EXPERIMENTAL STAND FOR THE STUDY OF THE WORK PROCESS OF A CONICAL SUSPENDED SIEVE WITH OSCILLATORY CIRCULAR MOTION

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REZUMAT: Sitele conice cu suprafaţa exterioară de lucru sunt utilizate puţin pentru curăţarea şi sortarea produselor agricole. În industria morăritului, aceste site sunt folosite pentru seminţe de grâu conditionate, înainte de măcinare, sunt aranjate orizontal şi pot fi fixe sau în mişcare de rotaţie. Lucrarea prezintă construcţia şi procesul de lucru al unei site conice suspendate, având mişcare alternativă circulară, în plan orizontal, care este folosită pentru eliminarea paielor mari de rapiţă. Sita poate fi utilizată, de asemenea, pentru sortarea dimensională a culturilor de seminţe, şi, pentru fracţiunile şrot din industria de morărit. Pentru a evalua eficacitatea sitei şi a mişcării materialelor de pe suprafaţa de screening, s-au făcut determinări asupra procesului de lucru al sitei. Pe baza rezultatelor obţinute, au fost întocmite curbe de distribuţie pentru materialul separat de sub sita, pe linia sa de generare. Lucrarea prezintă mai multe curbe de distribuţie a materialului separat pe linia generatoare de sita, aproximată prin corelare cu funcţie de regresie Lorentz.

Cuvinte cheie: site conice, morarit, curbe de distributie

ABSTRACT: Conical sieves with outer working surface are little used for cleaning and sorting agricultural products. In milling industry, these sieves are used for wheat seeds conditioning, before milling, are arranged horizontally and can be either fixed or in rotary motion.
This paper presents the construction and the working process of a conical suspended sieve, having alternative circular motion, in horizontal plane, which is used for the removal of large straw impurities from rapeseeds. The sieve can also be used for dimensional sorting of crop seeds, and also of grist fractions in milling industry. To assess the effectiveness of the sieve and of the material movement on the screening surface, determinations were made on the working process of the sieve. Based on the obtained results, distribution curves were drawn for the material separated under the sieve, on its generating line. The paper presents several distribution curves of the material separated on the sieve generating line, approximated by correlation with Lorentz reggresion function.

Keywords: conical sieves, milling, distribution curves

1. INTRODUCTION

For the study of vibration phemomena and the working process of conical sieves was considered the design and construction of an experimental stand, having an conical outer screening surface with vertical axis, suspended in three equidistant points at an equal distance from the vertical axis of the cone, by means of three metalic wires, on both upper and lower end [1,2].

Scheme of experimental stand is presented in Figure 1. The conical screening surface is made of perforated sheet with circular holes having diameter ϕ 4.2 mm, and the diameter at cone basis ϕ 430 mm.

Angle of tilt for cone generating line towards the horizontal surface is about 8^o.

Diameter of steel wires is ϕ1.5 mm. Driving mechanism of the sieve was designed to mainly ensure a circular alternative motion with a certain amplitude, measured at the edge of the conical sieve, on both sides of the neutral oscillation position in which is fixed an connection arm of lenght d, to the drive mechanism (horizontal oscillating circular saw).

As shown in Figure 1, the drive mechanism is composed of an AC electric drive with power of 710 W and a drive system worm-worm wheel with oscillating crank lever, whose operating button is eccentrically placed on the worm wheel of the drive transmission.

Oscillating crank lever's patch of the drive system is 16 mm, the levers arm beind jointed by ball joint to the rigid arm placed on radial direction to the base circle of the cone.

The experimental stand gives the possibility to adjust the parameters of oscillatory motion, namely, oscillation frequency F and oscillation amplitude A.

Oscillation frequency can be adjusted rom the electric drive by varying the parameters of electric current, while oscillation amplitude can be modified by changing the position of the drive mechanism against the radial arm of the sieve, joined together by ball joint 6, (see Fig.1).

