

Engineering design of technological parameters of separation of seed in the upward air flow of pneumatic sorting machines

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Abstract. It was showed the results of the determination the optimal parameters of the narrowing partitions installed in pneumatic channels with a vertical up air flow for cleaning seeds. The installation narrowing partitions in pneumatic channels makes it possible to increase the productivity and efficiency for cleaning seeds from difficult-to-remove impurities by no less than 20%, while the optimal ratio of the width of the partitions and the depth of the pneumatic canal sections varies from 0.3 to 0.5.

1 Introduction

The aim of separation of seed mixtures is complete selection of fractions based on the characteristic which provide the required quality of the final product with the smallest number of operations. These characteristics are taken into account during creating scheme for grain cleaning and sorting machines (separators) [1]. The diversity of characteristic of separation of seed mixtures requires the development of a common method for assessing the technological effect of each separator, regardless of the nature of the work of certain units, which is a complex problem that requires solving the following tasks:

- development of an objective method of sampling from the seed mixture in the flow and establishing the required sample size for analysis;
- development of the design of appropriate laboratory machines - small separators;
- development of analytical method and indicators for assessing the technological effect of separation.

This article is devoted to the last part of the problem.

The aim of the research is developing a method for calculating the indicator for evaluating the technological effect of separation on the example of separation of seed mixtures in the upward air flow of pneumatic sorting machines.

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2 Materials and Method

Research were carried out on the basis of the equation logisticians and methods of mathematical statistics.

3 Results and discussion

The questions of evaluation of the technological separation effect of bulk materials are reflected in the publications of various authors in various areas of production [2-5]. Analyzing these works, it can be made such conclusion that the formulas that determine the technological effect of separation take into account only the indicators of the fractional content of the mixture components, and their characteristics of separation such as size, weight, speed of winding, etc. are not taken into account.

Lets studied the logistic equation (Ferhulst equation by name of the first Belgian mathematician who first formulated it), which initially appeared at considering the population growth model [6-9]. The initial assumptions for deriving the equation are follows in considering population dynamics:

- the reproduction speed of a population is proportional to its current abundance in other things being equal;
- the reproduction speed of a population is proportional to the number of resources available in other things being equal;

The equation of logisticians is expressed as follows:

$$P(t) = \frac{KP_0 e^{rt}}{K + P_0(e^{rt} - 1)}, \quad (1)$$

or

$$\frac{P(t)}{P_0 e^{rt}} = \frac{1}{1 + \frac{P_0}{K}(e^{rt} - 1)}, \quad (2)$$

where P is population size; P_0 is the initial population size; t is time; K is coefficient implying the reproduction speed and long life of the population; r is a coefficient suggesting a reproduction rate and a short life of the population.

The exact solution of equation (2) is a logistic function, S-shaped curve, a logistic curve.

This equation has become quite widespread during describing processes with the so-called "saturation", for example, an increase in the number of publications, an increase in the amount of biomass, etc. However, at $t=0$ $P_0 = P_{max}/(1+c)$ (c is the integration constant), which contradicts the physical meaning of many processes in agriculture (threshing, separation, etc.) at $t=0$ P_0 should also be 0

The normalized (reduced to zero) equation of the logistic curve can be used to describe various processes with "saturation", but when the function changes from the zero point of the coordinates, it is presented in Zhalnina E.V. [10].

The equation of normalized logisticians (y_{μ}) in his publications has the following form:

$$y_{\mu} = \frac{y_{\max}}{1 + (c[\exp(kqy_{\max}) - 1])^{-1}}, \quad (3)$$

where y is the lossless of grain mass during threshing straw mass in the combine,%; q - supply of straw mass, kg / s; c is the integration constant determined by experimentally, a dimensionless quantity; k is coefficient of the growth speed of grain loss, a dimensionless quantity.

The measure result of the physico-mechanical properties of seeds (characteristic of separation) is expressed either in variation series or in variation curves that determine the frequency of a particular seed size of any combination. From the comparison of these data obtained for each component separately, it is possible to reveal which sizes of the main grain turn out to be the most different in comparison with those of impurities.

On the Figure 1 it is showed the vibrational curves (differential) distribution of the soaring speed of the seeds of oats and barley, and Figure 2 integral distribution curves of the same components [11].

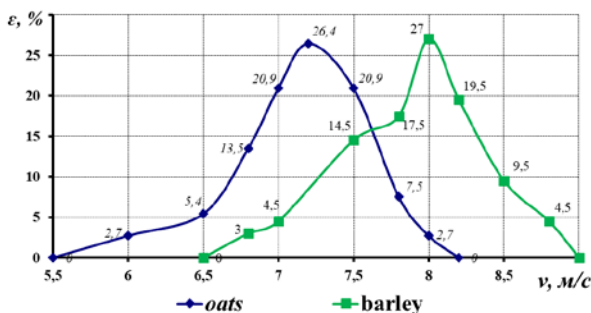


Fig. 1. Vibrational (differential) frequency distribution curves of ϵ speed of vitality ν of components of the grain mixture.

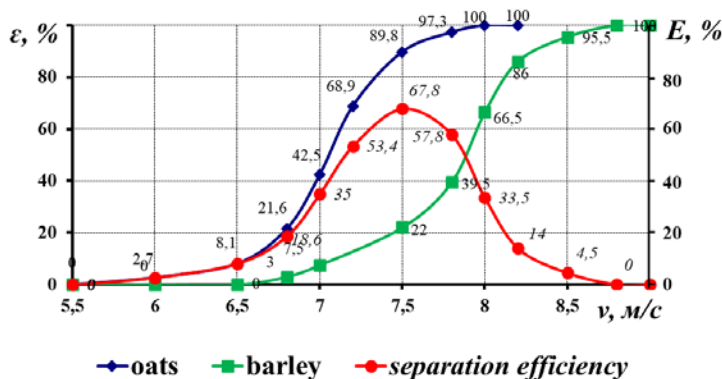


Fig. 2. Integral curves of the distribution frequency of the soaring speeds ν of the grain mixture components and the plot of the efficiency of their separation E from the airflow speed ν .

On the Figure. 2 integral curves can be represented by the equations of normal logism (3). Efficiency is determined by the formula G.V. Newton and V.G. Newton [12], as the difference between the value of the frequency of the extracted component of oats (completeness of extraction) and the value of the main component of barley (loss) at a certain value of the air flow rate.

Changing in formula (3) y_n by E is the indicator for evaluating the technological effect of separation (%), q by ν is the air flow speed (m / s), c_1 and k_1 are the coefficients of the separated component, c_2 and k_2 are the coefficients of the component being cleaned subtracting the first expression from the second, as a result, mathematical transformations,

we obtain the following formula for the effectiveness of the process of separation of seed mixtures in the upward air flow with their approximation by the equation of logisticians:

$$E = \frac{c_1(e^{k_1v} - 1) - c_2(e^{k_2v} - 1)}{(c_1(e^{k_1v} - 1) + 1) \cdot (c_2(e^{k_2v} - 1) + 1)}, \quad (4)$$

where k is the separation coefficient determined experimentally, the dimensionless quantity.

4 Conclusion

A formula has been obtained for evaluating the technological effect of separation on the example of the separation of seed mixtures in the upward air flow of pneumatic separators, which takes into account the soaring rate of the separated components as a characteristic of separation.

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