# INFLUENCE OF OSCILLATIONS AMPLITUDE OF SIEVE ON THE SCREENING PROCESS FOR A CONICAL SIEVE WITH OSCILLATORY CIRCULAR MOTION

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**Abstract:** A conical suspended sieve, with oscillatory circular motion, was tested for rapeseeds screening, in order to estimate the influence of oscillation parameters on the separation process. Amplitude and frequency of oscillation were modified, as well as the feed flow with material. Distribution curves were drawn for the separated seeds under the sieve for various distanced from the top edge of the sieve, where feeding was made. By regression analysis by means of Gauss distribution law, were determined the coefficients of distribution function and the correlation with the experimental data. By determining the position of the peak of distribution curve depending on the working regime parameters was estimated the influence of oscillation amplitude on the process of seeds separation.

**Keywords:** conical sieve, oscillatory circular movement, oscillation amplitude, sieving, rapeseeds, separating distribution curve, normal law, correlation

## 1. INTRODUCTION

Impurities separation after particle size is performed, generally, in separation blocks with sieves having oscillatory motion. Sieving and separation on sieves requires a relative motion of material particles on the separation surfaces, which is ensured by proper sieve tilting, or by the oscillatory motion of the sieving blocks. There are different forms of separation surfaces (flat, conical, cylindrical, parabolic), and the oscillatory motion is obtained by means of various mechanisms, such as crank-rod assembly (with eccentric) or by means of rotating unbalanced masses (moto-vibratory), or with other mechanisms that ensure the necessary oscillatory motion. Also, separation surfaces can be made in the form of metallic or textile matting, or that of perforated sheets with holes, usually elongated or circular.

Experimental researches on the separation process on sieves with oscillatory motion were performed by many researchers worldwide. Thus, material separation on the sieve is influenced by the amplitude and frequency of oscillations, which provides relative motion of the material on the separation surfaces. Other parameters influencing the separation are: sieve slope, the angles of internal and external friction of the material, opening of sieve holes, the average particle size [1, 3, 4]. Mechanical grading of seeds using sieves is not a full grading, each time in a fraction are found between 10-20% of the particles of another fraction [2].

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Oscillation parameters, mainly the frequency and amplitude, for sieve blocks with oscillatory motion, have direct influence on the separation process of the impurities from the mass of seeds, by the motion printed to material particles which must move from the feeding point towards the point where are collected the particles with sizes larger than the sieve holes. Thus, the two features of the sieve are highlighted: the function of separation for particles smaller than the holes and the function of transport for larger particles [5, 6].

## 2. MATERIAL AND METHODS

To estimate the influence of the working regime parameters of a conical suspended sieve, having the separation surface of perforated sheet with holes of ϕ4.2 mm and tilt of 8° to the horizontal, on the separation process, in the experiments were used mixtures of rapeseeds and large straws impurities. Seeds moisture ranged between 7.65-8.05%, and it was determined with Kern RH120-3 thermobalance, at 105°C drying temperature. Seed sizes were between ϕ1.25-2.5 mm (in over 95% percentage), sieved using a VAPO classifier with sieves, while the sizes of straws impurities were larger than 3.5 mm.

Simplified diagram of the equipment used for the experiments is presented in Figure 1.

