilayer feed forward network, so error back propagation algorithm can be adopted to adjust parameters. It mainly adjusts the link weight p_{ji}^1 of the fifth layer, as well as the central value c_{ij} and width δ_{ij} of parameters of membership function of the second layer. Suppose that the input of the j th neuron node of the q th layer of fuzzy neural network in Picture 1 is $f^{(q)}$, the output is $x_j^{(q)} = g^{(q)}(f^{(q)})$. The node functions in the first layer to the fifth layer of fuzzy neural network are as shown in formula 8 to formula 12. In which, x shall be computed with corresponding functions, which is omitted here.

学习算法的改进

本文所提出的模糊神经网络在本质上是一种多层前馈型神经网络模型，故可以采用传统的误差反向传播算法来调整计算相关参数，连接权 p_{ji}^1（第五层的）、c_{ij}（第二层的隶属函数参数的中心值）和 δ_{ij}（宽度）进行调整计算。假定模糊神经网络结构中的第 q 层第 j 个神经元节点（如图 1 所示）的输入输出分别为 $f^{(q)}$、$x_j^{(q)} = g^{(q)}(f^{(q)})$。则本文模糊神经网络结构中的第一层到第五层的节点函数值分别可以用公式 8 至公式 12 表示。公式中 x 可以通过相应的函数计算求得，这里不再赘述。

$$f_i^{(1)} = f_i^{(0)} = x_i, x_i = g_i^{(1)} = f_i^{(1)}, i = 1,2,...,n \tag{8}$$

$$f_{ij}^{(2)} = \frac{-(x_i^{(1)} - c_{ij})^2}{\delta_{ij}^2} \tag{9}$$

$$f_j^{(3)} = x_{1i}^{(2)} x_{2i}^{(2)} ... x_{ni}^{(2)} = \mu_1^{i1} \mu_2^{i2} ... \mu_n^{in} \tag{10}$$

$$f_j^{(4)} = \frac{x_j^{(3)}}{\sum_{i=1}^{m} x_j^3} = \frac{\alpha_j}{\sum_{i=1}^{m} \alpha_j} \tag{11}$$

$$f_1^{(5)} = \sum_{j=1}^{m} y_{1j} x_j^{(4)} = \sum_{j=1}^{m} y_{1j} \overline{\alpha_j} \tag{12}$$

Suppose that error cost function is as shown in formula 13, in which t_1 and y_1 indicate desired output and actual output respectively.

假设误差表示函数如公式 13 所表示，式中 t_1 和 y_1 分别为期望输出值和实际输出值。

Adjust p_{ji}^{1}, c_{ij} and ∂_{ij} according to error back propagation algorithm, and solve and train the learning algorithm accordingly.

可以根据误差反向传播函数来调节计算 p_{ji}^{1}、c_{ij} 和 ∂_{ij}，最后据此对学习算法进行求解运算。

$$E = \frac{1}{2}(t_1 - y_1)^2 \tag{13}$$

Improvement of calculation procedures

Improved operation process of the presented algorithm can be listed as follows [10]. ①Reduce dimension of samples with factor analysis, establish sample set; ②Calculate the fitness value of each individual in the group, save the optimal fitness value; ③Turn to the 4th step if reaching the set evaluation generation or current optimal individual meeting conditions; otherwise, turn to the 2nd step; ④ Decode the optimal individual in the 3rd step into network parameter to serve as the initial parameter of fuzzy BP neural network algorithm; ⑤Modify current network parameter with fuzzy BP neural network algorithm;⑥Terminate if reaching the condition for terminating fuzzy BP neural network algorithm; otherwise, turn to the 5th step.

算法运算步骤的改进

改进算法的计算步骤如下所示。①通过因子分析并建立样本集合，从而减少样本的维度；②计算群组中的每个个体适应值，并存着优化此适应值；③如果运算符合结束条件的话，则转入第四步进行计算，否则转入第二步进行计算；④将第三步中的优化个体进行解码模糊网络参数，作为模糊网络算法的初始参数；⑤采用模糊网络算法修改当前网络参数；⑥如果达到运算终止条件则中止运算，否则转入第五步进行计算。

RESULTS

Data acquisition and pre-processing

Choose m typical supply chains of fresh agricultural products, make use of statistical data to compute the values of n indicators of each supply chain, and compute corresponding overall evaluation score of each supply chain with n indicator weights through determination and normalization processing of experts, so as to obtain m training mode pairs, training the model of this paper with such m training mode pairs. Subsequently, model in this paper can be applied to the performance evaluation of supply chain of fresh agricultural products. Every time when inputting 18 third-class evaluation indicators of supply chain to be evaluated, we can obtain the performance of supply chain of the fresh agricultural products.

The questionnaires of all the evaluation indicators were made and surveyed to the enterprises and consumers related to get the score of each indicator for different supply chains of fresh agricultural products. The original data acquired by the survey are pre-processed to the scope of the fuzzy matrix and the final scope of the score is [0, 5].

实验结果

数据采集与预处理

本文在实际评价中，选取了 m 条典型的生鲜农产品企业供应链作为样本，采用统计数据逐一计算出每条供应链的 n 个评价指标的得分情况，再经过相关业内专家评判后确定取值，归一化预处理的 n 项指标分值，从而计算得出各供应链的相应的综合绩效得分，据此得到 m 对训练模式组队，随后用此 m 个训练组队作为训练样本验证模型。最后将本文模型应用于生鲜农产品供应链的绩效综合评价。每当输入待评价供应链的 18 个三级评价指标时，就能够得到改生鲜农产品的供应链绩效。

制定了每个评价指标的问卷调查，并对相关农鲜产品供应链企业和客户进行了现场调查，以获得每个不同农鲜产品供应链的每个指标的得分情况。获得原始数据经归一化预处理后，使之取值范围符合模糊矩阵以及最终的取值范围[0, 5]之间。

Experimental results and analysis

Limited to paper space, the evaluation of intermediate results is omitted here, only providing secondary evaluation results and final comprehensive evaluation results of three typical chains, see table 2.

实验结果与分析

考虑到论文字数有限，评价的中间过程这里略去，仅仅列举出三条典型农鲜产品供应链的绩效评价的二级评价结果和最终的评价结果，具体见表 2 所示。

Table 2 /*表 2*

Secondary evaluation results of the paper / ***二级指标的实证评价结果***

	Customer Service Level / *客户服务水平*	Adaptability of Logistics Service / *物流服务可行性*	Integration of Logistics Service / *物流服务集成性*	Enterprise Input / *企业投入*	Internal Operation / *内部运作*	Enterprise Income / *企业收入*
1	3.647	3.451	3.651	3.572	3.413	3.631
2	4.118	4.326	4.179	4.210	4.009	4.357
3	4.431	4.621	4.170	4.345	4.626	4.521

In order to illustrate the value of the presented algorithm and some other algorithms which are used for performance evaluation, the calculation indicators are realized with the same calculation platform in the paper. The indicators of the calculation platform can be listed as follows Intel i3 2120, 2GB DDR3, AMD Radeon HD 7450 and 3.3GHz CPU, and windows XP. The table 3 shows the evaluation accuracy and time consuming of the different algorithms. From the table we can see clearly that the algorithm in the paper has greater value than that of BP neural network [9] and fuzzy evaluation algorithms[5] in evaluation accuracy or time consuming. In practice, the paper takes some obvious indicators as sample to calculate evaluation accuracy in order to make our comparison more believable.

为了说明本文所提出算法与目前其他典型算法的优势，本文采用相同的计算平台实现了本文算法和常规模糊评价[9]和 BP 神经网络算法[5]。计算平台性能参数如下：Intel i3 2120, 2GB DDR3, AMD Radeon HD 7450 and 3.3GHz CPU, and windows XP。表 3 给出了本文算法、传统模糊评价方法和 BP 神经网络的评价精度和时间消耗对照表。通过此表可以清楚地看出本文算法应用于农鲜产品供应链绩效管理时在评价精度和时间消耗上具有明显优势。具有可在实际评估中，为了使得评价具有更好的可信度，本文采用了一些明显的参数作为评价准确度的参数。

Table 3 / *表 3*

Realization results of different algorithms/ *不同算法的实现结果*

	Algorithm in the paper / *本文算法*	**Ordinary Fuzzy model / *普通模糊算法***	**BP Neural Network / *普通 BP 算法***
Evaluation Accuracy / *评价准确率*	95.66%	71.34%	85.64%
Time Consuming (S) / *时间消耗（秒）*	13	13	793

CONCLUSIONS

It is shown through empirical research that the evaluation combination model of the performance of supply chain of fresh agricultural products based on fuzzy neural network established in this paper is practicable, effective and feasible, and is able to effectively conquer some shortcomings of traditional evaluation models, as well as equipped with capabilities like self-learning, self-adaptation, strong fault tolerance and ability of expression, able to reduce some human subjective factors to the hilt, so as to improve the reliability of the performance evaluation of enterprises, making evaluation results more objective and accurate. For the next studies, it is planned to further improve the adjustment and optimization of reduction and membership functions of fuzzy rule to enhance the generalization ability of model.

结论

本文提出了一个基于模糊神经网络农产品供应链绩效管理和评价新模型，通过实证研究也表明本文模型在实践应用中是可行性和有效性，同时实验结果还说明了本文模型不仅能够克服传统神经网络绩效评价模型的一些困难，还具有诸如自学习、自适应、容错力强、人为干预少的优势，因此本文模型能够提高农鲜产品企业供应链绩效评价的可靠性，并能够提高绩效评价的客观性和准确性。下一步研究中拟将模糊规则的约简和隶属函数参数的调整与优化方面继续改进，以提高模型的泛化能力。

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PARAMETERS OPTIMIZATION ALGORITHMS FOR IMPROVING THE PERFORMANCE OF OBSTACLES IDENTIFICATION IN FOREST AREA
/
提高林区障碍物识别效率的参数优化算法研究

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Abstract: *Accurate identification and measurement of obstacles in forest are particularly important for improving operational capability and efficiency of harvester. In this paper, three distinct algorithms, including grid search (GS), particle swarm optimization (PSO) and genetic algorithm (GA), are proposed for parameters optimization of support vector machine (SVM) to improve the performance of detecting obstacles in forest area. First, the three different optimization algorithms are respectively adopted to optimize parameters which are used in SVM. Then the SVMs with optimized parameters are applied to identify obstacles in forest. At last, their performances are compared based on the testing results of 150 samples of obstacles in the forest. The experimental results show that the GS algorithm with leave-one-out (LOO), PSO algorithm and GA algorithm have better classification accuracy than the GS with 6-fold cross-validation (CV). Especially for PSO and GA algorithms, the global optimal solution can be found rapidly without traversing all parameters within the grid.*

Keywords: *grid search,particle swarm optimization, genetic algorithm,support vector of machine, parameter optimization*

INTRODUCTION

To meet the needs of forestry production, it is imperative to develop multi-function and high-efficiency forestry equipment to complete logging operation instead of manual operation. However, the complexity of forest environment will increase the operation risk and reduce the operating efficiency. Therefore, accurate identification of obstacle in forest and measurement of its feature are particularly important for improving operational capability and efficiency.

In respect of obstacle identification, researchers have done a lot of work and proposed a variety of algorithms.

Harls Baltzakls et al. proposed a suitably modified version of vector field histogram algorithm for robot motion planning and collision avoidance based on both laser and visual data [1]. Jaehyun Han et al. developed a road boundary and obstacle detection method using a downward-looking light detection and ranging sensor [2]. Yihui Lu et al. used Dempster-Shafer algorithm to automatically detect buildings from aerial images [3]. So far, obstacle detection method is mainly applied to vehicle systems, robots and building modeling. As regards to algorithms, Bayesian inference [4], [5], Dempster-Shafer evidence theory [6], [7], artificial neural net (ANN) [8], and support vector machine (SVM) classifier [9], [10] are popular and widely used in researches. Compared with other algorithms, SVM has many unique advantages in solving small sample, nonlinear and high dimensional pattern recognition [11]. However, like other machine learning algorithms, SVM performance depends highly on parameter selection. For a classification task, picking the best value for each variable is a model selection problem that needs an exhaustive search over the space of

摘要: *准确的识别和测量林区障碍物，能够大大提高林业装备的工作性能和效率。本文提出了三种不同的参数优化算法来提高支持向量机（SVM）在林区障碍物识别中的作用效果，这三种算法分别是网格搜索（GS），粒子群优化（PSO）和遗传算法（GA）。首先，分别采用三种不同的优化算法来优化 SVM 中使用的参数。然后，将经过参数优化的支持向量机应用于林区障碍物的检测和识别。最后，基于 150 个样本的测试结果对不同算法的效果进行比较和分析。实验结果表明，利用留一法（LOO）的网格搜索，粒子群算法和遗传算法比利用 6 阶交叉验证的网格搜索具有更好的分类精度。尤其是 PSO 和 GA 算法，可以不用遍历网格内的所有参数而迅速找到全局最优解。*

关键词： *网格搜索，粒子群优化，遗传算法，支持向量机，参数优化*

研究背景

为了满足林业生产的需要，当务之急是要发展多功能、高效率的林业设备来代替手工操作完成采伐作业。然而，森林环境的复杂性会增加林业装备的操作风险，降低运行效率。因此，准确的识别和测量林区障碍对林业装备操作能力和效率的提高具有重要意义。

在障碍物识别方面，研究人员已经做了很多工作，并提出了各种各样的算法。

Harls Baltzakls 等，基于激光和可视化的数据对向量场直方图算法提出了修改，用于机器人的运动规划和避免碰撞 [1]。Jaehyun Han 等，利用下视角的光探测传感器提出了道路边界和障碍物检测方法 [2]。Yihui Lu 等使用 DS 证据算法自动检测建筑物航拍图像 [3]。到目前为止，障碍物检测方法主要适用于车辆系统，机器人和建筑建模。在算法方面，贝叶斯推理 [4], [5]，DS 证据推理理论 [6], [7]，人工神经网络（ANN）[8]，支持向量机（SVM）[9], [10]是近年来较受欢迎的算法并广泛应用于各种研究。与其他算法相比，SVM 在解决小样本，非线性及高维模式识别方面具有许多独特的优势 [11]。然而，像其他机器学习算法一样，支持向量机的分类性能高度依赖于参数的选择。对于分类任务来说，为每个参数变量选取最佳值需要详尽的搜索

hyper-parameters. Till now, most SVM practitioners selected these parameters only empirically by trying a finite number of values and retaining those with the least testing errors [12].

In parameter optimization, Grid search (GS) algorithm based on "Leave-One-Out" (LOO) is one widely used algorithm in machine learning. In this method, the parameter range of the approximate optimal value is firstly selected artificially, and then an exhaustive search on the set of parameters is conducted to obtain the optimal parameters [13]. Obviously, this method is time-consuming and the low efficiency is not desirable. In view of this, Chapelle et al. proposed a gradient descent method to automatically select SVM parameters [14], which made significant improvements in reducing computation time. However, it was often trapped in local optimal solution, and algorithm termination often occurred, which brought much trouble to the operation. Besides, Keerthi adopted quasi-Newton method for Gaussian kernel function parameter optimization of SVM model [15]. Particle swarm optimization (PSO) is a cluster optimization algorithm proposed by Kennedy and Eberhart in 1995 [16]. It is inspired by the movement behavior of birds and fish populations, and it is now the representative of swarm intelligence methods. Genetic algorithm (GA) was developed by Leung based on real-value to achieve automatic selection of the SVM model parameters [17]. This algorithm is used to select the parameters of SVM model based on the global optimal performance to improve the construction efficiency of SVM and the recognition rate of the classifier. During the past decades, SVM with GA and PSO have been applied in various fields, such as gene selection and classification [18], fault diagnosis [19], pattern recognition [20], and so on.

In this paper, the application field of parameter optimization method is extended to the forestry field for the first time and three different algorithms are proposed to identify obstacles by testing 150 obstacle samples in forest. Based on this, the principles and differences of the three algorithms are analyzed, and their advantages and disadvantages are summarized. The experimental results show that the GS algorithm with leave-one-out (LOO), PSO algorithm and GA algorithm have better classification accuracy than the GS with 6-fold cross-validation (CV).

PROPOSED PARAMETERS OPTIMIZATION METHOD

The parameters optimization process is shown in Figure 1, where three kinds of parameter optimization algorithms are listed as alternative methods. In this paper, RBF (Radius Basis Function) is selected as SVM kernel function and parameters that affect the performance of SVM are error penalty parameter C, and the kernel parameter σ. C represents the tolerable degree of the errors and σ is kernel width. Too high or too low value of the parameters will cause "over-learning" or "less-learning" in SVM so that it cannot identify samples effectively. In order to obtain appropriate C and σ, three algorithms are adopted to optimize the parameters. Next, the principle and flow of each algorithm will be illustrated for better understanding of testing results.

超参数的空间，这是一个复杂的模型选择问题。目前，大多数的 SVM 研究者选择参数是通过经验尝试有限数量的值，然后选择能够产生最小测试误差的参数 [12]。

在参数优化中，基于留一法（LOO）的网格搜索（GS）算法是一种被广泛使用的机器学习算法。在该方法中，首先在近似最优值的参数范围内进行人工选择，然后在参数集中进行穷举搜索以获取最佳的参数值 [13]。显然，这种方法是费时的，并且效率低。因此，Chapelle 等提出了一种梯度下降法来自动选择 SVM 参数 [14]，在减少计算时间方面有显着改善。然而，该算法容易陷入局部最优解，算法终止的经常发生为实际操作带来了很多麻烦。除此以外，Keerthi 采用了拟牛顿法高斯核函数参数优化算法来优化 SVM 模型 [15]。另外，粒子群优化（PSO）是由 Kennedy 和 Eberhart 于 1995 年提出一个集群优化算法 [16]。它的灵感来自于鸟类和鱼类的数量流动行为，现在是群体智能的代表算法。遗传算法（GA）是由 Leung 提出的 SVM 模型参数自动选择方法 [17]。该算法基于对全球最佳的性能来选取 SVM 参数，提高了 SVM 的操作效率和分类识别率。在过去的几十年里，基于 GA 和 PSO 的 SVM 已经应用在各个领域，如基因的筛选和分级 [18]，故障诊断 [19]，模式识别 [20]，等等。

在本文中，参数优化方法的应用领域第一次扩展到了林区，提出了三种不同的算法来识别林区障碍，通过测试 150 个林区障碍样品，分析了三种算法的原理和效果，并对它们的优点和缺点进行总结。实验结果表明，利用留一法（LOO）的网格搜索，粒子群算法和遗传算法比利用 6 阶交叉验证的网格搜索具有更好的分类精度。

参数优化算法

整个参数优化过程如图 1 所示，三种不同优化算法分别对 SVM 模型进行参数选择，用优化后的 SVM 模型对林区障碍物进行识别并输出结果。本文中 SVM 模型的核函数选择的是最常用的径向基函数 RBF(Radius Basis Function)，因此影响 SVM 模型性能的参数有误差惩罚参数 C 和核参数 σ。C 代表错误的容忍程度，σ 是核宽度。过高或过低的参数值会造成 SVM 模型的"过学习"或"学习不足"现象，造成 SVM 不能有效对目标进行分类。为了获得适当的 C 和 σ 值，采用了三种算法对参数进行优化。下面，对每个算法的原理和流程进行说明便于更好地理解测试结果。

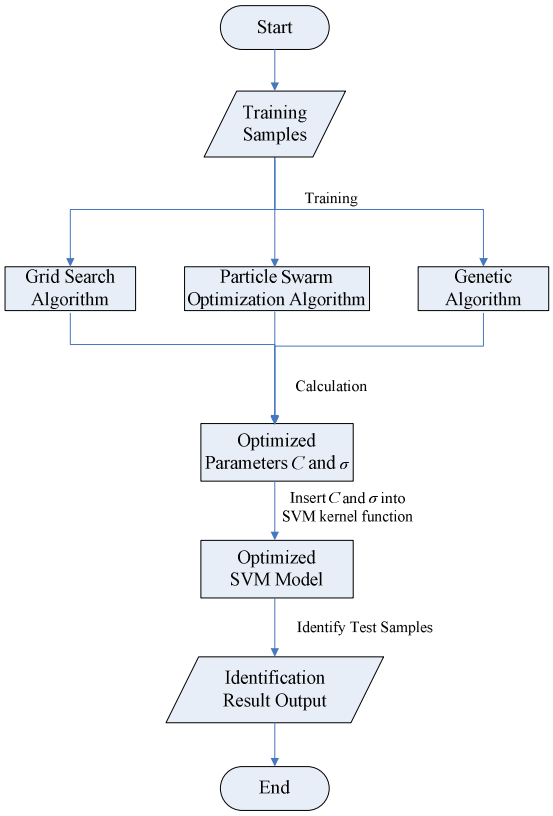

Fig. 1 - Flowchart of the parameters optimization process / *参数优化算法流程图*

Grid Search Algorithm

The basic principle of GS algorithm is that divide C and σ into grids within a certain range, and traverse all points within the grid values, then use the cross-validation (CV) method to validate each value of C and σ, finally C and σ with the best classification accuracy is chosen as the optimal parameters.

The CV method is a statistical analysis method which is used to validate the performance of classifier. The algorithm flow of k-fold CV is as follows:

(1) Initialize the parameters C and σ of SVM classifier;

(2) Randomly divide the training data into k mutually exclusive subsets of approximately equal size, and use one subset as testing set and the other k-1 subsets as training set to evaluate classifier performance;

(3) Calculate the classification accuracy with the initialized parameters, and repeat this procedure k times to ensure that each subset is used once for testing;

(4) Choose the parameters with the highest classification accuracy.

Leave-one-out (LOO) can be viewed as an extreme form of k-fold cross-validation in which k is equal to the number of examples.

PSO Algorithm

PSO is a new heuristic global search algorithm based on swarm intelligence, and it performs the global optimum search via competition and collaboration between the particles in a complex search space. In PSO algorithm, if there is a particle swarm composed of N particles in D-dimensional space, then each particle is a possible solution in the D-dimensional search space. Particles are moving in solution space, and dynamically adjust the speed and direction according to the instantaneous optimal solution of each particle and the whole population.

网格搜索算法

GS 算法的基本原理是：将 *C* 和*σ*的取值在一定范围内划分为网格，遍历所有网格内的值，利用交叉验证法 CV（Cross-Validation）来验证每一个 *C* 和*σ*的值，最终选取具有最佳分类精度的 *C* 和*σ*作为最优参数。

CV 方法是一种统计分析方法，用来验证分类器的性能。K-阶 CV 算法流程如下：

(1) 初始化 SVM 分类器参数 *C* 和*σ*；

(2) 随机将训练数据分成 *k* 份互斥且大小相等的子集，并使用其中一个子集作为测试集而其他 *k-1* 个子集作为训练集来检测分类器的性能；

(3) 计算经过参数初始化的 SVM 的分类精度，并重复此过程 k 次以确保每个子集被作为一次测试集；

(4) 选择具有最高分类精度的参数值作为最佳参数。

留一法（LOO）可以被看作是一种极端形式的 k-阶交叉验证法，其中，k 等于被测样本的数量。

粒子群算法

PSO 是基于群体智能的一种新的启发式全局搜索算法，它通过在复杂的搜索空间粒子之间的竞争和协作实现全局最优搜索。在 PSO 算法中，如果在一个 D 维空间中有 N 个粒子组成的粒子群，每个粒子是一个在 D 维搜索空间中可能的解。粒子在解空间移动，并根据每个粒子和整个群体的瞬时最优解动态地调整各自的速度和方向。

In a D-dimensional search space, a community is composed of N particles, of which the i-th particle is represented by a D-dimensional vector:

在一个 D 维搜索空间，一个群体是由 N 个粒子组成，其中第 i 个粒子可以由一个 D 维向量表示如下：

$$X_i = (x_{i1}, x_{i2}, \cdots, x_{iD}), i = 1,2,\cdots,N \quad (1)$$

The "flight speed" of the i-th particle is also a D-dimensional vector, denoted by:

第 i 个粒子的飞行速度也是一个 D 维的向量，表示为：

$$V_i = (v_{i1}, v_{i2}; \cdots, v_{iD}), \ i = 1,2,\cdots,N \quad (2)$$

The instantaneous best position of a particle i is called individual extremum, denoted by:

粒子瞬时最佳位置 i 被称为个体极值，记为：

$$p_{best} = (p_{i1}, p_{i2}, \cdots, p_{iD}), \ i = 1,2,\cdots,N \quad (3)$$

The instantaneous best position of the whole particle swarm is called global extremum, denoted by:

整个粒子群的瞬时最佳位置被称为全局极值，记为：第 i 个粒子的飞行速度也是一个 D 维的向量，表示为：

$$g_{best} = (p_{g1}, p_{g2}, \cdots, p_{gD}) \quad (4)$$

In the searching process, particles adjust the speed and direction according to the following formulae:

在搜索过程中，粒子根据下列公式调整速度和方向：

$$v_{id}(t+1) = w * v_{id}(t) + c_1 r_1 (p_{id}(t) - x_{id}(t)) + c_2 r_2 (p_{gd}(t) - x_{id}(t)) \quad (5)$$

$$x_{id}(t+1) = x_{id}(t) + v_{id}(t+1) \quad (6)$$

where c1, c2 are acceleration constant, r1 and r2 are the uniform random value in the range of [0, 1] .

The algorithm flow of PSO is as follows:

(1) Initialize the swarm, including population size N, the position x_i and velocity V_i of each particle;

(2) Calculate the fitness value $F_{it}[i]$ of each particle;

(3) For each particle, compare its fitness value $F_{it}[i]$ with individual extremum value $p_{best}(i)$. If $F_{it}[i] > p_{best}(i)$, replace $p_{best}(i)$ by $F_{it}[i]$;

(4) For each particle, compare its fitness value $F_{it}[i]$ with global extremum value g_{best}. If $F_{it}[i] > g_{best}$, replace g_{best} by $F_{it}[i]$;

(5) Update the particle velocity v_i and position x_i according to the equation (1) and (2);

(6) Output the result when the error is low enough or the maximum number of iteration is reached; otherwise return to step (2).

其中，c1，c2 为加速常数，r1 和 r2 是在[0, 1]范围内的随机值。PSO 算法流程如下：

（1）初始化粒子群，包括群体规模 N，每个粒子的位置 x_i 和速度 V_i；

（2）计算每个粒子的适应值 $F_{it}[i]$；

（3）对于每个粒子，比较它的适应值 $F_{it}[i]$ 与个体极值 $p_{best}(i)$。如果 $F_{it}[i] > p_{best}(i)$，用 $F_{it}[i]$ 替代 $p_{best}(i)$；

（4）对于每个粒子，比较它的适应值 $F_{it}[i]$ 与全局极值 g_{best}。如果 $F_{it}[i] > g_{best}$，用 $F_{it}[i]$ 替代 g_{best}；

（5）根据公式(1)和(2)更新粒子的速度和位置；

（6）当误差足够低或最大迭代次数达到最大值时输出结果，否则返回到步骤（2）。

GA Algorithm

The searching for the optimal solution of GA is an imitation process of biological evolution, which is done by chromosome crossover and mutation. The GA algorithm mainly uses the selection operator, crossover operator and mutation operator to simulate biological evolution, and produce generation after generation of the population. The three operations are defined according to evolutionary terms as follows. Selection operator is used to select individuals that adapt to the environment from the group by calculating fitness value, and these individuals are selected for breeding next generation. For the selected individuals, crossover operator is used to exchange genes in the same position of two different individuals based on some crossover probability, and mutation operator is used to change genes of some individuals, which is a simulation of gene mutation.

In GA, the initial solution group is composed of n binary string of length L. In each string, each binary bit is its individual chromosome gene. In a binary string, if a binary bit is 1, then it will be converted to 0 after mutation operation, and vice versa. The algorithm flow of GA is as follows:

遗传算法

GA 是一种模仿生物进化过程的算法，通过染色体的交叉和变异完成。遗传算法主要采用选择算子，交叉算子和变异算子模拟生物进化，并产生后代。三个算子操作定义根据进化条款如下：选择算子是通过计算适应值来选择适应环境的个体，然后选择这些个体来繁殖下一代。对于选定的体，交叉算子根据一定的交叉概率交换在同一位置的两个不同个体的基因，变异算子通过改变某些个体的基因来模拟基因突变的过程。

在遗传算法中，初始解组是由 n 个长度为 L 的二进制串组成。在每个字符串中，每个二进制位是个体的染色体基因。在一个二进制串中，如果一个二进制位是 1，经过变异操作后它会被转换为 0，反之亦然。

遗传算法的算法流程如下：

(1) Initialize the population, including population size N, crossover probability P_C, mutation probability P_m and the standard of the evolutionary termination;
(2) Calculate the fitness value of each individuals;
(3) Achieve population evolution by selection operator, crossover operator and mutation operator;
(4) Output the result when the standard of evolution termination is met; otherwise return to step (2).

（1）初始化的粒子群，包括群体规模 N，交叉概率 P_C，变异概率 P_m 和进化终止的条件；
（2）计算每个个体的适应值；
（3）通过选择算子，交叉算子和变异算子实现种群进化；
（4）当满足进化终止条件时输出结果，否则返回步骤（2）。

Support Vector Machine

In this paper, SVM model is used to identify obstacles in forest. As a new machine learning algorithm, its core idea is to convert nonlinear separable problems in low-dimensional space into linearly-separable problems in high-dimensional space.

If there are two classes in space H can be separated by a hyperplane as follows:

支持向量机 SVM

在本文中，SVM 模型被用来识别林区的障碍物。作为一种新的机器学习算法，其核心思想是将低维空间中非线性可分问题转换成在高维空间中线性可分问题。如果有两个类可以在空间 H 中由超平面进行分类，那么超平面表示如下：

$$\mathrm{w} \cdot x + \mathrm{b} = 0 \tag{7}$$

where x represents the feature vector, our goal is to calculate the values of w and b to determine the optimal hyperplane which maximizes the margins of the two classes (Figure 2).

其中 x 表示特征向量，我们的目标是计算 w 和 b 的值，以确定得到最佳的超平面，能够实现这两个类的间距最大化（图 2）。

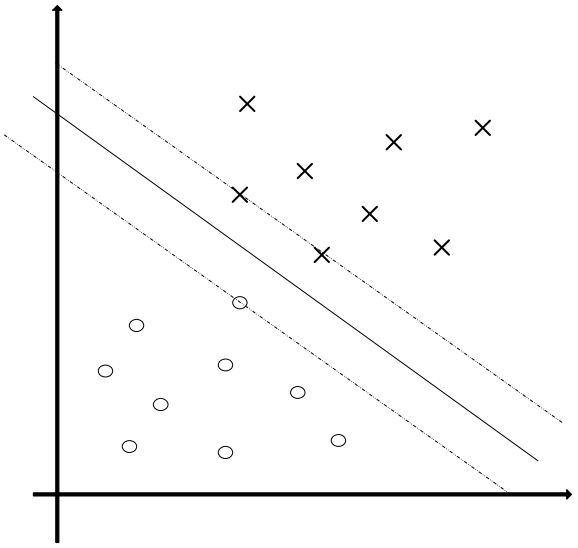

Fig. 2 - SVM maximum interval hyperplane / *SVM 最大间隔超平面*

In SVM model, it is not necessary to make all vectors far away from the hyperplane. What we care about most are the vectors that are nearest to hyperplane. By calculating the distance between the nearest vectors to the optimal hyperplane, the question can be described by the following formula:

在 SVM 模型中，没有必要使所有的向量远离超平面，而需要关心的是距离超平面最近的向量。通过计算距离最优超平面最近的向量之间的距离，问题可以由下式描述：

$$\begin{aligned} &\min_{w,b} \frac{1}{2}\|w\|^2 \\ &s.t. y^{(i)}(w^T x^{(i)} + b) \geq 1, i = 1, 2, ..., m \end{aligned} \tag{8}$$

To solve the above problem, Lagrange operator is introduced to the formula. By simplification and conversion, the optimal values of w and b can be obtained by solving a constrained minimization problem as follows:

为了解决上述问题，拉格朗日算子被引入到公式中。通过简化和转换，解决如下约束最小化问题，可以获得 w 和 b 的最佳值：

$$f(x) = \operatorname{sgn}\left(\sum_{i=1}^{m} \alpha_i y_i K(x_i, x) + b\right) \quad (9)$$

where *K (xi, x)* is the kernel function used to solve nonlinear separable problem. Commonly used kernel functions are linear kernel, polynomial kernel, RBF (Radius Basis Function) kernel and so on. In this paper, the SVM model parameter selection issue is considered based on RBF kernel as follows:

其中 K(x_i, x)是用于解决非线性可分问题的核函数。常用的核函数有线性核函数，多项式核函数，径向基函数（RBF）核函数等。在本文中，SVM 模型参数选择问题被认为是基于 RBF 核函数的，该核函数表示如下：

$$K(x,y) = \exp\left(-\frac{\|x-y\|^2}{2\sigma^2}\right) \quad (10)$$

Therefore, the performance of the SVM model depends on the error penalty parameter *C* and the kernel parameter *σ*. The above three algorithms are used to optimize the value of parameter *C* and *σ*. After that, the kernel function with optimized *C* and *σ* is adopted to construct SVM model to improve the obstacles identification performance.

因此，SVM 模型的性能取决于误差惩罚参数 *C* 和核参数 *σ*。上述三个算法用来优化的参数 *C* 和*σ*的值。然后，将优化后的 *C* 和*σ*代入 SVM 模型，以改善模型对林区障碍物的识别性能。

Fig. 3 - Sensors placed on the same horizontal plane in this experiment / *试验设备与装置*

EXPERIMENTAL RESULTS AND DISCUSSION

Figure 3 shows the 2D laser scanner and infrared thermal imager used for detecting obstacles in this experiment, and the sensors of the scanner and imager are placed on the same horizontal plane. Firstly, the position and image of obstacle is collected by the equipment. Then, after images fusion and data association, the features of the objects such as the height, width, shape, temperature, and color could be obtained from the laser points, visible images, and infrared images. Finally, three SVM parameter optimization algorithms, of which the GS algorithm includes 6-fold crossover-validate and LOO, are applied to a RBF SVM model to achieve obstacles recognition. In order to examine and compare the SVM performance, the three algorithms are tested using 150 forest obstacles samples, including 50 trees, 50 people, and 50 stones. For each type of obstacle, 40 samples were selected randomly as the training data and the other 10 as the test data (Table 1).

试验结果与讨论

图 3 显示了在本实验中用于检测林区障碍物的 2D 激光扫描仪和红外热像仪，激光扫描仪和红外热像仪被装置在同一水平面上。首先，通过两种传感器可以获得障碍物的位置和图像信息。然后，经过图像融合和数据关联，通过获得的激光点，可见光图像和红外图像可以得到被测对象的特征，如高度，宽度，形状，温度，颜色等。最后，三种 SVM 参数优化算法，其中 GS 算法中分别使用了 6 阶交叉验证和留一法，被应用于基于 RBF 的 SVM 模型来实现林区障碍识别。为了检验和比较支持向量机的性能，使用 150 个森林障碍物的样本（包括 50 棵树，50 人，50 石头）来进行结果测试。对于每一类型的障碍物，随机选取 40 个样本作为训练数据，剩余 10 个样本作为测试数据（表 1）。

Table 1 / *表 1*

Training data and test data / *训练数据和测试数据*

Sample Type / 样本类型	Total Samples / 样本总数	Training Samples / 训练样本	Test Samples / 测试样本
Tree / 树木	50	40	10
People / 人	50	40	10
Stone / 石头	50	40	10
Total / 总数	150	120	30

In GS algorithm, firstly the range and search step of the variables are set, where $C\in [2^{-8}, 2^{8}]$, $\sigma\in [2^{-8}, 2^{8}]$ and the search step is 0.5 for both C and σ. Then 6-fold CV and LOO methods are adopted respectively to validate the value of C and σ. Based on the calculation, when $k > 6$, the growth of the best accuracy by CV is relative slow, so the k is set as 6. Moreover, LOO method is used as an extreme of CV to be compared with 6-fold CV.

In PSO, acceleration constant $c_1=c_2=2$, inertia weight $\omega=1$, $C\in$ (0, 100], $\sigma\in$ [0, 1000]. Population size is set to 20 and the maximum iteration generation is 200. When the iteration time is up to 200 or the global fitness remains unchanged in 100 consecutive iterations, the operation stops.

In GA, acceleration constant $c_1=c_2=2$, inertia weight $\omega=1$, $C\in$ (0, 100], $\sigma\in$ [0, 1000]. Population size is set to 20 and the maximum iteration generation is 200. When the iteration time is up to 200 or the global fitness remains unchanged in 100 consecutive iterations, the operation stops.

After parameter settings, SVM model parameters can be calculated by different algorithms based on 120 training samples, and Table 2 presents one group of calculation results as an example.