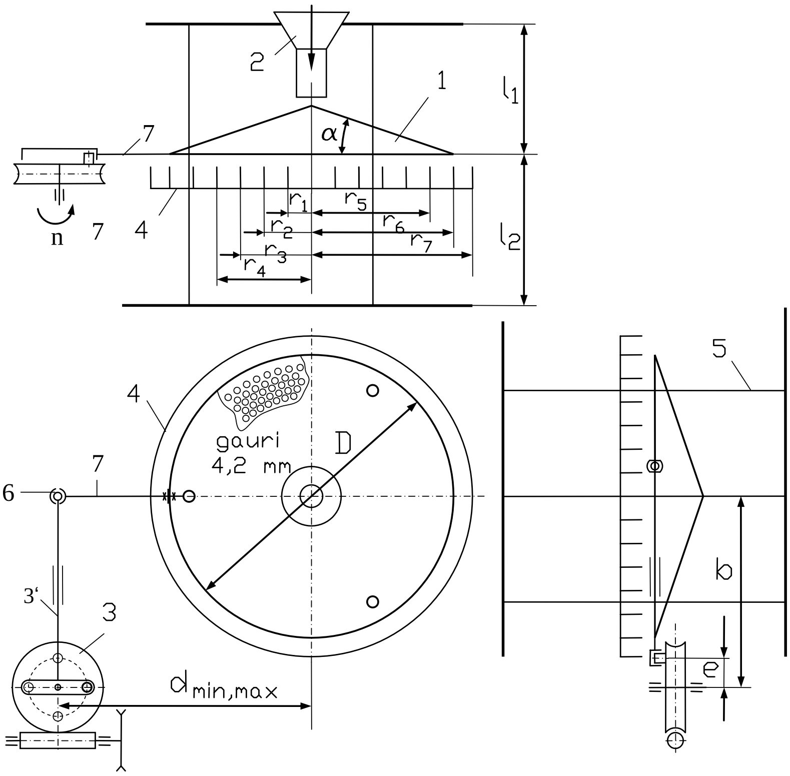


Fig.1. *Diagram of experimental stand with conical suspended sieve*
1. conical sieve with circular holes; 2. supply hopper; 3. drive mechanism with worm wheel and oscillating crank lever; 3'.arm of oscillating crank lever; 4. collector box for screened material; 5.metalic suspension wires; 6.ball joint; 7.radial connection arm

Thus, experimental researches were conducted on the behavior of sieve at the vibrations that occur during operation, and also on the material motion on the sieve and the screening process, using oscillation frequencies of 250, 520, 790 osc/min and oscillation amplitudes of 3.58; 3.74; 3.91; 4.10 mm, by varying distance d to 480, 460, 440 and 420 mm, the patch of operating button (joint 6) being 16 mm (fixed).

Figure 2 shows the diagram for the calculus of the amplitude of oscillatory motion.

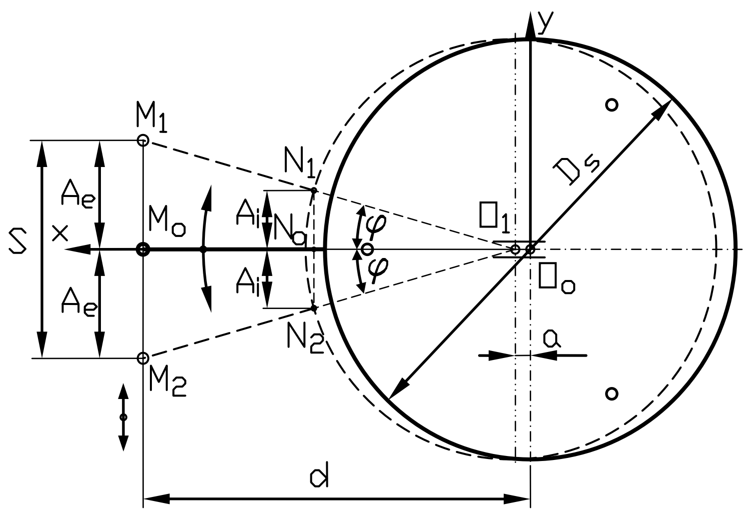


Fig.2. *Diagram for the calculus of the amplitude of sieve oscillations*

Density of circular holes on the screening surface was 2.25 holes/cm2, leading to an active surface of almost 31%, the lenght of the suspension wires of the sieve being ll =240 mm, l2 = 180 mm (see Fig.1).