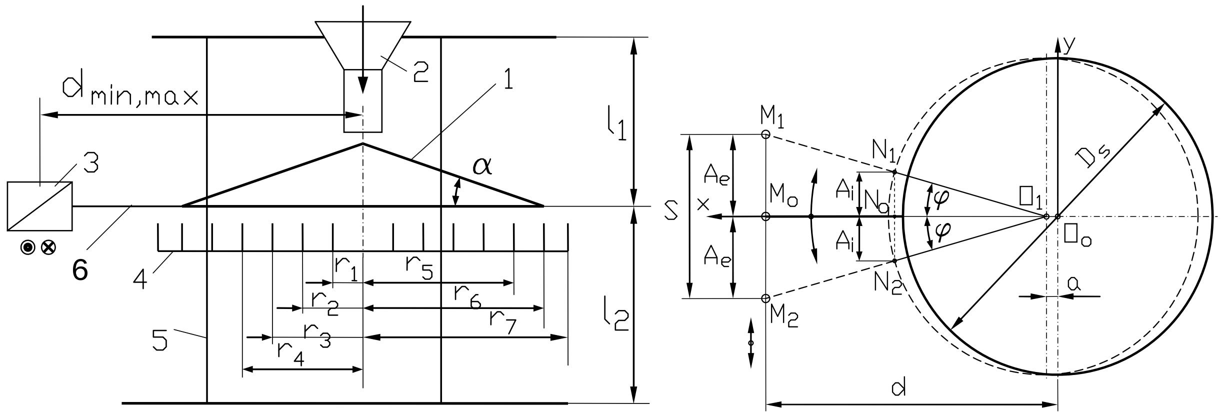


Fig. 1. Diagram of the conical suspended sieve used for the experiments:
1 — conical sieve with holes of ϕ4.2 mm; 2 — feed hopper with adjustable height; 3 — drive mechanism with oscillating crank lever; 4 — receiving box; 5 — elastically steel wires; 6 — oscillator lever (arm).

The conical sieve is suspended using steel wires of diameter ϕ1.5 mm, and its drive in oscillatory motion (alternative rotation) was made using a electrical drive fitted with an worm and wheel system with worm wheel with oscillating crank lever. The drive was made at the distance *d* (adjustable) from the centre of the sieve (in rest position) on the sieves edge being connected rigidly on radial direction the lever 6 (Figure 1). This was connected to the lever of the oscillating crank lever by means of a coupling spiral spring to reduce the oscillation of the sieve on the radial direction of lever 6, at the run ends of the stroke. Thus, the amplitude of the oscillation was controlled, in three levels, by modifying distance *d*, from $d_{min}$ at $d_{max}$, thus being obtained amplitudes of sieves oscillation of 4.10, 3.74 and 3.58 mm. Also, the frequency of sieve oscillations was controlled using the drive mechanism, three different oscillation frequencies being used: 250, 520 and 790 osc/min. The diameter of the conical sieve, at the bottom, is 430 mm, and the density of the circular holes on the separation surface is 2.25 holes/cm$^2$ (for a live surface of the sieve of about 31%). The lengths of suspension wires are $l_1$ = 240 mm, respectively $l_2$ = 180 mm [7].

Within the experiments, determinations were performed at each of the three oscillation frequencies and three amplitudes of sieve oscillation, for three different feed flows, obtained by positioning above or below the outlet of the feed hopper. The three feed flows used for the experiments were: 0.20, 0.33 and 0.42 kg/s, sample mass had the same amount of rapeseeds each time: 0.5 kg (with 3% of straw impurities larger than 3.5 mm). The outlet of the feed hopper had a diameter of 25 mm. Rapeseeds collection under the sieve was performed in a box with several sets of circular, concentric compartments, having diameters of: 80, 140, 200, 260, 320, 410 and 460 mm. Material samples had a large impurities content of 3% in comparison with the rapeseeds. Sensing of the beginning and ending moments of material supply was done visually, by starting and stopping each time a timer with digital display. To obtain the three desired feed flows, for each of the frequencies and amplitudes of the oscillations mentioned above, were performed several preliminary determinations, in order to detect the height adjustment of the feed hopper.

Mainly, it was followed the distribution of rapeseeds collected under the sieve, because large impurities were totally separated each time, as well as losses of seeds in the material that has passed the edge of the sieve. To estimate the sorting degree of the seeds, experimental measurements were performed by fractional sorting of the material collected in each of the boxes under the sieve, the seeds having sizes larger than $\phi$1.25 mm (in higher percentage than 95%).

## 3. RESULTS AND DISCUSSION

To estimate the amplitude influence of sieve oscillations on the separation process on the sieve, experimental data were analyzed and distribution curves were drawn comparatively (on the same graphic) seeds separation on the sieve generating line, for four values of amplitude oscillations dues in the experiments, while keeping constant the values of the other parameters of working regime (feed flow Q and oscillation frequency F). Variation of the amount of material collected under the sieve, on the generating line of the sieve with the oscillation amplitude of the sieve for three oscillation frequencies and the feed flow $Q_1$ = 0.020 kg/s is presented in Table 1.

