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Frequency dependence on the separation process at a conical screen with vibrating movement

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Abstract: The paper presents some aspects regarding the working process of a perforated sheet metal screen with external conical surface having an oscillating circular movement on the horizontal. The separation intensity curves were plotted on the sieve generator, and by regression analysis with the normal distribution law the coefficients of the equation and the correlation with the experimental data were determined. The movement of the material on the sieve and its working process, in general, was appreciated by the position of the maximum distribution curve depending on the oscillation frequency of the sieve.

Keywords: grain sieving, conical sieve, oscillatory circular movement, oscillation frequency, rapeseeds, normal distribution law

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1. Introduction

The separation of the material on the site with oscillating motion is a complex process influenced by a wide range of factors related to both the physical properties of the material subjected to separation and the geometry of the separation system and its kinematic and functional parameters, [1]. Thus we can enumerate here the angle of internal and external friction of the seeds on the separation surface, their humidity and density, the shape of the material particles (seeds), their dimensions, the content of impurities in the seed mixture, etc. The efficiency of the cleaning process is therefore influenced by these parameters. For chickpea seeds, with average dimensions between 6.7-9 mm (average size 7.8 mm) and floating speed between 10-15 m / s (average speed 12.6 m / s), with a coefficient of friction minimum of 0.28 per galvanized steel sheet, the efficiency of a separating block with flat sieves with oscillating motion was over 84% when the impurity content was 5.75%, [2]. The angle of inclination of the sieves and the shape of the material particles subjected to sieving are also the factors that indicate (show) the efficiency of the sieving process, [3,4].

In the case of seed cleaning systems from combine harvesters that have straw grain with oscillating movement, but also in the cleaning blocks of grain from mill silos (separators-vacuum cleaners), the frequency and amplitude of oscillations are the main factors that can appreciate optimal separation efficiency. For a traditional cleaning system from grain harvesters, the optimal oscillation frequency is around 280-300 osc / min, [5,6]. By using circular oscillations at the sieve of a cleaning system, mounted on parallel crankshafts, the effect of separating the seeds increases even at higher sieve loads, instead the transport effect of the material remaining on the sieve is limited, which requires the use of a air flow under the sieve to facilitate the transport of the material, [7].

Using the theory of dimensional analysis, a mathematical model was determined to determine the degree of separation of small impurities from cereal seeds, under the influence of a number of seven main parameters involved in the work of a site with oscillating motion, [8]. The oscillation of the sieve, the size and shape of the separation holes also influence the movement of the material on the sieve and the process of separating the particles of material on the sieve, [9,10]. Given the heterogeneous physical properties of the material subjected to separation, the constructive and functional parameters of the separation systems show that the process of seed separation on the site with oscillating motion has a random character that can be hardly described by mathematical relations.

Different types of statistical laws for the distribution of separation intensity along the sieve length have been proposed and tested for the process of seed separation in combine cleaning systems, [11]. A model of probabilistic beta density functions has been proposed and verified by Târcolea, Casandroiu and Voicu, [12,18], to describe the variation of seed separation intensity along the sieve length. The coefficients of the mathematical equations used to describe the process of seed separation along the oscillating motion sieve include the factors influencing the process given both the characteristics of the seeds and their impurities, as well as the constructive and functional parameters of the separation block, [5,6 , 8,11,12,13].

2. Materials and methods

The experimental stand consists of a conical sieve suspended with a perforated sheet metal separation surface with holes ϕ 4.2 mm having a horizontal inclination of 80, driven in oscillating motion by a mechanism with eccentric arranged tangentially at distance d (variable), front from the center of the site. The sieve is suspended at the top and bottom by means of three metal cables with a diameter of 1.5 mm. The experiments were performed with rapeseed with dimensions between ϕ 1.25–2.5 mm (over 95%), verified using the sieves of a VAPO classifier. The seed moisture was 7.65-8.05%. Straw particles with a size of 3-4 mm in a percentage of about 3% were introduced into the seed mixture to be separated. The eccentric drive system allowed the change of the oscillation frequency in three stages, thus 250, 520 and 790 osc / min. The diameter of the conical sieve at its bottom was ϕ 430 mm and the density (density) of the circular holes on the separation surface of about 2.25 holes / cm^2 (the living surface of the sieve of about 31%), the diameter of the sieve supply hole with material was ϕ 25 mm. The scheme of the experimental installation is presented in figure 1. The mass of the sample material subjected to separation (rapeseed and impurities was 515 g - 500 g seeds and 15 g impurities), [19].