The eccentric, tangential arrangement of the arm joint of the driving mechanism at the conical sieve develops almost circular oscillations towards the vertical axis of the cone, the motion being assumed oscillatory due to the fact that vertical axis of the sieve (its center) was not set to move in the direction of arm 7 jointed with the sieve, (placed radially to the base circle of the cone), even though the movements in arm direction are of 0.07 mm.

Small sizes of screening surface were chosen so that experimental measurements do not require a large amount of material, but, by geometric similarity, its sizes can increase so that the working capacity of the sieve in operating conditions can also be increased.

2. METHODICS OF EXPERIMENTAL DETERMINATIONS

The equipment designed and experimentally built was used for determinations of vibratory motions of screening surface (as working body for agricultural products) and also to estimate the motion of material on the sieve, as well as the efficiency of screening and sorting process of crop seeds.

Table 1. *Values of amplitude A_i for known lenghts of sieve arm*

d (mm)	φ (degree)	a (mm)	A_i (mm)
480	0.955	0.067	3.58
460	0.966	0.070	3.74
440	1.042	0.073	3.91
420	1.091	0.076	4.10

For experimental researches related to the work process of the sieve, determinations were conducted for each of the three previously mentioned frequencies, for four oscillation amplitudes of the sieve, and three different feed flows. For three adjusted distances of supply hopper towards the sieve, feed flow values were: 0.020 kg/s; 0.033 kg/s; 0.042 kg/s.

The collector box had following diameters: 80 mm; 140 mm; 200 mm; 260 mm; 320 mm; 410 mm; 460 mm. Mass of each material sample consisted of 500 g of rapeseeds and 15 g of large foreign bodies (straw leftovers from harvesting).

In order to ease data processing and drawing of representative experimental curves of the working process, the mass of material collected in each box under the sieve was reported at the sample seed mass, the results being computed as a percentage of it.

During the experiments, material amounts collected on sieve radius (measured in grams and in percentage), and material amounts passing sieve edge were recorded.

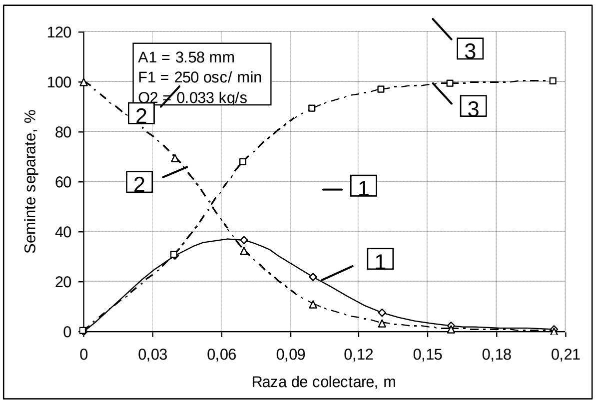
Based on the percentage of seeds screened on the collecting radius of the sieve were drawn the curves of screening intensity, namely, the relative distribution of screened material separated on the radius of base circle of sieves cone.

3. RESULTS AND DISCUSSIONS

Analyzing the distribution of experimental points for amounts of material screened on equidistant intervals along the lenght of a sieve with oscillatory motion concluded that the profile of intensity screening curve has a bell shape with some degree of asymmetry (left-right). For this purpose, it was first realised the regression analysis of experimental data with the known distribution function of Gauss [1,4,5]:

$$p_x(\%) = y_o + A \cdot \exp\left(-\frac{(x - x_c)^2}{2 \cdot w^2}\right); \quad y_o = 0, \qquad (1)$$

The multitudes of factors that influence the screening process and their randomness, as well as natural variability of the screened material, are contained in the values of constants in these equations.After studying the obtained graphics, it was found that these curves present a peak located at some distance from the feed point of the sieve, which leads to the conclusion that the motion of material on the screening surface of the sieve can be assessed by the position of this peak towards sieves end (in this case, the center, where material supply is performed).