Table 1. Variation of the amount of material collected under the sieve (%), for feed flow Q=0.02 kg/s and three oscillation frequencies, at different amplitudes of sieve oscillations.

| No. sample | Oscillatory frequency | Oscillating amplitude | U.M. | Sieve radius from which seeds are collected x, (m) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 0 | 0.04 | 0.07 | 0.1 | 0.13 | 0.16 | 0.205 | Over |
| 1 | $F_1$=250 osc/min | $A_1$=4.08 mm | g | 0 | 106 | 190 | 185 | 16 | 2 | 1 | 0 |
| | | | % | 0 | 21.2 | 38 | 37 | 3.2 | 0.4 | 0.2 | 0 |
| 2 | | $A_2$=4.25 mm | g | 0 | 147 | 2 | 140 | 12 | 1 | 0 | 0 |
| | | | % | 0 | 29.4 | 40 | 28 | 2.4 | 0.2 | 0 | 0 |
| 3 | | $A_*$=4.45 mm | g | 0 | 154 | 200 | 132 | 13 | 1 | 0 | 0 |
| | | | % | 0 | 30.8 | 40 | 26.4 | 2.6 | 0.2 | 0 | 0 |
| 4 | | $A_3$=4.65 mm | g | 0 | 161 | 201 | 123 | 15 | 0 | 0 | 0 |
| | | | % | 0 | 32.2 | 40.2 | 24.6 | 3 | 0 | 0 | 0 |
| 5 | $F_2$=520 osc/min | $A_1$=4.08 mm | g | 0 | 113 | 120 | 140 | 125 | 2 | 0 | 0 |
| | | | % | 0 | 22.6 | 24 | 28 | 25 | 0.4 | 0 | 0 |
| 6 | | $A_2$=4.25 mm | g | 0 | 201 | 215 | 84 | 0 | 0 | 0 | 0 |
| | | | % | 0 | 40.2 | 43 | 16.8 | 0 | 0 | 0 | 0 |
| 7 | | $A_*$=4.45 mm | g | 0 | 195 | 210 | 94 | 1 | 0 | 0 | 0 |
| | | | % | 0 | 39 | 42 | 18.8 | 0.2 | 0 | 0 | 0 |
| 8 | | $A_3$=4.65 mm | g | 0 | 187 | 208 | 102 | 3 | 0 | 0 | 0 |
| | | | % | 0 | 28 | 36.6 | 19 | 12 | 4 | 0.4 | 0 |
| 9 | $F_3$=790 osc/min | $A_1$=4.08 mm | g | 0 | 180 | 204 | 116 | 0 | 0 | 0 | 0 |
| | | | % | 0 | 36 | 40 | 23.2 | 0 | 0 | 0 | 0 |
| 10 | | $A_2$=4.25 mm | g | 0 | 216 | 205 | 79 | 0 | 0 | 0 | 0 |
| | | | % | 0 | 43.2 | 41 | 15.8 | 0 | 0 | 0 | 0 |
| 11 | | $A_*$=4.45 mm | g | 0 | 201 | 216 | 83 | 0 | 0 | 0 | 0 |
| | | | % | 0 | 40.2 | 43.2 | 16.6 | 0 | 0 | 0 | 0 |
| 12 | | $A_3$=4.65 mm | g | 0 | 186 | 225 | 89 | 0 | 0 | 0 | 0 |
| | | | % | 0 | 37.2 | 45 | 17.8 | 0 | 0 | 0 | 0 |

Regression analysis were performed for the experimental data, obtained for the pre-established work conditions, using Gauss distribution law (which is the distribution law frequently used in such analysis), for which were determined the correlation coefficients $\chi^2$ and $R^2$ (Equation 1).

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

where: $p_x(\%)$ is the percentage weight of the separated material on a length (radius) sieve range, $y_o$, $x_c$, A, w, – regression coefficients, dependent of the parameters of the work regime. Thus, in equation (1), A is the maximum percentage of material collected in the boxes placed under the sieve, $x_c$ is the radius of sieve base corresponding to the maximum percentage of separated seeds (or the mean from Gauss distribution function), and w is the dispersion towards the peak position.