For a certain amplitude of the sieve oscillation, the samples were performed in sets of three experiments using three different flow rates for each of the three oscillation frequencies, adjustable by the distance between the seed outlet and the surface of the sieve at its top. The amplitude of the oscillations could be adjusted by moving the eccentric mechanism horizontally by changing the clamping distance d. (see Fig.1). This was calculated according to Figure 1, b, at the edge of the sieve, at its point of connection with the rigid arm OoMo (at point No), assuming that the center of the sieve has movement only on the Ox axis, its displacement being denoted by a. During the experiments, the distribution of rapeseed collected under the sieve was especially monitored because the impurities separated each time. Seed losses over the lower edge of the sieve were relatively low.

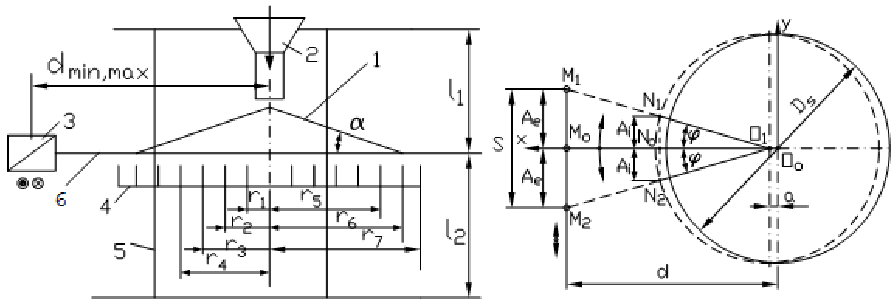

Figure 1. Scheme of the suspended conical sieve used in experiments

1.conical sieve with holes ϕ4.2 mm; 2. height-adjustable feeding funnel; 3. actuating mechanism with oscillating slide; 4. collection box; 5. elastic cables made of steel wire; 6. oscillating lever

3. Results

Main text paragraph The material collected in each of the concentric annular boxes was weighed and reported to the initial mass of the sample to determine the percentage of seeds separated at different distances from the top of the conical sieve (measured horizontally). The values in grams, respectively in percentages, of each fraction collected under the sieve for the material flow Q1 = 0.020 kg / s, four amplitudes of the sieve oscillations (3.58, 3.74 and 4.10 mm, considering the displacement of the sieve center only on the horizontal axis Ox - fig.1, b), at each of the three oscillation frequencies mentioned above are presented in Table 1.

Table 1. Variation of the amount of material collected under the sieve (%), for the feed rate Q=0.020kg / s and four amplitudes of the sieve oscillation, at different oscillation frequencies

Nr. crt.	Frequency of oscillations	Amplitude of oscillations	U.M.	The sieve range from which the seeds are collected. x_c (m)							
				0	0.04	0.07	0.1	0.13	0.16	0.205	Over the sieve
Q_1 = 0.020 kg/s											
1	F_1 = 250 osc/min	A_1 = 3.58mm	g	0	106	190	185	16	2	1	0
			%	0	21.2	38	37	3.2	0.4	0.2	0
2		A_2 = 3.74 mm	g	0	147	2	140	12	1	0	0
			%	0	29.4	40	28	2.4	0.2	0	0
3		A_3 = 4.10 mm	g	0	161	201	123	15	0	0	0
			%	0	32.2	40.2	24.6	3	0	0	0
4	F_2 = 520 osc/min	A_1 = 3.58mm	g	0	113	120	140	125	2	0	0
			%	0	22.6	24	28	25	0.4	0	0
5		A_2 = 3.74 mm	g	0	201	215	84	0	0	0	0
			%	0	40.2	43	16.8	0	0	0	0
6		A_3 = 4.10 mm	g	0	187	208	102	3	0	0	0
			%	0	28	36.6	19	12	4	0.4	0
7	F_3 =790 osc/min	A_1 = 3.58mm	g	0	180	204	116	0	0	0	0
			%	0	36	40	23.2	0	0	0	0
8		A_2 = 3.74 mm	g	0	216	205	79	0	0	0	0
			%	0	43.2	41	15.8	0	0	0	0
9		A_3 = 4.10 mm	g	0	186	225	89	0	0	0	0
			%	0	37.2	45	17.8	0	0	0	0