下面对不同算法的参数进行设置：在 GS 算法中，首先设置变量的范围和搜索步骤，其中 $C\in[2^{-8}, 2^{8}]$，$\sigma\in[2^{-8}, 2^{8}]$，搜索步长均为 0.5。通过计算可知，识别精度随着 k 值的增长而增长，而当 k> 6 时，识别精度的增长较慢，所以 k 被设置为 6。此外，LOO 法作为一个极端例子与 6 阶 CV 进行比较。

在 PSO 算法中，加速度常数 $c_1 = c_2= 2$，惯性权重ω= 1，$C\in$ (0，100]，$\sigma\in$[0，1000]。群体大小设置为 20，最大迭代次数为 200。当迭代次数高于 200 或全局极值连续迭代 100 次不变时，停止操作。

在遗传算法中，加速度常数 $c_1 = c_2=2$，惯性权重ω= 1，$C\in$ (0，100]，$\sigma\in$[0，1000]。群体大小设置为 20，最大迭代次数为 200。当迭代次数高于 200 或全局极值连续迭代 100 次不变时，停止操作。

经过以上参数设置，同时基于 120 个训练样本的测试，可以获得不同优化算法优化后的 SVM 模型参数，如表 2 所示为一组计算结果。

Table 2 / *表 2*

SVM model parameters obtained with different algorithms / *经过不同优化算法优化后的参数*

Algorithm / 算法		Best Fitness / 最佳适应度	Best C / 最佳 C 值	Best σ / 最佳 σ 值
GS / 网格搜索	6-fold / 6 阶	92.50%	2	0.0313
	LOO / 利用留一法	95.00%	2	0.0039
PSO / 粒子群优化		94.17%	3	0.0100
GA / 遗传算法		95.83%	2.89	0.0019

Due to the parameters obtained from the three algorithms, the SVM classifier can be used to classify the test samples, and their performances are shown in Figure3, according to which the average classification accuracy of each parameter algorithm can be calculated.

根据三种算法获得的参数，SVM 分类器可以用于分类测试样本，它们的测试结果如图 3 所示，由测试结果可以计算出每个算法的平均分类精度。

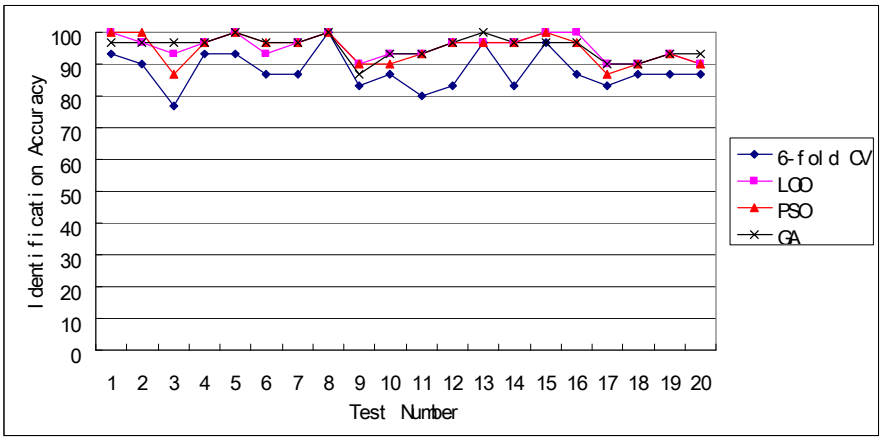

Fig. 3 - Identification accuracy of each algorithm in 20 tests / *三种算法的障碍物识别准确度结果*

The average recognition accuracy of GS with 6-fold CV, GS with LOO, PSO and GA are respectively 91%, 95.33%, 94.85% and 95.34%. It is obvious that the SVM model with the 6-fold CV has relative lower classification accuracy compared with the other three algorithms. In GS algorithm, almost all samples are used to train the model in each iteration for LOO method, which is the closest to the original sample distribution, so that LOO method has a better effect than 6-fold CV method dose, and the assessment outcome of the LOO method is more reliable. However, LOO method has the shortcoming of high computing cost, because the number of models requiring to be established is the same as the original number of data samples.

The identification accuracy of GS algorithm with LOO method and GA algorithm both can reach over than 95%, which is slightly better than that of PSO algorithm. GA algorithm and PSO algorithm are both trying to simulate the population adaptability on the basis of natural characteristics, and they adopt certain transformation rules to solve problems by searching space. In our study, these two algorithms both have high classification accuracy for obstacle detection in the forest. They have their own characteristics and advantages, as well as defects and deficiencies. PSO algorithm has more efficient information sharing mechanism than GA algorithm and all particles in PSO algorithm may converge faster to the optimal solution than the evolutionary individuals in GA algorithm. But this mechanism may lead to over-concentration of particles, which is likely to fall into the local minimum. For GA algorithm, coding techniques and genetic manipulation are simple, while PSO algorithm has no codes or crossover and mutation operations, and the particles are updated only by the internal speed. Therefore, the principle of PSO algorithm is more simply and easily to achieve.

Besides those above, it should be noted that although GS algorithm, especially with LOO method, can find the global optimal solution, it will be very time-consuming sometimes if people want to find the best parameters C and σ in a larger range. But for GA and PSO algorithms, they are both heuristic algorithms that can find the global optimal solution without traversing all parameters within the grid, which will save a lot of computing cost.

CONCLUSIONS

Three parameters optimization algorithms: GS algorithm, PSO algorithm and GA algorithm were proposed to a SVM classifier to identify obstacles in forest area in this paper. The principle and flow of each algorithm were introduced and the parameters of each algorithm were set according to experience. After that, parameters C

6 阶 CV，LOO，PSO 和 GA 的平均识别精度分别为 91%，95.33%，94.85%和 95.34%。显然，6 阶 CV 的 SVM 模型与其他算法相比，具有较低的分类精度。在 LOO 算法中，每次迭代几乎用到所有的样本来训练模型，这是最接近原始样本分布的方法，所以 LOO CV 法比 6 阶 CV 法具有较高的准确度，评估结果显示 LOO 方法更可靠。然而，因为需要建立的模型数目与原始的数据样本数量是相同的，所以 LOO 方法具有计算成本高的缺点。

LOO 法和遗传算法的识别准确度都可以达到 95%以上，略优于 PSO 算法。GA 算法和 PSO 算法都试图模拟基于自然特性的种群适应性，并且采取一定的变换规则，通过搜索空间来解决问题。在我们的研究中，这两种算法在森林的障碍物检测中都具有较高的分类准确率。它们有自己的特点优势，然而也有缺陷和不足。PSO 算法比遗传算法具有更高效的信息共享机制，并且 PSO 算法中的所有粒子比遗传算法的进化个体更快收敛于最佳解。但这种机制可能会导致粒子过度集中而陷入局部最小值。GA 算法的编码技术和遗传操纵方法虽然简单，而 PSO 算法不需要任何编码或交叉和变异操作，粒子仅进行内部速度更新。因此，PSO 算法的原理更简单，更容易实现。

除了上述分析结果，应当指出的是，虽然 GS 算法可以找到全局最优解，但是如果想在一个较大的范围内找到最佳 C 和σ是非常费时的。而 GA 和 PSO 算法都是启发式算法，可以在网格内无需遍历所有参数找到全局最优解，节省了大量的计算成本。

结论

文中提出了三种参数优化算法：GS 算法，粒子群算法和遗传算法，并将它们用于 SVM 分类器来对林区障碍物进行识别。介绍了每种算法的原理和流程，并根据经验设置了相应参数。然后，运用这些优化算法对 SVM 模型中的参数

and σ that were used in SVM were optimized by these algorithms. Then the optimized C and σ were inserted into kernel function in SVM to identify three kinds of obstacles in forest. Finally, the performances of the different algorithms were examined and the experimental results showed that the GS algorithm with LOO, PSO algorithm and GA algorithm had better classification accuracy than GS algorithm with 6-fold CV. Considering the time-consuming disadvantage of GS algorithm with LOO, the PSO and GA algorithm are considered as more suitable methods for obstacle recognition in the forest. Our work extends the application field of SVM to forestry, which may provide valuable reference for developing new forestry equipment.

Aknowlegement

This study is financially supported by National Natural Science Foundation of China (Grant No.31070634), China Postdoctoral Science Foundation (Grant No. 2012M510330), 948 project supported by State Forestry Administration, China (Grant No. 2011-4-02).

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C 和σ进行了优化。将优化后的 C 和σ分别代入 SVM 模型中，对林区中的三种常见障碍物进行识别和分类。最后，用 150 组样本数据对三种算法的识别结果进行了测试，实验结果表明，利用留一法（LOO）的网格搜索，粒子群算法和遗传算法比利用 6 阶交叉验证的网格搜索具有更好的分类精度。考虑到 LOO 法计算成本高的缺点，粒子群算法和遗传算法更适用于林区的障碍物识别。本文将支持向量机的应用扩展到了林业领域，为新型林业设备的开发提供了有价值的参考。

致谢

本项研究是由国家自然科学基金（批准 No.31070634），中国博士后科学基金（批准号：2012M510330），中国国家林业局 948 项目（批准号：2011-4-02）财政支持。

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RESEARCH & DEVELOPMENT OF INTELLIGENT FEEDING SYSTEM
/
精细喂鸡系统的设计

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***Abstract**: As the present feeding devices used in the chicken farm are mostly simple and less automated, an intelligent feeding system is established in this paper by comprehensive technological means like sensor detection, data processing and remote monitoring to control the feeding quantity accurately and monitor the feed intake in real time. The system consists of upper computer, control center and mechanical hardware equipment, of which the mechanical hardware equipment is about 44.2kg. Upon testing, the system takes 15s in feeding; the accuracy of feeding quantity is 90-99%, compared with 70-85% of that of traditional machine; the feeding efficiency is 1.4-1.9 times higher than that of traditional machine. Users can set the feeding parameters based on the chicken age, type of chicken and other information through the interface of the upper computer, and monitor the epidemic situation of the chicken farm, to achieve the requirement of intelligent feeding.*

***Keywords:** feeding system, real-time detection, man-machine interface, STC89C52*

INTRODUCTION

The research of feeding process and feeding equipment is an important link to the feeding and management of chicken farm[1][2]. Traditional feeding method is featured by low efficiency and waste, as it mainly depends on people experience to decide the feeding parameters, and transfer the feedstuffs to each feeding manually. Feed intake is a physical quantity which indirectly reflects the growth trend and health of the chickens. Monitoring the feed intake in real time is of significance to production raising and diseases prevention [3][4][5].

At present, with the all-round development of automation and mechanization technologies, many mechanized and semi-mechanized chicken large, medium and small farms, , appeared in succession in China, which greatly increased the feeding efficiency. However, they are still in the blank stage in figuring out how to control the feeding quantity accurately and monitor the feed intake in real time. Compared to foreign countries, the automation level of the domestic feeding device lags far behind, hindering the large and scale development of the chicken farms [6][7][8].

For above reasons, a feeding system for chicken farm is developed herein. This system, developed on the basis of the traditional feeding device, can effectively feed the chickens in a timely and quantitative manner and monitor the feed intake in real time, provides such functions like residual detection and epidemic warning, offset the shortages such as single feeding function and dispersed structure and feed the chickens in a highly-intelligent and accurate way.

STRUCTURE AND PRINCIPLE OF THE FEEDING DEVICE

This feeding device consists of charger, conveyer (including helical conveying pipe and DC gear motor), emptying device (including emptying valve and emptying pipe), feedstuff quantity detector (including ultrasonic ranging sensor, electric drive pusher and refining pusher), control system (upper computer, control center and serial communication module) and power supply system, of

***摘要**: 针对目前养鸡场喂食装置简单、自动化程度低等特点，本文通过传感器检测、数据处理、远程监控等综合技术手段，建立一套应用于养鸡场的智能喂食系统，能实现对喂食量的精确控制和对采食量的实时监控。该系统由上位机、控制中心、机械硬件设备三个部分组成，其中机械硬件设备约为 44.2kg。经实验测试，该系统完成一次喂食所需的时间为 15s；饲料量的投放精度为 90~99%，而传统机械喂食的投放精度为 70~85%；投食效率为传统机械投食的 1.4~1.9 倍。通过该系统的上位机界面，用户可以根据鸡龄、鸡种等信息自行设置喂食的相关参数，还可以实时监测鸡场疫情，达到智能喂食的要求。*

***关键词**: 喂食系统, 实时检测, 人机交互界面, STC89C52*

引言

养鸡场喂料工艺和喂料设备的研究是养鸡场饲养管理的重要环节[1][2]。传统的喂料方法主要依靠人工经验判断喂食参数，以人工卸料的方式将饲料传输到各食槽中，其效率低下，并且容易造成饲料的浪费。采食量是间接反映鸡群生长趋势、健康状况的物理量，实时对采食量进行监控对于生产养殖、鸡病预防有重要意义[3][4][5]。

目前，随着自动化和机械化技术的全面发展，国内相继出现了许多机械化、半机械化的大中小型养鸡场，喂料效率有了很大的提高，然而对喂料量的精确控制、采食量的实时监控等方面的研究仍处于空白阶段。与国外相比，国内喂料装置的自动化程度还远远不够，阻碍了国内养鸡场向大型化、规模化的发展[6][7][8]。

对此，本文研制了一套应用于养鸡场的喂食系统。该喂食系统在传统喂食装置的基础上，有效的实现了对鸡群的定时定量喂食和对采食量的实时监控，扩展出剩料检测、疫病预警等功能，弥补了现有喂料装置功能单一、结构分散的缺点，最终达到喂食系统高智能化、高精细度的目标。

喂食装置的结构与原理

该喂食装置由进料装置、输料装置（包括螺旋输料管道、直流减速电机）、漏料装置（包括漏料阀门、漏料管道）、料量检测装置（包括超声波测距传感器、电动推杆、匀料推杆）、控制系统（上位机、控制中心、串口通信模块）、供电系

which the control center is based on STC89C52 single chip. See figure 1 for mechanical structure design of the feeding device.

统等组成，其中控制中心是以 STC89C52 单片机为核心。喂料装置的机械结构简图如图 1 所示。

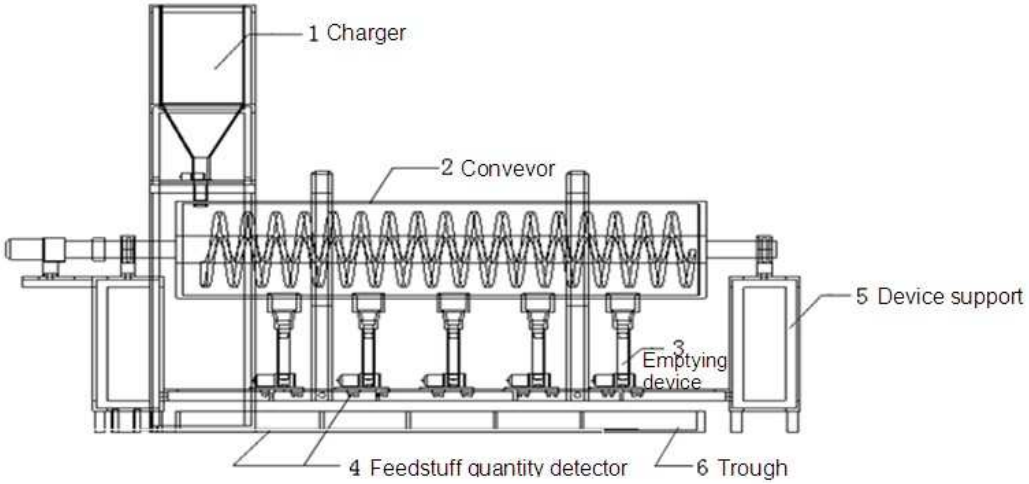

Fig. 1 - Intelligent mechanical structure for chicken feeding / *智能精细喂鸡系统机械结构*

The process of the whole system is depicted as follows: (1) Set the feeding time and quantity of that day on the interface of the upper computer; (2) When the feeding time comes, the upper computer will send the initial signal and feeding quantity to the control center through serial port; (3) Upon identifying the initial signal, the control center will drive the charger, conveyor and emptying device and then the feedstuffs will be conveyed from the charger to the feeding trough; (4) before feeding, the feed quantity detector will accurately measure the feedstuff quantity in the trough through ultrasonic ranging sensor and refining pusher and send the measuring data back to the control center while uploading it to the upper computer; (5) the control center will compare the measuring data with the feeding quantity. If both of them are equal, it will close the electrically operated valve (EOV) to the corresponding trough to stop feeding; if not, it will continue feeding. When feeding from all troughs stops, the system will enter dormant state and wait for next order. At all time when the system is powered on, user can collect and display the data of feedstuff quantity from any trough by means of the monitoring function of the upper computer.

整个系统的工作过程为：（1）用户在上位机界面中设置当日喂食时间和喂食量参数；（2）当喂食时间到达时，上位机经串口发送起始信号和喂食量参数到控制中心；（3）控制中心识别到起始信号后驱动进料装置、输料装置、漏料装置工作，实现饲料从进料装置到食槽的传输；（4）在进行投料操作之前，料量检测装置通过超声波测距传感器、匀料推杆，实现对食槽中饲料量的精确测量，并将测量数据返回控制中心，同时传送至上位机进行显示；（5）控制中心将测量数据与喂食量参数相比较，若相等则关闭对应食槽的电动阀门，停止投料操作；反之就进行对应食槽的投料操作，待所有食槽均停止投料后，系统处于休眠状态，等待下一次的操作命令。在系统上电的任意时刻，用户可以通过上位机中的监测功能，对任一个食槽中的饲料量进行数据采集并显示。

Design of feedstuff quantity detecting system

The feedstuff quantity detecting system which is used to accurately detect the feedstuff quantity in the trough mainly consists of refining module and height detecting module.

料量检测系统的设计

料量检测系统主要由匀料模块、高度检测模块组成，用于对食槽中饲料量的精确检测。

Refining module

As the feedstuffs coming from the emptying device are in irregular geometrical shape, a refining module is designed. The purpose of it is to level off the feedstuffs evenly in the trough to accurately detect the feedstuff quantity. Trough which is located below the hole of the emptying device (see figure 1) is the direct rectangle container (made of stainless steel) for chicken feeding. The whole trough is separated evenly with four iron plates, i.e., consisting of five independent sections. With the structural parameter of single trough of 39*8*10cm and the capacity of 1000g, it can be used to feed five chickens at the same time in one day. This independent trough not only prevents chickens from fighting for food, but also establishes a one-to-one relation between chicken and trough, facilitating the positioning analysis of single coop.

匀料模块

由于通过漏料装置漏下的饲料在食槽中呈不规则几何状，故设计了一个匀料模块，其功能是将食槽中的饲料均匀推平，以实现对料量的高度检测。食槽是鸡群采食的直接容器，其安装于漏料口正下方，如图 1 所示，特性为不锈钢制长方槽形容器；整个食槽被 4 个铁制挡板均匀隔开，形成 5 个独立食槽；单个食槽结构参数为 39*8*10cm，容量为 1000g，能够满足同时 5 只鸡的单日采食。通过独立式食槽，既可以避免鸡群之间的争食现象，也建立起食槽与鸡笼一一对应的关系，便于对单个鸡笼进行定位分析。

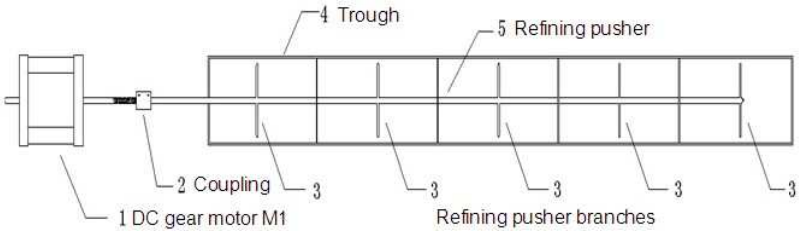

Fig. 2 - Refining device / *匀料装置*

The refining module (see figure 2) consists of refining pusher mounted in the bottom of the trough and linear motor M1. (1) Refining Pusher: 220cm L x 6cm W x 0.3cm H. The size can be neglected compared with the size of the trough. The refining pusher is composed of one main pusher and five sub-pushers. The sub-pushers are welded and perpendicular to the main pusher every 39 cm. (2) Linear motor M1 (also known as refining motor): Its parameters include 12 V DC voltage, 1200N maximum load, 540 mm/s maximum no-load speed and 600mm maximum stroke. M1 is fixed to one end of the main pusher through a coupling and directly drives the load for linear motion.

When refining operation is needed, the control center will activate M1. The refining pusher will start reciprocating motion under the control of M1 to level off the feedstuffs within a short time through friction and vibration. Upon repeated test, when the trough is full of feedstuffs, the horizontal motion speed of the refining pusher is 490~500mm/s. The feedstuffs can be leveled off by the refining pusher through two or more reciprocating motions under this speed.

Height detecting module

This module consists of ultrasonic ranging module HY-SPF05 and temperature sensor DS18B20; (1) Ultrasonic ranging module HY-SPF05: Two ultrasonic ranging modules are mounted horizontally right above each trough. The mean value of the feedstuff height detected by two ultrasonic sensors will be deemed as the final feedstuff height. The ultrasonic ranging module consists of ultrasonic launcher and receiver. Its parameters include 5V DC voltage, 15mA working current, 2~450mm measuring distance and 150 detection angle and 3mm measuring accuracy; (2) Temperature sensor DS18B20: The purpose of it is to compensate the temperature for ultrasonic ranging.

匀料模块如图 2 所示，主要包括：（1）放置于食槽底部的匀料推杆，其长度为 220cm，宽度为 6cm，高度为 0.3cm，体积相对于食槽体积可以忽略不计。匀料推杆由 1 根主推杆和 5 根分推杆组成，分推杆以每隔 39cm 的距离垂直焊钳于主推杆上；（2）控制匀料推杆的直线电机 M1（又称匀料电机），其参数为其参数为直流电压 12V、最大负载 1200N、最大空载速度 540mm/s、最大行程 600mm。M1 通过联轴器与主推杆的一端固定，其直接驱动负载做直线运动。

当需要进行匀料操作时，控制中心启动 M1 工作；匀料推杆在 M1 控制下做往复运动，并引起匀料推杆上方的饲料摩擦和抖动，使饲料能在短时间被均匀推平。经实验反复测试，在食槽为满饲料状态时，匀料推杆在水平运动速度能达到 490~500mm/s，在此速度下匀料推杆经过两次及两次以上往复运动即可将饲料推平至所需平整度。

料量高度检测模块

料量高度检测模块主要包括:（1）超声波测距模块 HY-SPF05。每个食槽正上方水平安装两个超声波测距模块，将两个超声波传感器测得的食料高度求均值，作为最后的饲料高度。单个超声波模块由超声波发射装置和接受装置组成，其工作参数为直流电压 5V、工作电流 15mA、测量距离 2~450mm、感应角度 15^0、测量精度 3mm；（2）温度传感器 DS18B20，其作用在于对超声波测距进行温度补偿。

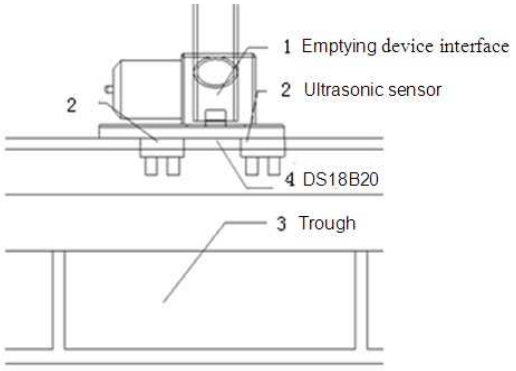

Fig.3-Height detecting module / *高度检测模块*

The ultrasonic ranging sensor is directly connected to the control center. When there is a need to detect the height of the feedstuffs in the trough, the control center will activate the ultrasonic launcher to launch the ultrasonic wave. The time interval between launching ultrasonic wave and receiving

超声波测距模块与控制中心直接相连，当需要对食槽中的饲料进行高度检测时，控制中心启动超声波发射装置发出超声波，发出超声波与接收到超声波回波的时间间隔为 t。

ultrasonic echo is t. As the propagation velocity of ultrasonic wave in the air is easily affected by the surrounding environment, it is a need to compensate the temperature for ultrasonic velocity. Upon compensation, the ranging formula is as follows [9]:

超声波在空气中的传播速度易受环境影响，对超声波速度进行温度补偿，补偿后的测距公式为[9]：

$$S = \frac{(c + \alpha * T) * t}{2} \quad (1)$$

Wherein: T is actual temperature (°C), $c = 331.5(m/s)$, $\alpha = 0.607m/(s \cdot °C)$ is temperature compensation coefficient, S is the distance (unit: cm) between sensor and object to be tested. If the feedstuffs in the trough are leveled uniformly, the space (S) between ultrasonic ranging module and feedstuffs can be tested accurately through ranging operation.

式中，T 为实际温度（°C），$c = 331.5(m/s)$，$\alpha = 0.607m/(s \cdot °C)$ 为温度补偿系数，S 为传感器与被测物体之间的距离（cm）。若食槽中的饲料均匀平整，通过测距操作，可以精确获得超声波测距模块与饲料之间的距离 S。

Conversion between height and mass

To perform quantitative feeding and real-time monitoring, it is necessary to directly obtain the mass of the feedstuff in the trough [10]. The following is mapping relation between mass (marked as m) and space (marked as S) which is obtained from relation between density and mass $m = \rho * v$:

高度与质量之间的转换

为了达到定量喂食和实时监测的目的，需要直接获得食槽中饲料的质量 m [10]。由密度与质量的关系 $m = \rho * v$，得到距离值 S 与质量值 m 之间的映射关系：

$$m = \rho * v = \rho * (s * (L - S)) \quad (2)$$

Where v means feedstuff volume (unit: cm^3) in each trough, ρ means the feedstuff density (unit: g/cm^3), s means the floor area of the trough and L means the space (unit: cm) between ultrasonic ranging sensor and trough base.

While the feedstuff quantity detecting device is working, first activate M1 for refining operation. The feedstuffs will be leveled of after 3.2s; then the control center will activate the ultrasonic ranging module and temperature sensor. When the return time of ultrasonic ranging sensor is 600 μs and the current room temperature tested by the temperature sensor is 25℃, the space between ultrasonic ranging module and feedstuffs is 11.6cm by means of formula (1). If $L = 20cm$, $s = 312cm^2$, $\rho = 0.35g/cm^3$, the mass is $m = 917.28g$ in the current trough by means of formula (2).

式中，v 为每个食槽中饲料体积（cm^3），ρ 为饲料密度（g/cm^3），s 为食槽底面积（cm^2），L 为超声波测距传感器与食槽底部之间的距离（cm）。

当料量检测装置工作时，首先启动 M1 进行匀料操作，经过约 3.2s 饲料被均匀推平；随后，控制中心启动超声波测距模块、温度传感器工作，超声波测距传感器返回时间为 600 μs，温度传感器测得当前室温为 25℃，由式（1）得到超声波测距模块与饲料的距离为 11.6cm。若已知 $L = 20cm$, $s = 312cm^2, \rho = 0.35g/cm^3$，由式（2）得到当前食槽中的饲料量 $m = 917.28g$。

Design of tubular helical conveyor

The helical conveyor which is used to convey granular or powdered feedstuffs is simple in structure, reliable in performance and designed in mechanical structure (See figure 4).

管式螺旋输料装置的设计

螺旋输料装置应用于颗粒或粉状饲料的传输，其结构简单、工作可靠，机械结构如图 4 所示。

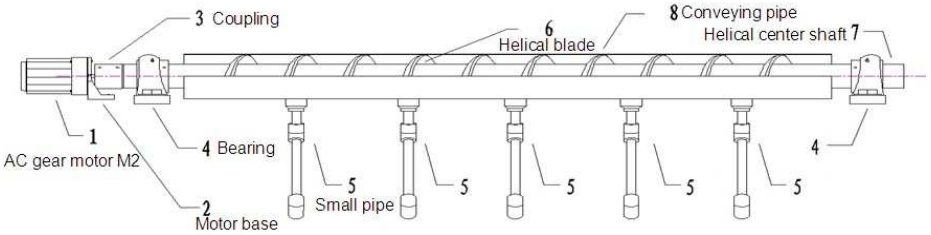

Fig. 4 - Helical conveyor / *螺旋输料装置*

It can be seen from figure 4 that the tubular helical conveyor consists of helical blades welded to the helical center shaft, AC gear motor M2 (also known as conveying motor) and main conveying pipe. (1) Helical blades welded to the helical center shaft: Stainless steel blade with 16cm external diameter, 4cm internal diameter and 16cm pitch; (2) AC gear motor M2: Its parameters include 22V AC voltage, 6W power, 13r/min rotating speed, and $3N \cdot m$ torque. The output shaft

由图 4 可知，管式螺旋输料装置主要包括：（1）焊钳在螺旋中心轴上的螺旋叶片，其为外径 16cm、内径 4cm、螺距 16cm 的不锈钢材质叶片；（2）交流减速电机 M2（又称输料电机），其参数为交流电压 220V、功率 6W、转速 13r/min、扭矩为 $3N \cdot m$，该电机的输出轴通过轴承与螺旋

of the motor is connected to the helical center shaft through the bearing to control the rotating direction and speed of the blades; (3) Main conveying pipe: With the parameters of 4cm radius and 210 cm length, it is an enclosed plastic pipe. The upper left of pipe is connected to the charger through the hole of the emptying device.

In the process of feedstuffs conveying, the control center controls the feedstuffs in the main conveying pipe by controlling the speed and direction of M2. While M2 is rotating in reverse clockwise direction, the feedstuffs will be conveyed from the left of the main pipe to the right (left to right) and distributed to the troughs corresponded to five small pipes; while M2 is rotating in clockwise direction, the feedstuffs will be conveyed from right to left and distributed to the troughs corresponding to five small pipes; When M2 stops, the feedstuffs conveying will also stop. See figure 1 for the control relation between feedstuff and main pipe. It takes about 30s to convey the feedstuffs from one side to the other side under the speeds in table 1.

中心轴相连，从而控制螺旋叶片的旋转方向和旋转速度；（3）输料主管道，其半径为 $4cm$ ，长度为 $210cm$ ，是封闭的塑料管道，其左上方通过一个漏料口与进料装置连接。

执行输料操作时，控制中心通过控制 M2 的速度和方向，从而对输料主管道中的饲料进行控制。当 M2 逆时针旋转时，使得饲料正向传输，饲料从输料主管道的左端传送到右端（从左至右），并分别从五个漏料小管道漏出至对应的食槽；反之当 M2 顺时针转动时，饲料从主管道右端传送到左端（从右至左），分别从五个漏料小管道漏出至对应的食槽；当 M2 停止转动时，饲料停止传送。M2 对饲料的控制关系如表 1 所示，在此速度下，饲料完成从管道一端到另一端的传输过程约需要 30s。

Table 1 / *表 1*

Control relation between AC gear motor M2 and feedstuff / *交输料电机 M2 对饲料的控制关系*

M2 rotating direction / *M2 转动方向*	M2 rotating speed / *M2 转速*	Conveying direction / *饲料传输方向*	Conveying speed / *饲料传输速度*
Reverseclockwise / *逆时针*	10r / min	Positive direction (Left to right) / *正方向（从左至右）*	7cm / s
Clockwise / *顺时针*	10r / min	Reverse direction (right to Left) / *反方向（从右至左）*	7cm / s

Design of electrically operated valve (EOV)

It can be seen from figure 1 that an EOV is mounted between the charger and tubular helical conveyor to control the feedstuff quantity of the conveyor. This EOV is known as the first switchgear of the charger. To separately control the charging process of each trough, an EOV is mounted between the emptying pipe and each of five trough sections. This EOV is known as the second switchgear of the emptying device. When either EOV is opened, the feedstuffs will pass through the corresponding valve. The height of the valve and the size of the feedstuffs passing through the valve per unit time are directly relative; When EOV is closed, the passing will stop. In this system, all the EOVs are of the same type. See figure 5 for its mechanical structure.

电动阀门的设计

从图 1 可知，为了对进入输料装置的饲料量进行控制，进料装置与管式螺旋输料装置之间安装有电动阀门，也称为进料装置的第一开关装置。为了对每个食槽进料过程单独控制，漏料管道与 5 个独立食槽之间都有对应的电动阀门，也称为漏料装置的第二开关装置。当任一电动阀打开时，允许饲料通过相应的阀门，阀门开度与单位时间通过的饲料体积直接相关；当电动阀关闭时，禁止饲料通过相应的阀门。在本系统中，各电动阀门是同一种类型，其机械结构如图 5 所示。

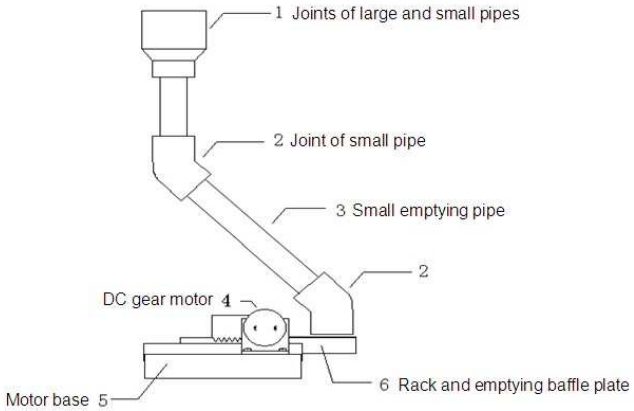

Fig. 5 - Electrically operated valve / *电动阀门*

EOV consists of: motor base, one metal rack mounted on the base of the iron trough, emptying baffle plate and DC gear motor. (1) Motor base: Fixed on the support below the hole of the emptying device with a hard iron trough separated; (2) Metal rack mounted on the base of the iron trough: As the width of the rack is the same as the width of the iron trough and the length is

电动阀门主要包括:（1）电机底座，其固定于漏料口下方的支架上，底座中间被一高硬度铁皮槽隔开；（2）1 根安装于底座铁皮槽上的金属齿条，其宽度与铁皮槽同宽，长度为铁皮槽长度的 2/3（略比漏料口半径大），因此齿条可以

2/3 of the length of the iron trough (slightly larger than the radius of the emptying hole), the rack may be moved right and left in the iron trough; (3) emptying baffle plate: It is a hard wood plate with one side connecting to the rack; (4) DC gear motor: Its parameters include 6V DC voltage, 3W power, 150r/min rotating speed, and 0.6 $\mathrm{N}\cdot m$ torque. As the motor is fixed on the base and the output shaft is embedded in the rack, the motor drives the rack to move left and right.

In this system, the diameter of the emptying hole is 3cm and the diameter of the output shaft of DC gear motor is 3mm. In the charging state, all the EOVs will be opened and the feedstuff can be sent to the troughs through the emptying pipe. When the charging operation stops, the control center will control the rverseclockwise rotation of the DC gear motor and the gear will drive the emptying baffle plate the move rightward. Under this case, the emptying hole is closed; when there is a need to open the EOVs for charging, the control center will control the clockwise rotation of the DC gear motor and then the EOVs open. See figure 6 for the opening width of the valves and the adjustment process of the helical conveyor direction. In the figure, M3 is the DC gear motor of the first gear switch for controlling the charger and M4-M8 are the DC gear motors (or trough motor) of the second gear switch for controlling the emptying device. Relays 1-3 are used to control the rotating direction of the conveying motor M2 to control the conveying direction of the tubular helical conveyor.

在铁皮槽中左右移动；（3）漏料挡板，其特性为高硬度的木板，其一端与齿条相连；（4）直流减速电机，其参数为直流电压 6V、功率 3W、转速 150r/min、扭矩为 0.6 $\mathrm{N}\cdot m$，机身固定在底座上，输出轴嵌在齿条中，因此能带动齿条左右移动。

本系统中，漏料口直径为 3cm，直流减速电机输出轴的直径为 3mm。当电动阀门处于投料状态时，阀门全开，饲料能完全通过漏料管道漏入食槽中。若需要停止投料操作时，控制中心控制直流减速电机逆时针旋转，齿轮带动漏料挡板向右移动，此时漏料口被完全挡住，停止饲料下漏；当需要再次打开电动阀门进行投料操作时，控制中心控制直流减速电机顺时针旋转，即可达到电动阀门的全开状态。电动阀门开度和螺旋输料方向的调节过程如图 6 所示。图中，M3 为控制进料装置的第一开关装置的直流减速电机，M4～M8 为控制漏料装置的第二开关装置的直流减速电机，也称为食槽电机。继电器 1～3 是用于控制输料电机 M2 的转向，从而实现控制管式螺旋输料装置中的输料方向。

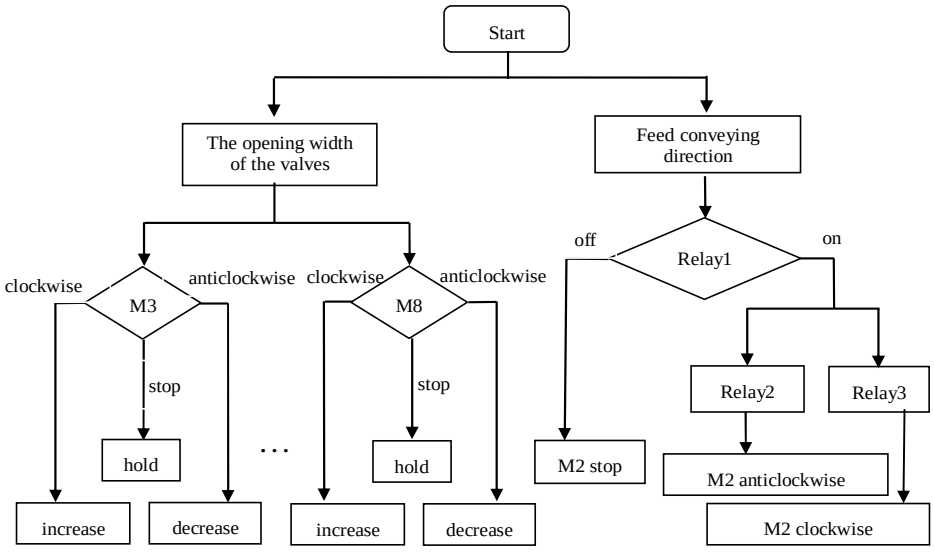

Fig. 6 - EOV and adjustment process of helical conveyor direction / *电动阀和螺旋输料方向的调节过程*

DESIGN OF CONTROL SYSTEM

Control system mainly refers to data collection and control system and interface control system. Based on the core of STC89C52 single chip, the parameter collection and control system sends the parameters obtained from the sensors mounted on the trough to the upper computer through serial port after the controls by refining motor M1, conveying motor M2, DC gear motor M3 and trough motors M4-M8 are completed. The interface system is a good presentation of man-machine interaction. It is responsible for controlling the feeding time, displaying the status of the trough and sending out epidemic warning signal.