Influence of the amplitude of sieve oscillations on the separation process, and ultimately, on seed losses in larger impurities that reach and pass beyond the bottom edge of the sieve was possible to estimate by the peak position of separation curves towards the top of the sieve (central position where material supply is made) presented in Figure 2, for various work conditions, previously established in the research programme, and determined by the performed regression analysis.

Values of coefficients of regression equations (1) for work regimes mentioned in Figure 1 and Table 1, A, $x_c$, w, respectively values of correlation coefficients $\chi^2$ and $R^2$ are presented in Table 2.

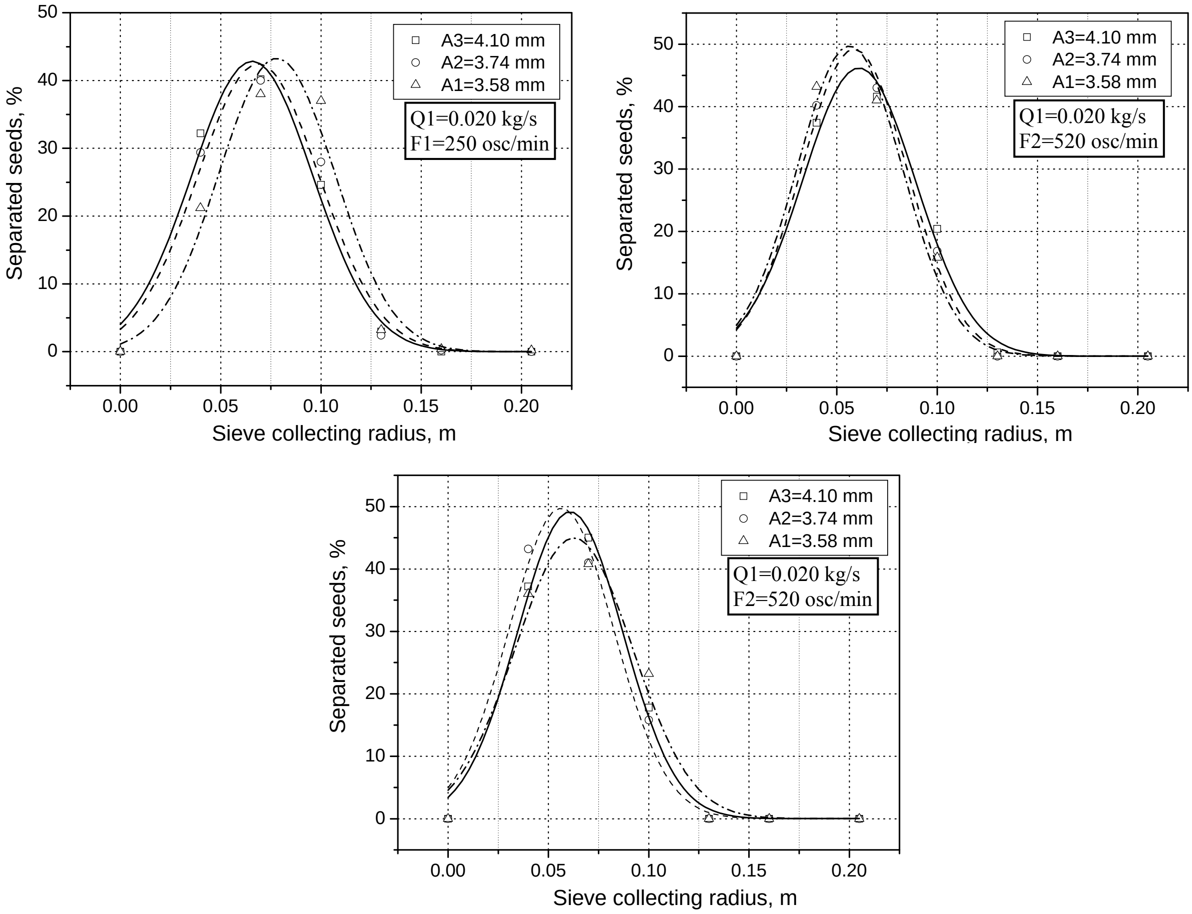


Fig. 2. Influence of the amplitude of sieve oscillation on the process of seed separation on the generating line of the conical sieve, for feed flow $Q_1$ = 0.020 kg/s and three oscillation frequencies.

