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PREPARATION OF GRAIN FRACTION FOR FEED PRODUCTION PROCESSES

Abstract

The preparation of grain components for the further production of compound feed is an urgent task for the production facilities that provide feed to the livestock sector of the agricultural sector. Grain feed components are an important source of energy, containing almost all the substances necessary for the normal functioning of the human, animal and poultry body.

Anatomy and components of cereals have a hull film, which in many technological processes must be removed from the surface without destroying the kernel of the grain. The expediency and necessity of removing flower, fruit and seed hulls from cereals for the production of feed, cereals and other products is determined by the requirements for obtaining a product that meets modern product quality standards.

The theoretical and methodological basis of the research is the dialectical method of cognition of physical phenomena, a systematic approach, the basic principles of technological operations, scientific developments of domestic and foreign scientists on the preparation of raw *materials for the manufacture of high-quality end products.*

The following tools were used to implement the tasks: monographic method - when processing sources of scientific specialised literature, DSTU and other regulatory documents regarding the implementation of technological operations for the preparation of grain raw materials in the conditions of processing industries of the agro-industrial complex, namely the process of cleaning the grain kernel from surface hulls; abstract and logical method - when analysing scientific opinions and substantiating the concepts of improving the technological process of grain processing; systematic approach - when studying the basic technological prerequisites for the implementation of grain processing processes.

Determination of the maximum force load of grain, which ensures effective separation of hulls during hulling with minimal destruction of the endosperm and grinding, as well as taking into account the strength of grain and its structural components. The necessary approach for determining the transporting capacity of the working rotor when using a friction machine is obtained, and the geometric and kinematic parameters of the rotor-blade machine are given to ensure its efficient operation.

Keywords: *feed, grain, film, forces, hulling.*

Introduction. Grain crops are used to produce feed, cereals and other products, as well as to manufacture processed grain products such as flour, pasta and bread. Feed and grain products are the main source of easily digestible carbohydrates, the main energy component of feed. Products made from high-grade or superior flour provide 21% to 64% of the daily requirement for essential acids. In feed, flour and cereal mills, the relevant preparation is carried out using hulling machines, which are part of the production line, to remove the flowers and produce bran, or, in the case of barley and oats, to remove the hulls and produce bran [1, 3, 4].

Analysis of recent research and publications. Cereal grains have a porous structure unsuitable for capillary action, and their properties are modified by special conditions associated with the separation of the kernel from the hull. The rate of strain increase, together with temperature and humidity, has a significant impact on the kernel's kinetic and elastic properties. When processing kernels in machines, significant relative velocities occur during the operation of the working bodies, which slows down fragmentation and causes the kernel bonds to remain unchanged at the molecular level, making it impossible for the processes of loosening and plastic fragmentation to occur.

As a result, grains have the properties of both brittle and elastic materials. Fracture and deformation are slow, so that during processing, fracture and stress increase, giving the grain the appearance of an elastic material with elastic properties. It becomes expedient to characterise the microhardness, endosperm stability, deformation and plasticity of the coating film. An increase in kernel microhardness increases its resistance to plastic deformation, while a decrease in this indicator makes the kernel less stable, more plastic and more prone to kernel shape changes. Studies have shown that an increase in grain moisture content and an increase in the time it takes for wheat grains to separate from the kernel to six hours are factors that lead to changes or decreases in grain microhardness. The grain processing industry is one of the main sectors of Ukraine's national economy, producing feed flour and cereals.

Grain processing is considered to be an important part of the agricultural sector, as it guarantees the production of flour and cereals, which are the main products for animal feeding and food supply. The products contain important nutrients needed by animals and humans.

The processing industry in our country has made significant progress in its development and productivity. Wheat contains about 77.83% of endosperm, of which the most valuable part is 0.83%, and modern flour mills produce products close to endosperm in quality. The efficiency of technological processes in flour and cereal production depends on energy consumption.