Data collection and control

Data collection and control means the above-mentioned control center. It takes STC89C52 single-chip and its peripheral circuit as the core. See figure 7 for the control principle. It can be seen from this figure that the data are collected through each ultrasonic ranging module; the relay and motor driver directly connected to I/O port are used to

控制系统的设计

控制系统主要指数据的采集与控制、界面控制系统。参数的采集与控制系统，是由安装在食槽上的多个传感器检测出对应的参数，以 STC89C52 单片机为核心，完成对匀料电机 M1、输料电机 M2、直流减速电机 M3、食槽电机 M4~M8 等的控制，并经串口将相关的参数传回上位机。界面控制系统实现人机交互过程，完成对喂食时间的控制、食槽状态显示、疫病报警等功能。

数据的采集及控制

数据的采集及控制即指前述的控制中心，是以 STC89C52 单片机及其外围电路为核心，其控制原理如图 7 所示。图中，各个超声波测距模块对数据进行采集；与 I/O 口直接相连的继

control motors to complete corresponding feeding; the upper computer uses RS232 serial port to receive feedback data and send feeding parameters through MAX232 level switch and single chip. The initialized serial communication parameters are 9600 baud rates, 8 data bits and 1 stop bit without parity check bit.

电器、电机驱动用于控制电机完成相应喂食操作；上位机通过 RS232 串行口经 MAX232 电平转换与单片机实现通信，用于接收反馈数据和发送喂食参数，串口通信参数初始化为 9600 波特率、无奇偶校验位、8 数据位和 1 停止位。

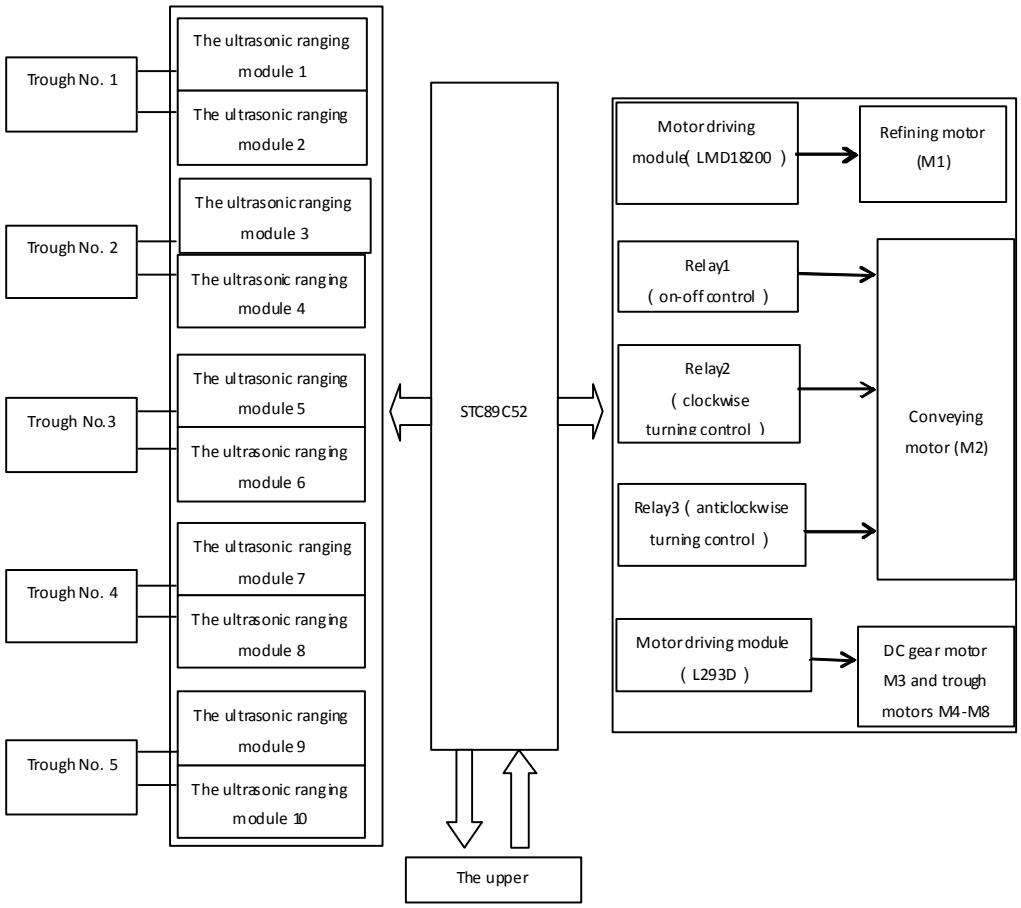

Fig. 7 - Principle of controlling system / *控制系统的原理*

Feedstuff quantity checking and feeding control

Feedstuff quantity checking and feeding control play a crucial role in improve the feeding accuracy and monitoring the trough state. Their steps include: (1) Upon receipt of the feeding signal, the control center will check the feedstuff quantity in each trough to see which trough has the set quantity; (2) The conveyor controlled by the control center begins to convey feedstuffs to each emptying device; (3) The control center opens the second gear switch of the emptying device to the trough in which the feedstuff quantity fails to reach the set value for releasing the feedstuffs; (4) The control center circularly checks the feedstuff quantity in each trough in proper order to see if they are up to the set value and close the second gear switch of the emptying device to the qualified troughs. If all the troughs are qualified, M1-M8 will be closed.

Design of the upper computer's feeding interface

Man-machine interaction interface is designed for the upper computer through VB6.0. This interface has such functions like feeding setup, residual monitoring and warning and should be able to directly control and test the feeding system. It accesses to Microsoft access 2003 database through ADO component, helping user to effectively manage and save the data in real time [11].

料量检测与喂食控制

料量检测与喂食控制是实现提高喂食精度、监控食槽状态的关键，其工作步骤为：（1）控制中心收到喂食信号后，检测各个食槽中食料量，确定食料量达到设定量的食槽；（2）控制中心控制输料装置开始输送食料，食料由输料装置传输到各个漏料装置中；（3）控制中心打开食料量未达到设定量的食槽对应的漏料装置的第二开关装置开始漏料；（4）控制中心依次循环检测各个食槽中的食料量是否达到设定量，并关闭食料量达到设定量的食槽对应的漏料装置的第二开关装置停止漏料，当检测到所有的食槽中的食料量均达到设定量后，则关闭 M1～M8。

上位机喂食界面的设计

上位机选用 VB6.0 设计了友好的人机交互界面，交互界面设有喂食设置、食槽内饲料余量监测与报警等功能，能对喂食系统直接进行控制和检测。界面通过 ADO 组件访问后台 Microsoft access 2003 数据库，有效地实现了对数据实时管理和存储[11]。

Setting of feeding parameters

To facilitate user operation and meet the feeding requirements given by the chicken farms, the feeding setting system consists of two sub-systems, "quick setting" and "advanced setting". The "quick setting" sub-system is used to set parameter on the basis of the expert system in the database. It will operate feeding according to the experience of feeding parameters given by the expert system as long as the basic parameters (such as chicken age and type) are set by the user, further facilitating user operation and making the promotion of the intelligent feeding system easier. "Advanced setting" sub-system is used to set parameters according to the needs of the chicken farms. User can set the feeding time, feeding frequency and feeding quantity separately through this subsystem to meet their needs.

Real-time feeding monitoring and disease warning

To avoid disease and decide the feedstuff quantity, the system will check the residual feedstuffs in each trough to decide whether additional feedstuffs are needed and the added quantity and take the result as a measuring indicator of disease warning (in case of any epidemic disease, the residual will exceed the threshold value more than one time) [12][13]. When the system is powered on, it will monitor the feedstuffs in the troughs in real time, helping the user to get to know the feedstuff condition in the trough in real time. If the residual in certain trough is three times higher than the threshold value, hidden epidemic threat of the chickens using this trough or mechanical fault may exist. Under this situation, the system will send a warning single through characters and buzzer and locate the suspected trough. At the same time, user can check the historical data of this abnormality and feeding quantity for statistical analysis and quantity adjustment.

TESTING

Test conditions and methods

The test time is May and June and the test location is the chicken farm in Yucheng district, Ya'an city, Sichuan province. Table 2 shows the parameters of the mechanical structure and performance upon the actual test of R&D system. To demonstrate the objectivity of the test results, 3 types of feedstuffs and 15 three-month old chickens are used for testing. At the same time, to fully ensure the stability of man-machine interface and hardware system, an all-round software performance test for man-machine interface is conducted.

喂食设置参数的设定

为了方便用户进行操作及满足不同养鸡厂的喂食要求，喂食设置系统主要包括"快速喂食设置"和"高级喂食设置"两个子系统。其中，"快速喂食设置"子系统是基于数据库中的专家系统进行设置的，用户只需设置所养殖鸡类的基本参数（包括鸡龄、鸡种等信息），系统将根据专家系统提供的经验喂食参数进行喂食操作，大大方便了用户的操作，同时更加利于该设备的推广。"高级喂食设置"子系统是根据养鸡场的自身需求来设置的，用户能对喂食时间、喂食次数和喂食量等参数单独设定，以此满足不同的用户需求。

喂食实时监测及鸡病预警

为了预警鸡病、确定需喂食的饲料量，系统在每次喂食时都会检测每个食槽内饲料的剩余量，以此判断是否需要添加饲料以及需要添加的饲料量，同时也作为鸡病预警的一个衡量指标(若存在疫病，饲料剩余量会多次大于阈值)[12][13]。该系统在上电的过程中，系统可以对食槽中的饲料量进行实时监测，方便用户实时了解食槽中饲料情况。此外，若某食槽中饲料剩余量超过阈值 3 次，则说明相应食槽的鸡群可能有鸡病隐患或者机械故障，系统会以出现报警字符和蜂鸣器鸣叫的形式向用户发出警告，定位可疑食槽。同时用户可以查询异常情况的历史数据及喂食量的历史数据，方便用户进行统计及喂食量的调整等。

试验测定

实验条件与方法

试验时间在 5～6 月，试验地点选在四川省雅安市雨城区养鸡场。经过对研发系统的实际测试，其机械结构性能参数如表 2 所示。为了体现测试结果的客观性，测试共采用了 3 种类型的鸡饲料，15 只 3 个月月龄的鸡进行测试，同时在人机交互界面中进行了全方面的软件性能测试，充分保证人机交互界面及硬件系统的稳定性。

Table 2 / *表 2*

Performance parameters of whole machine / *整机性能参数*

Net weight of mechanical structure /*机械结构净质量*	Mechanical structure size /*机械结构尺寸*	Rated power /*额定功率*	Rated voltage /*额定电压*	Rated current /*额定电流*	Storage battery capacity /*蓄电池容量*	Diameter of emptying pipe /*漏料管道直径*	Parameter of refining pusher /*匀料推杆参数*
44.2kg	1.73m×0.55m ×2.6m	60w	12v	5A	960VAH	4cm	220cm×6cm×0.3cm
Length of main pipe /*主管道长度*	**Diameter of the emptying hole of main pipe /*主管道漏料口直径***	**Single trough capacity /*单个食槽容量***	**Number of trough /*食槽数量***	**Trough parameter /*食槽参数***	**Storage tower capacity /*储料塔容量***	**Number of ultrasonic sensors on one trough /*单槽上超声波传感器数量***	**Total number of ultrasonic sensors /*超声波传感器总数***
1.98m	6cm	1kg	5	39cm×8cm×10cm	30L	2	10

Result analysis

Tables 3 and 4 show the results of feeding accuracy test and feeding efficiency test. Feeding accuracy means the ratio of actual feedstuff quantity and desired feedstuff quantity. Feeding efficiency means the feedstuff quantity released by the system each hour (Unit: kg/h).

结果分析

喂食系统精确度测试表，投食效率测试表如表 3~4 所示，其中投放精度定义为实际投放的饲料量与期望的饲料量之比，投食效率定义为每小时系统投放的饲料量，单位为 kg/h。

Table 3 / *表 3*

Feeding accuracy test / *饲料投放精度测试*

Feedstuff quantity/g */饲料投放量*	Feeding accuracy of the traditional machine */传统机械喂食精度*	Feeding accuracy of this system */本系统喂食精度*
1000g	0.70~0.75	0.90~0.99
500g	0.80~0.85	0.92~0.99
300g	0.80~0.85	0.92~0.99
200g	0.80~0.85	0.92~0.99
100g	0.70~0.75	0.92~0.99

Feeding accuracy test in table 3 demonstrates that the quantitative feeding accuracy of this feeding system is relatively high and better than that of the traditional mechanical feeding system.

表 3 的饲料投放准确度测试表表明，该喂食系统在定量喂食精度上准确度较高，优于传统机械式的喂鸡系统。

Table 4 / *表 4*

Feeding efficiency test / *投食效率测试*

Type of feedstuff */饲料种类*	Traditional machine */传统机械投食*	This system */本系统投食*
1#	100 kg/h	185 kg/h
2#	100 kg/h	160 kg/h
3#	100 kg/h	140 kg/h

Note: The feedstuffs are granular. See above for feedstuff type.

In table 4, the granular sizes of 1#, 2# and 3# are presented from small to big. The test result demonstrates that the feeding efficiencies for different types of feedstuffs are basically the same when traditional system is used, while the feeding efficiencies vary with granular sizes when this system is used. The smaller the size is, the higher the feeding efficiency is. As the feeding efficiency of this system is higher than that of the traditional system, the operation effectiveness is improved.

注：饲料均采用颗粒饲料，种类见上

表 4 中，1#、2#和 3#的饲料颗粒尺寸是由小变大的趋势。试验结果表明传统机械式喂鸡系统在不同饲料品种情况下投食效率相当，而本系统则根据饲料颗粒的大小不同，投食效率不同，颗粒越小，投食效率越高，并且投食效率均比传统纯机械式的喂鸡系统要高，提高了作业实施的有效性。

CONCLUSIONS

The intelligent feeding system in this article integrates the basic functions of charging, conveying, feeding at regular time and quantity and residual checking and the extended functions of epidemic warning and feedstuff warning. It can offset the shortages of the existing feeding device such as single function and dispersed structure to meet the feeding requirements on an intelligent basis.

(1) The mass of the model machine is 44.2kg, which can feed 15 chickens and takes about 15s in feeding, greatly increasing the feeding speed.

(2) This system is a full automatic working system with the feeding accuracy of 90-99%, higher than that of the traditional machine (which is only 70-85%); the feeding efficiency is 1.4-1.9 times higher than that of traditional machine.

(3) The system is equipped with favorable man-machine interface, which facilitates user operation and can provide such functions like epidemic warning, abnormality positioning, user warning and timely check the abnormal position to see if the epidemic disease exists.

结 论

本文研制的智能喂食系统，实现了集进料、输料、定时定量喂料、剩料检测为一体的基本功能，并实现了集疫病预警、饲料预警等为一体的扩展功能，弥补了现有喂料装置功能单一、结构分散的缺点，从而达到智能喂食的要求。

1）样机的质量为 44.2kg，可实现 15 只左右鸡的喂食，完成一次喂食所需的时间约 15s，大大提高了喂食速度。

2）本系统采用全自动操作，饲料量的投放精度为 90~99%，高于传统机械喂食的精度 70~85%；本系统的投食效率为传统机械投食的 1.4~1.9 倍。

3）该系统拥有友好的人机交互界面，方便用户的操作，还可以提供疫病预警功能，定位异常位置，提醒用户及时排查该位置的鸡群是否存在疫病。

As the system has better feeding accuracy and working efficiency compared with those of manual feeding, it offsets the shortages of the traditional machine such as poor automation, low efficiency and inaccurate feeding. Besides, it is featured by lower cost and is able to feed chickens in an efficient and scientific manner, better preventing epidemic disease.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the support from the key natural science project of Sichuan education department under the grant number of 12ZA277 and the national innovation experiment fund of China.

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该系统在喂食精度和工作效率等方面均高于人工喂食方式，弥补了传统机械式装置自动化程度低，工作效率低，喂食精度不高的缺陷，并且成本较低，具备高效率喂食、科学喂食和鸡群疫病预警等功能。

致谢

本文受四川省教育厅自然科学重点项目（12ZA277）和大学生科研兴趣项目资助。

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ANALYSIS OF THE CUTTER PROFILE IN SLIDE CUTTING AT SELF-LOADING FODDER TRAILERS
/
DETERMINAREA PROFILULUI CUȚITULUI LA REMORCILE AUTOÎNCĂRCĂTOARE FURAJE FIBROASE LA TĂIERE CU ALUNECARE

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Abstract: *To achieve high efficiency in exploiting the existing agricultural harvesting machines and gathering fibrous fodder the specialists should be always preoccupied to improve these machines performance. This is possible through careful consideration of each working process, performed by the machine, which at its turn should lead to ideal values. In this paper we have proposed improvements of cutter grinding operation, comprising the self loading trailers.*

Keywords: *cutter profile*

INTRODUCTION

Shredding, chopping fibrous fodder is considered a complex technological process, not to mention a very expensive operation. Choosing a random profile knife can increase these costs. To reduce energy losses caused by the improper shredding blade used, we considered important to study and research the cutting phenomenon [1, 2, 3, 4, 5, 6].

We analyzed the movement of a material point along the cutter edge which is located in the intake channel for fibrous fodder shredding, under certain conditions.. So, we want to achieve a universal blade profile usable to the self-loading fodder trailers.

MATHERIAL AND METHOD

Starting from the cutting process carried out along the intake channel of a self-loading fodder trailer we can graphically represent this in the next image (fig. 1):

Rezumat: *Pentru a obține un randament ridicat în exploatarea maşinilor agricole existente în domeniul recoltatului şi adunatului furajelor fibroase, trebuie în permanență să existe preocupari din partea specialiştilor de a le îmbunătății performanțele ale acestora. Acest lucru este posibil printr-o analiză atentă al fiecărui proces de lucru, în parte, executat de maşină, care la rândul lui trebuie să tindă către valori ideale. În această lucrare am propus îmbunătățiri la funcționarea cuțitului de mărunțire, care intră în componența remorcilor autoîncărcătoare de furaje.*

Cuvinte cheie: *profilul cuțitului*

INTRODUCERE

Mărunțirea, tocarea furajelor fibroase se consideră un proces tehnologic complex şi nu în ultimul rând o operațiune extrem de costisitoare. Alegerea unui profil de cuțit la întâmplare poate sporii aceste costuri. Pentru a reduce pierderile energetice cauzate de utilizarea cuțitelor necorespunzatoare la mărunțirea furajelor fibroase, am considerat important studiul şi cercetarea fenomenului de tăiere [1, 2, 3, 4, 5, 6].

Se urmăreşte analiza deplasării unui punct material pe tăişul cuțitului aşezat în canalul de mărunțire a furajelor fibroase în anumite condiții. Astfel, dorim să obținem profilul cuțitului universal utilizabil la remorcile autoîncărcătoare furaje.

MATERIAL ŞI METODĂE

Pornind de la procesul de tăiere ce se petrece într-un canal de alimentare al unei remorci autoîncărcătoare furaje, se poate afirma că acest lucru se reprezentă în mod schematic conform fig.1.

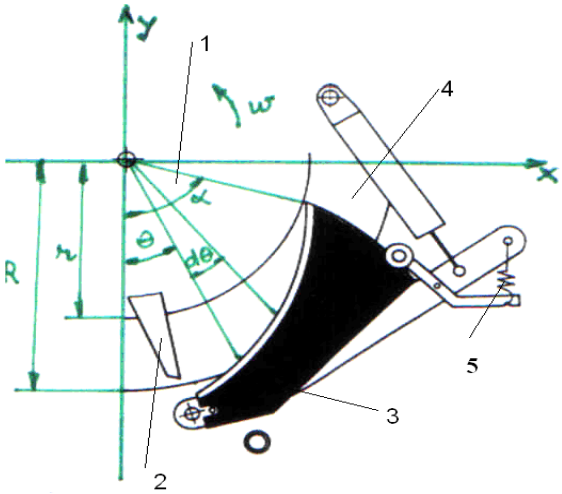

Fig. 1 - The cutting process carried out along the intake channel of a self-loading trailer /
Reprezentarea schematică a procesului de tăiere din canalul de alimentare al unei remorci autoincărcătoare furaje

The chopping drum 1 has been featured with parallel counter blades 2 U shaped, set so that the main cutter 3 placed in intake compartment 4 can pass between them.

Toba de tocare, notată cu 1 este echipată cu contracuțite 2, care sunt de forma literei,,u" paralele, aşezate astfel încât printre ele să poată să treacă cuțitul propriu-zis 3, care este aşezat în canalul de alimentare 4.

The blades are regularly jointed depending on the targeted tehnological demands, and can be inserted or removed from the intake channel, their number being able to oscillate depending on:

- the forage type;
- the forage's humidity at cutting time;
- the agricultural and livestock standards;
- preservation method used before giving it for consume

This jointing system 5 also protects the cutters from destruction or damage in the event of coming against rough materials in the intake channel.

The rotation of the chopping drum should be marked by ω, and the radiuses are according to R marking the radius of the chopping drum featured with counter blades r represents the radius of the drum. During the rotation of the cutting barrel the counter blades grab the forage material and pass it over the cutter set in the intake channel. The cutting process is optimum if we have a latitudinal and longitudinal movement which describes the slide cutting.

RESULTS

After choosing the cutting method we need to estabilish the cutter's profile that will permit the execution of the chosen work conditions.

By analyzing the movement of a material unit on the cutter's blade, forced by the counter blade, with the center in the turning center of the cutting drum, in a XOY coordinates system, we find that:

- slide cutting is performed at each angular displacement dθ if there is a radial displacement dδ

Cuțitele de regulă sunt articulate, în funcție de cerințele tehnologice urmărite se pot introduce sau scoate din canal de alimentare, numărul lor variază în strânsă legătură cu:

- felul furajului;
- umiditatea acestuia în momentul mărunțirii;
- cerințele agro-zootehnice impuse;
- modalitatea de conservare al acestuia înainte de a da în consum.

Acest sistem de articulare 5, permite totodată salvarea de la distrugere sau avarierea cuțitelor caz de pătrundere în canalul de alimentare a unor piese metalice şi a pietrelor sau alte materiale dure.

Rotația tobei de tocare se notează cu ω, iar razele sunt după cum urmează R raza tobei de tocare echipat cu contracuțit, r reprezintă raza tobei propriu-zisă. În cazul rotirii tobei, contracuțitul apucă materialul furajer şi tinde să treacă peste cuțitul aşezat în canalul de alimentare. Procesul de tăiere se desfăşoară în condiții bune dacă se realizează deplasarea cuțitului atât pe direcția radială, cât şi pe direcția transversală, ceea ce reprezintă de fapt tăierea cu alunecare.

REZULTATE

După stabilirea tipului de tăiere, trebuie să stabilim şi profilul cuțitelor care ne va permite executarea regimului de lucru ales.

Analizând mişcarea unui punct material, care se deplasează pe tăişul cuțitului, forțat de contracuțit, într-un sistem de coordonate XOY, cu centrul ales în centrul de rotație a tobei de tocare:

- se realizează tăierea cu alunecare dacă la fiecare deplasare unghiulară dθ are loc o deplasare radială dδ

$$\frac{\delta d\theta}{d\delta} = k, \tag{1}$$

- k is a constant value showing the ratio between forces that operate vertically and horizontally in slide cutting

- k este o valoare constantă, reprezentă factorul de tăiere cu alunecare

$$d\theta = k\frac{d\delta}{\delta}, \tag{2}$$

by multiplying the above equality we get:

înmulțind egalitatea de mai sus cu dt, se obțin:

$$\frac{d\theta}{dt}dt = k\frac{d\delta}{\delta}, \tag{3}$$

$$\omega dt = k\frac{d\delta}{\delta} \tag{4}$$

where:

ω is the angle rotation speed of the drum;

δ is the measured length from O (the center of the coordinates axes that is the same with the center of the rotation of drum) to the material unit that moved on the cutter's blade;

θ the angle formed by the material unit in the XOY coordinate system during the movement along the cutter's blade from the beginning to the end of the cut.

By fitting this ratio in, we get:

unde:

ω este viteza unghiulară a tobei;

δ este lungimea măsurată din punctul O (centrul axelor de coordonate ce coincide cu centrul de rotație a tobei) până la punctul material care s-a deplasat pe tăişul cuțitului;

θ unghiul realizat în sistemul de coordonate XOY de punctul material în timpul deplasării pe tăişul cuțitului socotit de la începerea tăierii, până la terminarea tăierii.

Integrând această relație, se obține:

$$\omega\int_{o}^{i} dt = k\int_{R}^{\delta}\frac{d\delta}{\delta}, \tag{5}$$

$$\int_{0}^{i} dt = \frac{k}{\omega}\int_{R}^{\delta}\frac{d\delta}{\delta}, \tag{6}$$

where:

i = $\frac{k}{\omega}\ln\frac{\delta}{R}$, it results the movement of the material unit on the cutter's blade ratio, which is the curve that determines the cutter's profile:

unde:

i = $\frac{k}{\omega}\ln\frac{\delta}{R}$, de unde rezultă ecuația de mişcare a punctului material pe tăişul cuțitului, adică curba care determină profilul cuțitului:

$$\delta = \mathrm{Re}^{\frac{\theta}{k}} \tag{7}$$

where :

unde:

$$\omega = \frac{\theta}{i}, \Rightarrow \theta = k\ln\frac{\delta}{R} \tag{8}$$

If were : $\theta = \alpha \Rightarrow \delta = r$, where r is the drum's radius (fig. 1) the above ratio becomes:

În cazul când $\theta = \alpha \Rightarrow \delta = r$, unde r este raza tobei (fig. 1), ecuația de mai sus devine de forma următoare:

$$r = \mathrm{Re}^{\frac{\alpha}{r}} \tag{9}$$

$$\frac{r}{R} = e^{\frac{\alpha}{k}} \tag{10}$$

$$\Rightarrow k = \frac{\alpha}{\ln\frac{r}{R}} \tag{11}$$

where: α represents the maximum angle where δ = r.

By replacing the ratio of the trajectory of the material unit movement on the cutter's blade we get:

unde: α reprezintă unghiul maxim la care δ = r.

Înlocuind în ecuația ce descrie traiectoria de mişcare a punctului material pe tăişul cuțitului, se obține:

$$\delta = \mathrm{Re}^{\frac{\theta}{\frac{\alpha}{\ln\frac{r}{R}}}} = \mathrm{Re}^{\frac{\theta}{\alpha}\left(\ln\frac{r}{R}\right)}, \tag{12}$$

$$\delta = \mathrm{Re}^{\ln\left(\frac{r}{R}\right)^{\frac{\theta}{\alpha}}} = R\left(\frac{r}{R}\right)^{\frac{\theta}{\alpha}}, \tag{13}$$

$$\Rightarrow \delta = R\left(\frac{r}{R}\right)^{\frac{\theta}{k\ln\left(\frac{r}{R}\right)}} \tag{14}$$

By obtaining the above ratio we can replace in order to check it some known values of good results obtained with existing farming machines.

The values of θ angle oscillate between 0 to 90^0, and usually are not higher than 70^0.

R represents the length of one of the counter blades; to which we add the r radius of the drum. R's value oscillates between broad limits, usually the necessary power for rotating the drum is considered, and also the forage type is considered, its humidity, so R = 250 – 450 mm, the lift – cutting barrel's values are situated between r = 150 – 350 mm.

K value that considers the cutting method used in the process oscillates between different values k = 1.8 – 2.25. This is normal as it is a force proportion between the forces that act vertically on the forage and the force that acts horizontally for moving the cutter, performing a slide cut. This requires a reduce use of forces performing a continuous cut without shock or vibrations.

This permits to manufacture equipment with enhanced working capacity without altering the quality required by the agricultural and livestock standards.

We can see that the extreme values of δ oscillate between maximum, when θ = 0, δ = R; and reach the minimum value when $\theta = \alpha, \delta = r$.

By representing these values on a graphic fig.2,

Obținând relația de mai sus, putem să înlocuim pentru verificarea ei unele valori cunoscute de la utilajele existente care au dat rezultate bune în exploatare.

Valorile unghiului θ oscilează între 0 şi 90°, iar în majoritatea cazurilor nu depăşeşte 70°.

R reprezintă lungimea degetului contracuțitului la care se adaugă raza r a tobei. Valoarea lui R oscilează între limite largi, de regulă se ține seama de puterea necesară pentru angrenarea tobei, de felul furajului care urmează a fi tocat, de umiditatea acestuia, etc., astfel R = 250 – 450 mm, valorile tobei de ridicare-tocare de regulă se regăsesc între r = 150 – 350 mm.

Valoarea coeficientului k care ține seama de tipul tăierii utilizat în cadrul procesului de lucru oscilează între diferite valori. Acest lucru este firesc, ținând cont că este vorba de un raport de forțe dintre cele care acționează pe verticală asupra furajului şi cele care acționează pe plan orizontal în vederea deplasării cuțitului, realizând o tăiere cu alunecare, care presupune un consum redus de forțe, realizarea tăieturii făcându-se continuu, fără şocuri şi vibrații.

Acest lucru ne permite construirea unor utilaje cu capacitate de lucru sporite, păstrând nealterat calitatea impusă de cerințele agro-zootehnice.

Se poate observa că valorile extreme a lui δ oscilează între maximă, când θ = 0, δ = R; minima atinge la valoarea $\alpha = \theta$, δ = r.

Reprezentând grafic aceste valori, figura 2., ținând

considering their oscillation scales, we can obtain and build the cutter's pofile.

For each precise value of R and r, by calculating k's values we will draw a number of curves of angle oscillation θ from 0 – 90^0.

seama de plajele de variație ale acestora, se reuşeşte obținerea şi construirea profilului cuțitului.

Pentru fiecare valoare exactă a lui R şi r, socotind valorile lui k se va trasa o familie de curbe pentru variații unghiulare θ de la 0 -90°.

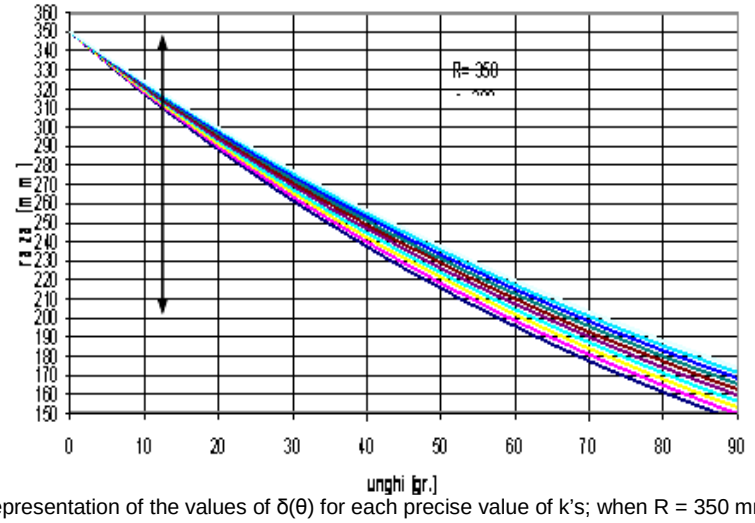

Fig. 2 – Graphical representation of the values of δ(θ) for each precise value of k's; when R = 350 mm and r = 200 mm / *Reprezentarea grafica a valorilor δ (θ) pentru fiecare valoare exactă a k; atunci când R = 350 mm şi r = 200 mm*

CONCLUSIONS

By studying the research made on the cutter's profile obtained by slide cutting we found the following:

- due to low consumption of specific cutting force per unit area in machine operation is performed minimum fuel consumption compared to similar machines not using this type of knife;
- shocks significantly decreased during the cutting in the supply channel of the machine, because cutting is performed on the entire length of the blade by continously moving the fodder on the knife edge, while there is also a pressing force perpendicular to the knife edge (slide cutting);
- a fodder minced at lengths according to requirements and standards of modern livestock agriculture is obtained.

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CONCLUZII

Cercetările în scopul realizării unui profil de cuțit universal utilizabil, au fost finalizate cu obținerea unui profil care are următoarele avantaje în exploatare:

- datorită consumului mic de forță de tăiere specifică pe unitate de suprafață, în funcționarea utilajului se realizează un consum minim de combustibil, față de utilaje asemănătoare care nu utilizează acest tip de cuțit;
- s-a redus considerabil şocurile produse în timpul executării tăierilor în canalul de alimentare al utilajului, deoarece tăierea se realizează pe întreagă lungime a cuțitului, prin deplasarea continuă a materialului furajer pe tăişul cuțitului, totodată existând şi o forță de presare perpendiculară pe tăişul cuțitului (tăiere cu alunecare);
- se obține un furaj mărunțit la lungimi corespunzătoare cerințelor şi standardelor agro-zootehnice moderne.

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EXPERIMENTAL RESEARCH OF WORKING PROCESS OF PNEUMATIC INTAKE DEVICE FOR SAPROPEL EXTRACTION
/
ЕКСПЕРИМЕНТАЛЬНІ ДОСЛІДЖЕННЯ РОБОЧОГО ПРОЦЕСУ ПНЕВМАТИЧНОГО ЗАБІРНОГО ПРИСТРОЮ ДЛЯ ДОБУВАННЯ САПРОПЕЛЮ

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Abstract: *An alternative source of maintaining soil fertility are sediments of freshwater lakes – sapropels. The pneumatic intake device allows to mine sapropel of natural humidity. To investigate the influence of process parameters on the performance and visual observation mode motion of the air flow of sapropel made experimental setup was made.*

Methodology of research in this setting is using mathematical method of experiment planning. This method developed for obtaining the mathematical model of the process in the form of the regression equation. It is also found that air flow of sapropel moves with shell structure.

Keywords: *sapropel, air, intake device, experimental setup, mode, mathematical model, regression equation*

Резюме: *Альтернативним джерелом підтримання родючості ґрунтів є донні відклади прісноводних озер – сапропелі. Добувати сапропель природної вологості дозволяє пневматичний забірний пристрій. Для дослідження впливу технологічних параметрів на продуктивність та візуального спостереження за режимом руху повітряно-сапропелевого потоку виготовлена експериментальна установка. Розроблена методика досліджень на даній установці із використанням математичного методу планування експерименту. Ця методика забезпечила отримання математичної моделі процесу у вигляді рівняння регресії. Також встановлено, що сапропеле-повітряний потік рухається із снарядною структурою.*

Ключові слова: *сапропель, повітря, забірний пристрій, експериментальна установка, режим, математична модель, рівняння регресії*

INTRODUCTION

To reduce resource of traditional organic fertilizers considerably increased the value of alternative species. For conditions in Polessie zone of Ukraine, should be considered as bottom sediments of freshwater basin-sapropels. But their wide use hampered by lack of environmentally safe and energy saving means for extracting.

During the development and design tools for the extraction of sapropel, should pay attention to the choice of rational design parameters of working bodies as well as take into account technological parameters of the material with which they interact. Proper selection of these parameters provides optimal modes of operation and increases the technical and economic indicators.

Use of pneumatic intake devices for the extraction of sapropel [1], [2] is a perspective development which is under investigation. In comparison with other known means for obtaining sapropel this development has several advantages, namely: the lack of need for draining the reservoir, the process can be easily automated, minor energy cost per unit of the material, reducing material consumption, the possibility of obtaining sapropel natural moisture continuity process, low maintenance. So, this development of intake device is commendable, but since it was the first proposed it requires laboratory and experimental researches related to the workflow.

In order to elucidate the influence of design and process parameters on the performance of pneumatic intake a device for extracting of sapropel [1] appropriate to apply the mathematical method of experiment planning was performed. This method allows to obtain the dependence of productivity of intake device of the factors in the form of the regression equation. Should be visually assess the structure of sapropel-type air flow that matches the values obtained productivity.

ПЕРЕДУМОВА

За скорочення ресурсу традиційних органічних добрив значно зростає значення альтернативних їх видів. Для умов Поліської зони України у такій якості слід розглядати донні відклади прісноводних водойм - сапропелі. Але широке їх використання стримується відсутністю екологічно безпечних та енергоощадних засобів для добування.

Під час розробки і проектування засобів для добування сапропелю, слід звернути увагу на вибір раціональних конструктивних параметрів їх робочих органів, а також враховувати технологічні параметри матеріалу з яким вони взаємодіють. Правильний підбір даних параметрів забезпечує оптимальні режими роботи та підвищує техніко-економічні показники.

Використання пневматичних забірних пристроїв для добування сапропелю [1], [2] є перспективною розробкою, яка перебуває на стадії дослідження. У порівнянні з іншими відомими засобами для добування сапропелю дана розробка має ряд переваг, а саме: відсутність потреби в осушенні водойми; процес легко піддається автоматизації; незначні енергетичні затрати на одиницю добутого матеріалу; зменшення матеріалоємності; можливість добування сапропелю природної вологості; неперервність процесу; низькі експлуатаційні витрати. Таким чином дана розробка забірного пристрою заслуговує позитивної оцінки, а оскільки вона запропонована вперше то потребує лабораторно-експериментальних досліджень пов'язаних з робочим процесом.