The separate seed distribution curves on the sieve generator were plotted for the three values of the oscillation frequency at the four values of the sieve oscillation amplitude presented above. Such an approach was used by Ermolev in to show the influence of site type on the separation process at different feed rates. (It should also be mentioned about Regge's work).

In order to estimate the influence of the oscillation frequency on the seed separation process on the sieve, the regression analysis of the experimental data (in%) with the normal distribution function was performed: $p_x(\%) = a \cdot e^{-b(x-c)^2}$ (1)

where: px (%) represents the percentage weight of the separated material over a sieve length range; a, b, c - regression coefficients that depend on the parameters of the working regime and on the physical characteristics of the processed material.

Thus, in relation (1), a represents the maximum percentage of material collected in the boxes under the sieve, c represents the radius of the sieve corresponding to the maximum percentage of separated seeds (or the average of the normal distribution function), and b provides dispersion data with respect to position of maximum. The values of the coefficients of the regression equations, for the proposed function and the specified working regimes (Table 1), a, b and c together with the values of the correlation coefficients $\chi 2$ and R^2 are presented in table 2. The influence of the frequency of the oscillations of the sieve on the separation process and finally on the seed losses that reach and pass beyond the lower edge of the sieve could be estimated by the position of the maximum separation curves towards the top of the sieve (where the material is fed) In Figure 2, under different working conditions determined by the regression analysis performed.

Figure 2. The influence of the oscillation frequency of the sieve on the seed separation process on the conical sieve generator, at the flow rate Q1 = 0.020kg / s and four amplitudes of the oscillation

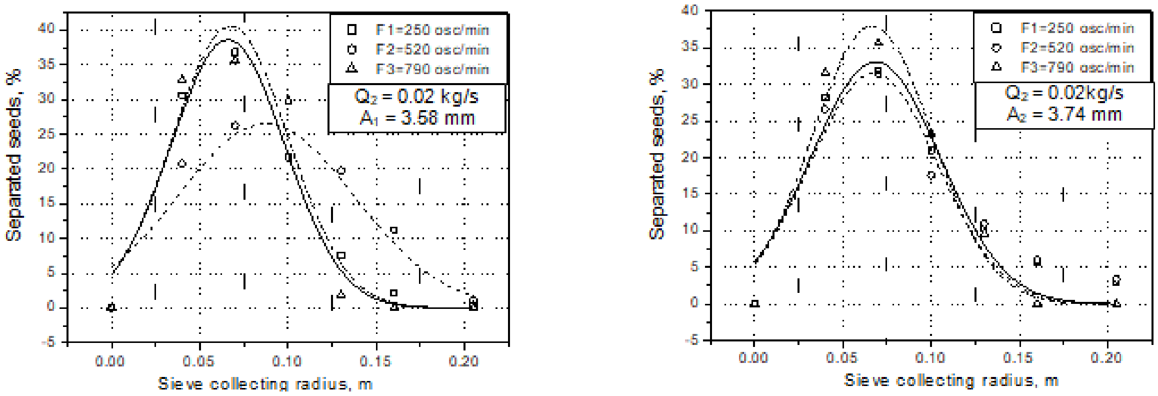

Table 1. **Coefficients of the regression equation a, b and c and correlation coefficients χ^2 and R^2 with the experimental data, for the kinematic parameters modified at the feed rate Q1 = 0.020kg / s**