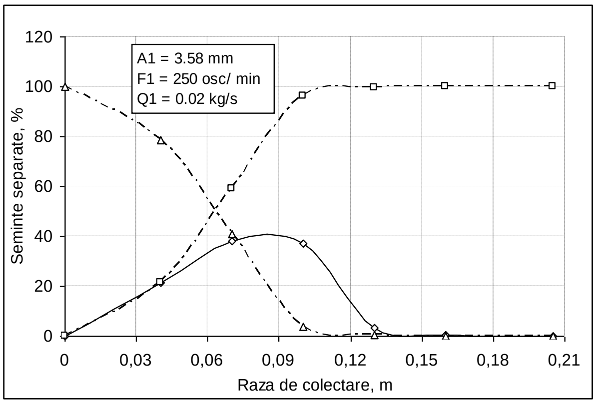


Fig.3. *Examples of separation curves of the material on the generating line of conical sieve*
1 – distribution curve of the material screened on sieve lenght (radius); 2 – cumulative percentage curve of unscreened material; 3 – cumulative percentage curve of screened materia

Thus, these curves can present some assimetry to the the collection center of material on the sieve, either left or right, which shows the speed or delay of material screening.

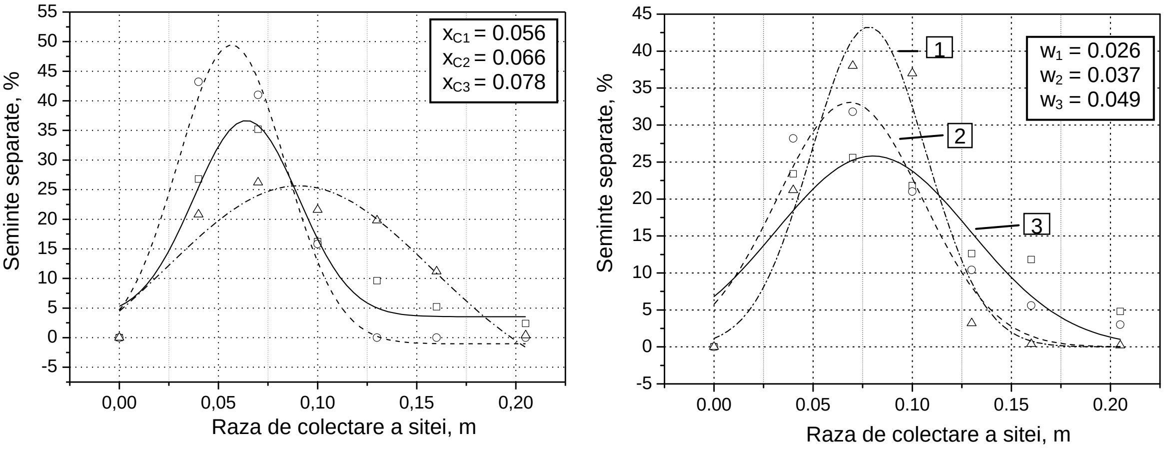


Fig.4. *Types of distribution curves with asymmetry or different dispersion*
1. curves of left asymmetry; 2. no asymmetry curves; 3. curves of right asymmetry

If the graphic shows an left asymmetry, respectively the peak curve is closer to the supply end of the sieve, it means that the material was screened faster, respectively if the graphic shows an right asymmetry, namely the peak position of distribution curve is further from the supply end, it means that screening was done later.

Literature states that a good screening and the existence of a proper screening process are given by the peak position of distribution curve in the first third of collection area (sieve lenght).

From the analysis of the distribution curves obtained from experiments can be seen that they have a lesser or greater extent than the length of collection area (Fig. 4b), being more or less flat, which indicates dispersion of the material on the sieve during the screening process. This dispersion is presented by one of the coefficients of regression equation (w parameter of the equation Gauss or normal). The higher the dispersion, the material is more evenly on the sieve during screening, which indicates the participation in the screening of a larger area of sieve surface.

However, as mentioned before, left asymmetry of the curve gives us a lower percentage of seed losses (even if not the entire sieve surface is evenly covered with material).