З метою встановлення закономірності впливу конструктивних та технологічних параметрів на продуктивність пневматичного забірного пристрою для добування сапропелю [1] доцільно застосувати математичний метод планування експерименту. Даний метод дозволяє отримати залежність продуктивності забірного пристрою від досліджуваних факторів у вигляді рівняння регресії. Також необхідно візуально оцінити вид структури сапропеле-повітряного потоку, яка відповідає отриманому значенню продуктивності.

MATERIALS AND METHOD

Since sapropel extraction occurs from underwater deposits, and the process takes place in an environment of deposits, so for a clearer understanding of the operation and structure of the flow in the laboratory condition was designed stationary experimental setup (Fig. 1).

МАТЕРІАЛИ ТА МЕТОДИКИ

Оскільки добування сапропелю відбувається з підводних родовищ, а сам процес проходить в середовищі покладів, тому для більш чіткого уявлення про режим роботи та структуру потоку в лабораторних умовах була сконструйована стаціонарна експериментальна установка (фіг. 1).

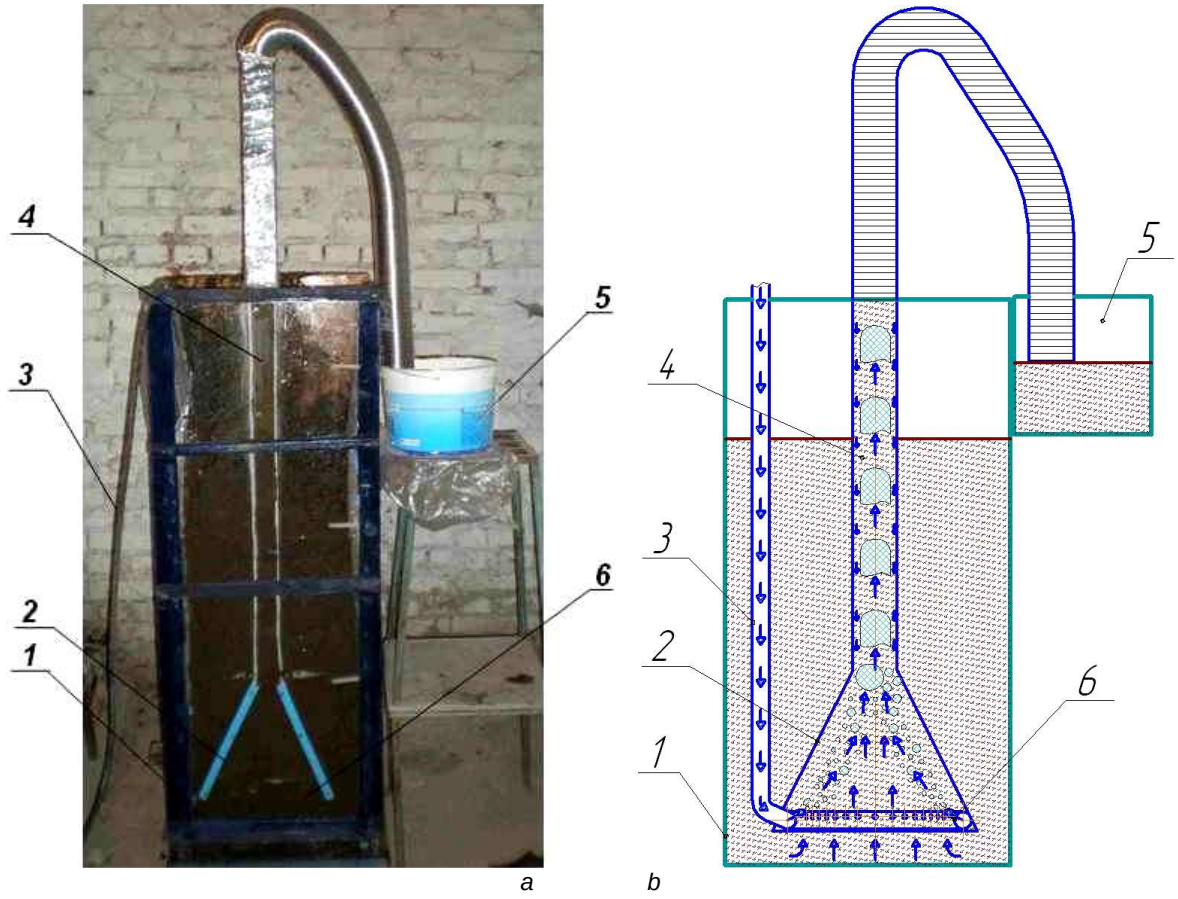


Fig. 1 - Experimental setup: a - picture; b - scheme / *Експериментальна установка: а – фото; b – схема*
1 – body / *корпус; 2* – cone breakdown / *конус у розрізі; 3* – manifold supply compressed air / *магістраль подачі стиснутого повітря; 4* – pipeline breakdown / *трубопровід у розрізі; 5* – measuring vessel / *мірна посудина; 6* – penstock with injectors / *напірний трубопровід з форсункам*

This setting provides body 1 as a reservoir the front wall of which is made of transparent plastic, and is designed for visual observation of the processes occurring in the environment of sapropel. Also, transparent to the front wall of the shell is tightly fastened (according to [1]) upright and longitudinal section (fig. 1). Intake device consists of a cone 2, at the bottom of which is fixed penstock 6 with jets. Cone attached to two vertical pipes 4. Supply of compressed air from the compressor to the injectors pressure pipe 6 is realized through magistral3. Income of sapropel from vertical pipe 4 to measuring vessel provided a flexible pipe.

Analysis of the literature and previous studies have found that the determining influence on performance of the device with sapropel layer height influenced by injection air pressure in operating process and the length of the transporting pipe.

So, three factorial experiment with changing factors at levels that are shown in the table 1 were performed.

Дана установка містить корпус 1 у вигляді ємкості, передня стінка якої виготовлена з прозорого пластику, і призначена для візуального спостереження за процесами, що відбуваються в середовищі сапропелю. Також до передньої прозорої стінки корпусу герметично кріпиться пневматичний забірний пристрій (відповідно до [1]) у вертикальному положенні та поздовжньому розрізі (фіг. 1). Забірний пристрій у свою чергу складається із конуса 2, у нижній частині якого закріплений напірний трубопровід 6 із форсунками. До конуса 2 приєднаний вертикальний трубопровід 4. Подача стиснутого повітря від компресора до форсунок напірного трубопроводу 6 здійснюється через магістраль 3. Надходження сапропелю із вертикального трубопроводу 4 до мірної посудини забезпечується пучкою трубою.

Аналіз літературних джерел та попередні досліджень дозволили встановити, що визначальний вплив на продуктивність роботи розглядуваного забірного пристрою мають висота шару сапропелю *l* з під якого ведеться добування, робочий тиск нагнітання повітря *P* , та довжина транспортуючого трубопроводу *h* .

Таким чином проводили 3–фактрний експеримент із зміною факторів на рівнях, які наведені у таблиці 1.

Table / Таблиця 1

Factors and their levels of variation / Фактори та рівні їх варіювання

Levels of variation / *Рівні варіювання*	Factors / Фактори		
	Working air pressure / *Робочий тиск повітря P , kPa*	Thickness of sapropel / *Товщина шару сапропелю l, m*	Length of pipeline / *Довжина трубопроводу h, m*
	x_1	x_2	x_3
Upper/ *Верхній (+1)*	300	1.3	2.0
Basic / *Основний (0)*	200	1.0	1.5
Lower / *Нижній (–1)*	100	0,7	1.0
Interval variation / *Інтервал варіювання, ε*	100	0.3	0.5

To reduce the number of experiments and obtaining the influence of the factors in a regression equation was applied mathematical method for planning the experiment and carried out an experiment by symmetric uncomposition plan of Boksa-Benkina of the second order [6].

Planning and conducting experiments included the following steps:

- encoding factors;
- scheduling matrix experiment;
- randomization tests;
- implementation plan of the experiment;
- test reproducibility of the experiments;
- calculation of regression coefficients;
- assessment of the significance of regression coefficients;
- adequacy test model.

Method of the experiment was as follows. Capacity installation completed sapropel humidity 92-94% at the height of its layer according to the plan of the experiment. The working pressure air supply plan defined experimental set adjusting valve compressor and controlled by the pressure gauge. To change the length of the transport pipeline have been used QUICK segments of pipe length of 0.3 m.

Then, turning on the air supply brought into force intake device. Due to the expense of energy air flow coming out of the nozzles, we can observe the loosening sapropel and its receipt by the vertical pipe. Further transportation sapropel is due to lift force upward air flow and strength of Archimedes. Detailed description of the principle of pneumatic intake device is shown in [3].

Through the transparent wall of the installation was conducted visual observation of the movement of material. Based on these observations estimated two-component structure of ascending currents flow.

The experiment consisted of 27 experiments by threefold repetition in each of them. Productivity was determined by weighing on laboratory scales sapropel that came in a pipeline measuring vessel within one minute.

RESULTS

Data processing threefold experiment was carried out on a PC designed program among Mathcad 14.

Some homogeneity of variances were tested by the criterion Kohrena. Since, $G^{calc.} = 0{,}313 < G^{tabl.}(0.05;15;2)$ $< G^{tabl.}(0.05;15;2) = 0.335$ [6] the process plays.

During the determining confidence intervals for regression coefficients used criterion of Student, tabular value is a 5 -% level of significance and the number of degrees of freedom of variance reproducibility experiment $f_1=2$ is = 4.3 [6].

Для скорочення кількості дослідів та отримання закономірності впливу досліджуваних факторів у вигляді рівняння регресії було застосовано математичний метод планування експерименту та здійснено експеримент за симетричним некомпозиційним планом Бокса–Бенкіна другого порядку [6].

Планування і проведення експерименту включало наступні етапи:

- кодування факторів;
- складання плану–матриці експерименту;
- рандомізація дослідів;
- реалізація плану експерименту;
- перевірка відтворюваності дослідів;
- розрахунок значень коефіцієнтів регресії;
- оцінка значущості коефіцієнтів регресії;
- перевірка адекватності моделі.

Методика проведення експерименту полягала в наступному. Ємкість установки заповнювали сапропелем вологістю 92–94% за висоти його шару відповідно до плану експерименту. Величину робочого тиску подачі повітря визначену планом експерименту встановлювали регулювальним вентилем компресора та контролювали за манометром. Для зміни довжини транспортуючого трубопроводу використовували швидкознімні відрізки труб довжиною 0,3 м.

Далі, вмикаючи подачу повітря, приводили в дію забірний пристрій. За рахунок дії енергії повітряного потоку, що виходив із форсунок, відбувається розпушення сапропелю та його надходження до вертикального трубопроводу. Подальше транспортування сапропелю відбувається за рахунок підіймальної сили висхідного повітряного потоку та сили Архімеда. Детальний опис принципу дії пневматичного забірного пристрою наведений в [3].

Через прозору стінку даної установки велись візуальні спостереження за рухом матеріалу. На основі цих спостережень оцінювалась структура висхідної течії двокомпонентного потоку.

Експеримент складався із 27-и дослідів за трикратної повторюваності у кожному з них. Продуктивність визначали зважуванням на лабораторних вагах сапропелю, що надійшов із трубопроводу в мірну посудину на протязі однієї хвилини.

РЕЗУЛЬТАТИ

Обробка даних трифакторного експерименту здійснювалась на ПЕОМ розробленою програмою у середовищі Mathcad 14.

При цьому однорідність ряду дисперсій перевіряли за критерієм Кохрена. Оскільки, $G^{ðî\ çð.} = 0{,}313 < G^{ò\ àáë.}(0.05;15;2) = 0.335$ [6] 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 $t=4.3$ [6].

Test the significance of regression coefficients was performed according to their confidence intervals and covariance.

As a result, the regression equation acquired form:

Перевірку значущості коефіцієнтів регресії проводили за встановленими їх довірчими інтервалами та коваріаціями.

У результаті рівняння регресії набуло вигляду:

$$y = 8,822 + 3,058x_1 + 5,387x_2 - 2,104x_3 - 0,415x_1^2 + 0,993x_2^2 - 0,39x_3^2 + 0,993x_1x_2 ,$$

where: x_1 - encoded value of air pressure;

x_2 - encoded value thickness of sapropel;

x_3 - encoded value length of the pipeline.

Adequacy of test hypotheses obtained by regression equation was performed by the Fisher criterion. The estimated value of this criterion in the dispersion of inadequacy $S^2_{inadeq.}$ =3,102 and dispersion S^2_y =0,028 reproducibility of the experiment was: $F^{calc.}$ =2,189. Tabular value of Fisher's exact test adopted by the 5 -% of significance, according to [6], was: $F^{tabl.}(0.05; f_2; f_1) = 19,38$, where f_2 = 7 number of degrees of freedom variance inadequacy $f_1 = 2$ - the number of degrees of freedom variance reproducibility experiment.

Since, $F^{calc.}$ =2,189< $F^{tabl.}(0.05; f_2; f_1) = 19,38$, the hypothesis by the adequacy of the regression equation is confirmed.

Final regression equation of the factors in the kind acquired form:

де: x_1 - кодоване значення робочого тиску повітря;

x_2 - кодоване значення товщини шару сапропелю;

x_3 - кодоване значення довжини трубопроводу.

Перевірку гіпотези адекватності отриманого рівняння регресії проводили за критерієм Фішера. Розрахункове значення даного критерію при дисперсії неадекватності $S^2_{\text{íåàä.}}$ =3,102 і дисперсії відтворюваності досліду S^2_y =0,028 становило: $F^{\text{ðîç.}}$ =2,189. Табличне значення критерію Фішера за прийнятого 5-% значущості, згідно [6], склало: $F^{\text{òàáë.}}(0.05; f_2; f_1) = 19,38$, де f_2 = 7 - число ступенів вільності дисперсії неадекватності; $f_1 = 2$ - число ступенів вільності дисперсії відтворюваності досліду.

Оскільки, $F^{\text{ðîç.}}$ =2,189< $F^{\text{òàáë.}}(0.05; f_2; f_1) = 19,38$, то гіпотеза адекватності рівняння регресії підтверджується.

Остаточно рівняння регресії із факторами у натуральному вигляді набуло вигляду:

$$Q = 3,54467 + 0,01408 \cdot P - 10,73 \cdot l + 0.472 \cdot h - 0,0000415 \cdot P^2 + 11,03333 \cdot l^2 - 1,56 \cdot h^2 + 0,0331 \cdot P \cdot l$$

where: P - the working pressure of air supply, kPa;

l - sapropel thickness is during the extraction, m;

h - pipe length of lifting sapropel, m.

To track dynamics of changes in productivity derived from regression equation was constructed a response surface (Fig. 2a) and its two-dimensional section of (Fig. 2, b, c, d)

Based on visual observation of the movement of sapropel-air flow is established that the structure of the flow is not homogeneous, but consists of large bubbles (shells) and sapropel congestion, which in turn contain the gas phase in the form of small bubbles. Shells and air plugs sapropel move alternately. In the wall film of the reverse movement sapropel. This means that this phenomenon obeys shell structure movement sapropel-air flow [4], [5].

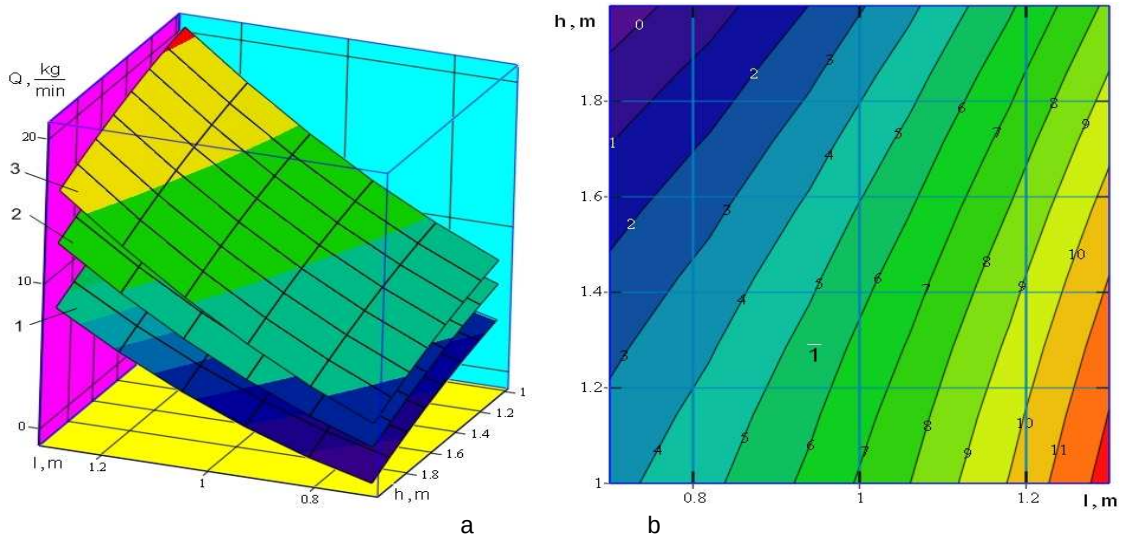
де: P - робочий тиск подачі повітря, кПа;

l - товщина шару сапропелю з під якого ведеться добування, м;

h - довжина трубопроводу підіймання сапропелю, м.

Для відслідковування динаміки зміни продуктивності за отриманим рівнянням регресії були побудовані поверхні відгуку (фіг. 2, а) та двомірні їх січення (фіг. 2, b, c, d)

На основі візуального спостереження за рухом сапропеле - повітряного потоку встановлено, що структура даного потоку не є гомогенною, а складається із великих бульбашок (снарядів) і сапропелевих пробок, які у свою чергу містять газову фазу у вигляді дрібних бульбашок. Снаряди повітря та пробки сапропелю рухаються почергово. У пристінній плівці відбувається зворотній рух сапропелю. Це означає, що дане явище підпорядковується снарядній структурі руху сапропеле-повіряного потоку [4], [5].



a b

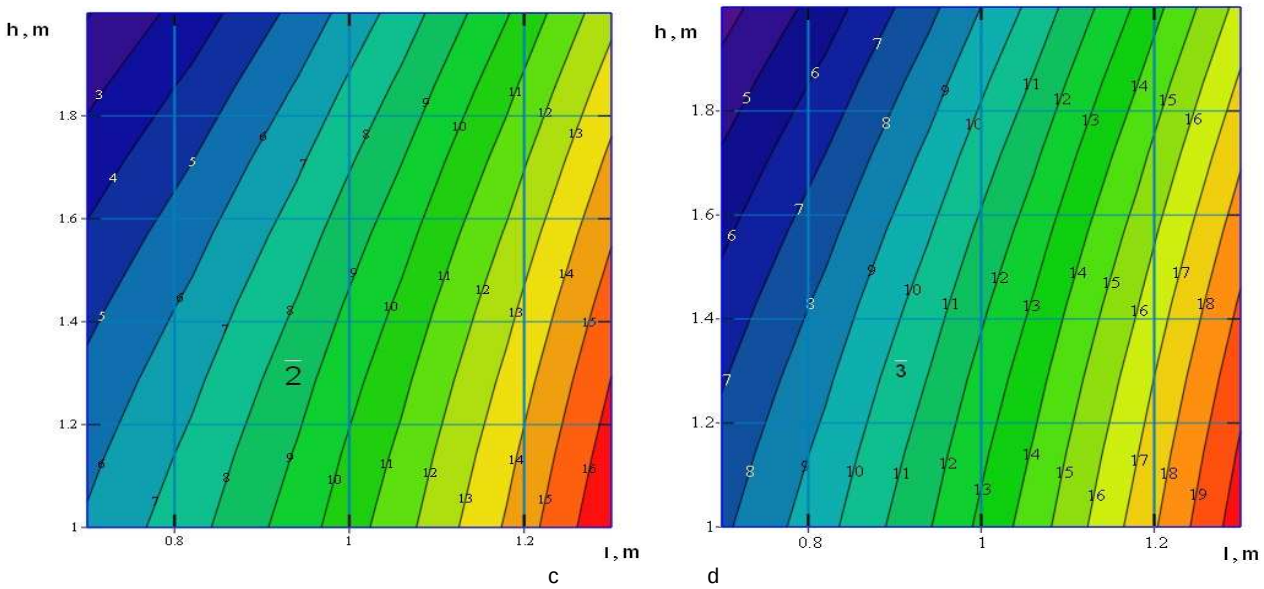


Fig. 2 - Dependence performance Q pneumatic intake device on the depth of sapropel *l* pipeline length h and a pressure air injection: 1 - P = 100 kPa, 2 - P = 200 kPa, 3 - P = 300 kPa /*Залежність продуктивності Q пневматичного забірного пристрою від глибини залягання сапропелю l та довжини трубопроводу h при тиску нагнітання повітря: 1 – P =100 кПа; 2 – P=200 кПа; 3 – P=300 кПа*

CONCLUSION

Analysis of the results shows that all the factors have a significant impact on pneumatic intake device. In all variants of the experiment with increasing air pressure performance of pneumatic intake device increases regardless of the depth and length of the pipeline sapropel. By increasing depth of sapropel device performance increases as the deposit of the force of the weight of the upper layers. Increasing the length of the pipeline transporting causes partial reduction performance of pneumatic intake device. However, this does not significantly affect the workflow as lifting sapropel from underwater deposits with a minimum thickness of water surface investigated range of lengths is sufficient.

Also, can be noted that the values of the investigated structural and technological parameters observed slug regime movement upward sapropel-air flow.

ВИСНОВОК

Аналіз отриманих результатів показує, що всі досліджувані фактори мають суттєвий вплив на продуктивність пневматичного забірного пристрою. У всіх варіантах досліду за збільшення тиску повітря продуктивність пневматичного забірного пристрою збільшується незалежно від глибини залягання сапропелю та довжини трубопроводу. За збільшення глибини залягання сапропелю, у досліджуваних межах, продуктивність пристрою зростає, оскільки на поклади діє сила ваги верхніх шарів. Збільшення довжини транспортуючого трубопроводу спричинює часткове зменшення продуктивності пневматичного забірного пристрою. Проте це суттєво не впливає на робочий процес, оскільки для підйому сапропелю з підводних родовищ із мінімальною товщиною водного дзеркала досліджуваний діапазон довжин є достатнім.

Також можна констатувати що за досліджуваних значень конструктивних та технологічних параметрів спостерігається снарядний режим руху висхідного сапропеле-повітряного потоку.

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RESEARCH OF THE PROCESS OF AERATION OF A LAYER OF BULK MATERIAL
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ДОСЛІДЖЕННЯ ПРОЦЕСУ ВЕНТИЛЮВАННЯ ШАРУ СИПКОГО МАТЕРІАЛУ

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Abstract: *The results of theoretical researches of the process of aeration of bulk material in the cylindrical drying chamber of the dryer [1] are suggested in the article.*

Keywords: *dryer, drying chamber, aeration, pressure loss, porosity*

INTRODUCTION

During convective drying the agent of drying (hot air) contacts with wet material and imbibes its moisture. A layer of bulk material resists to passing of drying agent through it. The research of the process of aeration of a layer of bulk material in the suggested dryer [1] will allow to substantiate the rational mode and constructive parameters of the dryer.

MATERIALS AND METHOD

A layer of bulk material which is filled in the cylindrical drying chamber of the dryer [1].

RESULTS

The construction of a dryer [1] with the cylindrical drying chamber (Fig.1) formed by outer cylindrical perforated wall and inner cylindrical perforated wall was suggested. Inner perforated wall is intended to supply of drying agent into the drying chamber. In the drying chamber spiral activators are mounted. The spiral activators are intended for loosening and agitation of material during drying process.

For research of aeration of a layer of bulk material in the dryer of this construction the following assumptions were accepted:

- the material is in a loosened condition [2] during aeration (drying);
- as a result of loosening of material with spiral activators its porosity increases

$$\varepsilon_{сп} < \varepsilon = f(n, k, D, a, d, \varepsilon_{сп}),$$

where: n – the frequency of rotation of the activator, [min^{-1}];
k – the pitch of the helix, [m];
D – the diameter of the spiral, [m];
a – the center distance between adjacent activators, [m];
d – the diameter of generatrix of a turn of the helix, [m];
$\varepsilon_{сп}$ – porosity of material in stationary state.

- drying agent after passing through the inner perforated wall moves to the periphery of the drying chamber perpendicularly to the axis of the cylindrical drying chamber;
- specific mass of drying agent that passes through the layer of material is assumed to be constant at any point of the material, the amount of air supplied to the drying chamber through the inner perforated wall per unit of time is equal to the amount of drying agent, leaving the drying chamber through the outer perforated wall, the velocity of drying agent decreases by its movement from the inner to the outer perforated wall of the drying chamber;
- porosity of material ε varies by the height of the drying chamber due to compaction of material under its own weight. The relationship between the pressure of the material and its porosity are described by a linear law.

Резюме: *В статті представлено результати теоретичних досліджень процесу вентилювання сипкого матеріалу в циліндричній сушильній камері сушарки [1]*

Ключові слова: *сушарка, сушильна камера, вентилювання, втрата тиску, шпаруватість*

ПЕРЕДУМОВА

В процесі конвективного сушіння сушильний агент (нагріте повітря) контактує з вологим матеріалом, відбираючи в нього вологу. Шар сипкого матеріалу, крізь який проходить сушильний агент, чинить опір його проходженню. Дослідження процесу вентилювання шару сипкого матеріалу в запропонованій сушарці [1] дозволить обґрунтувати раціональні режимні і конструктивні параметри сушарки.

МАТЕРІАЛИ ТА МЕТОДИКИ

Шар сипкого матеріалу, що заповнює циліндричну сушильну камеру сушарки [1].

РЕЗУЛЬТАТИ

Запропонована конструкція сушарки [1], циліндрична сушильна камера якої (Fig.1) утворена зовнішньою циліндричною перфорованою стінкою і внутрішньою циліндричною перфорованою стінкою. Внутрішня перфорована стінка призначена для підведення сушильного агента в сушильну камеру. В сушильній камері встановлені спіралеподібні активатори. Вони призначені для розпушування і перемішування матеріалу в процесі сушіння.

Для дослідження процесу вентилювання шару сипкого матеріалу в сушарці даної конструкції було прийнято наступні допущення:

- в процесі вентилювання (сушіння) матеріал перебуває в розпушеному стані [2];
- в результаті розпушування матеріалу спіралеподібними робочими органами збільшується його шпаруватість

$$\varepsilon_{сп} < \varepsilon = f(n, k, D, a, d, \varepsilon_{сп}),$$

де n – частота обертання активатора, [$хв^{-1}$];
k – крок спіралі, [м];
D – діаметр спіралі, [м];
a – міжосьова відстань між сусідніми активаторами, [м];
d – діаметр твірної витка спіралі, [м];
$\varepsilon_{сп}$ – шпаруватість матеріалу у стані спокою.

- сушильний агент після проходження крізь внутрішню перфоровану стінку рухається до периферії сушильної камери перпендикулярно до осі циліндричної сушильної камери;
- питома маса сушильного агента, що проходить крізь шар матеріалу приймається постійною у будь-якій точці матеріалу, кількість повітря, що подається в сушильну камеру через внутрішню перфоровану стінку за одиницю часу, рівна кількості сушильного агента, що виходить з сушильної камери через зовнішню перфоровану стінку, при цьому швидкість сушильного агента зменшується при його переміщенні від внутрішньої до зовнішньої перфорованої стінки сушильної камери;
- шпаруватість матеріалу ε неоднакова за висотою сушильної камери внаслідок ущільнення матеріалу під власною вагою. Зв'язок між тиском на матеріал і його шпаруватістю описується лінійним законом.

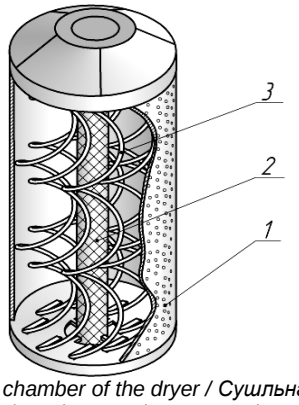


Fig. 1 – *The drying chamber of the dryer / Сушильна камера сушарки*
1 – outer perforated wall of the drying chamber / *зовнішня перфорована стінка сушильної камери;* 2 – inner perforated wall of the drying chamber for supplying of drying agent / *внутрішня перфорована стінка сушильної камери для подачі сушильного агента*; 3 –spiral activators for loosening and agitation of material / *спіральні активатори для розпушування і перемішування матеріалу*

Consider a layer of material with a constant cross section, conventionally limited by two parallel planes (flat layer) through which the gas stream passes. The loss of pressure in this layer of material can be determined by the formula of Koseni-Carman [3]:

Розглянемо шар матеріалу з постійним перерізом, умовно обмежений двома паралельними площинами (плоский шар), крізь який проходить газовий потік. Втрату тиску в цьому шарі матеріалу можна визначити за формулою Козені-Кармана [3]:

$$\Delta p = K \cdot l \cdot \left(\frac{(1-\varepsilon)^2}{\varepsilon^3} \right) \cdot s_y^2 \cdot \mu \cdot \omega_0 \,, \qquad (1)$$

where: Δp – the loss of pressure in the layer of material, [Pa];
K – the Koseni-Carman constant, K=4,5…5;
l – thickness of the material in the direction of the gas flow, [m];
ε – relative porosity of a layer of material;
s_y – specific surface area of material, [m^2/m^3];
μ – dynamic viscosity coefficient, [Pa·s];
ω_0 – brought flow velocity, [m/s].

де: Δp – втрата тиску в шарі матеріалу, [Па];
K – стала Козені-Кармана, K=4,5…5;
l – товщина шару матеріалу в напрямку подачі газу, [м];
ε – відносна пористість шару матеріалу;
s_y – питома поверхня матеріалу, [м^2/м^3];
μ – динамічний коефіцієнт в'язкості, [Па·с];
ω_0 – приведена швидкість потоку, [м/с].

Consider a layer of bulk material, which is limited by the outer and the inner cylindrical walls of the dryer of the suggested construction (Fig. 2). During the drying, the agent of drying moves through this layer of material (cylindrical layer) from the inner perforated wall of the drying chamber to the periphery. Assuming that the amount of drying agent that inlets a layer of material is equal to the amount of drying agent at the output of a layer of material and the specific mass of the drying agent is constant at all volume of material, the speed of drying agent ω_l at any point x of material as a function of coordinate of the drying chamber radius can be represented as:

Розглянемо шар сипкого матеріалу, який обмежений зовнішньою і внутрішньою циліндричними стінками сушарки запропонованої конструкції (рис.2). Крізь цей шар матеріалу (циліндричний шар) в процесі сушіння проходить сушильний агент у напрямку від внутрішньої перфорованої стінки сушильної камери до периферії. За умови, що кількість сушильного агента на вході в шар матеріалу рівна кількості сушильного агента на виході з шару матеріалу, а питома маса сушильного агента є постійною за всім об'ємом матеріалу, швидкість сушильного агента ω_l в будь-якій точці x матеріалу як функцію від координати радіуса сушильної камери можна записати у вигляді:

$$\omega_x = \frac{\omega_0 \cdot r_0}{r_0 + l_x} \qquad (2)$$

where: r_0 – the inner radius of the drying chamber, [m];
l_x – the difference between the coordinate of the point x and the inner radius of the drying chamber, [m];
ω_0 – brought velocity of a flow at the inlet of material, [m].

де r_0 – внутрішній радіус сушильної камери, [м];
l_x – різниця між координатою точки x і внутрішнім радіусом сушильної камери, м;
ω_0 – приведена швидкість потоку на вході в матеріал, [м].

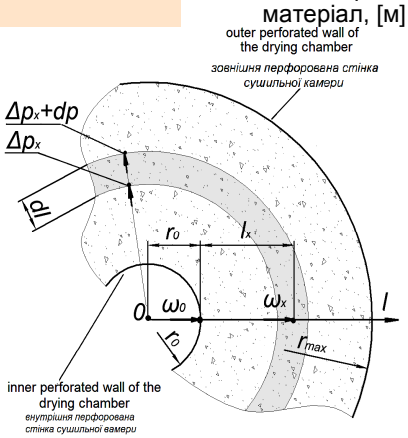


Fig. 2 – *Determination of the velocity and the pressure loss of drying agent / Визначення швидкості і втрати тиску сушильного агента*

Loss of pressure in the elementary thin layer of material:

Втрата тиску в елементарному тонкому шарі матеріалу:

$$dp = \left(K \cdot l_x \cdot \left(\frac{(1-\varepsilon)^2}{\varepsilon^3} \right) \cdot s_y^2 \cdot \mu \cdot \frac{\omega_0 \cdot r_0}{r_0 + l_x} \right) dl \,. \quad (3)$$

Integrate and define the loss of pressure $\Delta p_{ц}$ of cylindrical layer of any thickness $l = r_{\max} - r_0$.

Проінтегруємо і встановимо втрату тиску $\Delta p_{ц}$ циліндричного шару довільної товщини $l = r_{\max} - r_0$.

$$\Delta p_{ц} = \int \left(K \cdot l \cdot \frac{(1-\varepsilon)^2}{\varepsilon^3} \cdot s_y^2 \cdot \mu \cdot \frac{\omega_0 \cdot r_0}{r_0 + l_x} \right) dl \,,$$

$$\Delta p_{ц} = K \cdot \frac{(1-\varepsilon)^2}{\varepsilon^3} \cdot s_y^2 \cdot \mu \cdot \omega_0 \cdot r_0 \cdot \left(l - r_0 \cdot \ln(|l + r_0|) \right) + C \,, \quad (4)$$

where: *C* – the constant of integration

Determine the constant of integration if at *l*=0 pressure loss $\Delta p_{ц} = 0$.

де *C* – стала інтегрування.

Знайдемо сталу інтегрування, якщо при *l*=0 втрата тиску $\Delta p_{ц} = 0$.

$$C = K \cdot \frac{(1-\varepsilon)^2}{\varepsilon^3} \cdot s_y^2 \cdot \mu \cdot \omega_0 \cdot r_0^2 \cdot \ln(|r_0|) \quad (5)$$

Substituting (5) into (4) after simplification we obtain:

Підставивши (5) в (4) після спрощення отримаємо:

$$\Delta p_{ц} = K \cdot \frac{(1-\varepsilon)^2}{\varepsilon^3} \cdot s_y^2 \cdot \mu \cdot \omega_0 \cdot r_0 \cdot \left(l - r_0 \cdot (\ln(|l + r_0|) + \ln(|r_0|)) \right) \quad (6)$$

Expression (6) allows to determinate the loss of pressure of drying agent as the result of passing it through a layer of material in the cylindrical drying chamber of the dryer.

Determine the change of porosity of the material by the height of the layer.

Law of compaction in differential form looks like [4]:

Вираз (6) дозволяє встановити втрату тиску сушильного агенту в результаті проходження його крізь шар матеріалу в циліндричній сушильній камері сушарки.

Визначимо зміну пористості матеріалу за висотою шару.

Закон ущільнення в диференційній формі має вигляд [4]:

$$d\varepsilon = -a_0 \cdot dp \,, \quad (7)$$

where: a_0 – the compression coefficient.

$d\varepsilon$ – the change of the coefficient of porosity with the infinitely small pressure change *dp*.

Assuming that the pressure of the upper layers of material on lower ones is insignificant the porosity of material in some point *y* can be determined by compaction law for the straight-line section of compression curve [4]:

де: a_0 – коефіцієнт стискуваності.

$d\varepsilon$ – зміна коефіцієнту шпаруватості при нескінченно малій зміні тиску *dp*.

Приймаючи, що сила тиску верхніх шарів матеріалу на нижні незначна, шпаруватість матеріалу в довільній його точці *y* можна визначити за законом ущільнення для прямолінійної ділянки компресійної кривої [4]:

$$\varepsilon_y = \varepsilon_0 - a_0 \cdot p_{y.м.} \,, \quad (8)$$

where: ε_0 – the initial porosity of a material without applied pressure (Fig. 3);

$p_{y.м.}$ – the pressure which is produced by higher layers of material on a layer of material in a point *y*.

де: ε_0 – початкова шпаруватість матеріалу без прикладеного тиску (рис.3);

$p_{y.м.}$ – тиск, який здійснюють верхні шари матеріалу на шар матеріалу в точці *y*.

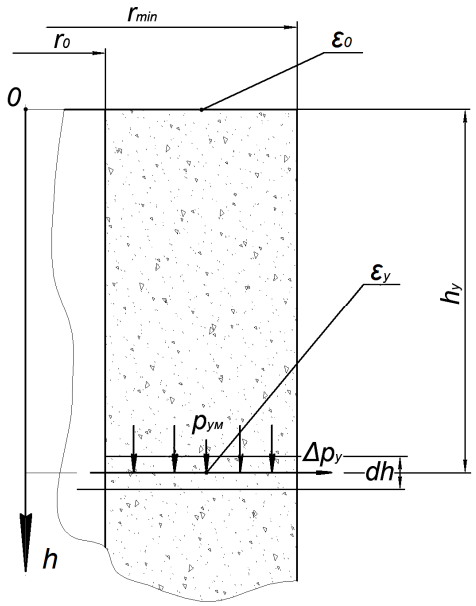


Fig. 3 – *Determination of porosity of material depending on its height / Визначення шпаруватості матеріалу залежно від його висоти*

Pressure of upper layers of material can be determined by the formula [4]:

Тиск верхніх шарів матеріалу можна визначити за формулою [4]:

$$p_{y.м.} = \frac{m_y}{v_y} \cdot g \cdot h_y , \quad (9)$$

where m_y – the mass of a material height of point *y*, [kg];

v_y – the volume of a material height of point *y*, [m^3];

Relation of the mass to the volume is determined as an average density of a material

де: m_y – маса матеріалу вище точки *y*, [кг];

v_y – об'єм матеріалу вище точки *y*, [м^3].