Table 2. Coefficients of regression equation (1) A, $x_c$, w, respectively correlation coefficients $\chi^2$ and $R^2$ with the experimental data for various work conditions.

| **No. sample** | **Working parameters** | | **Equation coefficients** | | | **Correlation** | |
|---|---|---|---|---|---|---|---|
| | | | **A** | **$x_c$** | **w** | **$\chi^2$** | **$R^2$** |
| $Q_1$ = 0.020 kg/s | | | | | | | |
| 1 | $F_1$ = 250 osc/min | $A_1$=4.08 mm | 43.281 | 0.078 | 0.029 | 24.569 | 0.960 |
| 2 | | $A_2$=4.25 mm | 42.485 | 0.069 | 0.030 | 13.578 | 0.978 |
| 3 | | $A_*$=4.45 mm | 42.540 | 0.067 | 0.030 | 9.344 | 0.980 |
| 4 | | $A_3$=4.65 mm | 42.835 | 0.066 | 0.030 | 8.336 | 0.982 |
| 5 | $F_2$ = 520 osc/min | $A_1$=4.08 mm | 49.741 | 0.056 | 0.026 | 11.892 | 0.980 |
| 6 | | $A_2$=4.25 mm | 49.184 | 0.059 | 0.026 | 7.889 | 0.986 |
| 7 | | $A_*$=4.45 mm | 47.473 | 0.060 | 0.028 | 9.930 | 0.982 |
| 8 | | $A_3$=4.65 mm | 46.194 | 0.061 | 0.028 | 13.583 | 0.981 |
| 9 | $F_3$ = 790 osc/min | $A_1$=4.08 mm | 49.979 | 0.063 | 0.029 | 14.104 | 0.973 |
| 10 | | $A_2$=4.25 mm | 49.746 | 0.056 | 0.0263 | 11.892 | 0.980 |
| 11 | | $A_*$=4.45 mm | 49.370 | 0.059 | 0.026 | 7.483 | 0.987 |
| 12 | | $A_3$=4.65 mm | 49.143 | 0.061 | 0.026 | 4.899 | 0.991 |

From the analysis of data presented in the table, it can be observed a good correlation of the experimental results (ratio of material amounts collected under the sieve on its horizontal radius in percents), with the proposed regression function (equation 1), for which the correlation coefficient $R^2$ had very good values ($R^2 \geq 0.960$).

Thus, for relatively small feed flows ($Q_1 \approx 0.020$ kg/s) it can be noticed that at small oscillation frequencies ($F_1$ = 250 osc/min), by increasing the amplitude of oscillations (from $A_1$ = 4.08 mm to $A_3$ = 4.65 mm) the peak position of distribution curve moves to the sieve radius (generating line), from the exterior towards its interior (namely, from the material outlet to feeding, from $x_c$ = 0.078 m for oscillation amplitude of the sieve $A_1$ = 3.58 mm, to $x_c$ = 0.069 m and then to $x_c$ = 0.067 m reaching $x_c$ = 0.066 m for oscillation amplitude of the sieve $A_3$ = 4.10 mm), which, form the workflow point of view, represents an improvement due to the fact that it can be considered that seed losses could decrease, but, for a reduced feed flow, seeds become totally separated even before reaching the bottom edge of the sieve, as it can be noticed by analyzing the data presented in Table 1 and from the distribution curves of the material separated on the generating line of the sieve presented in Figure 1.