No Test	Working regime		a	b	c	χ^2	R^2
1		F_1=250 osc/min	43,281	0.078	0.029	24,569	0.971
2	A_1= 3.58 mm	F_2=520 osc/min	49,741	0.056	0.026	11,892	0.891
3		F_3=790 osc/min	49,979	0.063	0.029	14.104	0.937
4		F_1=250 osc/min	42,485	0.069	0.030	13,578	0.914
5	A_2= 3.74 mm	F_2=520 osc/min	49,184	0.059	0.026	7,889	0.882
6		F_3=790 osc/min	49,746	0.056	0.0263	11,892	0.960
7		F_1=250 osc/min	42,835	0.066	0.030	8,336	0.800
8	A_4= 4.10 mm	F_2=520 osc/min	46,194	0.061	0.028	13.583	0.932
9		F_3=790 osc/min	49,143	0.061	0.026	4,899	0.937

The analysis of the data in the table shows a very good correlation of the experimental results (weights of quantities of material collected under the sieve on its horizontal radius in percent) with the proposed regression function (equation 1), for which the correlation coefficient R2 had very good (R2=0.88), in most cases analyzed. 0.88),

For small feed rates (Q = 0.020kg / s) and the oscillation amplitude of the sieve of A1 = 3.58 mm, it is observed that with the increase of the frequency from F1=250 osc/min to F2 =520 osc/min the position of the maximum curve of the distribution of the separated material on the sieve generator (expressed by the value of the coefficient c from equation 1) moves on the radius (generator) of the sieve from inside to outside (ie from supply to discharge, from c = 0.029 m to c = 0.026 m , after which it approaches again to the supply point (c = 0.029 m) at the frequency F3 = 790 osc / min, from which it can be deduced that at high oscillation frequencies the separation process is uneven.

4. Discussion

By changing the oscillation amplitude from A1 = 3.58 mm to A2 = 3.74 mm there is an improvement of the separation process, with the increase of the oscillation frequency of the sieve, expressed by the position of the maximum distribution curve of the separated material on the sieve generator. -from the outside to the center of the sieve (ie from the outlet to the supply, from c = 0.030 m for the oscillation frequency of the sieve F1 = 250 osc / min, to c = 0.026 m, for the frequency F2 = 520 osc / min, respectively at 0.0263 m for the oscillation frequency F3 = 790 osc / min The same phenomenon shows the movement of the material on the sieve and for the amplitudes A3 and A4, respectively there is a slight improvement of the movement of the material on the sieve with increasing frequency of oscillation, which leads us to assume that the speed of the material moving through the sieve increases, but although the maximum percentage of separated seeds on the sieve generator is closer to the e separates later, so the dispersion is larger. Also, although the feed rate is relatively low, due to the greater spreading of seeds on the sieve there may be seed losses over the edge of the sieve, which is observed at the frequency of 520 osc / min and at higher amplitudes.

5. Conclusions

For a conical oscillating sieve suspended at the top and bottom in three points, diameter ϕ 430 mm, at low material feed rates, the separation process is influenced by the oscillating movement of the sieve, through its kinematic parameters: frequency of oscillation and amplitude of oscillation. Various known distribution laws (Lorentz, Gauss, gamma, beta, Weibull, etc.) can be used for regression analysis. It was found that the normal distribution function, used by us in the regression analysis, correlates the experimental data well enough, the correlation coefficient R2 having in most of the analyzed cases values R2 = 0.88. In our experiments, the position of the maximum distribution curve changed with the change of the oscillation frequency, a higher oscillation frequency generally leading to a faster movement of the seeds on the sieve, but there must be enough time for them to pass through the holes. Our research was focused primarily on the working process of a site with an external conical profile that we want to propose as a machine for cleaning, separating and sorting seeds and other granular agricultural materials. Therefore, we tried to find out the influence of some kinematic parameters of the machine on the separation process and, finally, on its efficiency through the losses of seeds over the sieve or through the purity of the separated material.

For the analyzed sieve, the results obtained in laboratory experiments lead to the conclusion that such a sieve (conical, suspended, with reciprocating circular motion) can be used successfully to separate impurities from seed mixtures, but there must be a correlation corresponding between the kinematic parameters of the sieve, the diameter of the holes and the physical characteristics of the separate material. The data presented in this paper can be useful to specialists in the field of seed cleaning and conditioning in order to choose the optimal working regime.

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