Відношення маси до об'єму визначається як середня щільність матеріалу

$$\frac{m_y}{v_y} = \frac{\rho_{vy} - \rho_{v0}}{2} . \quad (10)$$

Porosity

Шпаруватість

$$\varepsilon_y = \left(1 - \frac{\rho_{vy}}{\rho_\tau}\right), \quad (12)$$

$$\varepsilon_0 = \left(1 - \frac{\rho_{v0}}{\rho_\tau}\right), \quad (13)$$

ρ_τ – real density without taking into account porosity, [kg/m^3].

After substitution ρ_{vy} from (12) and ρ_τ from (13) into (11) we obtain

ρ_τ – дійсна щільність без врахування пор, [кг/м^3].

Після підстановки ρ_{vy} з (12) і ρ_τ з (13) в (11) одержимо.

$$\varepsilon_y = \varepsilon_0 - a_0 \cdot \frac{(1-\varepsilon_y)\cdot\left(\frac{\rho_{v0}}{1-\varepsilon_0}\right) + \rho_{v0}}{2} \cdot g \cdot h_y$$

or

або

$$\varepsilon_y = \varepsilon_0 - a_0 \cdot g \cdot h_y \cdot \rho_{v0} + \frac{a_0^{\,2} \cdot g^2 \cdot h_y^{\,2} \cdot \rho_{v0}^{\,2}}{2 \cdot \varepsilon_0 + a_0 \cdot g \cdot h_y \cdot \rho_{v0} - 2} . \quad (14)$$

Substituting the value ε_y of expression (14) into expression (6) the loss of pressure of drying agent when it moves through a layer of a material in the cylindrical drying chamber on the height h_y can be determined.

The results of calculations are represented as graphs on the fig. 4.

Підставивши значення ε_y виразу (14) в залежність (6) можна визначити втрату тиску сушильного агента при його проходженні крізь шар матеріалу в циліндричній сушильній камері на висоті h_y.

Результати розрахунків у вигляді графіків представлені на рис. 4.

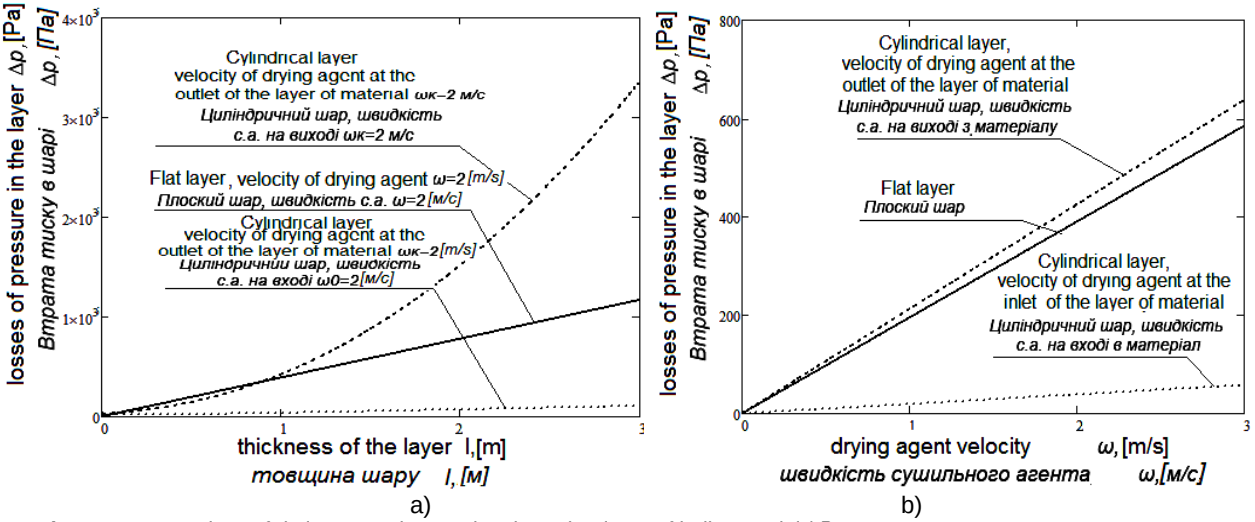


Fig. 4 – Pressure loss of drying agent by passing through a layer of bulk material / *Втрата тиску сушильного агента при проходженні крізь шар сипкого матеріалу,* $\varepsilon_0 = 0,5$, $\mu = 1,95 \cdot 10^{-5}$, $s = 1000$ *м^2/м^3,* $r_0 = 0,2$ *м:*

a) depending on the thickness *l* with the velocity $\omega = 2$ *[m/s] / залежно від товщини шару l при швидкості* $\omega = 2$ *[м/с];*
b) depending on the velocity of the drying agent ω for *l* = 1 *[m] / залежно від швидкості сушильного агента* ω *при l* = 1 *[м]*

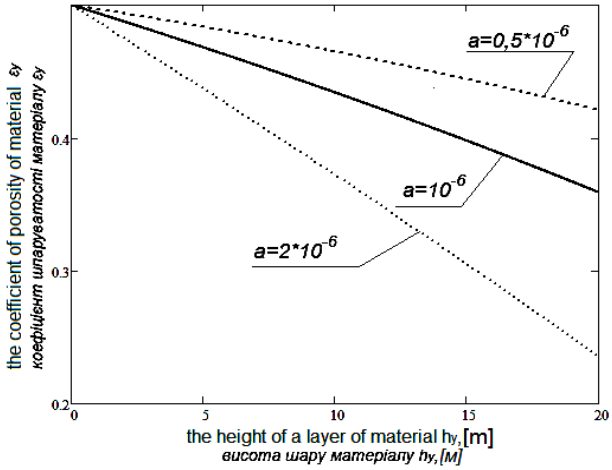
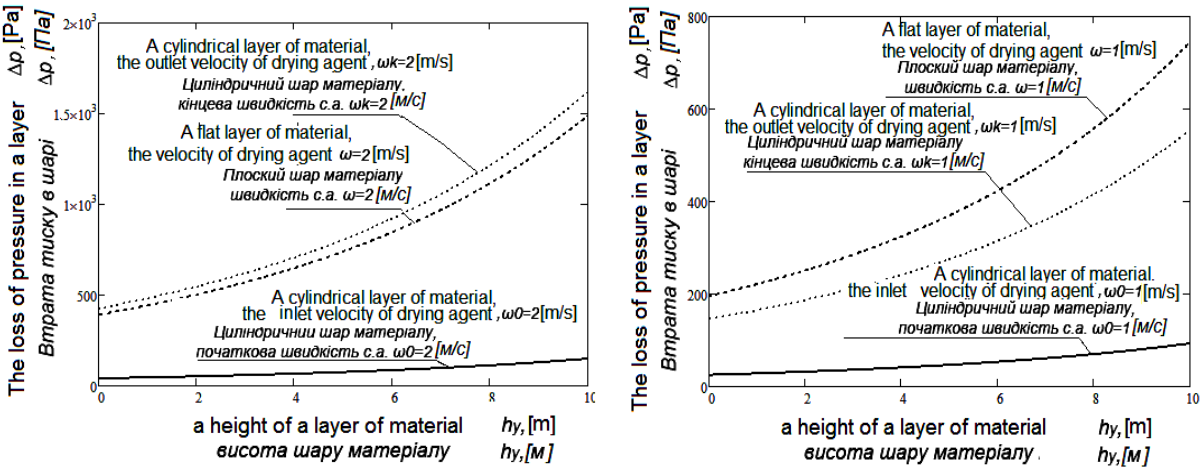


Fig. 5 – Dependence of the porosity from material layer height / *Залежність коефіцієнта шпаруватості від висоти шару матеріалу*



a) b)

Fig. 6 – Changing of a material layer resistance to the airflow in height / *Зміна опору шару матеріалу повітряному потоку за висотою*

a) $\omega = 2$ *[м/с];* $l = 1$ *[м], b)* $\omega = 1$ *[м/с];* $l = 0,5$ *[м]*

The resistance of material, which fills a cylindrical drying chamber with a height $h_{c.к.}$.

Опір матеріалу, що заповнює циліндричну сушильну камеру висотою $h_{c.к.}$.

$$\Delta p_{c.к.} = \frac{1}{h_{c.к.}} \cdot \int_0^{h_{c.к.}} \Delta p_ц = K \cdot \frac{\left(1 - \left(\varepsilon_0 - a_0 \cdot g \cdot h_y \cdot \rho_{v0} + \frac{a_0^2 \cdot g^2 \cdot h_y^2 \cdot \rho_{v0}^2}{2 \cdot \varepsilon_0 + a_0 \cdot g \cdot h_y \cdot \rho_{v0} - 2}\right)\right)^2}{\left(\varepsilon_0 - a_0 \cdot g \cdot h_y \cdot \rho_{v0} + \frac{a_0^2 \cdot g^2 \cdot h_y^2 \cdot \rho_{v0}^2}{2 \cdot \varepsilon_0 + a_0 \cdot g \cdot h_y \cdot \rho_{v0} - 2}\right)^3} \times$$
$$\times s_y^2 \cdot \mu \cdot \omega_0 \cdot r_0 \cdot \left(l - r_0 \cdot (\ln(|l + r_0|) + \ln(|r_0|))\right) dh_y \qquad (14)$$

After integrating and simplification:

Після інтегрування і спрощення:

$$\begin{cases} \Delta p_{c.к.} = \frac{A \cdot D^3}{B \cdot E} \cdot \left(\left(\frac{16 \cdot D \cdot (B \cdot h \cdot E \cdot (2 \cdot \varepsilon - 1) - 2 \cdot \varepsilon \cdot (2 \cdot E \cdot \varepsilon + 3) + 2)}{(B \cdot h \cdot E - 2 \cdot D \cdot \varepsilon)^2} \right) - \right. \\ \left. -4 \cdot \ln\left(\left| \frac{B \cdot h \cdot E - 2 \cdot D \cdot \varepsilon}{B \cdot E} \right| \right) \cdot (\varepsilon + 1) - B \cdot h \cdot \frac{E}{D} \right), \\ A = K \cdot \mu \cdot r_0 \cdot s_y^2 \cdot \omega \cdot (l - r_0 \cdot (\ln(|l + r_0|) - \ln(|r_0|))), \\ B = a_0 \cdot g \cdot \rho_{v,} \\ D = (\varepsilon - 1), \\ E = (\varepsilon - 1), \end{cases} \qquad (15)$$

where: *A*, *B*, *D*, *E* – coefficients.

System (15) describes the loss of pressure of drying agent when it moves through a layer of bulk material with its height $h_{c.к.}$ which fills the cylindrical drying chamber with the radius of outer perforated wall r_{max} and the radius of inner perforated wall r_{min} .

де *A*, *B*, *D*, *E* – коефіцієнти.

Система (15) характеризує втрату тиску сушильним агентом при його проходженні крізь шар матеріалу висотою $h_{c.к.}$, що заповнює циліндричну сушильну камеру з радіусом зовнішньої перфорованої стінки r_{max} і радіусом внутрішньої перфорованої стінки r_{min} .

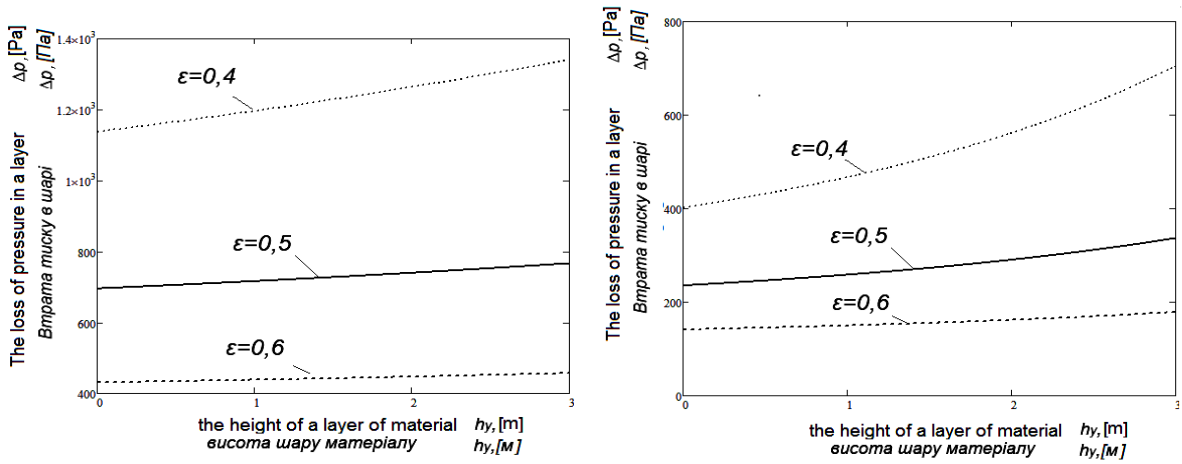


Fig. 7 – Drying agent pressure loss to overcome the resistance of material in the cylindrical drying chamber of the dryer / *Втрата тиску сушильним агентом на подолання опору матеріалу в циліндричній сушильній камері сушарки*

a) $a_0 = 2 \cdot 10^{-6}$; *b)* $a_0 = 5 \cdot 10^{-6}$

CONCLUSIONS

The relations which allow calculating the resistance of a bulk material layer in the cylindrical drying chamber of the dryer taking into account the change of porosity of material by height were obtained. The obtained results indicate that a flat and a cylindrical layer of material produce different resistances of drying agent for the same initial speed of the agent of drying. The less resistance $\Delta p_ц$ of a cylindrical layer than a flat layer with the same thickness *l* and initial velocity of the drying agent ω_0 entering into the material can be explained by a decreasing of the speed of the drying agent in a cylindrical drying chamber as a result of moving it from the center to the periphery: $\omega_x = f(l_x)$.

ВИСНОВКИ

Отримано залежності, які дозволяють обчислити опір шару сипкого матеріалу в циліндричній сушильній камері сушарки з врахуванням зміни шпаруватості матеріалу за висотою шару. Отримані результати показують, що при однаковій початковій швидкості сушильного агента плоский і циліндричний шар матеріалу чинять різний опір сушильному агенту. Менший опір $\Delta p_ц$ циліндричного шару, ніж плоского, при однаковій їх товщині *l* і початкової швидкості сушильного агента ω_0 на вході в матеріал можна пояснити зменшенням швидкості сушильного агента в циліндричній сушильній камері внаслідок переміщення його від центру до периферії $\omega_x = f(l_x)$.

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VARIATIONS OF KINEMATIC PARAMETERS OF THE CARDANIC JOINTS ACCORDING TO TEHNOLOGICAL DEVIATIONS
/
VARIAȚIILE PARAMETRILOR CINEMATICI AI ARTICULAȚIEI CARDANICE ÎN FUNCȚIE DE ABATERILE TEHNOLOGICE

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Abstract: Technological deviations determine in the intermediate couples of the cardan joint supplementary efforts due to restrained movement. This paper sets as goal the determination of dependency between the technological deviations and the size of these movements.

Key words: deviations, cardan, kinematics.

Rezumat: *Abaterile tehnologice fac ca in cuplele intermediare ale articulației cardanice să apară eforturi datorită unor deplasări împiedicate.*
Această lucrare îşi propune determinarea dependenței între abaterile tehnologice şi mărimea acestor deplasări.

Cuvinte cheie: *abateri, cardan, cinematică.*

INTRODUCTION
Spatial RCCC mechanism

The mechanism with one cardanic joint [3], [4], [8] is a RRRR mechanism and a particular case of a spatial RCCC mechanism, where by C, R [9] was noted the cylindrical kinematic rotation couple.

The technological deviations determine the apparition of some efforts in the intermediary couple of the cardanic joint.

In order for one to have a measure for these displacement it is first necessary to study the RCCC spatial mechanism kinematics.

The positional analysis of the RCCC mechanism

The RCCC mechanism (fig. 1) is made of four elements noted with 1, 2, 3 and 4, the forth element (the base) being fixed and the elements being connected through the kinematic couples O_1, O_2, O_3 and O_4, the O_1 being the rotation couple and O_2, O_3 and O_4 being the cylindrical kinematic couples.

INTRODUCERE
Mecanismul spațial RCCC

Mecanismul cu o articulație cardanică [3], [4], [8] este un mecanism RRRR şi un caz particular al mecanismului spațial RCCC, unde prin C, R, [9] s-a notat cupla cinematică cilindrică, respectiv cupla cinematică de rotație.

Abaterile tehnologice fac ca în cuplele intermediare ale articulației cardanice să apară eforturi datorită unor deplasări împiedicate.

Pentru a avea o măsură a acestei deplasări este necesar a studia mai întâi cinematica mecanismului spațial RCCC.

Analiza poziționlă a mecanismului RCCC

Mecanismul RCCC (fig.1) este format din patru elemente, notate cu 1, 2, 3, 4, elementul 4 (baza) fiind fix, elementele fiind legate între ele prin cuplele cinematice O_1, O_2, O_3, O_4, cupla cinematică O_1 fiind de rotație iar cuplele, O_2, O_3, O_4 fiind cuple cinematice cilindrice.

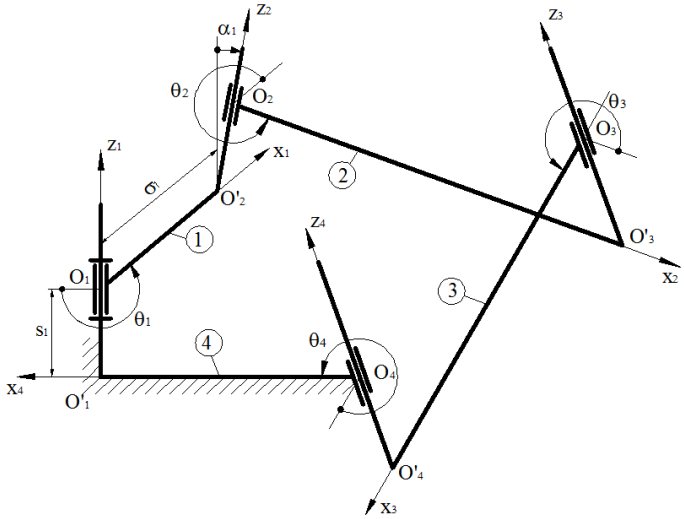

Fig. 1 – *RCCC Spatial Mechanism / Mecanismul spațial RCCC*

The axes of the kinematic couples are noted with $O_i'z_i$, $i=1,2,...$, and the following perpendiculars are noted with $O_i'O_{i+1}'$, $i=1,2,3,4$, point O_5 being identical with point O_1.

One notates with σ_i, α_i, $i=1,2,3,4$ the length of the axes and the angle between them.

Axele cupleleor cinematice sunt notate cu $O_i'z_i$, $i=1,2,...$, iar perpendicularele comune succesive sunt notate cu $O_i'O_{i+1}'$, $i=1,2,3,4$, punctul O_5 fiind identic cu punctul O_1.

Se notează cu σ_i, α_i, $i=1,2,3,4$ lungimile distanțelor dintre axe respectiv unghiurile dintre axe.

So it is chosen a local reference system $O_i x_i y_i z_i$, $i = 1,2,3,4$ so that the axes $O_i x_i$ to be situated on the shared perpendiculars of the axes $O_i' z_i$, $O_{i+1}' z_{i+1}$. It is noted with s_i the distances $O_i' O_i$ and with θ_i the angle between the axes $O_{i-1} x_{i-1}$, $O_i x_i$, $i = 1,2,3,4$.

In these conditions, the geometrical parameters s_i, σ_i, α_i, $i = 1,2,3,4$ being known, the positional analysis for determining $\theta_2, \theta_3, \theta_4, s_2, s_3, s_4$ is based on the angle θ_1.

From the equation of rotations closing, using the diagram „$\theta\alpha$" [9] and the order 3, 4, 1 and 2 is obtained the following equation, where:

Se aleg sistemele de referință locale $O_i x_i y_i z_i$, $i = 1,2,3,4$ astfel încât axele $O_i x_i$ să fie situate pe perpendicularele comune ale axelor $O_i' z_i$, $O_{i+1}' z_{i+1}$, se notează cu s_i, distanțele $O_i' O_i$, şi cu θ_i unghiurile dintre axele $O_{i-1} x_{i-1}$, $O_i x_i$, $i = 1,2,3,4$.

În aceste condiții parametrii geometrici s_i, σ_i, α_i, $i = 1,2,3,4$ fiind cunoscuți, analiza poziționlă constă în determinarea $\theta_2, \theta_3, \theta_4, s_2, s_3, s_4$ în funcție de unghiul θ_1.

Din ecuația de închidere a rotațiilor, utilizînd diagrama „$\theta\alpha$" [9] şi ordinea 3, 4, 1, 2, se obține ecuația, unde:

$$A_3(\theta_1) s\theta_4 - B_3(\theta_1) c\theta_4 + C_3(\theta_1) = 0 \quad (1.1)$$

$$A_3(\theta_1) = s\alpha_3 s\theta_1 s\alpha_1 \quad (1.2)$$

$$B_3(\theta_1) = s\alpha_3 (c\alpha_4 c\theta_1 s\alpha_1 + s\alpha_4 c\alpha_1)$$

$$C_3(\theta_1) = -c\alpha_3 s\alpha_4 c\theta_1 s\alpha_1 + c\alpha_3 c\alpha_4 c\alpha_1 - c\alpha_2$$

The trigonometrical functions cos, sin being noted with c, s. Through the conventional derivate of the relations (1.1), (1. 2) having as basis [9] the relations:

Funcțiile trigonometrice cos, sin,fiind notate cu c, s. Prin derivarea convențională notată a relațiilor (1.1), (1.2) având la bază [9],relațiile:

$$D(c\theta_i) = -s_i s\theta_i;\ D(s\theta_i) = s_i c\theta_i \quad (1.3)$$

$$D(c\alpha_i) = -\sigma_i s\alpha_i;\ D(s\alpha_i) = \sigma_i c\alpha_i \quad (1.4)$$

Is obtained the equation:

se obține ecuația:

$$D_3 s_4 + F_3 s_1 + F_3 \sigma_1 + G_3 \sigma_2 + H_3 \sigma_3 + K_3 \sigma_4 = 0 \quad (1.5)$$

where:

unde:

$$D_3 = s\alpha_3 c\theta_4 s\theta_1 s\alpha_1 + s\alpha_3 s\theta_4 c\alpha_4 c\theta_1 s\alpha_1 + s\alpha_3 s\theta_4 s\alpha_4 c\alpha_1 \quad (1.6)$$

$$E_3 = s\alpha_3 s\theta_4 c\theta_1 s\alpha_1 + s\alpha_3 c\theta_4 c\alpha_4 s\theta_1 s\alpha_1 + c\alpha_3 s\alpha_4 s\theta_1 c\alpha_1$$

$$F_3 = s\alpha_3 s\theta_4 s\theta_1 c\alpha_1 - s\alpha_3 c\theta_4 c\alpha_4 c\theta_1 c\alpha_1 - c\alpha_3 s\alpha_4 c\theta_1 c\alpha_1 + s\alpha_3 c\theta_4 s\alpha_4 s\alpha_1 - c\alpha_3 c\alpha_2 s\alpha_1$$

$$G_3 = s\alpha_2$$

$$H_3 = c\alpha_3 s\theta_4 s\theta_1 s\alpha_1 - c\alpha_3 c\alpha_4 c\theta_1 s\alpha_1 + s\alpha_3 s\alpha_4 c\theta_1 s\alpha_1 - c\alpha_3 c\theta_4 s\alpha_4 c\alpha_1 - s\alpha_3 c\alpha_4 c\alpha_1$$

$$K_3 = s\alpha_3 c\theta_4 s\alpha_4 c\theta_1 s\alpha_1 - c\alpha_3 c\alpha_4 c\theta_1 s\alpha_1 - s\alpha_3 c\theta_4 c\alpha_4 c\alpha_1 - c\alpha_3 s\alpha_4 c\alpha_1$$

The angle θ_4 is determined by solving the equation (1.2) and through the equation (1.5) is known the parameter s_4.

With circular permutations the relations follows:

Prin rezolvarea ecuației (1.2) se determină unghiul θ_4, iar apoi din ecuația (1.5) se determină parametrul s_4.

Prin permutări circulare se obțin relațiile:

$$A_2(\theta_4) s\theta_3 - B_2(\theta_4) c\theta_3 + C_2(\theta_4) = 0 \quad (1.7)$$

$$A_1(\theta_3) s\theta_2 - B_1(\theta_3) c\theta_2 + C_1(\theta_3) = 0 \quad (1.8)$$

from which are determined, in order, the angles θ_3 and θ_2 and also the equations:

din care se determină în ordine unghiurile θ_3, θ_2 precum şi ecuațiile:

$$D_2 s_3 + E_2 s_4 + F_2 \sigma_4 + G_2 \sigma_1 + H_2 \sigma_2 + K_2 \sigma_3 = 0 \quad (1.9)$$

$$D_1 s_2 + E_1 s_3 + F_1 \sigma_3 + G_1 \sigma_4 + H_1 \sigma_1 + K_1 \sigma_2 = 0 \quad (1.10)$$

from which are determined the parameters s_3, s_2. The expressions of the coefficients A_i B_i, C_i, D_i, E_i, F_i, G_i, H_i, K_i, i=3,2,1,are given in table 1.1

din care se determină parametrii s_3, s_2.Expresiile coeficienților $A_i, B_i, C_i, D_i, E_i, F_i, G_i, H_i, K_i$, i = 3, 2, 1, sunt date în tabelul 1.1

Table 1.1 / *Tabelul 1.1*

i	3	2	1
A_i	$s\alpha_3 s\theta_1 s\alpha_1$	$s\alpha_2 s\theta_4 s\alpha_4$	$s\alpha_1 s\theta_3 s\alpha_3$
B_i	$s\alpha_3(c\alpha_4 c\theta_1 s\alpha_1 + s\alpha_4 c\alpha_1)$	$s\alpha_2(c\alpha_3 c\theta_4 s\alpha_4 + s\alpha_3 c\alpha_4)$	$s\alpha_1(c\alpha_2 c\theta_3 s\alpha_3 + s\alpha_2 c\alpha_3)$
C_i	$c\alpha_3(-s\alpha_4 c\theta_1 s\alpha_1 + c\alpha_4 c\alpha_1)$ $-c\alpha_2$	$c\alpha_2(-s\alpha_3 c\theta_4 s\alpha_4 + c\alpha_3 c\alpha_4)$ $-c\alpha_1$	$c\alpha_1(-s\alpha_2 c\theta_3 s\alpha_3 + c\alpha_2 c\alpha_3)$ $-c\alpha_4$
D_i	$s\alpha_3 s\alpha_1(c\theta_4 s\theta_1 + s\theta_4 c\alpha_4 c\theta_1)$ $+s\alpha_3 s\theta_4 s\alpha_4 c\alpha_1$	$s\alpha_2 s\alpha_4(c\theta_3 s\theta_4 + s\theta_3 c\alpha_3 c\theta_4)$ $+s\alpha_2 s\theta_3 s\alpha_3 c\alpha_4$	$s\alpha_1 s\alpha_3(c\theta_2 s\theta_3 + s\theta_2 c\alpha_2 c\theta_3)$ $+s\alpha_1 s\theta_2 s\alpha_2 c\alpha_3$
E_i	$s\alpha_3 s\alpha_1(s\theta_4 c\theta_1 + c\theta_4 c\alpha_4 s\theta_1)$ $+c\alpha_3 s\alpha_4 s\theta_1 s\alpha_1$	$s\alpha_2 s\alpha_4(s\theta_3 c\theta_4 + c\theta_3 c\alpha_3 s\theta_4) +$ $c\alpha_2 s\alpha_3 s\theta_4 s\alpha_4$	$s\alpha_1 s\alpha_3(s\theta_2 c\theta_3 + c\theta_2 c\alpha_2 s\theta_3) +$ $c\alpha_1 s\alpha_2 s\theta_3 s\alpha_3$
F_i	$s\alpha_3 c\alpha_1(s\theta_4 s\theta_1 - c\theta_4 c\alpha_4 c\theta_1) -$ $c\alpha_3 s\alpha_4 c\theta_1 c\alpha_1 +$ $s\alpha_3 c\theta_4 s\alpha_4 s\alpha_1 - c\alpha_3 c\alpha_2 s\alpha_1$	$s\alpha_2 c\alpha_4(s\theta_3 s\theta_4 - c\theta_3 c\alpha_3 c\theta_4) -$ $c\alpha_2 s\alpha_3 c\theta_4 c\alpha_4 +$ $s\alpha_2 c\theta_3 s\alpha_3 s\alpha_4 - c\alpha_2 c\alpha_1 s\alpha_4$	$s\alpha_1 c\alpha_3(s\theta_2 s\theta_3 - c\theta_2 c\alpha_2 c\theta_3) -$ $c\alpha_1 s\alpha_2 c\theta_3 c\alpha_3 +$ $s\alpha_1 c\theta_2 s\alpha_2 s\alpha_3 - c\alpha_1 c\alpha_4 s\alpha_3$
G_i	$s\alpha_2$	$s\alpha_1$	$s\alpha_4$
H_i	$c\alpha_3 s\alpha_1(s\theta_4 s\theta_1 - c\theta_4 c\alpha_4 c\theta_1)$ $+ s\alpha_3 s\alpha_4 c\theta_1 s\alpha_1 -$ $c\alpha_3 c\theta_4 s\alpha_4 c\alpha_1 - s\alpha_3 c\alpha_4 c\alpha_1$	$c\alpha_2 s\alpha_4(s\theta_3 s\theta_4 - c\theta_3 c\alpha_3 c\theta_4)$ $+ s\alpha_2 s\alpha_3 c\theta_4 s\alpha_4 -$ $c\alpha_2 c\theta_3 s\alpha_3 c\alpha_4 - s\alpha_2 c\alpha_3 c\alpha_4$	$c\alpha_1 s\alpha_3(s\theta_2 s\theta_3 - c\theta_2 c\alpha_2 c\theta_3)$ $+ s\alpha_1 s\alpha_2 c\theta_3 s\alpha_3 -$ $c\alpha_1 c\theta_2 s\alpha_2 c\alpha_3 - s\alpha_1 c\alpha_2 c\alpha_3$
K_i	$s\alpha_1(s\alpha_3 c\theta_4 s\alpha_4 c\theta_1 - c\alpha_3 c\alpha_4 c\theta_1)$ $-c\alpha_1(s\alpha_3 c\theta_4 c\alpha_4 + c\alpha_3 s\alpha_4)$	$s\alpha_4(s\alpha_2 c\theta_3 s\alpha_3 c\theta_4 - c\alpha_2 c\alpha_3 c\theta_4)$ $-c\alpha_4(s\alpha_2 c\theta_3 c\alpha_3 + c\alpha_2 s\alpha_3)$	$s\alpha_3(s\alpha_1 c\theta_2 s\alpha_2 c\theta_3 - c\alpha_1 c\alpha_2 c\theta_3)$ $-c\alpha_3(s\alpha_1 c\theta_2 c\alpha_2 + c\alpha_1 s\alpha_2)$

In the initial position, $\theta_i^0 = 0$ the expressions are obtained:

În poziția inițială, $\theta_i^0 = 0$ se obțin expresiile:

$$A_3 = 0;\ B_3 = s\alpha_3 s(\alpha_1 + \alpha_4);\ C_3 = c\alpha_3 c(\alpha_1 + \alpha_4) - c\alpha_2 \tag{1.11}$$

and it results that:

şi rezultă:

$$c\theta_4^0 = \frac{c\alpha_3 c(\alpha_1 + \alpha_4) - c\alpha_2}{s\alpha_3 s(\alpha_1 + \alpha_4)} \tag{1.12}$$

For solving the calculus for such a mechanism it is first necessary to make some specifications:

- the joint perpendiculars between the axes with the index *i, i+1* are noted with O_i, O'_{i+1};
- the direction of the axis $O_i x_i$ is given by the rotation direction of the axis $O'_i z_i$ over the axis $O'_{i+1} z_{i+1}$, direction that also specifies the measurement direction of the angle α_i;
- the positive measurement direction of angle θ_i between the axes $O_{i-1}x_{i-1}$ $O_i x_i$, is given by the direction of the $O_i x_i$ axis rotation around the axis $O'_i z_i$.

Pentru efectuarea calculului unui astfel de mecanism este necesar a se face următoarele precizări:

- perpendicularele comune între axele cu indici *i, i+1* se notează cu O_i, O'_{i+1};
- sensul axelor $O_i x_i$ este dat de sensul rotirii axei $O'_i z_i$ peste axa $O'_{i+1} z_{i+1}$, sens care precizează şi sensul de măsurare al unghiului α_i;
- sensul pozitiv de măsurare al unghiului θ_i între axele $O_{i-1}x_{i-1}$ $O_i x_i$, este dat de sensul rotirii axei $O_i x_i$ în jurul axei $O'_i z_i$.

The cardanic joint without technical deviations

The normal cardanic joint

The cardanic joint enables the transmission of the rotation movement from the shaft 3 through the cardanic cross 2.

The cardanic cross is tied to the brackets of the shafts 1 and 2 through the Kinematic rotation couples A, A' and respectively *B*, *B*'.

Articulația cardanică fără abateri tehnologice

Articulația cardanică normală

Articulația cardanică face posibilă transmiterea mişcării de rotație de la arborele 1 (fig. 2) la arborele 3 prin intermediul crucii cardanice 2.

Crucea cardanică este legată la furcile arborilor 1, 2 prin cuplele cinematice de rotație *A, A'* respectiv *B, B*'.

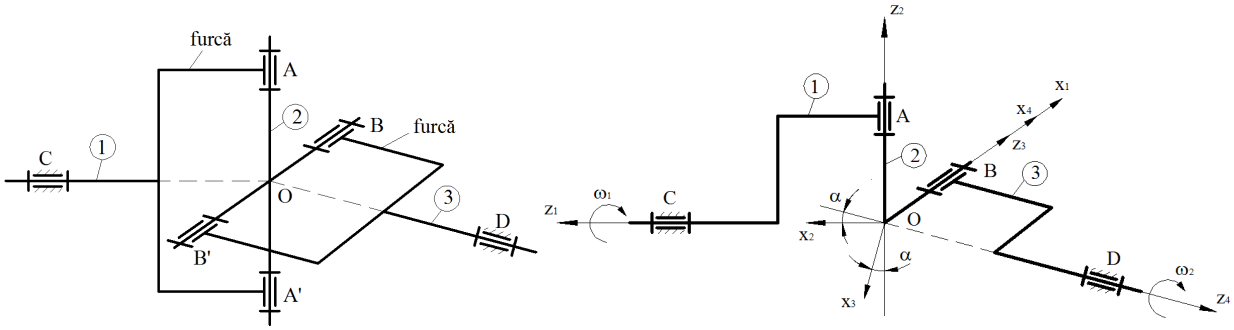

Fig. 2 – *Cardanic joint / Articulație cardanică*

Structurally speaking [9], the kinematic couples A', B' are passive and then, structurally and kinematically speaking, the cardanic crosscan be replaced with the element 2 from figure 2.

So are considered the bearings C and D and the concurrent rotation axes Oz_i, $i=1,2,3,4$.

The axes are being concurrent in the points O_i, O_i', $i=1,2,3$ and they coincide, so the mechanism from figure 2 becomes an RCCC mechanism where:

Din punct de vedere structural, [9], cuplele cinematice A', B' sunt pasive şi atunci, din punct de vedere structural şi cinematic, crucea cardanică se poate înlocui cu elementul 2 din fig. 2.

Se consideră palierele C, D şi axele de rotație concurente Oz_i, $i=1,2,3,4$.