The choice of a rational technology that creates the conditions for the most complete mechanical separation of the husk from the grain part can be based on the differences in the mechanical and technical properties of this anatomical part during soaking and short-term dehydration. Therefore, the establishment of regularities of changes in strength, stresses, frictional deformations, elastic, plastic and viscous properties, fluidity, hardness, stiffness, microhardness and stress relaxation in anisotropic structural grain systems under variable parameters of hydrothermal and hydromechanical treatment is of practical importance in order to increase productivity and fractionation of components with minimal energy consumption. This is of great practical importance.

Rational control of the technological process of grain preparation for hydromechanical processing and subsequent separation is associated with the need to justify the choice of optimal kinematic and dynamic parameters of the machine's working body [5]. The technical characteristics of wheat determine the possibility of obtaining a standard quality end product with a stable yield during processing. Therefore, feed mills, flour mills and cereal plants are evaluated by the following key indicators: production of the final product (gross and categorical); quality of the final product; and specific operating costs, including labour and energy, for the production of a unit weight of grain or flour [6, 8, 9]. The last indicator is particularly important because it is related to the economic evaluation of the technology used. In principle, it is possible to achieve perfect results in terms of flour and cereal yield and quality, but the technological process will be unnecessarily complicated. The technological properties of grain crops are determined by their natural characteristics and are formed under the influence of many factors during the growing season, after harvesting, after processing and after storage. They are associated with a group of structural, mechanical, biochemical, physicochemical and other properties.

Modern research has proven that it can be used to obtain results close to production or to determine the best way to process grain. For example, 3 kg of wheat was milled in 1 hour in a laboratory mill and 45 minutes in an industrial mill.

According to [8, 10, 11], milling in the laboratory and industrial mills produced identical results with similar ash content and whiteness: correlation coefficient of 0.895 .... The range is 0.976. Several laboratory facilities have been set up to directly test the technical properties of cereals. However, there is little information in the literature on the possibility of converting laboratory test data into production results. Differences tend to be particularly noticeable for crops with low grain stability, such as rice and buckwheat. In addition to assessing the results of grain processing, it is necessary to evaluate consumer preferences as well as the biological and nutritional value of cereals and flour. These conclusions are based on direct inspection of the final product and measurement of its chemical composition. An important part of production and inspection practice is the use of various instruments, such as phonographs, starch meters, yeast analysers and extractors [12].

Thus, no single indicator has been found that would clearly define the milling characteristics of cereals and grains. However, research and production experience have accumulated material that can be used to make some recommendations. For example, according to the wheat standards adopted by the Council of the European Economic Community, soft wheat is considered to be standard if it is free from live baking pests, has a natural weight of at least 750 g/l, moisture content of less than 16%, total impurities of less than 5%, germinated grain content of less than 1% and trash content of less than 0.5%. Specifications for durum wheat should be 780 g/l, germinated grain content less than 0.5%, etc. In modern technological complexes, this problem is solved by ensuring the necessary quality of training at each link of the technological chain. Surface preparation operations are recognized as part of the grinding process, such as cleaning, stripping and polishing.

However, at the beginning of the wheat processing chain, preferably before storage, the only correct and preventive treatment is a peeling process containing known and unknown, measurable and non-destructive impurities. If the cleaning process is performed flawlessly, meets all the requirements and guarantees everything you need, you get a very well-cleaned grain (in this case, pure grain). The peeling process removes as much impurities as possible, while maintaining high quality (the nutrients contained in the grain are preserved). Grain should have the properties and taste preferred by consumers. The peeling process can be dry or wet, depending on the technical equipment of the mill. In the first method, a peeling device is used, the main part of which is a beater mounted on steel or abrasive rollers [12, 13, 15]. As a result of impact, friction and interaction, the grain is cleaned of various kinds of pollution, crushed straw and stuck soil. To remove grass dust, the scraper unit is equipped with a suction. The second method involves more intensive removal of the surface layer of the grain with a sink or humidifier to make the outer shell of the grain more plastic. Unlike previous methods, the method of wet washing of grain is characterized by high efficiency. This method uses washing equipment with a water flow rate of 2 m3/t. However, its use is complicated by the need to treat wastewater before discharge into the sewer. As an alternative, the wet granulation method was chosen, since it significantly reduces the consumption of wastewater and does not degrade the quality. In the process of production, flour is crushed both endosperm and husk of grain. The husk is more resistant to abrasion and therefore grinds worse than the endosperm, and the greater the difference in strength, the greater the likelihood of their subsequent grinding.

