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Technology of Processing into Refined Grains

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Abstract
The article describes the properties of separating grain mixtures in different types of separators. In the grain processing industry, digitization allows the development of mathematical models of queue sorting systems. Algorithms for analyzing the physical properties of the grain mass have been developed. The study of wheat processing products is based on the analysis of ground grain using computer vision techniques and artificial neural networks developed by software tools. The classification of grain according to the geometric properties of Mill particles makes it possible to predict the technological characteristics of Wheat Quality, in particular the indicator of its hardness, with high accuracy (the evaluation error does not exceed 3.7%).

Keywords: Grain, wheat, grain processing.

Introduction

In the EU countries, there is a high dependence of grain crops on the weather conditions of the year. Thus, 9.65 million tons were harvested in the UK in 2020 [1]. This is 40.5% less than in 2019, due to a reduction in winter wheat crops by farmers after the wet autumn of 2019. Also, the low wheat harvest was aggravated by the subsequent dry spring. The wheat harvest in Russia in 2020 amounted to about 88 million tons. In the next five years, Russian farmers will expand their acreage by 40% due to the introduction of new wheat varieties and modernization of production technologies. This will increase the production of durum wheat to 2 million tons per year [2]. Stimulation of durum wheat production will be supported by subsidies at the federal level - an appropriate draft regulation for the allocation of subsidies for the production of such grain has been prepared [3].

Digitalization of the selection of the operating mode of equipment for wheat grain separation is relevant. An important aspect of increasing the efficiency of grain processing is the development of models of the technological separation process [4].

The modern development of technology in the field of information technology makes it possible to modernize existing information and measurement systems for grain processing and develop new ones by developing algorithms for analyzing the physical characteristics of grain mass [5].

Materials and Methods of Research

Wheat of 14 varieties of the Orenburg region was studied, the natural weight of which ranged from 720 g to 850 g, humidity from 12.5% to 14.7%, vitreous content from 45% to 100%.

Characteristics of grinding. In order to obtain grain grinding samples, trial grain grinding was carried out at a laboratory mill. 10 kg of grain of each sample was ground. The grinding was carried out with five ragged systems with the selection of upper gatherings [6], [7], [8].

Fractographic analysis of grinding particles was performed, using a laboratory installation (SonyIMX digital camera, RaspberryPi4 mini-computer), particle images were analyzed using software created using OpenCV vision libraries, Deeplearning4 artificial neural network libraries [9].

Results and their Discussion

The result of the separation of grain mixtures in the separator is determined by two types of accidents. The first (mass) is characterized by the interaction of particles at high concentrations on the separating organ, some particles prevent others from passing through the separation without hindrance. The second (individual) is detected in the absence of mass randomness, when single particles are separated at an ultra-low concentration of grain flow. In this case the result of separation is also unknown in advance, since the orientation of the grain in the separator is random [10], [11], [12]. Within this approach, the probabilistic separation result naturally takes into account the influence of both components.

When creating models of separating queuing systems, it is necessary:

- to present the working body in the form of a parallel-sequential system of separating elements (trier cells, sieve holes, elementary volumes of the air channel, etc.), which will act as channels (devices) of separating systems;
- express the intensity of the input and output grain flows through the technological characteristics of the separator, and in particular through productivity;
- determine the discipline of maintenance (separation) of grain particles (applications) in the elements of the working body: priority, degree of reliability, patience, priority, etc.;
- describe the possible conditions of the working body (there is not a single grain in service; one grain; two; three, etc.) [13].

The model defined in this way allows us to obtain equations for calculating the probabilistic characteristics of the separating system using standard methods for queuing theory [14].

Studies have shown that the result of separation naturally depends on the individual and mass components of the randomness of the separation process. At the same time, it predicts the existence of two groups of separators, one of which admits the possibility of separation by one particle, the other does not. The first group includes most of the known types of separators (air, sieve, electric, magnetic, optical, etc. D.), and to the second - only a disk trier and high-intensity sieve modules, which differ in slightly larger sizes of sieve openings than the separated particles. In addition, it correctly reflects the known experimental dependences of separation quality on the specific load and speed of the grain flow, on productivity, etc. [15].

It is necessary to study the state of the separating system when its productivity tends to zero, which physically represents the separation of single particles, and therefore requires the use of classical models of well-known separators, i.e. such models that are nothing more than well-known equations of dynamics. The nature of such equations is determined by the initial conditions of motion, the physical properties of grain particles, and the modes of operation of the separating organ. With sufficient computing power, it is possible for separators of various types in any given modes to calculate the probability of the output of different components of grain mixtures at ultra-low productivity. Thus, the proposed modeling approach made it possible for separators of various

types to practically calculate (predict) the planned quality indicators (yield and content of mixture components in fractions) for any given operating modes, including productivity.

Based on the models of individual separators, it was possible to predict the quality of separation of mixtures in grain purification production lines and solve the following optimization tasks:

- cleaning of a grain batch (the composition and content of the mixture components are known) on a rigid production line (the number of separators, their type and installation sequence are known) in the specified operating modes of each separator; the model will answer whether this mixture will be cleaned to the requirements of GOST and what will be the output;
- cleaning of the grain batch to the requirements of GOST on a rigid technological line; the model will determine whether all separators in this line should work and in what modes, which fractions are the main ones and what output will be, how much more it is than in the baseline;
- cleaning of a batch of grain to the requirements of GOST on a flexible processing line; the model will determine the number, type and sequence of separators in such a line, the main fractions and operating modes of each separator, the yield of refined grain and excess compared to the baseline.

Digitalization in the grain processing industry includes methods for assessing grain quality according to various physico-chemical indicators. For example, there are methods for assessing the clogging and vitreousness of grain using computer vision algorithms. To increase the efficiency of grain cleaning machines, methods of separating impurities from grain by optical properties are used - photoseparation or photo-cleaning. High-speed scanning of the grain mass and subsequent image processing according to a predetermined algorithm (distinctive criterion) are used for photoseparation. The grain can be sorted by size, color characteristics, shape and other characteristics.

Grain raw materials in the stream are evenly distributed in a single layer thanks to vibratory feeders, which allows you to scan the image of each individual particle. Particle selection is carried out using air jets (due to a pneumatic ejector), redirecting impurities or substandard grain into a waste tank. Modern methods of photoseparation make it possible to sort raw materials by a whole set of properties, individually and collectively, obtaining a product with the highest possible technological properties.

Additional information about the quality of the raw materials under study can be obtained by using infrared or ultraviolet grain illumination instead of visible light. Different grain areas reflect slightly different wavelengths. Thus, the endosperm (its grinding) is characterized by a high reflection coefficient in the IR range compared to the embryo. Color analysis can also be used to distribute grain processing products by fractions (according to the morphological characteristics of grain parts - germ, endosperm, bran).

It is possible to increase the informativeness of granulometric analysis due to modern information tools. The study of wheat processing products was based on the analysis of ground grain using computer vision methods (estimation of particle size and shape) by a developed software tool.

In the practice of the milling industry, an indicator of its vitreousness is often used to classify grain, but this indicator does not fully characterize the milling advantages of wheat of different varieties (genotypic factor). The variability of vitreous is also associated with soil-climatic, agrotechnical conditions (phenotypic factor). Therefore, to quantify the consistency and strength properties of grain, it is proposed to use the grain hardness index. Direct methods for determining

this indicator with hardness testers are time-consuming and therefore practically have not found application in wide practice.

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