Axele fiind concurente rezultă că punctele O_i, O_i', $i=1,2,3$ coincid şi atunci, mecanismul din fig.2 devine un mecanism RCCC în care:

$$\sigma_i = 0;\ s_i = 0\ \ i=1,2,3,4 \tag{2.1}$$

If the angles α_i, $i=1,2,3$ are fulfilling the condition:

Dacă în plus unghiurile α_i, $i=1,2,3$ îndeplinesc condiția :

$$\alpha_i = \frac{\pi}{2} \tag{2.2}$$

then the cardan joint is called normal cardan joint. For such a joint ($\theta_1^0 = 0$) one considers that $\alpha_4 = \pi - \alpha$ and from figure1.2.1 results:

atunci articulația cardanică se numeşte articulație cardanică normală. Pentru o astfel de articulație ($\theta_1^0 = 0$) considerăm că $\alpha_4 = \pi - \alpha$, din fig.1.2.1 rezultă:

$$\theta_2^0 = \frac{\pi}{2};\ \theta_3^0 = \frac{3\pi}{2} + \alpha;\ \theta_4^0 = \frac{\pi}{2} \tag{2.3}$$

Taking into account the relations 2.1 it results that the relations (1.5), (1.9) and (1.10) are identically fulfilled and conduct to solving the equations (1.1), (1.7), (1.8). From table 1 it results that:

Ținând seama de relațiile 2.1 rezultă că relațiile (1.5), (1.9), (1.10), sunt identic îndeplinite şi ca atare studiul cinematic se reduce la rezolvarea ecuațiilor (1.1), (1.7), (1.8). Din tabelul 1. rezultă:

$$A_3 = s\theta_1;\ B_3 = -c\alpha c\theta_1;\ C_3 = 0 \tag{2.4}$$

$$A_2 = s\theta_4 s\alpha;\ B_2 = -c\alpha;\ C_2 = 0 \tag{2.5}$$

$$A_1 = s\theta_3;\ B_1 = 0;\ C_1 = c\alpha \tag{2.6}$$

And the equations (1.1), (1.7) and (1.8) become:

şi ecuațiile (1.1), (1.7), (1.8) devin :

$$s\theta_1 s\theta_4 + c\alpha c\theta_1 c\theta_4 = 0 \tag{2.7}$$

$$s\theta_4 s\alpha s\theta_3 + c\alpha c\theta_3 = 0 \tag{2.8}$$

$$s\theta_3 s\theta_2 + c\alpha = 0 \tag{2.9}$$

from which, with the notations:

din care cu notațiile:

$$\theta_i = \theta_i^0 + \theta_i^*,\ \ i=1,2,3 \tag{2.10}$$

are obtained the results:

se obțin rezultatele:

$$tg\theta_4^* = \frac{1}{c\alpha} tg\theta_1 \tag{2.11}$$

$$tg(\alpha + \theta_3^*) = tg\alpha c\theta_4^* \tag{2.12}$$

$$c\theta_2^* = \frac{c\alpha}{c(\alpha + \theta_3^*)} \tag{2.13}$$

where: unde :

$$\theta_4^* = \begin{cases} arctg(\frac{1}{c\alpha} tg\theta_1); 0 \le \theta_1 < \frac{\pi}{2} \\ \frac{\pi}{2}; \theta_1 = \frac{\pi}{2} \\ \pi + arctg(\frac{1}{c\alpha} tg\theta_1); \frac{\pi}{2} \le \theta_1 < \frac{3\pi}{2} \\ \frac{3\pi}{2}; \theta_1 = \frac{3\pi}{2} \\ 2\pi + arctg(\frac{1}{c\alpha} tg\theta_1); \frac{3\pi}{2} < \theta_1 \le 2\pi \end{cases} \tag{2.14}$$

and the variation diagrams from figure 3 a,b,c: şi diagramele de variație din fig. 3. a,b,c:

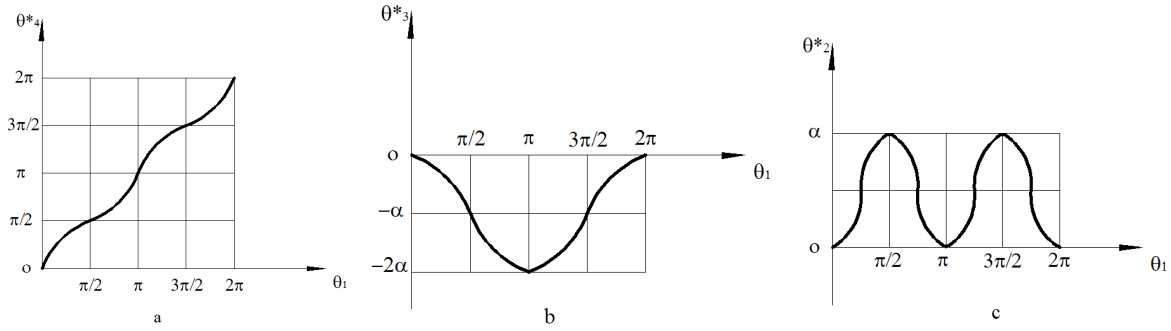

Fig.3 – *Variation diagrams / Diagrame de variație*

Below are presented the variation diagrams for the angles θ_4^*, θ_3^*, θ_2^* depending on the angle θ_1 for $\alpha = 20^\circ$, for a cardan joint with no technical deviations.

The variation graphs are presented in figure 4.

Mai jos sunt prezentate diagramele de variație a unghiurilor θ_4^*, θ_3^*, θ_2^* funcție de θ_1 pentru $\alpha = 20^\circ$ pentru o articulație cardanică fără abateri tehnologice.

Graficele de variație sunt prezentate în fig.4

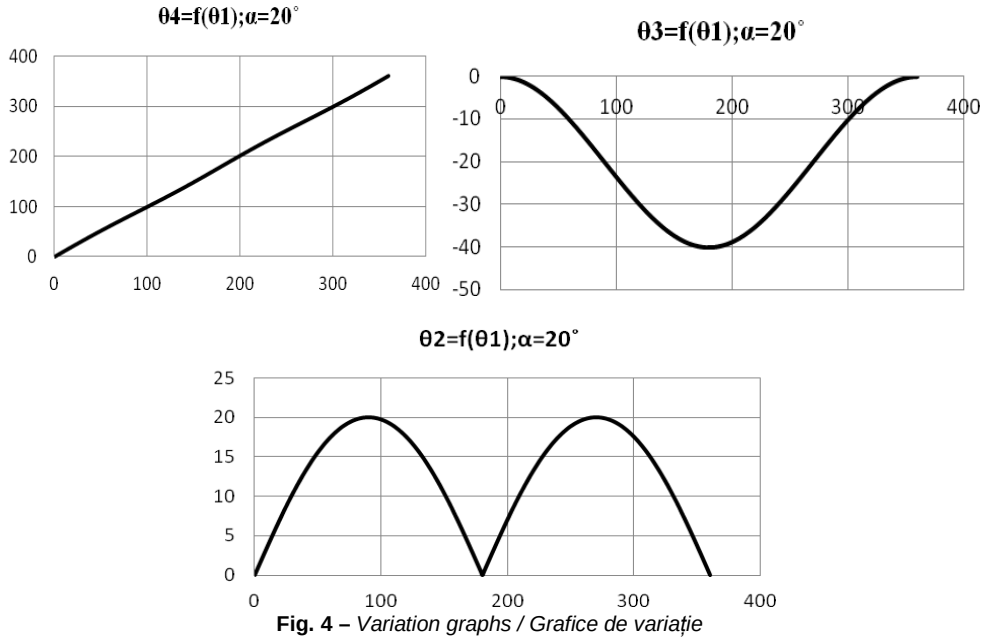

Fig. 4 – *Variation graphs / Grafice de variație*

MATERIALS AND METHOD

The kinematics of cardanic joints with technical deviations

Identifying the geometrical deviations (technological)

A kinematic diagram that represents a mechanism with one cardan joint, with all geometrical deviations possible, is presented in figure 5.

MATERIALE ŞI METODĂ

Cinematica articulației cardanice cu abateri tehnologice

Identificarea abaterilor geometrice (tehnologice)

O schemă cinematică care reprezintă un mecanism cu articulație cardanică cu toate abaterile geometrice posibile este redată în fig. 5.

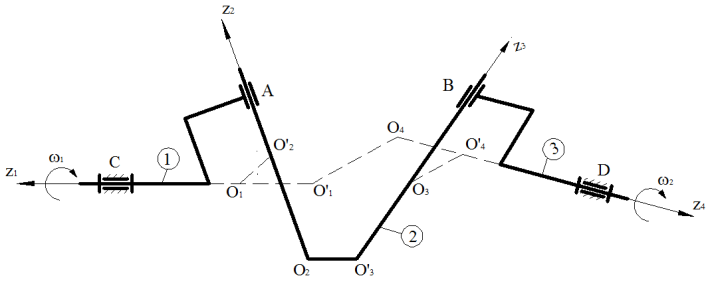

Fig. 5 – *Technological deviations / Abateri tehnologice*

These deviations are small and fulfill the condition:

Aceste abateri sunt mici şi îndeplinesc condițiile :

$$\alpha_i = \frac{\pi}{2} + \Delta\alpha_i,\ i = 1,2,3;\ \alpha_4 = \pi - \alpha;\ \sigma_i = O_i O'_{i+1},\ i = 1,2,;\ \sigma_4 = O_4 O'_i \tag{3.1}$$

The angular deviation of the main shaft bracket is defined by the parameter $\Delta\alpha_1$ and the smoothness deviations for the same bracket is given by the parameter σ_1.

The angular deviation of the cardanic cross 2 is given by the parameter $\Delta\alpha_2$ and also the deviation from smoothness is given by the parameter σ_2.

The angular deviation of the driven shaft bracket 3 is given by the parameter $\Delta\alpha_3$ and the smoothness deviation is given by the parameter σ_3.

The angular deviation of the driven shaft 3 depending on the driving shaft 1 is given by the parameter σ_4.

Abaterea unghiulară a furcii arborelui conducător este definită de parametrul $\Delta\alpha_1$ iar abaterea de la planeitate pentru aceeaşi furcă este dată de parametrul σ_1.

Abaterea unghiulară a crucii cardanice 2 este dată de parametrul $\Delta\alpha_2$ iar abaterea de planeitate este dată de parametrul σ_2.

Abaterea unghiulară a furcii arborelui condus 3 este dată de parametrul $\Delta\alpha_3$ iar abaterea de planeitate este dată de parametrul σ_3.

Abaterea de planeitate a arborelui condus 3 față de arborele conducător 1 este dată de parametrul σ_4.

The influence of technological deviations over the kinematic parameters

As shown in default of shafts 1 and 3 points are known (figure 4).

O_4, O'_1, O_1, O'_2, O_2, O'_3, O_3, O'_4, are overlaid with point O (fig. 5) and the kinematic cylindrical couples A, B and D become rotation kinematic couples (there are no displacements s_2, s_3, s_4, along the axes Oz_2, Oz_3, Oz_4).

The existence of technical deviations conducts to the displacements s_i, $i = 1,2,3,4$ and by blocking them, the excess efforts from the rotation kinematic couples A, B, C, D appear (fig. 2).

In order to determine these displacements it is first necessary to calculate the angular parameters θ_2, θ_3, θ_4 variation depending on the angle θ_1 from the equation system:

Influența abaterilor tehnologice asupra parametrilor cinematici

Aşa cum s-a arătat în lipsa abaterilor arborilor 1, 3 sunt cunoscute, punctele (fig. 4).

O_4, O'_1, O_1, O'_2, O_2, O'_3, O_3, O'_4, se suprapun cu punctul O (fig. 5) iar cuplele cinematice cilindrice, A, B, D, devin cuple cinematice de rotație (nu există deplasări s_2, s_3, s_4, în lungul axelor Oz_2, Oz_3, Oz_4).

Existența abaterilor tehnologice duce la producerea deplasărilor s_i, $i = 1,2,3,4$ iar acestea fiind împiedicate fac să apară eforturi suplimentare în cuplele cinematice de rotație A, B, C, D (fig. 2)

În vederea determinării acestor deplasări este necesar a calcula mai întâi variația parametrilor unghiulari θ_2, θ_3, θ_4, în funcție de unghiul θ_1 din sistemul de ecuații:

$$A_i s\theta_{i+1} - B_1 c\theta_{i+1} + C_i = 0;\ i = 1,2,3 \tag{3.2}$$

For this purpose, one uses the Newton method [11] and with the notations:

În acest sens, se utilizează metoda Newton [11] şi cu notațiile :

$$[\theta] = \begin{bmatrix} \theta_2 \\ \theta_3 \\ \theta_4 \end{bmatrix};\ [\Delta\theta] = \begin{bmatrix} \Delta\theta_2 \\ \Delta\theta_3 \\ \Delta\theta_4 \end{bmatrix} \tag{3.3}$$

$$\Psi_i = A_i s\theta_{i+1} - B_i c\theta_{i+1} + C_i,\ i = 1,2,3\ ; \quad \{\Psi\} = \begin{bmatrix} \Psi_1 \\ \Psi_2 \\ \Psi_3 \end{bmatrix} \tag{3.4}$$

$$A_1^* = s\alpha_1 s\alpha_3 c\theta_3;\ B_1^* = -s\alpha_1 c\alpha_2 s\theta_3 s\alpha_3;\ C_1^* = c\alpha_1 s\alpha_2 s\theta_3 s\alpha_2 \tag{3.5}$$

$$A_2^* = s\alpha_2 s\alpha_4 c\theta_4;\ B_2^* = -s\alpha_2 c\alpha_3 s\theta_4 s\alpha_4;\ C_2^* = c\alpha_2 s\alpha_3 s\theta_4 s\alpha_4 \tag{3.6}$$

$$[J] = \begin{bmatrix} A_1 c\theta_2 + B_1 s\theta_2 & A_1^* s\theta_2 - B_1^* c\theta_2 + C_1^* & 0 \\ 0 & A_2 c\theta_3 + B_2 s\theta_3 & A_2^* s\theta_3 - B_2^* c\theta_3 + C_2^* \\ 0 & 0 & A_3 c\theta_4 + B_3 s\theta_4 \end{bmatrix} \tag{3.7}$$

is obtained the matric equation:

se obține ecuația matricială:

$$\{\Delta\theta\} = -[J]^{-1}\{\Psi\} \tag{3.8}$$

from which results the variation $\{\Delta\theta\}$ for the known values of angles θ_1, θ_2, θ_3, θ_4

din care se obține variația $\{\Delta\theta\}$ pentru valorile cunoscute ale unghiurilor θ_1, θ_2, θ_3, θ_4

RESULTS

One considers a cardanic joint for which:

$\alpha = 0^\circ;\ \Delta\alpha_i = 0{,}001rad;\ s_1 = 0{,}001;\ \sigma_i = 0{,}001$, i = 1,2,3.

The variation graphs are presented in figure 6.

REZULTATE

Se consideră o articulație cardanică pentru care:

$\alpha = 0^\circ;\ \Delta\alpha_i = 0{,}001rad;\ s_1 = 0{,}001;\ \sigma_i = 0{,}001$, i=1, 2, 3

Graficele de variație sunt prezentate în fig.6

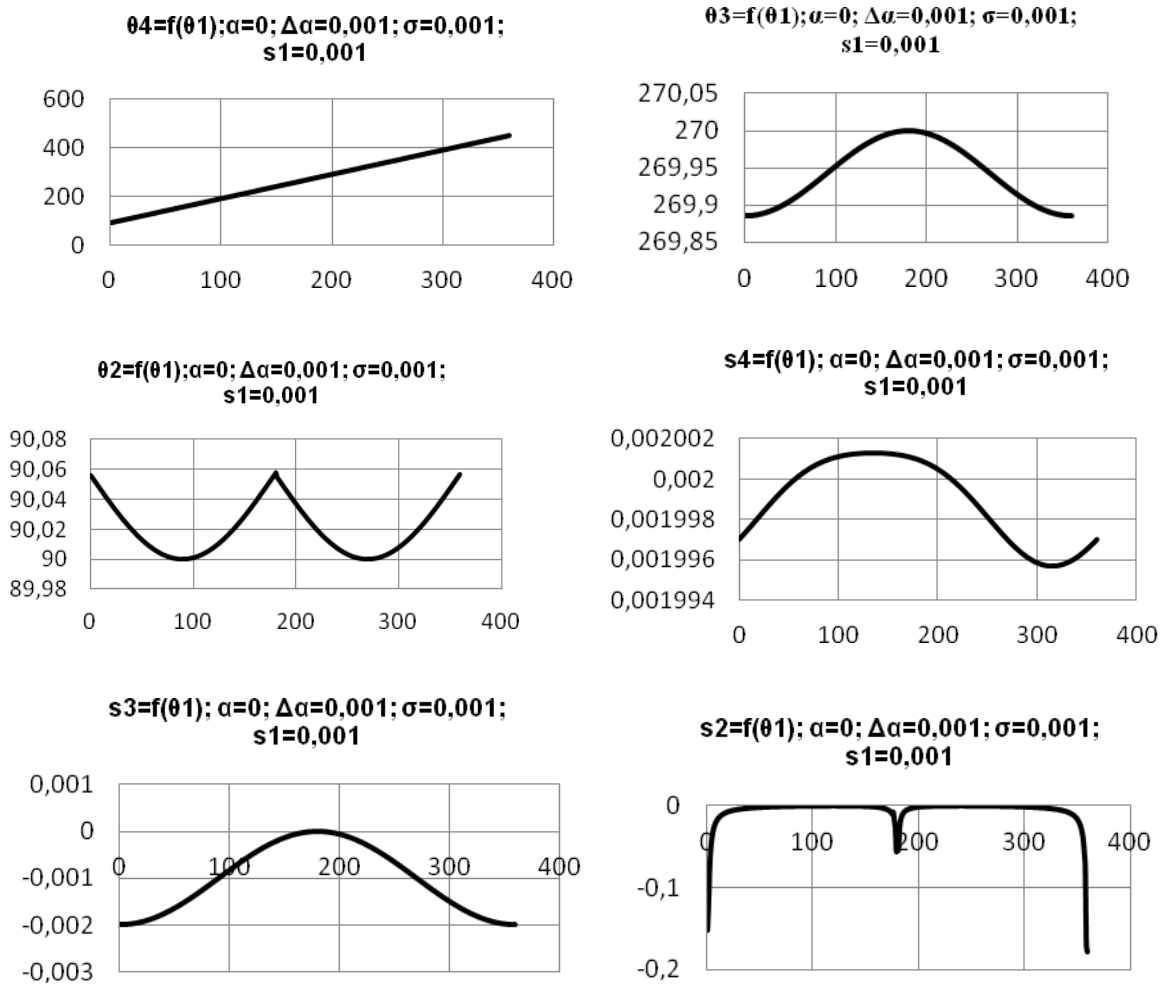

Fig. 6 – *Variation graphs / Grafice de variație*

CONCLUSIONS

For the normal cardan joint with no technical deviations:

- in the initial position where, $\theta_1^0 = 0$ results $\theta_2^0 = \frac{\pi}{2}$; $\theta_3^0 = \frac{3\pi}{2} + \alpha$; $\theta_4^0 = \frac{\pi}{2}$.

- for $\alpha = 20^\circ$:when θ_1 covers the interval $0 - 360^\circ$, the angle θ_4^* varies between $0 - 360^\circ$; angle θ_3^* varies between $0 \div -2\alpha$; angle θ_2^* varies between $0 \div \alpha$;

For the normal cardan joint with technical deviations with $\alpha = 0^\circ$ and $\Delta\alpha_i = 0{,}001rad$,when θ_1 covers the interval $0 - 360^\circ$, the angle θ_4 varies between $90 - 450^\circ$; angle θ_3 varies between $269{,}88 - 270^\circ$; angle θ_2 varies between $90 - 90{,}06^\circ$;

The influence of σ_i and s_1 deviations over the angles $\theta_4; \theta_3; \theta_2$ are insignificant as value.

The variation of angles $\Delta\alpha_i$ i=1,2,3 does not influence the displacements s_i, i=2,3,4.

The displacements s_i, i=2,3,4. are influenced only by the value of the σ_i and s_1 parameters.

For $\alpha = 0^\circ$, the variation curves form of the kinematic parameters are alike.

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CONCLUZII

Pentru articulația cardanică normală fără abateri tehnologice:

- în poziția inițială când, $\theta_1^0 = 0$ rezultă $\theta_2^0 = \frac{\pi}{2}$; $\theta_3^0 = \frac{3\pi}{2} + \alpha$; $\theta_4^0 = \frac{\pi}{2}$.

- pentru $\alpha = 20^\circ$:când θ_1 parcurge intervalul $0 - 360^\circ$, unghiul θ_4^* variază între $0 - 360^\circ$; unghiul θ_3^* variază între $0 \div -2\alpha$; unghiul θ_2^* variază între $0 \div \alpha$;

Pentru articulația cardanică normală cu abateri tehnologice cu $\alpha = 0^\circ$ şi $\Delta\alpha_i = 0{,}001rad$,când θ_1 parcurge intervalul $0 - 360^\circ$, unghiul θ_4 variază între $90 - 450^\circ$; unghiul θ_3 variază între $269{,}88 - 270^\circ$; unghiul θ_2 variază între $90 - 90{,}06^\circ$;

Influențele abaterilor σ_i şi s_1 asupra unghiurilor $\theta_4; \theta_3; \theta_2$ sunt nesemnificative ca valoare.

Variațiile unghiurilor $\Delta\alpha_i$ i=1,2,3 nu influențează deplasările s_i, i=2,3,4.

Deplasările s_i, i=2,3,4. sunt influențate doar de variația parametrilor σ_i şi s_1.

Pentru $\alpha = 0^\circ$, forma curbelor de variație a parametrilor cinematici sunt asemănătoare.

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MANAGEMENT OF POLLUTING SYSTEMS IN THE AGRICULTURAL CROPS / *MANAGEMENTUL SISTEMELOR POLUANTE ÎN CULTURILE AGRICOLE*

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Abstract: *Environmental protection is of major importance because economic development takes place in the natural environment in which we are existing and working. According to the Environmental Protection Law 137/1995, pollution is the direct or indirect introduction, as a result of activities carried out by humans, of substances in soil or air that can harm human society and environment quality. Pollutants can be characterized according to the source, the aggregation, of changes determined. Among the elements that characterize a pollutant analyzed through its interactions with the environment, the most important are the maximum permissible concentration, degree of persistence and synergy effects that trigger when they are together with other pollutants. This article presents the optimal level of pollution reduction and of losses in correlation with the benefits and the costs of implementing.*

Keywords: *agricultural crops, environment, economy, pollution*

INTRODUCTION

By the uncontrolled application of pesticides in agricultural crops, occur the following disturbing factors:

- affects trophic chains, endangering species which feed with insects or rodents eradicated - interference which then is amplified as a chain reaction;
- favors the appearance of other pests that thrive in the "released" ecological niche or whose natural enemies have been killed by pesticides;
- determines genetic mutations at some species, especially insects or fungi which are becoming resistant to pesticides action. Thus it is estimated that currently 266 harmful species are resistant to common pesticides;
- destroys the soil by killing the earthworms and of some microorganisms having essential role in the incorporation of organic materials in soil;
- pollutes water. In the case of pesticides of organophosphorus substances type, the pollution manifests itself by an explosive increase of algae, which end up "to suffocate" all forms of life from the respective aquatic biotope.

The negative effects are aggravated by the fact that some pesticides have periods of extremely high remanence, being almost non-biodegradable.

To treat the agricultural crops with minimal environmental impact, in a number of countries have been introduced environmental marking systems, starting from their regulation and in the European Union and even at international level. Through ecological marking it aims the acquisition of pollutant environmental-friendly products, determining the increase of companies interest for the design and achievement of such products.

The ecological marking thus becomes an instrument for promoting of products that are distinguished by ecological characteristics, able to influence the buying decision. The environment management is performed in accordance with ISO 14011. Application of pollutant products to the agricultural works is done by some strategic technologies, according to the scheme shown in Figure 1.

Rezumat: *Protecția mediului ambiant prezintă o importanță majoră, deoarece dezvoltarea economică are loc în cadrul natural în care există şi ne desfăşurăm activitatea. Conform legii protecției mediului 137/1995, poluarea reprezintă introducerea directă sau indirectă, ca rezultat al unei activități desfăşurate de om, de substanțe în sol sau în aer, care poate produce prejudicii societății umane sau calității mediului. Poluanții se pot caracteriza în funcție de sursă, de agregare, de modificări determinate. Între elementele ce caracterizează un poluant, analizat prin prisma interacțiunilor sale cu mediul, cele mai importante sunt concentrația maximă admisibilă, gradul de persistență şi efectele sinergice pe care le declanşează în momentul în care se află împreună cu alți poluanți. În acest articol se prezintă nivelul optim de reducere a poluării şi a pierderilor în corelație cu beneficiile şi costurile de aplicare.*

Cuvinte cheie: culturi agricole, economie, mediu, poluare

INTRODUCERE

Prin aplicarea necontrolată a pesticidelor în culturi agricole apar următorii factori perturbatori care:

- afectează lanțurile trofice, punând în pericol specii care se hrănesc cu insecte sau rozătoarele stârpite - perturbație care se amplifică apoi în lanț;
- favorizează apariția altor dăunători care prosperă în nişa ecologică “eliberată” sau ai căror duşmani naturali au fost ucişi de către pesticide;
- determină mutații genetice la unele specii, în special insecte sau fungi, care devin rezistente la acțiunea pesticidelor. Se apreciază astfel că în prezent 266 specii dăunatoare sunt rezistente la pesticidele uzuale;
- distrug solul, prin uciderea râmelor şi a unor microorganisme care au rol esențial în încorporarea materialelor organice în sol;
- poluează apele. În cazul pesticidelor de tip substanțe organofosforice, poluarea se manifestă printr-o creştere explozivă a algelor, care ajung să “sufoce” toate formele de viață din biotopul acvatic respectiv.

Efectele negative sunt agravate de faptul că unele pesticide au perioade de remanență extrem de mari, fiind aproape nebiodegradabile.

Pentru a trata culturile agricole cu impact ambiental minim, într-o serie de țări au fost introduse sisteme de marcare ecologică, pornind de la reglementarea acestora şi în cadrul Uniunii Europene şi chiar la nivel internațional. Prin marcarea ecologică se urmăreşte achiziționarea produselor poluante prietenoase cu mediul, determinând creşterea interesului firmelor pentru proiectarea şi realizarea unor asemenea produse.

Marcarea ecologică devine astfel un instrument de promovare a produselor care se disting prin caracteristici ecologice, în măsură să influențeze decizia de cumpărare. Managementul de mediu se realizează în conformitate cu standardele ISO 14011. Aplicarea produselor poluante la lucrările agricole se realizează după unele tehnologii strategice, conform schemei din figura 1.

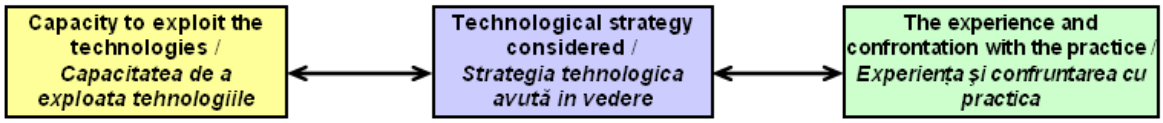

Fig. 1 - Management of technologies within the application of polluting products to the agricultural works / *Gestionarea tehnologiilor în cadrul aplicării produselor poluante la lucrările agricole*

Thinking the technology from the strategic point of view means to ask to what extent the technologies applied could affect in the future the control of environmental protection. A production unit which possesses a wider range of core technologies and of specific differentiation, may be more vulnerable to the attack of some diseases and pests. As the number of alternative technologies increases, the production unit vulnerability decreases.

Pollution reduction can be done by mounting in the tractor exhaust system of the exhaust gases of a catalytic cartridge that allows the separate evacuation of three types of most important pollutants from the burnt gases. The catalytic cartridge is realized based on some noble metals (Pt, Pd, Rh) integrated on a ceramic support honeycomb type. The evolution of the catalytic cartridges was classified according to the filtration percentage of pollutant gases. The first filter cartridges were of the Euro I type, and at present the engines are equipped with Euro VI filter cartridges.

MATERIAL AND METHOD

From the researches carried out worldwide results that the technologies used and the related equipment are permanently upgrading in order to equip with components which ensure the compliance of the product dosage per hectare, in correlation with the impact and increasing the efficiency of the treatments.

A gândi tehnologia din punct de vedere strategic înseamnă a te întreba în ce măsură tehnologiile aplicate ar putea afecta în viitor controlul protecției mediului. O unitate de producție care posedă o gamă mai largă de tehnologii de bază şi de diferențiere specifice, poate fi mai vulnerabilă la atacul unor boli şi daunători. Pe măsură ce numărul de tehnologii alternative creşte, vulnerabilitatea unității de producție scade.

Reducerea poluării se poate realiza prin montarea în sistemul de evacuare a gazelor de eşapament la tractoarele din dotare a unui cartuş catalitic ce permite evacuarea separată a trei tipuri de poluanți majori din gazele arse. Cartuşul catalitic este realizat pe baza unor metale nobile (Pt, Pd, Rh) integrate pe un suport ceramic gen fagure. Evoluția cartuşelor catalitice a fost clasificată în funcție de procentul de filtrare a gazelor poluante. Primele cartuşe filtrante au fost de tipul Euro I, iar în prezent motoarele sunt echipate cu cartuşe filtrante Euro VI.

MATERIAL ŞI METODĂ

Din cercetările efectuate pe plan mondial, rezultă că tehnologiile aplicate şi utilajele aferente se modernizează permanent în ideea echipării cu componente care să asigure respectarea dozei de produs la hectar, în corelație cu impactul şi creşterea eficienței tratamentelor.

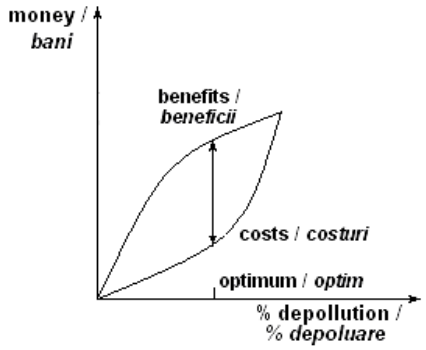

Fig. 2 - Determination of the optimal level of pollution reduction / *Determinarea nivelului optim de reducere a poluării*

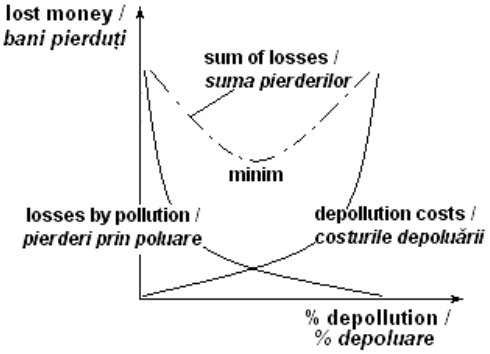

Fig. 3 - Estimation of "losses" due to pollution / *Estimarea "pierderilor" datorate poluării*

Reduction of environmental pollution amplifies the enterprises expenditure (fig. 2). In this way these become less competitive. The state has the role to establish a balance between the two contradictory trends: high costs for an environment as cleaner as possible and low costs for the satisfaction of enterprises.

The costs of pollution follows an exponential curve, and the effects ("the benefits") a logarithmic curve (Fig. 3). Maximum economic advantages are obtained in the point, where economically speaking, the difference between the total benefit achieved and total cost of anti-pollutant procedures is maximum.

In order to determine the correct correlation between the economic growth and preservation of the environment respecting the principles of the sustainable development, must be taken into consideration the current rhythm of development and the structuring mode of the world economy, in which the demand for material resources exceeds the maximum offer

Reducerea poluării mediului amplifică cheltuielile întreprinderilor (fig. 2). În felul acesta ele devin mai puțin competitive. Statului îi revine rolul de a stabili un echilibru între cele două tendințe contradictorii: costuri mari pentru un mediu înconjurător cât mai curat şi costuri scăzute pentru satisfacția întreprinderilor.

Cheltuielile de poluare urmează o curbă exponențiala, iar efectele ("beneficiile") o curbă logaritmică (fig. 3). Avantajele economice maxime se obțin în punctul unde din punct de vedere economic, diferența dintre beneficiul total realizat şi costul total al acțiunilor antipoluante este maxim.

În vederea determinării corecte a corelației dintre creşterea economică şi conservarea mediului cu respectarea principiilor dezvoltării durabile, trebuie luat în considerare ritmul dezvoltării actuale şi modul de structurare a economiei mondiale, în care cererea de resurse materiale depăşeste oferta maximă ce poate fi asigurată de ecosistemele naturale.

which can be assured by the natural ecosystems.

Being in a permanent evolution, concrete and real in time and space, the economic growth has to be in balance with the environmental factors which support it, helping to ensure the desideratum of sustainable economic development.

To achieve this goal must found the solutions of some problems such as:

- how high the economic growth can be compared to the natural resources that it requires, so that the latter to remain in an ecological equilibrium;
- within what limits and for how long can be maintained the ecological equilibrium, under conditions in which, within a national economy, the import and export modify permanently the size and quality of economic activities.

Thus, it is necessary to respect the limit beyond which occurs the depletion of natural resources and the ecological balance disturbance, dynamically evolving.

Estimation of the effects of pollution can be done: at the polluting companies level, as *internalities* - represented by the inclusion of pollutant emissions treatment costs into the manufacturing costs; at the whole society level, in the form of externalities - represented by the social costs needed by the restoring and / or maintaining of environmental quality, including the health status of the people.

At the level of productive activities is necessary the *internalisation of externalities*, because in this way increases the responsibility of entrepreneurs towards the environmental issues. In this way it renounces to the idea that the society as a whole, by subsidies from the budget, has to bear the anti-polluting cost and shall be established *the principle according to which "polluter pays"*, under which it is forced to remedy the issues that have caused environmental incidents. It is also necessary to be instituted the legal framework requiring the companies to transform the externalities in internal environmental costs of their activities.

Kolm company representatives have introduced and defined the concept of environmental function (1), as a way to express the quality of environmental factors, starting from the reasoning according to which pollution increases with economic activity.

Aflată într-o evoluție permanentă, concretă şi reală în timp şi spațiu, creşterea economică trebuie să se afle într-un echilibru față de factorii de mediu care o susțin, contribuind la asigurarea dezideratului de dezvoltare economică durabilă.

Pentru realizarea acestui deziderat trebuie găsite soluțiile unor probleme cum ar fi:

- cât de mare poate fi creşterea economică în raport cu resursele naturale pe care le necesită, astfel încât acestea din urmă să rămână într-un echilibru ecologic;
- în ce limite şi pentru cât timp poate fi menținut echilibrul ecologic, în condițiile în care, în general, într-o economie națională, importul şi exportul modifică permanent dimensiunea şi calitatea activităților economice.

Astfel, este necesară respectarea limitei dincolo de care are loc epuizarea resurselor naturale şi perturbarea echilibrului ecologic, aflat în evoluție dinamică.

Estimarea efectelor poluării poate fi realizată: la nivelul companiilor poluatoare, sub formă de *internalități* - reprezentate de includerea cheltuielilor de tratare a emisiilor poluante în costurile de fabricație; la nivelul întregii societăți, sub formă de *externalități* - reprezentate de costurile sociale necesitate de refacerea şi/sau menținerea calității mediului, inclusiv a stării de sănătate a oamenilor.

La nivelul activităților productive este necesară *internalizarea externalităților*, deoarece în acest mod creşte responsabilitatea întreprinzătorilor față de problemele de mediu. Se renunță astfel la ideea că societatea în ansamblu, prin subvenții de la buget, trebuie să suporte costurile antipoluante şi se instituie *principiul conform căruia "poluatorul plăteşte"*, în baza căruia acesta este constrâns să remedieze aspectele care au generat incidente de mediu. De asemenea, este necesar să fie instituit cadrul legal care să oblige firmele sa transforme externalitățile in costuri ecologice interne ale propriei activități.

Reprezentanții firmei Kolm au introdus şi definit noțiunea de funcție de mediu (1), ca o modalitate de exprimare a calității factorilor de mediu, plecând de la raționamentul conform căruia poluarea creşte odată cu activitatea economică.

$$E = f(Q, B) \quad (1)$$

Thus, the environmental function (1) can be expressed generally by *the environmental quality index* (noted with E) as a decreasing function, both in relation to gross domestic product (Q), and for the part of Q allocated to the costs of environmental protection (more precisely for the defense, conservation or the amelioration of this (*B*)). The first order partial derivatives of the function of environment in relation to the gross domestic product, respectively in relation to the allocated expenditure for environmental protection become: $E_Q < 0$ and $E_B > 0$. The function itself is not sufficiently comprehensive, because it does not take into account neither *technical progress (PT)* specific to production activities, materialized in the form of eco-technologies and nor the *production eco-structure (Es)*, materialized in the form of a new production structure, occurring as a result of investments approaches oriented towards greening the activity and of the entire production process.

Taking into account of these variables, would make that the first order partial derivatives of the function of environment in relation to the technical process, respectively with the eco-structure of production to be $E_{PT} > 0$ şi $E_{Es} > 0$, respectively the environmental quality increases with the improvement of production on the basis of introduction of technical progress specific to ecological interest, and the production structure changes to the detriment of branches and sub-branches of production that degrade the environment.

Astfel, funcția de mediu (1) poate fi exprimată la modul general prin *indicele de calitate a mediului* (notat cu E) sub forma unei funcții descrescătoare, atât în raport cu produsul intern brut (Q), cât şi în raport cu partea din *Q* alocată cheltuielilor de protecția mediului (mai exact pentru apărarea, conservarea sau amelioarea acestuia (*B*)). Derivatele parțiale de ordinul întâi ale funcției de mediu în raport cu produsul intern brut, respectiv în raport cu cheltuielile alocate pentru protecția mediului devin: $E_Q < 0$ şi $E_B > 0$. Funcția ca atare nu este suficient de cuprinzătoare, deoarece nu ia în calcul nici *progresul tehnic (PT)* specific activităților de producție, materializat sub forma ecotehnologiilor şi nici *ecostructura de producție (Es)*, materializată sub forma unei noi structuri de producție, care apare drept consecință a demersurilor investiționale orientate spre ecologizarea activității şi a întregului proces productiv.

Luarea în calcul a acestor variabile, ar face ca derivatele parțiale de ordinul întâi ale funcției de mediu în raport cu procesul tehnic, respectiv cu ecostructura de producție să fie $E_{PT} > 0$ şi $E_{Es} > 0$, respectiv calitatea mediului creşte odată cu îmbunătățirea producției pe baza întroducerii progresului tehnic specific interesului ecologic, iar structura producției se modifică în detrimentul ramurilor şi subramurilor de producție care degradează mediul.

The conception according to which environmental protection is only consuming of Gross Domestic Product was launched by the authors of the theory *The economic dilemma of pollution*, claiming that the environmental protection is a brake on the economic growth. The hypothesis was invalidated by the fact that the actions oriented towards environment protection produce effects favorable to the economic growth through:

- *positive influence on the economy* manifested at:
  - macroeconomic level → *increases the national income by improving the health of the population and implicitly of the quantity and quality of work; increases the creative life of the population by reducing the number of premature retirements;*
  - microeconomic level → *increases the labor productivity by improving the working capacity, diminishing of periods of inactivity, materialized in medical leaves or professional diseases.*
- *the positive influence upon the environmental factors*, manifested by:
  - preservation of natural resources necessary to human existence;
  - favoring the resource economy, by their complex using or recycling and recovery of waste.