If the frequency increases from $F_1$ = 250 osc/min to $F_2$ = 520 osc/min, the situation reverses, so, by increasing the oscillations amplitude, the peak position of the distribution curve of the separated material on the generating line of the sieve moves on the radius (generating line) of the sieve, from the interior to its exterior, (namely, from material feeding to the outlet), from $x_c$ = 0.056 m for oscillation amplitude of the sieve $A_1$ = 3.58 mm, to $x_c$ = 0.059 m and back to $x_c$ = 0.060 m, reaching $x_c$ = 0.061 m for oscillation amplitude of the sieve $A_3$ = 4.10 mm), which, form the workflow point of view, represents an aggravation due to the fact that it can be considered that seeds slip (or roll) longer on the sieve before passing through the holes, thus leading to losses of good seeds which would pass beyond the bottom edge of the sieve and would be collected together with large impurities. However, due to a reduced feed flow, all seeds were separated before reaching the bottom edge of the sieve. Further experiments will be performed to see what happens for higher feed flows.

By continuously increasing the oscillation frequency to $F_3$ = 790 osc/min, it can be noticed that for oscillation amplitude of the sieve ($A_1$ = 3.58 mm), the peak of distribution curve of separation is further than the feeding point ($x_c$ = 0.063 m), it approaches a little the feeding point ($x_c$ = 0.056 m) if the amplitude increases to $A_2$ = 3.74 mm, but it distances from the feeding point ($x_c$ = 0.059 m) if the amplitude increases to $A_*$ = 3.91 mm reaching $x_c$ = 0.061 m for oscillation amplitude $A_3$ = 4.10 mm leading to the conclusion that the separation process is not uniform at this oscillation frequency.

Synthetically, Figure 3 shows the movement of peak position of separation curve $x_c$ with various oscillation amplitudes for the three analysed frequencies at the considered feed flow $Q_1 \approx 0.020$ kg/s.

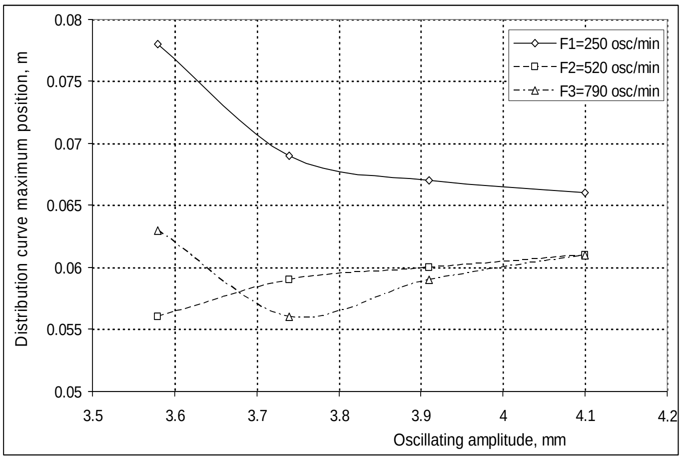


Fig. 3. Peak position of separation curve ($x_c$) for various oscillation amplitudes for feed flow $Q_1 \approx 0.020$ kg/s.

From the data presented, for feed flow $Q_1 = 0.020$ kg/s, and for the mentioned oscillation amplitudes, it can be stated that the value of the optimal oscillation frequency is about $F_2 = 520$ osc/min, in this case being observed a good correlation of the experimental results with Gauss regression function, for which correlation coefficient $R^2$ had very good values ($R^2 \geq 0.980$).

## 4. CONCLUSIONS

In laboratory conditions, for a conical suspended oscillatory sieve, of small dimensions and for reduced material feed flows, the separation process is influenced by the oscillatory motion of the sieve, by oscillation parameters: oscillation frequency and amplitude of oscillation.

Evaluation of the separation process and material movement on the sieve was estimated by the peak position of distribution curves of separation that were drawn by computed regression analysis, in Microcal Origin program, based on the amounts if rapeseeds collected under the sieve, at different distances from the top of the sieve, where material supply was made.

It was found that Gauss function of distribution correlates well the experimental data, correlation coefficient $R^2$ having, in all analysed situations, values exceeding 0.960. Peak position of distribution curve modifies with the modification of oscillations amplitude, a smaller amplitude and a higher oscillation frequency leading, in general, to a faster separation of the material through sieve holes.

Data obtained by the experiments conducted in laboratory conditions, for the analysed sieve, lead to the conclusion that such sieve (conical, suspended, with circular alternative motion) can be used to separate the impurities from seed mixtures. These data can be useful for specialists in cleaning and conditioning of seeds, in order to choose the optimal work regime.

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