Achievement of high grain quality allows to reduce the frequency of replacement of grain processing equipment. The grain industry has developed a combination of pre-grinding and heat treatment to achieve this goal. The correct combination of different components of the grain, such as moisture, gluten, endosperm and price, allows you to get the grain with the expected yield, predictable characteristics and reasonable cost. The dosage not only increases the efficiency of grain grinding, but also helps to avoid rejection of grain with low value, to obtain a product with the desired characteristics and to ensure that grain with a high content of nitrates can not be processed for reasonable use. The grain may be heat treated prior to forming the grinding mixture. This increases the recovery of endosperm and reduces energy consumption during the grinding process. Peeling wheat has a larger volume and lower density than naked wheat. The ratio of holozerny and film wheat depends on a number of factors: - Varietal differences - the yield per 1000 grains varies between 55-75 percent of the shelled mass. - Grain moisture. Equipment (different equipment, yield depends on equipment settings, speed and operator skills). Under ideal conditions, 70% of the weight of the grain can be achieved.

A more reliable reference value for most commercial varieties is about 63% of the shell weight, and a conservative estimate is about 50% of the shell weight. The trial weight ranges from 17 kg, and the yield of purified nuclei is less than 50%, but with such a low trial weight it is better to leave the purified nuclei and feed them to ruminants: about 51% of the nuclei were purified in the first pass, 60% in the second and 70% in the third, and the average number of crushed nuclei was about 8% in three trials. Due to the high demand and high natural biological properties, the range of grain-based products is increasing, and the production of grain products requires a special approach to the processing of these raw materials [16]. The processing process involves a number of technical operations prior to obtaining the final product, one of which is the surface treatment of the grain and the removal of the husk covering the grain. This process is related to the initial hydrothermal treatment, which largely determines the moisture content of the raw material, which is the basis for processing.

One of the ways to improve the quality of the final product is intensive surface treatment of wheat grains. For this, peeling machines of various designs, shield beaters and machines with friction rotary knives are used. Grain is processed in the working area of the machine under the influence of impact and frictional influences, external friction forces are applied to the grain on the sides of the beater and formed on the grain surface by sliding layers with different abrasive properties over the surface of the beater. The transport movement of grain, which determines the time spent by grain in the working area, is achieved by placing beaters of various shapes at an angle to the rotor shaft, equipping the working area with slopes, arranging the roller at an angle to the horizontal plane and changing the rotation speed. The main disadvantages of such machines are the low efficiency of the peeling process and the uneven surface treatment of individual grains in the cut state. The analysis of existing schemes for preparing grain for processing made it possible to conclude that the quantity and location of grain. Processing in a peeling machine changes the structural and mechanical properties of grain - strength and hardness decrease; - grinding resistance and energy consumption for grinding decreases; - the time of soaking and moistening of grain is almost halved compared to unprocessed grain due to more intensive penetration of moisture into the grain (the quality of flour improves).

The expediency of using a machine with continuous friction bodies for surface treatment of dry and wet barley grains during processing into cereals and compound feed has been determined. It has been established that the strength of the outer shell under load along the longitudinal axis of the barley grain is 1.44...1 times higher than along the transverse axis. Along the transverse axis, it is 2.06 times higher than along the longitudinal axis. [11, 14]. This is due to the interweaving of the three fibrous layers of the pericarp and the tubular layers of the transverse axis. The seed coat, which has a more homogeneous structure, is attached to the pericarp mainly by gluing, which is a prerequisite for their separation. Since the cleaning process consists of separating the coated fabric, change data is needed to check the parameters of the preparation and cleaning process.