The productive character which the environment protection activity has (of maintaining or restoring of the environmental quality and increasing the added value), becomes an important element in any economic development program.

On the other hand, *at company level*, internalisation of environmental protection costs is liable to combat with viable arguments the mentality that the environmental protection is only consuming of Gross Domestic Product through:

- highlighting the real costs of production;
- triggering the minimization mechanisms of production costs (necessary strategy in a competitive free market system);
- maximization of useful results obtained on each unit cost consumed for environmental protection;
- correlation between technical progress, environmental progress and economic progress.

Renewing coefficient (replacement and accumulation) of the technological capital, the volume of investment in relation to the existing technical capital and the capital replacement rate (as a result of physical and moral depreciation or of the technical resources conservation) are part of the elements that may allow an accurate correlation on the evolution of some economic structures. The opportunity of approaching the environmental protection priorities from the perspective of the types of economic structures could be expressed by defining of an *environmental function*, having as arguments the gross domestic product (Q, with exponential growth) and the volume of pollutant emissions (Ep, with a logarithmic growth) compared with the capital technical active fund(*k*):

Concepția potrivit căreia protecția mediului este doar consumatoare de produs intern brut a fost lansată de autorii teoriei *Dilema economică a poluării*, care susțineau că protecția mediului constituie o frâna în calea creşterii economice. Ipoteza a fost infirmată de faptul că acțiunile orientate spre protecția mediului produc efecte favorabile creşterii economice, prin:

- *influența pozitivă asupra economiei*, manifestată la:
  - *nivel macroeconomic* → creşte venitul național prin îmbunătățirea stării de sănătate a populației şi implicit a cantității şi calități muncii; creşte durata de viață creativă a populației prin reducerea numărului de pensionări premature;
  - *nivel microeconomic* → creşte productivitatea muncii prin îmbunătățirea capacității de muncă, determinând diminuarea perioadelor de inactivitate, materializate în concedii medicale sau boli profesionale.
- *influența pozitivă asupra factorilor de mediu*, manifestată prin:
  - conservarea resurselor naturale necesare existenței umane;
  - favorizarea economiei de resurse, prin utilizarea lor complexă sau reciclarea şi valorificarea deşeurilor.

Caracterul productiv pe care îl are activitatea de protecție a mediului (de menținere ori restaurare a calității mediului şi de creştere a valorii adăugate), devine un element important în cadrul oricărui program de dezvoltare economică.

Pe de alta parte, *la nivel de firmă*, internalizarea costurilor de protecție a mediului este de natură să combată cu argumente viabile mentalitatea conform căreia protecția mediului este doar consumatoare de produs intern brut prin:

- punerea în evidență a costurilor reale de producție;
- declanşarea mecanismelor de minimizare a costurilor de producție (strategie necesară într-un sistem concurențial de piață liberă);
- maximizarea rezultatelor utile obținute pe fiecare unitate de cost consumată pentru protecția mediului;
- corelarea progresului tehnic cu progresul economic şi progresul ecologic.

Coeficientul de înnoire (înlocuire şi acumulare) a capitalului tehnic, volumul de investiții în raport cu capitalul tehnic existent şi rata de înlocuire a capitalului (ca urmare a uzurii fizico-morale sau a conservării mijloacelor tehnice) fac parte din elementele care pot să permită o corelație corectă asupra evoluției unor structuri economice. Posibilitatea de abordare a priorităților de protecție a mediului din perspectiva tipurilor de structuri economice ar putea fi exprimată prin definirea unei *funcții de mediu*, având ca argumente produsul intern brut (Q, cu creştere exponențială) şi volumul de emisii poluante (*Ep*, cu o creştere logaritmică) în raport cu fondul de capital tehnic activ (*k*):

$$Q=F(k) \quad (2)$$

$$Ep = Z(k) \quad (3)$$

According to function (3), any growth of technical capital leads to an increase of polluting emissions, because the polluting process is a continuous one and therefore cumulative. The pollution occurs even when the level of technical capital does not change, because this factor of production incurred in time a physical wear. Considering the fact that the material goods (any product obtained as a result of a manufacturing process) may pollute the environment both during production processes (through technology and / or technical means of production), and during the consumption process (by using the product / good material worn up, became a waste),

Conform funcției (3), orice creştere a capitalului tehnic conduce la o creştere a emisiilor poluante, din cauza faptului că procesul de poluare este unul continuu şi deci cumulativ. Poluarea se produce chiar şi atunci când nivelul de capital tehnic nu se modifică, din cauza faptului că acest factor de producție suportă în timp o uzură fizică. Luând în considerare faptul că bunurile materiale (orice produs obținut ca rezultat al unui proces de fabricație) pot polua mediul atât în timpul proceselor de obținere (prin tehnologie şi/sau mijloace tehnice de producție), cât şi în timpul procesului de consum (prin utilizarea produsului/bunului material uzat, devenit deşeu), volumul

emission volume is expressed by taking into account one coefficient of environmental pollution for both situations (production and consumption):

qf - polluting process coefficient due to the process of production, measured in kg waste / 1000 units Q;

qc - coefficient of pollution due to consumption, measured in kg waste / 1000 units Q.

In this case, Ep will be expressed cumulatively through the equation (4), which took into account the total amount of savings S achieved during the manufacturing process, savings intended for general investments for development, modernization or even of pollution control:

emisiilor poluante se exprimă luând în calcul câte un coeficient de poluare a mediului, pentru ambele situații (producție şi consum):

qf - coeficient de poluare datorat procesului de producție, măsurat în kg deşeu/1000 unități Q;

qc - coeficient de poluare datorat consumului, măsurat în kg deşeu/1000 unități Q.

În acest caz, *Ep* se va exprima cumulativ prin relația (4), în care s-a luat în calcul şi volumul total al economiilor S realizat în timpul procesului de fabricație, economii destinate investițiilor generale de dezvoltare, modernizare sau chiar de combatere a poluării:

$$Ep = qfQ + qc(Q - S) \quad (4)$$

or

sau

$$Ep = (qf + qc)Q - qcS \quad (5)$$

Starting from a known level of pollution determined at some point *D*, expressed by the amount of pollutant emissions (kg pollutant, waste) related to the volume or area of environments affected by pollution *V* (m^3 for air and water, respectively km^2 or ha for soil), one can determine an evolution of pollution in the form of an average annual variation of polluting process level, *dD/dt*, where it takes into account also the interest in investment granted to the environment (technical /technological anti-pollutant investments or to improve the capacity of absorption / assimilation of the environment) for reducing it:

Pornind de la un nivel cunoscut de poluare determinat la un anumit moment *D*, exprimat prin cantitatea de emisii poluante (kg poluant, deşeu) raportată la volumul sau suprafața mediilor afectate de poluare *V* (m^3 pentru aer şi apă, respectiv km^2 sau ha pentru sol), se poate determina o evoluție a poluării sub forma unei variații medii anuale a nivelului de poluare, *dD/dt*, în care se ia în calcul şi interesul investițional acordat mediului (investiții tehnice/tehnologice antipoluante sau de îmbunătățire a capacității de absorbție/asimilare a mediului) pentru reducerea lui:

$$\frac{dD}{dt} = \frac{Ep}{V} - hIr - \delta \quad (6)$$

where:

h - investment volume coefficient used to prevent pollution expressed by kg of pollutant, waste / one monetary unit invested;

Ir - volume of investments for increasing the absorption capacity of pollution in the natural environment targeted by pollution, expressed in lei/m^3, lei/km^2 or lei/ha;

δ - capacity of absorption / assimilation associated to the natural environment;

dt - l (annual time variation).

To determine the economic equilibrium from the ecological perspective, one will also quantify the average annual variation of the technical capital, *dk/dt*, depending on the rate of saving intended to the technical anti-polluant investment, *sk* and of the volume of production of technical capacities taken out of service as a result of physical or moral depreciation of technical capital, *gk*. Therefore:

în care:

h - coeficientul volumului de investiții utilizat pentru prevenirea poluării exprimat prin kg poluant, deşeu/un leu investit;

Ir - volumul investițiilor pentru creşterea capacității de absorbție a poluării în mediul natural vizat de poluare, exprimat în lei/m^3, lei/km^2 sau lei/ha;

δ - capacitatea de absorbție/asimilare aferentă mediului natural;

dt - l (variația de timp anuală).

Pentru determinarea unui echilibru economic, din perspectiva ecologică, se va cuantifica şi variația medie anuală a capitalului tehnic, *dk/dt*, în funcție de rata de economisire destinată investiției tehnice antipoluante, *sk* şi de volumul capacităților tehnice de producție scoase din funcțiune ca urmare a uzurii fizice sau morale a capitalului tehnic, *gk*. Astfel:

$$\frac{dk}{dt} = sk - gk \quad (7)$$

with dt = 1 (annual variation of time)

An *economic and ecological* stationary balance could be achieved when:

- the annual average variation of the level of pollution is zero, respectively dD = 0;
- the annual average variation of technical capital is zero, respectively dk = 0.

Analyzing each one of these two situations:

The first condition for achieving of an economic and ecological stationary equilibrium is represented by the annulment of the first derivative of the function *D*, (dD = 0), in the conditions of an annual variation of time *(dt = 1)*, situation in which the relation (6) becomes:

cu dt = 1 (variația de timp anuală)

Un *echilibru economico-ecologic* staționar se va putea realiza atunci când:

- variația medie anuală a nivelului de poluare este nulă, respectiv dD = 0;
- variația medie anuală a capitalului tehnic este nulă, respectiv dk = 0.

Analizăm pe rând aceste două situații:

Prima condiție pentru realizarea unui echilibru economico-ecologic staționar este reprezentată de anularea primei derivate a funcției *D*, (dD = 0), în condițiile unei variații anuale de timp *(dt = 1)*, situație în care relația (6) devine:

$$\frac{Ep}{V} - hIr - \delta = 0 \quad (8)$$

This relation combined with the savings achieved in the production process can be addressed in two different situations:

A. In the event that were not realize economies, (*S = 0* and *s = 0*). This means that without some loans, will not be able to make any kind of investments, and hence *hIr = 0*, situation in which the relation (8) becomes:

Aceasta relație coroborată cu economiile realizate în procesul de producție, poate fi abordată în doua ipoteze distincte:

A. În situația în care nu s-au realizat economii, (*S = 0* şi *s = 0*). Această situație înseamnă că, în lipsa unor împrumuturi, nu se vor putea realiza nicun fel de investiții, deci şi *hIr = 0*, situație în care relația (8) devine:

$$\frac{Ep}{V} - \delta = 0 \quad (9)$$

Introducing into this relation the volume of polluting emissions according to relation (8), we obtain:

Introducând în această relație volumul emisiilor poluante conform relației (8), obținem:

$$(qf + qc)\frac{Q}{V} - \delta = 0 \text{ or } (qf + qc)\frac{Q}{V} = \delta \quad (10)$$

Thus, from relation (10) results the equation that describes curve of the gross domestic product:

Astfel, din relația (10) rezultă ecuația care descrie curba produsului intern brut:

$$Q = \frac{\delta V}{qf+qc} \quad (11)$$

According to relation (11) follows that without investments in anti-pollutant technical equipment, there is a certain level of the gross domestic product Q for which operates a particular absorption capacity of the environment, δ corresponding to the volume or surface of environment affected by pollution V in relation to the cumulative pollutant effect emerged after the production, respectively, consumption processes (qf + qc).

B. In the event that was achieved a volume of savings *S* out of which were made anti-pollutant investments *hIr*, under the conditions of the existence relatively constant of the parameters *V, qf* and *qc* (supporting the hypothesis that the volume of polluting emissions depends directly on the volume of technical capital in service), will determine the absorption capacity / accumulation of the environment, starting from the equation (9) in which is entered Ep according to the relation (11):

Conform relației (11) rezultă că fără investiții în echipamente tehnice antipoluante, există un anumit nivel al produsului intern brut *Q* pentru care funcționează o anumită capacitate de absorbție a mediului, *δ* aferentă volumului sau suprafeței de mediu afectată de poluare *V* în raport cu efectul poluant cumulativ apărut în urma proceselor de producție şi, respectiv, de consum *(qf + qc)*.

B. În situația în care s-a realizat un volum de economii *S* din care s-au făcut investiții antipoluante *hIr*, în condițiile existenței relative constante a parametrilor *V, qf* şi *qc* (care susțin ipoteza că volumul emisiilor poluante este în dependență directă cu volumul capitalului tehnic aflat în funcțiune), se va determina capacitatea de absorbție / acumulare a mediului, pornind de la relația (9) în care introducem *Ep* conform relației (11):

$$\delta = \frac{(qf + qc)Q - qcS}{V} \quad (12)$$

Thus, from relation (12) results the equation that describes curve of the Gross Domestic Product:

Astfel, din relația (12) rezultă ecuația care descrie curba Produsului Intern Brut:

$$Q = \frac{\delta V + qcS}{qf + qc} \quad (13)$$

In comparison with the previous hypothesis, in this situation, according to relation (13), may be seen an increase of the gross domestic product *Q* supporting the capacity to absorb / accumulate the environment following the introduction of antipollution investments.

Within the Figure 4 was built the *equilibrium curve* as the geometric locus of different levels of gross domestic product, for which the quantity of the emitted pollutant is entirely absorbed by the environment, taking into account that *dD/dt = 0* where *dt = 1*.

According to the chart, follows that in the area *A* is manifested a level of pollution that puts pressure on the absorption capacity (assimilation) of the environment, over solicitating it, regardless of the level reached by the gross domestic product. Comparatively, in the area *B* the capacity of assimilation / absorption of the environment copes with the pollution level being undervaluated, regardless of the level reached by the gross domestic product.

În raport cu ipoteza anterioară, în această situație, conform relației (13), se poate constata o creştere a nivelului produsului intern brut *Q* care să susțină capacitatea de absorbție/acumulare a mediului ca urmare a introducerii investițiilor antipoluante.

În cadrul figurii 4 s-a construit *curba de echilibru* ca locul geometric al diferitelor nivele ale produsului intern brut, pentru care cantitatea de poluant emisă este absorbită în totalitate de mediu, ținând cont că *dD/dt = 0* în care *dt = 1*.

Conform graficului, rezultă că în zona *A* se manifestă un nivel de poluare care pune presiune pe capacitatea de absorbție (asimilare) a mediului, suprasolicitând-o, indiferent de nivelul atins de produsul intern brut. Comparativ, în zona *B* capacitatea de asimilare/absorbție a mediului face față nivelului de poluare, fiind sublicitată, indiferent de nivelul atins de produsul intern brut.

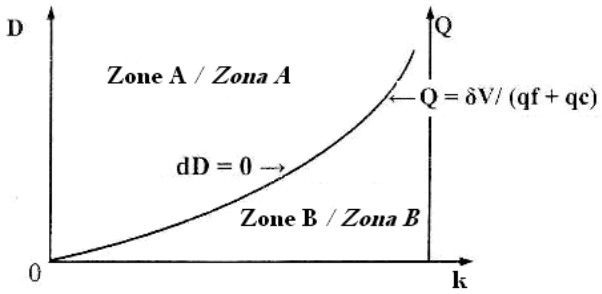

Fig. 4 – Gross domestic product influence on the absorbtion capacity of the environment, correlated with active technical capital fund / *Influența produsului intern brut asupra capacității de absorbție a mediului, corelată cu fondul de capital tehnic activ*

The second condition for achieving of economic and ecological stationary equilibrium is related to the annual variation of technical capital, illustrated by the relation dk/dt = 0, namely:

A doua condiție pentru realizarea echilibrului economico-ecologic staționar este legată de variația anuală a capitalului tehnic, ilustrată de relația dk/dt = 0, adică:

$$sF(k) - gk = 0 \quad (14)$$

or:

sau:

$$sF(k) = gk \quad (15)$$

From these relations follows that the premises of an economic and ecological stationary equilibrium will be reached only when the volume of technical capital put into operation through an investment *sk* equals the volume of technical capital removed from service *gk*.

Within the figure 5 was constructed the curve for the annual variation of the technical capital in relation to the active capital fund, the active technical capital stock appearing as a curve difference between the curves sk and gk.

From the figure follows that the annual variation of the technical capital is influenced by two factors, namely: amount of savings realized for investments (as a natural tendency of saving) and rate of technical capital removed from service(as a natural tendency of saving).

Din aceste relații rezultă că premisele unui echilibru economico-ecologic staționar se vor putea atinge doar atunci când volumul capitalului tehnic pus în funcțiune printr-o investiție *sk* egalează volumul capitalului tehnic scos din funcțiune *gk*.

În cadrul figurii 5 a fost construită curba pentru variația anuală a capitalului tehnic în raport cu fondul de capital activ, stocul de capital tehnic activ apărând ca o *curbă diferență* a curbelor *sk* şi *gk*.

Din figură rezultă că variația anuală a capitalului tehnic este influențată de cei doi factori, şi anume: volumul de economii realizate pentru investiții (ca tendință firească de economisire) şi rata scoaterii din funcțiune a capitalului tehnic.

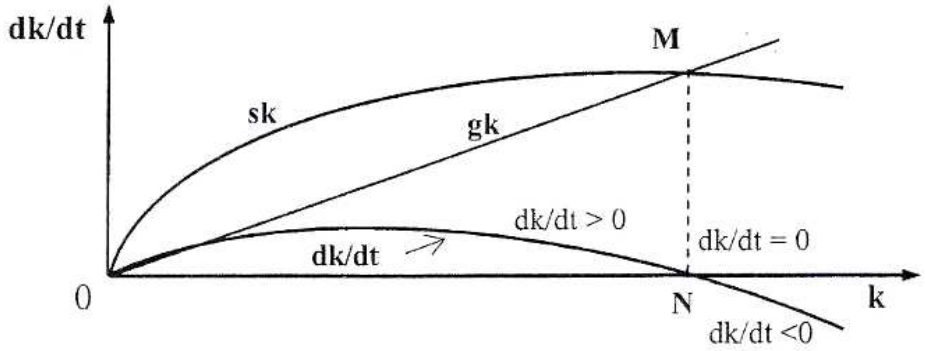

Fig. 5 – Annual variation of the technical capital depending on the fund and the stock of active technical capital / *Variația anuală a capitalului tehnic în funcție de fondul şi stocul de capital tehnic activ*

According to the chart, we have the relation *dk/dt > 0* when the volume of the invested capital is greater than the capital removed from service, that is when *sk > gk*, situation appeared as a result of the existence of a saving process converted into investments, mostly antipollution. In other words, the process of saving is the one that fosters and subsequently determines the replacement of technical capital physically or morally outdated.

In the case in which *sk = gk* (respectively the variation *dk/dt = 0*), the annual variation curve of the technical capital is represented by the straight *MN*. If *sk < gk* (respectively *dk/dt < 0*), the annual variation curve of the technical capital reflects a counterproductive process, of disinvestment.

When during one year the technical capital fund and the technical capital stock *k* are relatively constant, the annual

Conform graficului, avem relația *dk/dt > 0* atunci când volumul capitalului investit este mai mare decât volumul capitalului scos din funcțiune, adică atunci când *sk > gk*, situație apărută ca urmare a existenței unui proces de economisire convertit în investiții, majoritar antipoluante. Cu alte cuvinte *procesul de economisire* este cel care favorizează şi ulterior determină înlocuirea capitalului tehnic depăşit fizic sau moral.

În cazul în care *sk = gk* (respectiv variația *dk/dt = 0*), curba variației anuale a capitalului tehnic este reprezentată de dreapta *MN*. În cazul în care *sk < gk* (respectiv *dk/dt < 0*), curba variației anuale a capitalului tehnic reflectă un proces contraproductiv, de dezinvestire.

Atunci când pe parcursul unui an fondul de capital tehnic şi stocul de capital tehnic *k* sunt relativ constante,

variation of the technical capital becomes zero, *dk/dt = 0*, which will determine that in the coordinates represented by the annual polluting level in relation to the fund and the active technical capital stock, the annual variation curve of the technical capital (dk/dt) to be represented by the vertical straight AN, according to the chart from Figure 6.

variația anuală a capitalului tehnic devine nulă, *dk/dt = 0*, ceea ce va determina ca în coordonatele reprezentate de nivelul anual de poluare în raport cu fondul şi stocul de capital tehnic activ, curba variației anuale a capitalului tehnic (dk/dt) să fie reprezentată de dreapta verticală AN, conform graficului din figura 6.

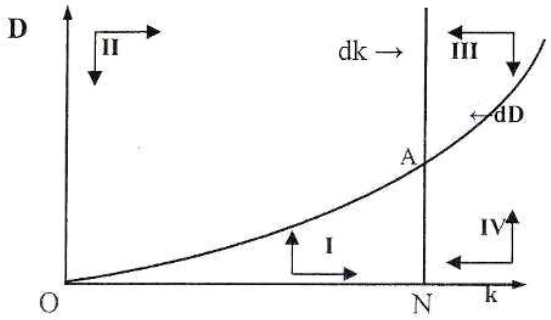

Fig. 6 – Stationary state of economic - ecological equilibrium /
Starea staționară de echilibru economico-ecologic

The intersection point *A* represents the state of stationary economic and ecological equilibrium when the variation of technical capital is zero, and the quantities of pollutants arising from the operation of technical capital at a time are totally assimilated / absorbed by the environment. Practically, the point A illustrates graphically the steady state taking into account the limited capacity for absorption / assimilation of the environment and supports its improvement.

Important researches are done concerning the plant protection equipment for the achievement of a treatment with a coefficient of variation (cv) of the solutions uniformity per unit of area as small as possible (6-9%). In this respect are studied the spraying systems, the control systems of working width by mounting on the aggregation tractors of some electronic systems (GPS) for the control of the treated surface and of the working width and are studied the mechanical systems for mounting of spraying ramps on the machine framework. Maintaining the spraying ramps in a stable position against the soil surface imposes their mounting through a pendular system, of various constructive shapes in correlation with the achievement of running system of the machine on air cushions. Besides the possibility of parallel positioning against the soil surface of spraying ramps is also used the position of "geo-variable". This constructive solution allows the independent adjustment of each lateral section of the ramp related to the ground.

Regarding the equipments for application of polluting products in vineyard and orchard is used equipment with hydraulic spray with carried jet or with pneumatic spray. The most important element of this equipment is the air flow adjustment and of spraying system in correlation with the characteristics of the crop to reduce the losses of pollutants on soil and increasing of the coefficient (R) of droplets retention on plants. The best values of R fit in percentages between 60-70% of the volume of norm of solution applied and retained on the foliar system of the plants. Maintaining of the coefficient R as close to the application of the entire volume of solution depends also on the type of spraying equipment and of its performance.

By repeated experimentations, it was found a direct correlation between the covering degree of foliar apparatus and the biological effect of treatment.

RESULTS

In order to solve the environmental problems, even in a hypothetical approach, can be expected two directions:

- ensuring equality between the rate of absorption / assimilation of wastes by the environment and the wastes resulting from

Punctul de intersecție *A* reprezintă starea echilibrului economico-ecologic staționar atunci când variația capitalului tehnic este nulă, iar cantitățile de poluanți care apar ca urmare a funcționării capitalului tehnic la un moment dat sunt în totalitate asimilate/absorbite de mediu. Practic, punctul A ilustrează grafic starea de echilibru care ia în considerare capacitatea limitată de absorbție/asimilare a mediului şi sustine îmbunătățirea ei.

Cercetări importante se fac asupra utilajelor de protecție a plantelor pentru realizarea unui tratament cu un coeficient de variație (cv) al uniformității soluțiilor pe unitatea de suprafață cât mai mic (6-9%). În acest sens se studiază sistemele de pulverizare, sistemele de control al lățimii de lucru prin montarea pe tractoarele de agregare a unor sisteme electronice (GPS) pentru controlul suprafeței tratate şi a lățimii de lucru şi se studiază sistemele mecanice de montare a rampelor de pulverizare pe cadrul maşinii. Menținerea rampelor de pulverizare într-o poziție stabilă față de suprafața solului impune montarea acestora printr-un sistem pendular, de diverse forme constructive în corelație cu realizarea sistemului de rulare a utilajului pe perne de aer. Pe lângă posibilitatea de poziționare paralelă față de suprafața solului a rampelor de pulverizare se utilizează şi poziția de “geo-variabil”. Această soluție constructivă permite reglarea independentă a fiecărui tronson lateral al rampei față de sol.

În ceea ce priveşte utilajele pentru aplicarea produselor poluante în vie şi livadă se folosesc utilaje cu pulverizare hidraulică cu jet purtat sau cu pulverizare pneumatică. Elementul cel mai important la aceste utilaje este reglarea debitului de aer şi a sistemului de pulverizare în corelație cu caracteristicile culturii pentru a reduce pierderile de poluanți pe sol şi creşterea coeficientului (R) de reținere pe plante a picăturilor. Cele mai bune valori ale lui R se încadrează în procente cuprinse între 60-70% din volumul normei de soluție aplicată şi reținută pe aparatul foliar al plantelor. Menținerea coeficientului R cât mai apropiat de aplicarea întregului volum de soluție este în funcție şi de tipul utilajului de stropit şi de performanțele acestuia.

Prin experimentări repetate, s-a constatat o corelație directă între gradul de acoperire al aparatului foliar şi efectul biologic al tratamentului.

REZULTATE

Pentru a putea rezolva problemele de mediu, chiar şi într-o abordare ipotetică, se pot preconiza două direcții:

- asigurarea egalității dintre rata de absorbție/asimilare a deşeurilor de către mediu şi deşeurile rezultate din

the economic activity implying a post-treatment of production / consumption wastes, so that they become perfectly assimilable (qualitative and quantitative) in the environment;
- ensuring of a parity between the economic development and the environmental degradation (inputs = outputs), which in microeconomical terms involves the use of only those types of technologies which do not generate any kind of wastes / residues, and in macroeconomical terms assumes the integral development of the industry exclusively based on the use of clean / non-polluting technologies.

At a microeconomic level, the approach of an alternative or another is possible when the technologies applied are new or continuously improved and when there are financial availabilities for their acquisition.

However, at both micro and macroeconomic level, the decision to invest in non-polluting technologies depends primarily of the vision of the economic agents management on the technological approach of productive organization, in accordance with the principles of a sustainable development of production.

Thus it reaches to a ***clean technology*** that can be, as it was defined within the European Union since 1985, a technology newly created when since from designing was modified radically the manufacturing process or a technology appropriately modified at the level of the existing manufacturing process, so that to isolate, eventually to minimize and reuse the secondary products which appear and which otherwise would lose.

The clean technology objectives stated two years later into the same EU Commission are:
- reducing the amount of pollutant substances discharged to air, water and soil;
- reducing the quantities of waste produced in the manufacturing process;
- reducing consumption of raw materials, water and energy.

In 1994 the U.N. gave a much broader definition to the clean technology, supposing the continuous improvement of industrial processes and products, to reduce the use of material and energetic resources, in order to prevent the air, water and soil pollution, to reduce the appearance of wastes and to minimize the risks at which are subjected the human population and the environment.

CONCLUSIONS

In order to apply the management of polluting systems to the agricultural crops, can be drawn the following conclusions:
- according to the Law 137/1995 of environmental protection the pollution represents the introduction directly or indirectly, arising from an activity performed by human, of substance that may disturb the human society or the environment quality;
- application of polluting products at the agricultural works is done by technologies that can not affect now and in the future the quality of the environment;
- from the national and international researches it follows that the technologies for the application and related equipment are constantly modernizing;
- compliance with the product dosage per hectare correlated with the treatment type and the characteristics of the crop represents an organizational problem of high importance;
- the spraying systems have elements for positioning towards the treated crop;
- correlating the tractors power with the characteristics of the agricultural equipment leads to the reduction of fuel consumption, and by installing of catalytic converters in the evacuation circuit of combustion gases it reduces the pollution.
- the agricultural equipment used within these technologies is in permanent modernization by equipping it with electronic elements for the control of the treated surfaces in correlation with the applied norm;

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activitatea economică ceea ce presupune o post-tratare a deşeurilor de producție/consum, astfel ca acestea să devină perfect asimilabile (calitativ şi cantitativ) în mediu;
- asigurarea unei parități între dezvoltarea economica şi degradarea mediului (intrări = ieşiri), ceea ce în termeni microeconomici implică utilizarea doar a acelor tipuri de tehnologii care nu generează niciun fel de deşeuri/reziduuri, iar în termeni macroeconomici, presupune dezvoltarea integrala a industriei exclusiv pe baza utilizării de tehnologii curate/nepoluante.

La nivel microeconomic, abordarea unei alternative sau a alteia este posibilă atunci când tehnologiile aplicate sunt noi sau continuu îmbunătățite şi când există disponibilitățile financiare pentru achiziționarea acestora.

Totodată, atât la nivel microeconomic, cât şi la nivel macroeconomic, decizia de a investi în tehnologii nepoluante depinde în primul rând de viziunea managementului agenților economici asupra abordării tehnologice a organizației productive, în conformitate cu principiile unei dezvoltări durabile a producției.

Se ajunge astfel la o ***tehnologie curată***, care poate fi, aşa cum a fost definită în cadrul Uniunii Europene încă din 1985, o tehnologie nou creată atunci când încă din proiectare s-a modificat radical procedeul de fabricație sau o tehnologie modificată corespunzător la nivelul procedeului de fabricație existent, astfel încât să izoleze, eventual să minimalizeze şi să reutilizeze produsele secundare care apar şi care altfel s-ar pierde.

Obiectivele tehnologiei curate precizate doi ani mai târziu în cadrul aceleiaşi Comisii a Uniunii Europene sunt:
- reducerea cantităților de substante poluante deversate în aer, apă şi sol;
- reducerea cantităților de deşeuri produse în procesul de fabricație;
- reducerea consumurilor de materii prime, apă şi energie.

În 1994 ONU a dat o definiție mult mai largă tehnologiei curate, care presupune îmbunătățirea continuă a proceselor industriale şi a produselor, pentru a reduce utilizarea resurselor materiale şi energetice, în scopul de a preveni poluarea aerului, apei, solului, a reduce apariția deşeurilor şi a minimiza riscurile la care este supusă populația umană şi mediul.

CONCLUZII

În vederea aplicării managementului sistemelor poluante în culturile agricole, rezultă următoarele concluzii:
- conform Legii de protecție a mediului 137/1995 poluarea reprezintă introducerea direct sau indirect, ca rezultat al unei activități desfăşurate de om, de substanță care poate produce perturbații societății umane sau calității mediului;
- aplicarea produselor poluante la lucrările agricole se realizează după tehnologii care nu pot afecta în prezent şi în viitor calitatea mediului;
- din cercetările pe plan național şi mondial rezultă că tehnologiile de aplicare şi utilajele aferente se modernizează permanent;
- respectarea dozei de produs la hectar corelat cu tipul tratamentului şi caracteristicile culturii reprezintă o problemă organizatorică de mare importanță;
- sistemele de pulverizare au elemente de poziționare față de cultura tratată;
- corelarea puterii tractoarelor cu caracteristicile utilajelor agricole conduce la reducerea consumului de combustibil, iar prin montarea catalizatorilor în circuitul de evacuare a gazelor de ardere se reduce poluarea;
- utilajele agricole folosite în cadrul acestor tehnologii sunt în permanentă modernizare prin echiparea lor cu elemente electronice de control a suprafeței tratate în corelare cu norma aplicată;

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MONITORING SOLAR RADIATION INTENSITY WITH SUN-EARTH ANGLE IN THE YEAR 2011 IN THE NORTH WEST OF BUCHAREST
/
MONITORIZAREA INTENSITĂȚII RADIATIEI SOLARE IN ANUL 2011 IN PARTEA DE NORD-VEST A ORASULUI BUCURESTI CU AJUTORUL UNGHIURILOR SOARE-PĂMÂNT

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Abstract:*. In this paper is monitored the intensity of solar radiation by the meteorological station based on solar radiation intensity and are calculated: intensity of diffuse radiation, direct radiation intensity, declination angle, hour angle, zenith angle, azimuth angle. The weather station type: AWS / EV is a product born from the need to frequently monitor the environment variables. Use of appropriate mathematical algorithm that we presented in this paper for determining sun-earth angle makes it possible to accurately follow the sun in the sky.*

The results of this monitoring solar radiation intensity, allow interpretations that can be exploited to determine the local potential of solar energy utilization. The efficiency of a solar collector (of thermal or PV panel type) can be meaningfully increased if the collector is tracked in accordance with the sun so that the incidence angle (angle between the sun ray and the perpendicular line on the collector's plane) becomes null or very small. Achieving this requirement involves modeling the Sun-Earth angle, which must be accurate, relatively simple to achieve.

Keywords: *global, direct and diffuse radiation, declination angle, hour angle, zenith angle, azimuth angle.*

INTRODUCTION

The sun is the Earth's energy source and is the only energy source able to maintain life on Earth. The sun is an inexhaustible source of energy, with an estimated duration of solar radiation of about 4...5 billion of years. Sun is not only the source of life on earth but also an important source of energy.

Global radiation from the Sun arrives on a horizontal surface at ground level in a clear day, as the sum of direct radiation and diffuse radiation. Direct solar radiation depends on the orientation of surface receivers.

In the proper design of buildings and/or other systems with the energy of the sun, solar radiations models suitable to reality are required.

Extraterrestrial solar radiation can be described, in a deterministic way, for any space and time position on earth, as a function of the sun-earth distance, the earth's inclination and the sun's zenith angle. The ground-level solar radiation is attenuated by atmosphere conditions, clouds distribution, climate type etc. So, for a given constant spatiotemporal position, the ground-level radiation is very difficult to predict. However, some statistical approximations for a specific period of the year can be carried out. [1]

MATERIAL AND METHOD

Global solar radiation intensity G in the horizontal plane was monitored by the weather station type: AWS / EV of the Faculty of ISB the U.P.B. SIAP + MICROS Geco program version 2.3.2 which automatically records the following parameters: atmospheric temperature, wind direction and speed, atmospheric humidity, solar radiation, rainfall.

Rezumat *În această lucrare, am monitorizat intensitatea radiației solare de către stația meteorologică, pe baza intensității radiației solare am calculat: intentistatea radiațeia difuze, intensitatea radiației directe, unghiul de declinație, unghiul orar, unghiul zenit, unghiul azimut.. Stația meteo tip: AWS/EV monitorizează frecvent variabilele de mediu. Utilizarea algoritmului matematic adecvat pe care l-am prezentat în lucrare pentru determinarea unghiurilor soare-pământ, face posibilă urmărirea cu exactitate a soarelui pe bolta cerească.*

Rezultatele acestui studiu de monitorizare a intensității radiației solare, permit interpretări care pot fi valorificate în vederea stabilirii potențialului local de utilizare a energiei solare. Eficiența unui colector, poate fi semnificativ crescută în cazul în care colectorul este amplasat în conformitate cu soarele astfel încât unghiul de incidență (unghiul dintre raza de soare şi linia perpendiculară pe planul colector) devine nul sau foarte mic. Realizarea acestei cerințe presupune o modelare a unghiurilor Soare-Pământ, care trebuie să fie corecte, relativ simplu de realizat.

Cuvinte cheie: *intensitatea radiației directe şi intensitatea radiației difuze, unghiul de declinație. unghiul orar, unghiul zenith, unghiul azimuth*

INTRODUCERE

Soarele este sursa de energie a Pământului şi este sursa de energie posibilă de a menține viața pe Pământ. Soarele este o sursă inepuizabilă de energie, cu o durată estimată a radiației solare de aproximativ 4....5 miliarde de ani. Soarele nu este doar sursa de viață de pe pământ, este de asemenea, o sursă importantă de energie.

Radiația solară directă depinde de orientarea de receptoare de suprafață. Radiația globală de la Soare ajunge pe o suprafață orizontală, la nivelul solului într-o zi ca sumă de radiație directă şi difuză.

În proiectarea corectă a clădirilor şi / sau alte sisteme cu energie de la soare, sunt necesare modelări ale radiației solare.

Radiația solară extraterestră poate fi descrisă, în funcție de distanța Soare-Pământ, înclinația pământului şi unghiul zenit. Radiația solară la nivelul solului este atenuată de condițiile de atmosferă, de prezența norilor, etc Deci, pentru o poziție constantă acordată spatiotemporal, radiatia la nivelul solului este foarte dificil de prezis. Cu toate acestea, unele aproximări statistice pentru o anumită perioadă a anului poate fi efectuată [1].

MATERIAL ŞI METODĂ

Intensitatea radiației solare globale G, în plan orizontal a fost monitorizată cu Stația meteo: AWS/EV de la Facultatea de ISB, cu programul SIAP MICROS Geco versiunea 2.3.2 programul înregistrează automat următorii parametrii: temperatura atmosferică, direcția şi viteza vântului, umiditatea atmosferică, radiația solară, cantitatea de precipitatii.

RESULTS

Based on global radiation intensity, were calculated diffuse and direct components of solar radiation.

Figure 1 shows the proportion of diffuse radiation intensity and direct radiation in global radiation.

It is interesting to note that the intensity of diffuse radiation is rather high compared with direct radiation. Based on Weather Station Record, 24 hours of 24, in year 2011, was found a diffuse radiation to be equal to one fifth of the value of global radiation, and direct radiation is the difference between global and diffuse radiation.According to equation (1)

Where: D - is diffuse radiation intensity;
G - global or total radiation intensity
B - direct radiation intensity

REZULTATE

Pe baza intensității radiației globale înregistrate, am calculat componentele difuză şi directă ale intensității radiației solare.

