STUDY OF THE GRAIN MIXTURES SEPARATION PROCESS BY USING OF SURFACE MECHANICAL SEPARATORS – PART I

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Abstract: Sieves as mechanical separators are primarily means of separating the grain size mixtures which are subject to cleaning or sorting. Commonly used sieves with flat working surface and oscillated movement. Regardless of their design, however, the separation process has a probabilistic nature and on the length of the separating bodies are most accurately describes the exponential dependence. Separation capability, respectively quality performance of the mechanical separators are characterized respectively by the coefficient of separation \( \mu \), and completeness (effect) of splitting (\( \varepsilon \)). Each of these features may depend on many factors, but it was found that the most strongly influenced by the length of the separator ’s body. In its essence, the coefficient \( \mu \) expresses the probability of screening a single grain particle moves through in a length unit. 

The change in the coefficient of separation with separators having equal work areas do not necessarily lead to a change in the quality of their work. This can be explained by the fact that, under equal operating conditions the change of the length does not change their surface area, and this means a constant specified load and accordingly the same effect on the separation. From this standpoint, the coefficient of separation and the effect of separation can be justified based on the design parameters of the separator, which determine the working area.

Key words: flat sieves, separation process, coefficient of separation, separation effect, grain losses

Introduction

By their physical nature, the process of separation of the grain in the mechanical separators is carried out in the same way - the grain passes through the first grid of the space separating layer and then through the planar array of the separator. This gives reason to believe that the separation for this type separators will be described by the same relationship that in a number of studies have shown that there is an exponential character \([1,2,3,4,5]\).

This type of dependence indicates the strong sensitivity of the process of separation from the length of the separator. Real process occurs over the entire working surface of the separator, which justifies the need to find depending describing both process length and width of the separator. Finding such a relationship will allow optimization of the geometrical dimensions of the separator so that its separation ability and quality of work to be as high for the given conditions.

Solution of the examined problem

Separation ability of each separator is characterized by the coefficient of separation \( \mu(x) \), which not constant along the length of the separator \([1,4]\).

Inherently the coefficient \( \mu(x) \) expresses the probability of sieving single grain particles throughout a unit with a length unit. This can be expressed by the equation:

\[
\mu(x) = \frac{q}{y \Delta x} = \frac{-\Delta y}{y \Delta x}, \quad (1)
\]

Where: \( \frac{q}{y} \) is statistical (experimental) probability of sieving the individual grain through the unit with length \( \Delta x \);

\( q \) – quantity of grain sifted in stretch \( \Delta x \);

\( y \) – amount of non sieved but separable grain.

The differential equation described the sieving process along the mechanical separators is displayed by equation \((1)\) \([1, 3]\):

\[
\frac{dy}{dx} = -\mu(x).y, \quad (2)
\]

which after integration yields the type:

\[
y = e^{-\int \mu(x).dx} \quad (3)
\]

Taking into account the initial condition \((y = a \) - separable amount of grain at the beginning of the separator at \( x = 0 \)\) equation \((3)\) yields the form:

\[
y = a e^{-\phi(x)}, \quad (4)
\]

where \( \phi(x) \) function related to the rate of separation of \( \mu(x) \).

Presented depends show that, with an increase of the length of the separator and increase the separation ability, grain losses will decrease appreciably, which separation effect increases, and thus the performance of the separator.

Notwithstanding the separation process must be considered in terms of the geometric dimensions (length and width usually) defining the separation area of the separator.

Reasons for such a statement gives the fact that separators of the same length may have different coefficient of separation due to difference in their widths, respectively. change in the experimental probability of sifting grain.

In three dimensions the separation process can be represented as shown in the Figure 1 dependence.

Figure 1. Surface of the sieving process in the area of the separator

where \( x \) is the distance from the top of the separator to any of its cross-section;

\( y \) – distance from the top of the separator to any of its longitudinal section;

\( z \) - amount separable grain that has not sifted through a length \( x \);

\( x_1, y_1 \) – Cartesian coordinates of the point \( M_1 \);

\( r, a \) and \( h \) - cylindrical coordinates of a point on the surface with function \( z = f(x, y) \);

\( r_1, a_1, h_1 \) - cylindrical coordinates Of p.\( M_1 \);

\( a \) - fed into the top of the separator \((x = 0)\) the releasable quantity of grain.

The curve \( z = f(x) \) lying in the plane Oxz described by the type \((4)\) and is regarded as a generatrix of the curved surface representing the requested function \( z = f(x, y) \).
Random point (r,M) of a generatrix in its rotation around the z-axis at an angle $\alpha = \pi / 2$ describes the arc of a circle. A point position (r,M) on the arc can be defined by its cylindrical coordinates:

$$r_1 = \sqrt{x_1^2 + y_1^2},$$
$$\tan \alpha_1 = \frac{\Delta z_1}{x_1},$$
$$h_1 = z_M$$  

(5)

Gender and coordinates $z_M \& h_1 \& z$ shows that regardless of the angle $\alpha$, which is rotated generatrix quantity non sieved grain remains the same. This gives reason to write the following equation:

$$\mu(x) = \mu(r),$$
$$\frac{\Delta x}{\Delta r} = \frac{\Delta h}{h_1},$$  

(6)

Therefore for p. M1 expression (4) will have the form:

$$h_1 = a_1 \cdot e^{-\varphi(r)},$$  

(7)

where $\varphi(r)$ is a function related to the ratio of separation by size $\mu(r)$.

Let the Cartesian coordinates of the projection p.M1 on the plane $Oxy$ ask the geometrical dimensions of the separator. The resultant figure is the same diagonals equal to the cylindrical coordinate $r_1$. Screening area of the separator e equal to:

$$S = \frac{r_1^2}{2} \cdot \sin \beta,$$  

(8)

where $\beta$ is the angle included between the diagonals.

Expression (7) gives grounds to assert that if the change of coordinates and $x \& y \& r$ not lead to a change of coordinate $r_1$, it non sieved amount in grain separator will remain constant.

This would however be accompanied by a change in the working area of the separator, which according to expression (8) will be greatest at $\beta = \frac{\pi}{2}$.

Therefore separator whose working area is in the shape of a square will work with the greatest load, and the losses of grain remain unchanged.

Presented dependencies (5, 6, 7 and 8) show that the process of separation with mechanical separators should be determined on the basis of its working area by simply using the expression:

$$z = a \cdot e^{-\varphi(r)}x = a \cdot e^{-\mu(x)y}/x^2 + y^2,$$  

(9)

In this correlation coefficient $\mu(xy)$ under certain conditions $r = \sqrt{x^2 + y^2} = const$ remains constant while the coefficient $\mu(x)$ proved [4] change under these terms depending on $x$.

Definition of $\mu(xy)$ should be performed at the maximum load of the separator which grain losses do not exceed. So certain this factor makes it possible to optimize the geometry of the separator.

Conclusion

The performance of all types of mechanical separators depends very much on their geometrical dimensions. However demonstrated the strong influence of the length, the separation process must be considered in relation to the working area of the separator.

In this case, when determining the grain losses may suitably be of the type used in expression (9).

With the increase of the parameter $r$, respectively the area of the separator grain losses decreased exponentially.

Under certain conditions, the ratio of separation by size to be regarded as a constant, while the coefficient $\mu(x)$ is changed in the same conditions, depending on $x$.

The geometric parameters which determine the coefficients of the separation in space is optimal for the separator, while the working area is in the shape of a square. The presented theoretical dependencies representing the process of separating cereal mixes on the surface of mechanical separators should be checked experimentally.

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