A distribution curve showing a medium dispersion and a very slight asymmetry (or no asymmetry), leads to obtaining some cumulative curves which presents an central inflection point with uniform material screening, on the first area of the sieve, and also on its second half.

If the asymmetry is visibly left, the profile of cumulative screening curves might show a pronounced horizontality, (a plateau on the last collection area), while if the asymmetry of distribution curve is visibly right, the profile of cumulative screening curves might present an small plateau on the first area of the sieve (from the supply point to the exhaust).

Such analysis of screening curves may allow estimations on the motion of material on the sieves surface, which constituted the objective of this experimental research related to the screening process performed by the proposed and used sieve for the experiments.

Peak position movement of screening curve, (xc), with variation of oscillation amplitudes for the three analyzed frequencies at the considered feed flow Q1≈ 0.020 kg/s is shown in Fig.5.

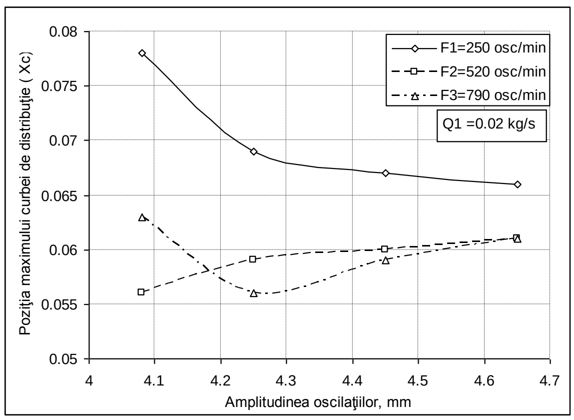


Fig.5. *Peak position of screening curve (x_c) with various oscillation amplitudes*
for feed flow $Q_1 \approx 0{,}020$ kg/s

From the analysis of obtained results for feed flow Q1 = 0.020 kg/s, for the presented oscillation amplitudes, it can be stated that the optimal oscillation frequency is around the frequency F2 = 520 osc/min, for which there is a very good correlation of the experimental results with Gaussian regression function, for which the correlation coefficient R2 had very good values (R2≥0.980).

4. CONCLUSIONS

This paper aims to demonstrate that conical sieves with alternative circular motion can be used successfully for the screening of foreign bodies from cereal seed mixtures, and material motion on the sieve is similar to that on plane sieves with translational oscillating motion [1,2]. For this purpose it was designed an experimental stand with conical suspended sieve in three points, which was used for experimental determinations to estimate the motion of material on the sieve and to assess the screening process. Appreciation of the screening process on the conical sieve with oscillatory motion (altermative circular) as represented by distribution curves of screened material, drawn by regression analyzis of experimental data with Gauss distribution function.It was found that an effective screening of seeds through the sieve holes occurs at a oscillation frequency ranging between 250-520 osc/min and mean amplitudes of sieve motion on the direction of driving arm.

The sieve can also be used successfully for size sorting of seeds of the same crop, if work regime parameters are chosen properly.

REFERENCES

[1] **Stoica D**., *Contribuţii la studiul fenomenelor vibratorii privind utilajele din domeniul prelucrării produselor agricole,* Teză de doctorat, Universitatea Politehnica Bucureşti, 2011;

[2] **Stoica D., Voicu Gh., Ungureanu N., Voicu P., Carp C. C**,. *Influence of oscilations amplitude of sieve on the screening process for a conical sieve with oscillatory circular motion*, Journal of Engineering studies and research, pag 83-89, Bacău, 2011

[3] **Tucu D**., *Morăritul – Sisteme tehnologice şi structuri productive*, Editura Mirton, Timişoara, 1994;

[4] **Voicu Gh., Stoica D., Ungureanu N.** - *Influence of oscillation frequency of a sieve on the screening process for a conical sieve with oscillatory circular motion*, Journal of Agricultural Science and Technology, USA, 2011, Vol.5, No.2 (in print);

[5] **Voicu Gh., Târcolea C., Căsăndroiu T., Eulerian and Weibullean** *Function Used for Simulation the Seedsof the Cleaning System*, Journal of Agricultural Machinerz Science, vol.4, nr.4, Turcia, 2008