Figura 1 prezintă proporția de intensități de radiații difuze şi intensități de radiații directe în radiația globală.

Este interesant de observat că intensitatea radiației difuze are o pondere ridicată comparativ cu intensitatea radiației directe. Bazat pe înregistrarea stației meteo 24 de ore din 24 în anul 2011, am presupus intensitatea radiației difuze egală cu o cincime din valoarea intensității radiației globale, iar intensitatea radiației directe este diferența între globală şi difuză. Conform ecuației (1),

D – este intensitatea radiației difuză;
G – intensitatea radiației globală sau totală
B – intensitatea radiației directă

$$D = \frac{G}{5}, B = G - D \quad (1)$$

In figure 2 we presented the variation of global radiation recorded by the weather station in July 2011. Note that the value of global radiation was high on July 2, 2011 at 13, with a value of 960 W/m^2.

Based on measured and calculated values of global, diffuse, direct radiation from January 2011 – December 2011 it was graphically represented Figure 4. It is noted that large amounts of global radiation were recorded on May 24 at 2 o'clock p.m, with a value of 983, on June 18, at 1 o'clock p.m was the highest value of global radiation from 2011, namely of 1017 [W/m^2].

În figura 2, am prezentat variația radiației globale înregistrată de stația meteo în luna iulie 2011. Se observă că valoarea radiației globale a fost maxima în data de 02 iulie 2011 la ora 13, având valoarea de 960 [W/m^2].

Pe baza valorilor măsurate şi calculate de radiație globală, difuză, directe din ianuarie 2011-decembrie 2011 am reprezentat grafic figura 4. Se observă că valoare mare a radiației globale s-a înregistrat pe 24 mai la ora 14, având valoarea de 983, în data de 18 iunie, ora 13 a fost înregistrată cea mai mare valoare a radiației globale din anul 2011 aceasta fiind de 1017 [W/m^2].

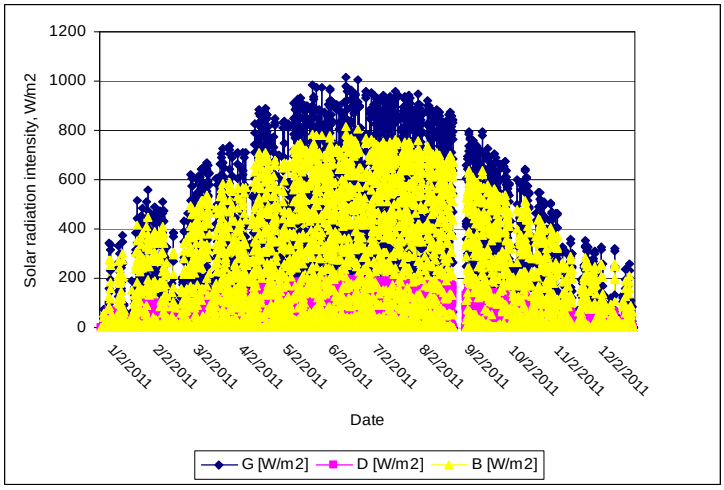

Fig. 1 - Variation of global direct and diffuse radiation for 2011 /
Variația radiației globale, directe si difuze pentru anul 2011

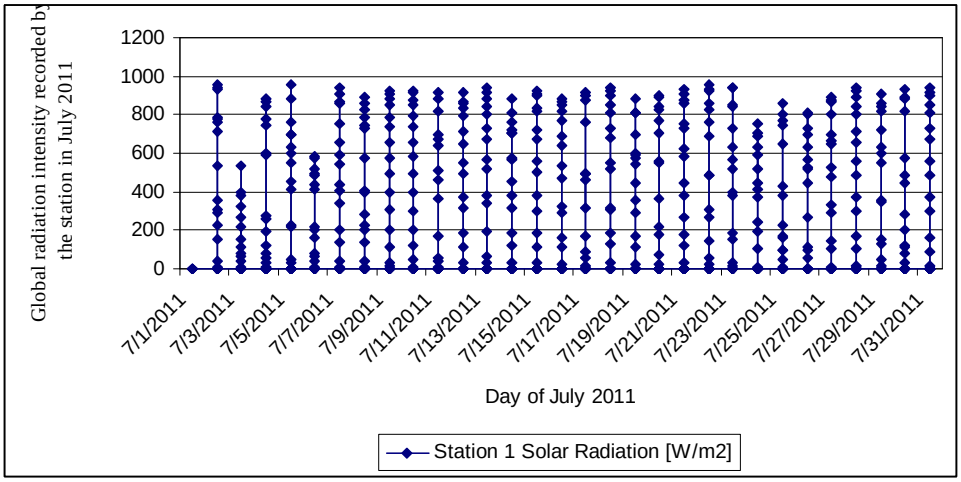

Fig. 2 - Variation of global radiation intensity recorded by the weather station in July 2011 /
Variatia intensitatii radiației globale înregistrate de stația meteo în luna iulie 2011

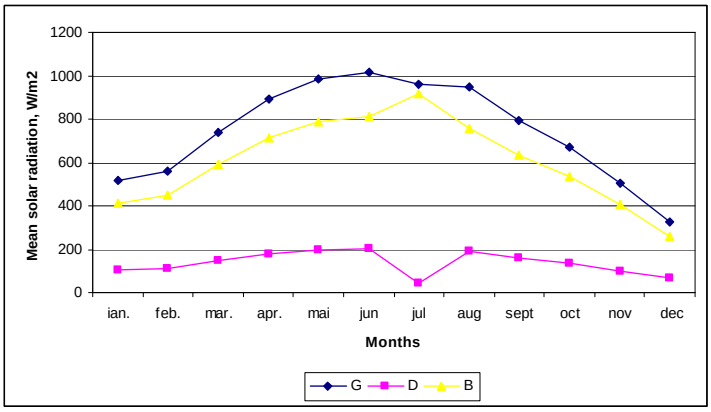

Fig. 3 - Mean global intensity of direct and diffuse radiation, in 2011 /
Valoarea medie a intensitatii radiației globale, directe şi difuze în anul 2011

Even in clear sky conditions, the radiation that reaches earth's surface in all directions from the diffusion phenomena, known as diffuse radiation, is 5...15% of the flux of solar radiation that reaches Earth's surface without being affected by this phenomenon, called direct radiation. Together, direct and diffuse radiation, represent the so called total or global radiation.

In Figure 3 is shown the correlation between components: global, direct, diffuse of radiation, the global component of the weather station being recorded at the Biotechnical Faculty Engineering Bucharest.

Calculation of angles

To determine the position of collector of solar radiation from the sun so the yield be maximum, the following angles are important :θ_z - zenith angle and solar azimuth angle γs (in figure 4 are the γ_s solar azimuth, elevation angle of the sun zenith angle α and hour angle ω) [2]

The calculation of these angles is done using mathematical formulas. Formula for the zenith angle is given by:

Chiar în condiții de cer senin, radiația care ajunge la suprafața pământului, în toate direcțiile datorată fenomenelor de difuzie, cunoscută sub numele de radiație difuză, este de 5...15 % din fluxul de radiație solară care ajunge la suprafața pământului, o altă radiație fără a fi afectată de acest fenomen, este numită radiație directă. Împreună, radiația directă şi difuza reprezintă radiația totală sau globală.

În figura 3 este prezentată corelația între componentele: globale, directă, difuză ale radiație, componenta globală a fost înregistrată de stația meteo de la Facultatea de Ingineria Sistemelor Biotehnice Bucureşti.

Calculul unghiurilor

Pentru a determina poziția captatorului de radiatii solare față de soare astfel încât randamentul său să fie maxim sunt importante următoarele unghiuri: azimutul solar γ_s (în figura 4 sunt azimutul solar γ_s, unghiul de înălțare a soarelui α_s şi θ_z unghiul zenith, unghiul orar ω) [2].

Calculul acestor unghiuri se face folosind formule matematice. Formula pentru unghiul zenit este:

$$\cos\theta = \sin\phi\sin\delta + \cos\phi\cos\delta\cos\omega \quad (1)$$

where Φ is a constant depending on the place where weather station is positioned to Bucharest, the latitude is 44°5'N and longitude 26°2'44", δ is the declination, and ω is the angle zone.

Angle β of the plan: It has values between 0 ≤ β ≤ 180°. Azimuth angle γ is: the angle of projection on the horizontal plane perpendicular to the sensor surface and the local meridian. Is 0 when the sensor plane is oriented to the south, is negative when oriented to east and positive when is orientated to west. Solar azimuth angle γ_s: is the angle between the south and the horizontal projection of direct radiation, α_s sun height angle: the angle of the sunlight falling on the sensor and the horizontal plane.

This angle depends on the latitude of the place of capture *Φ*, the declination angle δ and ω time. Relationship calculation is:

unde Φ este o constantă în funcție de locul unde este amplasată stația meteo latitudinea este 44°5'N şi longitudinea 26°2'44'', δ este unghiul de declinație, ω unghiul orar.

Unghiul de înclinare a planului β are valori cuprinse între 0 ≤ β ≤ 180°. Unghiul azimutal γ: este unghiul dintre proiecția pe planul orizontal a perpendicularei pe suprafața captatorului şi meridianul local. Are valoarea 0 când planul captatorului este orientat spre sud, este negativ când are orientarea spre est şi pozitiv când are orientarea spre vest, unghiul de azimut solar γ_s: este unghiul dintre direcția sud şi proiecția pe planul orizontal a radiației directe, unghiul de înălțime a Soarelui α_s: este unghiul dintre direcția razei solare ce cade pe captator şi planul orizontal.

Acest unghi depinde de latitudinea locului de captare Φ, de declinația δ şi de unghiul orar ω. Relația de calcul este:

$$\sin\boldsymbol{\alpha}_s = \sin\boldsymbol{\delta}\cdot\sin\boldsymbol{\Phi} + \cos\boldsymbol{\delta}\cdot\cos\boldsymbol{\Phi}\cdot\cos\boldsymbol{\omega} = \cos 0_z \quad (2)$$

Zenith angle θ_z is the angle between vertical and solar ray falling on the sensor. In other words it is the complementary angle α_s.

Angle zone ω: determines the position of the sun in the sky at a certain moment. Is 0 when the sun passes over the local meridian corresponding to point of the sensor location. This angle is positive to the east and negative to the west.

In one hour the sun crosses the sky with a 15^0 angle and its position at any time (T) is determined by the

Unghiul zenital θ_z: este unghiul dintre verticală şi raza solară ce cade pe captator. Altfel spus este unghiul complementar a lui α_s.

Unghiul orar ω: determină poziția Soarelui pe bolta cerească în momentul dat. Are valoarea 0 în momentul în care Soarele trece meridianul local corespunzător punctului de amplasare al captatorului. Acest unghi este pozitiv spre est (la răsărit) şi negativ spre vest (la asfințit).

Într-o oră Soarele traversează bolta cerească cu un unghi de 15^o, iar poziția lui la orice oră (T) se determină cu

relationship:

relația:

$$\omega = 15 \cdot (12 - T) \quad (3)$$

If the angle of declination, latitude and time angle are known, can be determined the Sun position by calculating the Sun high angle and solar azimuth angle, applying the above calculation relations.

The angle between the direction to the Sun in the place of capture and equatorial plane is called declination δ.

Formulas for calculating the angle of declination:

Dacă sunt cunoscute unghiul de declinație, latitudinea şi unghiul orar se poate determina poziția Soarelui pe bolta cerească calculând unghiul de înălțime a Soarelui şi unghiul de azimut solar, aplicând relațiile de calcul prezentate mai sus.

Unghiul dintre direcția spre Soare din locul de captare şi planul ecuatorial se numeşte declinația δ.

Relațiile de calcul a unghiului de declinație δ, sunt:

$$\delta = 23{,}45 \cdot \sin\left(360 \cdot \frac{284 + n}{365}\right) \quad (4)$$

$$\delta = 23{,}45 \sin\left(\frac{360(n - 80)}{365}\right) \quad (5)$$

where n is the day of the year when the measurements were taken: n = 30,416 (l-1) + x, In which l ∈ (1.....12): it is the month of the year; x – number of days in that month.

Based on the mathematical algorithm described above, the results are presented in the graph in Figures 5-10.

According to relations (4, 5) and Figure 5 and 6 the angle of declination is dependent on the day the measurements of solar radiation were made. In Figure 5 are represented the declination angle values in July 2011 and in Figure 6 are represented the minimum and maximum declination angle values based on statistical analysis in 2011.

From figure 7 is observed as shown in literature of specialty [4, 5] that time angle values are positive in the morning and negative after twelve o'clock.

According to Figure 10, azimuth angle γ is 0 when the plane collector faces south and is positive when it has west orientation.

unde n este ziua din an în care au fost luate măsurătorile. n = 30,416 (l-1) + x, l ∈ (1.....12) luna din an; x – numărul zilei din lună.

Pe baza algoritmului matematic, descris am prezentat rezultatele în figurile 5-10.

Conform relațiilor (4, 5) şi figurilor 5 şi 6 valoarea unghiului de declinație este dependentă de ziua n în care au fost făcute măsurătorile intensității radiației solare. În figura 5 sunt reprezentate valoarile unghiului de declinație în luna iulie 2011 iar în figura 6 sunt reprezentate valorile minime şi maxime ale unghiului de declinație pe baza analizei statistice în anul 2011.

Din figura 7 se observă aşa cum reiese şi din literaturade specialitate [4, 5] că valorile unghiului orar sunt pozitive dimineata şi negative după amiază.

Conform figurii 10, unghiul azimutal γ are valoarea 0 când planul captatorului este orientat spre sud şi valori pozitive când are orientarea spre vest.

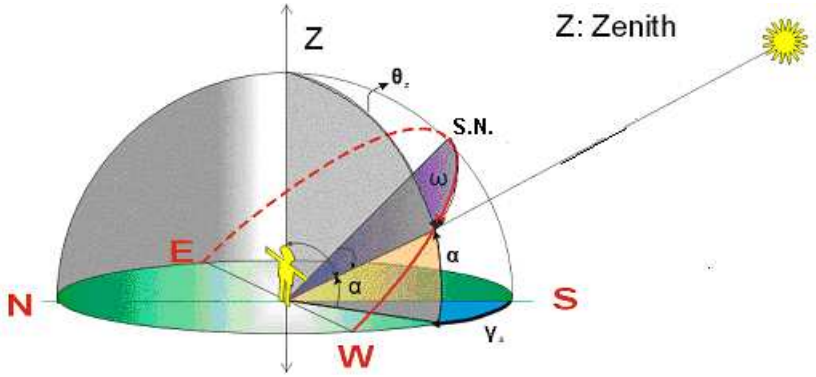

Fig. 4 - Trajectory of the sun in the sky- important angles / Reprezentarea unghiurilor de stabilire a poziției Soarelui pe bolta cerească [3]

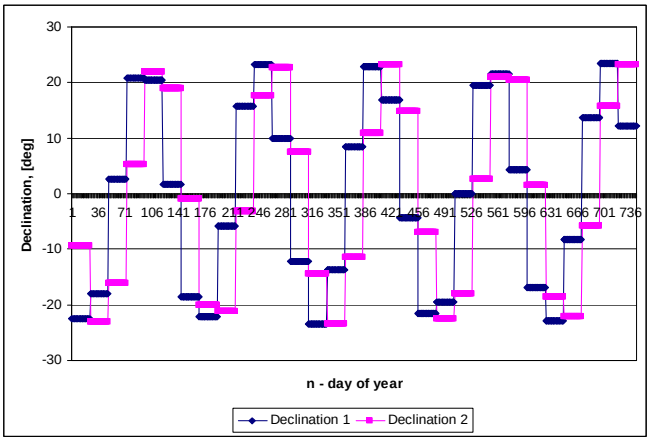

Fig. 5 - The variation of the declination angle depending on the day number of the year (n), calculated with the formulas of the two authors in July 2011 / *Variația unghiului de declinație în funcție de ziua n calculată conform celor doi autori în iulie 2011*

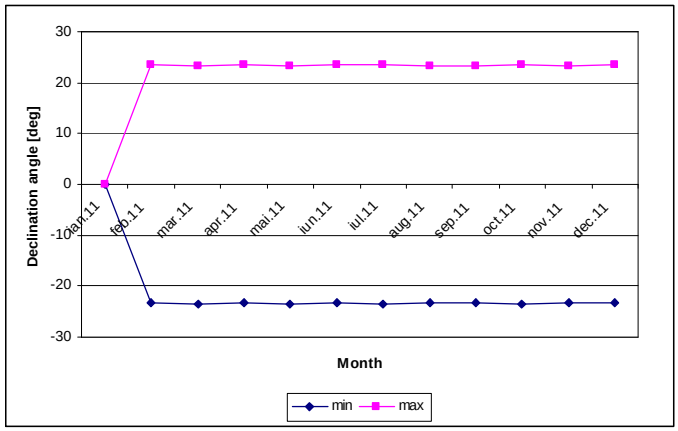

Fig. 6 - Variation of minimum and maximum values of the angle of declination in 2011 / *Variația valorilor minime şi maxime ale unghiului de declinație in anul 2011*

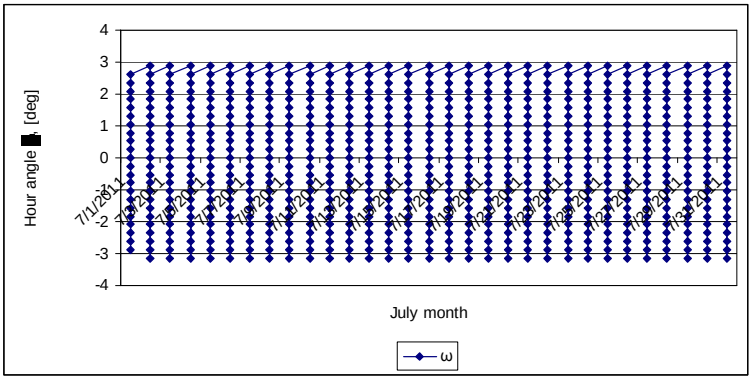

Fig. 7 - The variation of the hour angle in July 2011 / *Variația unghiului orar în luna iulie 2011*

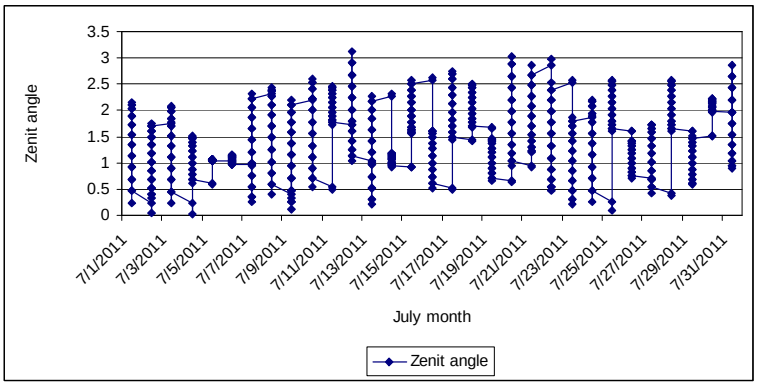

Fig. 8 - Zenith angle in July 2011 / *Unghiul zenit in luna iulie 2011*

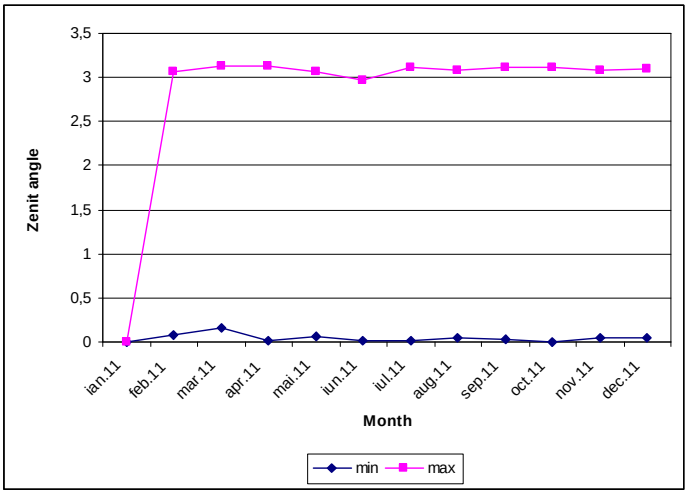

Fig. 9 - Variation of minimum and maximum values of the angle of zenith in 2011 / *Variația valorilor minime şi maxime ale unghiului de zenit in anul 2011*

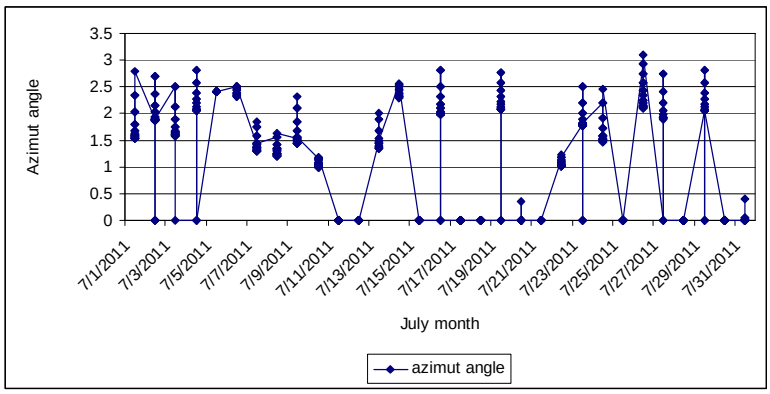

Fig. 10 - Azimuth angle in July 2011/ *Unghiul azimut în luna iulie 2011*

CONCLUSIONS

Using mathematical algorithm presented in this paper to determine the sun-earth angle (angle of declination, zenith angle, Solar azimuth), makes it possible to determine the position of collector of solar radiation from the sun so that its efficiency is maximum.Based on mathematical algorithm, we determined the values of these angles for 2011 and we plotted the values of angles for July, month when was recorded maximum solar radiation and minimum and maximum values for the whole year.

The results of this study of monitoring the intensity of solar radiation, allow interpretations that can be capitalized for the purposes of determining the local potential of using solar energy. To complete this study, it takes longer to monitor the intensity of solar radiation. Solar energy is the gateway to a new era, with its use in heating, resulting in reduction of environmental pollution.

The efficiency of a solar collector (of thermal or PV panel type) can be meaningfully increased if the collector is tracked in accordance with the sun so that the incidence angle (angle between the sun ray and the perpendicular line on the collector's plane) becomes null or very small. The achievement of this requirement supposes a modelling of the Sun-Earth angles that have to be accurate, relatively simple.

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CONCLUZII

Utilizarea algoritmului matematic prezentat in lucrare, pentru determinarea unghiurilor soare-pământ (unghiul de declinație, unghiul zenit, azimutul solar), face posibila determinarea poziției captatorului de radiatii solare față de soare astfel încât randamentul său să fie maxim. Pe baza algoritmului matematic, am determinat valorile acestor unghiuri pentru anul 2011 şi am reprezentat grafic valorile unghiurilor pentru luna iulie, lună în care s-a înregistrat valoarea maximă a intensității radiației solare, precum şi valorile minime şi maxime pe întreg anul.

Rezultatele acestui studiu de monitorizare a intensității radiației solare, permit interpretări care pot fi valorificate în vederea stabilirii potențialului local de utilizare a energiei solare. Pentru a finaliza acest studiu, este nevoie de mai mult timp de monitorizare a intensității radiației solare. Energia solară este poarta către o nouă eră, cu utilizarea acesteia în sistemele de încălzire, rezultând reducerea poluării mediului.

Eficiența unui colector solar (de tip panou termic sau PV), poate fi semnificativ crescută în cazul în care colectorul este amplasat în conformitate cu soarele astfel încât unghiul de incidență (unghiul dintre raza de soare şi linia perpendiculară pe planul colector) devine nul sau foarte mic. Realizarea acestei cerințe presupune o modelare a unghiurilor Soare-Pământ, care trebuie să fie corecte, relativ simplu.

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[5]. Messenger R., Ventre J. (2000) - *Sistemul fotovoltaic de inginerie*, Boca Raton, London, New York, Washington, CRC Press.

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Three types of manuscripts may be submitted:

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- All portions of the manuscript must be typed *single-spaced, A4***,** top and bottom: 2 cm; left: 2.3 cm; right: 1.7 cm, font: **Arial,** size 9 pt, except the title which will be 11 pt. and explicit figures, which will be 8 pt.
- 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.
- Text will be written in English in the left column, respectively in native language in the right column.
- 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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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

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Trei tipuri de manuscris pot fi trimise:

1. Articole obişnuite (normale): acestea trebuie să descrie cercetări noi şi confirmate, iar procedurile experimentale să fie descrise pentru a putea fi verificate in detaliu, fără a leza dreptul de proprietate intelectuală. Mărimea unei lucrări trebuie să cuprindă minimul necesar pentru a descrie şi interpreta în mod clar conținutul (ma.8 pagini);

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Notă: Sunt acceptate numai lucrările care nu au mai fost publicate anterior. În cazul în care autorii trimit spre publicare lucrări ce conțin date, informații, capitole, etc., din alte lucrări publicate anterior şi nu se fac referiri la acestea în text, răspunderea aparține acestora.

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- Titlurile capitolelor sunt scrise cu majuscule (ex: INTRODUCERE, MATERIAL ŞI METODE), între capitole se lasă un spațiu de 9 pt. La începutul fiecărui paragraf se lasă un "tab" de 0.5 cm;
- Lucrarea va fi scrisă în Word, aliniere "Justify".
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Titlul trebuie să fie o frază scurtă care să descrie conținutul lucrării. Acesta *va fi scris cu majuscule, centrat*, mărime: 11 pt*.,* bolduit, (titlul in engleză) şi *bolduit italic (titlul în limba maternă)*. Sub titlul lucrării după un spațiu de 9 pt., se scriu numele autorilor (ex: Vasilescu G.) (9 pt., bold), imediat sub numele autorilor se scrie: afilierea autorilor (9 pt., normal) iar pe următorul rând: telefonul, faxul, e-mailul corespunzător celui care a trimis lucrarea - primului autor (8 pt., italic).
Titlul trebuie să fie scurt, specific şi informativ. Evitați titlurile lungi, un titlu de sub 100 caractere este recomandat (fără spații).

Rezumatul trebuie să fie informativ şi uşor de înțeles; prezentați pe scurt topica, stadiul experimentelor, date semnificative, şi evidențiați descoperirile majore şi concluziile. Rezumatul trebuie să cuprindă între 100 şi 300 cuvinte. Propozițiile complete, verbele active, şi persoana a III-a trebuiesc folosite (rezumatul să fie scris la timpul trecut). Se va utiliza nomenclatura standard iar abrevierile trebuiesc evitate. Nu se vor utiliza citări de lucrări în

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.

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.

The **CONCLUSIONS** should interpret the findings in terms of the results obtained in this and in past studies on this topic. State the conclusions in a few sentences at the end of the paper. The Results and Discussion sections can include subheadings, and when appropriate, both sections can be combined.

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) and bold italic native language then separated by a slash. In the table, each row will be written in English (Arial, regular, size: 9 pt.) / *native language* (Arial, italic, 9 pt.). The table and its number is written right justified, bold - in English and bold italic - native language, separated by a slash (/).

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 - "rezumat" (font: 9 pt., titlu - *bold italic*; textul rezumatului - *italic*).

Cuvinte cheie: ca urmare a rezumatului, între 3 şi 10 cuvinte cheie trebuiesc listate, aceste oferind referințe de indexare (font: 9 pt., **bold italic** – titlul şi 9 pt., *italic* - textul).

Trebuie adăugată o listă de abrevieri specifice. În general, aceste abrevieri se folosesc atunci când termenul folosit este foarte lung şi des întâlnit în lucrare. Fiecare abreviere ar trebui introdusă în paranteză pentru prima dată când este folosită în text. Doar unități din SI trebuiesc folosite. Autorii trebuie să folosească prezentarea Solidus (mg/ml). Abrevierile standard (ca ATP sau ADN) nu trebuiesc definite.

INTRODUCEREA trebuie să ofere o expunere clară a problemei, esența relevantă a subiectului şi abordarea propusă sau soluția. Aceasta trebuie să poată fi înțeleasă de către colegi din diferite domenii ştiințifice.

MATERIALE ŞI METODE: trebuie să fie suficient de complete pentru a permite experimentelor să fie reproduse. Totuşi, numai metodele cu adevărat noi trebuie descrise în detaliu; metodele publicate anterior trebuie citate; modificările importante ale metodelor publicate trebuie menționate pe scurt. Scrieți cu majuscule denumirile comerciale şi includeți numele şi adresa producătorilor. Subcapitolele trebuie utilizate. Metodele utilizate în general, nu trebuie descrise în detaliu.

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CONCLUZIILE trebuie să interpreteze constatările în ceea ce priveşte rezultatele obținute în această lucrare şi în studiile anterioare pe această temă. Concluziile generale vor fi prezentate în câteva fraze la sfârşitul lucrării. Rezultatele şi discuțiile pot include subpoziții, şi atunci când este cazul, ambele secțiuni pot fi combinate.

Mulțumirile către oameni, cei care au acordat burse, fonduri, etc., trebuie să fie scurte (dacă este necesar).

Tabelele trebuie menținute la un nivel minim şi să fie proiectate pentru a fi cât mai simple posibil. Tabelele vor fi scrise la un rând, inclusiv titlurile şi notele de subsol. Fiecare tabel trebuie scris pe întreaga lățime a paginii, între textul în care se face trimitere; coloanele sunt eliminate - o singură coloană (vezi ataşat modelul). Tabelele trebuie să fie auto-explicative, fără referire la text. Detaliile cu privire la metodele utilizate în experimente trebuie să fie, de preferință, descrise în legendă şi nu în text. Aceleaşi date nu trebuie prezentate atât în tabel cât şi sub formă grafică (decât dacă este absolut necesar) sau repetate în text. Titlul tabelului va fi scris centrat, bold (în engleză) şi bold italic (în limba maternă), separate de un slash (/). În tabel, fiecare rând va fi scris în limba engleză (9 pt., normal) / limba maternă (9 pt., italic). Tabelul şi numărul acestuia se scrie aliniat la dreapta, bold - în limba engleză şi bold italic în limba maternă, despărțite de un slash (/).

Figurile trebuie scrise în ordine numerică. Grafica trebuie realizată utilizând aplicații capabile să genereze JPEG de înaltă rezoluție, înainte de a introduce în dosarul manuscris Microsoft Word (Insert - From File - ... JPEG).

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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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REFERENCES: are made in the text; a reference identified by [1], [2], ... [n] is written in the order that was placed at the end of the work - alphabetically.

Example:

[1], [2], [3], ..., [n]

References should be listed at the end of the paper in alphabetical order. 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:

Journal / Magazine:

[1]. Nicolescu M.A. (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.

[2]. Pirna I, Nicolescu M., Marin M., Voicea I (2009) - *Alternative supply of agricultural tractors with raw oils*. INMATEH - Agricultural Engineering, vol. 29, no. 3/2009, ISSN 1583-1019, pg. 89-92.

Conference or Symposium:

[1]. Bungescu S, Stahli W, Biriş S, Vlăduț V, Imbrea F, Petroman C (2009) - *Cosmos programme used for the strength calculus of the nozzles from the sprayers,* Proceedings of the 35 International Symposium on Agricultural Engineering *"Actual Tasks on Agricultural Engineering",* Opatija - Croatia, ISSN 1333-2651, pg. 177÷184.

Book:

[1]. Vlăduț V (2009) – *Study of threshing proces in axial flow apparatus*, Editura "Terra Nostra"Publishing, ISBN 973-1888-26-8, Iasi - Romania.

Book Chapter:

[1]. Vlăduț V (2009) – Considerations and hypotheses on modelling a threshing and separation process In: *Study of threshing proces in axial flow*, Editura "Terra Nostra" Publishing, ISBN 973-1888-26-8, pg. 61-69, Iasi - Romania.

Folosiți cifre arabe, pentru a desemna cifre şi litere majuscule pentru părțile lor (Figura 1). Începeți fiecare legendă cu un titlu care să includă o descriere suficientă, astfel încât figura să poată fi înțeleasă, fără citirea textului din manuscris. Informațiile furnizate în legende, nu trebuie repetate în text. Fiecare figură trebuie introdusă pe întreaga lățime a paginii, în text, acolo unde se face referire, o singură coloană (vezi ataşat eşantion), centrat. Lăsați un spațiu între figură şi textul figurii, mărimea: 3 pt.; numărul figurii va fi scris cu bold, 8 pct., centrat, urmat de ceea ce reprezintă figura sau graficul, scris cu 8 pt., normal. Prima dată se scrie textul în limba engleză (normal), urmat de un slash (/) apoi textul în limba maternă (italic). Exemplu:

Fig. 1 - Test stand / *Stand de testare* (mărimea: 8 pt.)

Figurile introduse trebuie să fie "*In line with text*" - Center, nu "*Square*"; "*Tight*"; "*Behind text*" or "*In front of text*" (din "*Format picture*" - butonul dreapta mouse pe figură şi apoi "*Layout*").

Formulele matematice, ecuațiile: autorii trebuie să furnizeze instrucțiuni privind modul de simbolizare şi de ecuații stabilite şi utilizate. Ecuațiile trebuie numerotate secvențial, în partea dreaptă şi în paranteze. Ele trebuie menționate în text ca ecuația (4) sau Ex. (4). Fiecare ecuație trebuie scrisă pe întreaga lățime a paginii, în text, acolo unde se face referire, o singură coloană (vezi ataşat model).

REFERINȚELE: se fac în text; o referință identificată prin intermediul [1], [2], ...[n], se scrie în ordinea în care a fost trecută la sfârşitul lucrării - ordine alfabetică.

Exemplu:

[1], [2], [3], ..., [n]

Referințele trebuie prezentate la sfârşitul lucrării în ordine alfabetică. Articole în curs de pregătire sau articole trimise spre publicare, observațiile nepublicate, comunicările cu caracter personal, etc, nu trebuie incluse în lista de referință, dar pot fi menționate în textul lucrării (exemplu, A. Danciu, Universitatea din Bucureşti, România, comunicare personală). Autorii sunt pe deplin responsabil pentru exactitatea referințelor.

Exemple:

Jurnal / Revistă

[1]. Nicolescu M.A. (2007) - *Proprietățile relevante ale combustibililor lichizi alternativi vizați pentru exploatarea motoarelor diesel în regim policarburat*, INMATEH - Inginerie Agricolă, vol. 27, nr. 1 / 2009, ISSN 1583-1019, pg. 50-55;

[2]. Pirna I, Nicolescu M., Marin M., Voicea I (2009) - *Alimentarea alternativă a tractoarelor agricole cu uleiuri vegetale crude,* INMATEH - Inginerie Agricolă, vol. 29, nr. 3 / 2009, ISSN 1583-1019, pg. 89-92.

Conferință / Simpozion

[1]. Bungescu S, Stahli W, Biriş S, Vlăduț V, Imbrea F, Petroman C (2009) - *Cosmos programm used for the strength calculus of the nozzles from the sprayers,* Proceedings of the 35 International Symposium on Agricultural Engineering *"Actual Tasks on Agricultural Engineering",* Opatija - Croația, ISSN 1333-2651, pag. 177÷184.

Carte

[1]. Vlăduț V (2009) - *Studiul procesului de treier în aparatul cu flux axial*, Editura "Terra Nostra", ISBN 973-1888-26-8, Iaşi - România.

Capitol din carte

[1]. Vlăduț V (2009) - Considerații şi ipoteze privind modelarea unui proces de treier şi separare. În: *Studiul procesului de treier în aparatul cu flux axial*, Editura "Terra Nostra", ISBN 973-1888-26-8, pg. 61-69, Iaşi - România.

Dissertation / Thesis:

[1]. Constantinescu A (2010) – *Optimization of aggregates of high power tractors and agricultural machines for preparing the field to be sown*. PhD dissertation, University of Transylvania Braşov, Braşov, Romania.

Units, Abbreviations, Acronyms

- Units should be metric, generally SI, and expressed in standard abbreviated form.
- Acronyms may be acceptable, but must be defined at first usage.

2. SHORT COMMUNICATIONS

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.

3. REVIEWS

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.

Disertații / Teze de doctorat

[1]. Constantinescu A (2010) - *Optimizarea agregatelor formate din tractoare de putere mare cu maşini agricole pentru pregătirea terenului în vederea însămânțării*. Teză de doctorat, Universitatea Transilvania Braşov, Braşov, România.

Unități, Abrevieri, Acronime

- unitățile metrice trebuie să fie, în general, SI, şi exprimate în formă prescurtată standard;
- acronimele pot fi acceptate, dar trebuie să fie definite la prima utilizare.

2. COMUNICĂRILE SCURTE

Comunicările scurte sunt limitate la maxim 2 figuri şi un tabel. Acestea trebuie să prezinte un studiu complet, care este mai limitat decât în cazul articolelor normale (de dimensiuni mai mari). Elementele de pregătire a articolelor normale (manuscriselor) enumerate mai sus se aplică şi la comunicările scurte, cu următoarele diferențe: (1) Rezumatul este limitat la 100 cuvinte; (2) capitolele Materiale şi Metode, Procedurile experimentale pot fi scrise împreună, încorporând figurile şi tabelele; (3) Rezultatele şi Concluziile pot fi combinate într-o singură secțiune.

SINTEZELE

Sintezele, comentariile şi perspectivele acoperind subiecte de interes din domeniu sunt încurajate şi acceptate spre publicare. Sintezele trebuie să fie concise şi nu mai mari 8 pagini. Toate celelalte condiții sunt similare cu cele de la articolele normale (obişnuite), enumerate mai sus.

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