Goal: analyze the forces acting in the peeling process, to identify the result of their joint work on the process of peeling grain by the working surface of the organs of action on the grain.

Presentation of the main research material. Functional and parametric characteristics of the grain peeling process make it possible to control the analysis of the peeling process in a blade-type hulling machine, which has the following zones:
- distributive;
- preparatory;
- peeling and unloading.

As grain is transported from inlet to outlet, the zone is characterised by an increase in intergrain pressure and a filling factor that transfers grain from intermittent flow to densely structured flow. These values are determined by the speed in the gravitational field and the influence of centrifugal forces in contact with the rotor blades, which transport the product from the base of the rotor and the surface of the shell, where it is compacted.

The degree of compaction and the thickness of the outer compacted layer increase in the transition zone and reach the limit value in the zone of dense peeling. The filling factor in the first zone is 0.1-0.3, in the second zone it increases to 0.6-0.8 and reaches a maximum value close to 1 in the third zone. At the same time, the intergrain pressure varies from a minimum value to a value at which the coating structure is partially separated in the second zone and finally in the third zone.

Separation of shells is a microcontact system, in the process of relative movement of interaction zones on the grain surface. Under the influence of compressive and shear forces, when there is an instantaneous local pressure on the grain shell tissue in the contact zone, the deformation of the shell occurs in the phase of elastic deformation, and with an increase in stress, micro- and macro destruction of structural bonds with the grain occurs at the lowest strength. As a result of accidental collisions of different parts of the grain surface with each other or with the working body, repeated re-loading of the surface creates prerequisites for irreversible processes, such as micro-sections, ruptures and displacement of the shell tissues. The separation of the grain shell can be interpreted as a pattern of wear that occurs when abrasive grains slide movingly relative to external friction on the elements of the working body. A prerequisite for the grain separation process is the development of normal preparatory and tangential stresses in the contact zone, which ensure the forceful closure of grains.

This is possible when installing movable and fixed driving and braking surfaces of the working body of the machine, increasing the effect of mixing the grain layer in the working area and creating devices for activating the relative displacement of the grain flow and individual grains in it. A general description of the process of peeling the peel during peeling shows the complexity of developing a generalized theory of this process. In addition, the experimental determination of the number of instantaneous rearrangements of the contacting grains at high kinematic parameters of the working body of the machine causes serious difficulties of a different nature associated with the assessment of process dynamics. It should also be noted that an increase in the number of separating bodies, depending on time, creates conditions that change the coefficient of internal and external friction, mixing of the products of the separation of bodies and significantly affect the efficiency of the process.

The contact of the processed grains in the process of sliding along the actual trajectory, on the contrary, provides accelerated cutting of parts with various surface damages and microcracks. It has been established that the number of damaged kernels during various methods of harvesting and post-harvest processing is 90-95%, which has a positive effect on the peeling process and belongs to the preparation stage. In the intersecting grain flow, zones of increased stress concentration with micro-incisions appear on the surface of the kernel, which reduces the tensile force of the husk and facilitates the separation of the husk. When the moistened grain is processed in a shelling machine for a short time, the volumetric stress state of the shells results in delamination along the surface with the lowest bond strength. As such a conditional boundary of the interface, the boundary between the two longitudinal layers in relation to the transverse cells of the husk should be considered.

The amount of moisture supplied to the surface layer and the time of its penetration into the husk should be chosen in such a way that the adhesion strength is the weakest, which is especially important for machines based on the principle of friction. In conditions of excessive humidity, when mechanical moisture remains on the surface of the grain, conditions will arise that greatly worsen the separation of the husk due to the fact that it acts as a kind of lubricant that reduces the amount of friction that prevails in the peeling process. The efficiency of the process is evaluated by the number of shells removed (% of the initial grain weight); the content of surface microflora (bacterial SB and fungal SG thousand / g); decrease in ash content Δ3%; increase in crushed grain ΔB%, fibre content in shells K%, starch content in waste Sk%, specific energy consumption Nud, kWh/t, efficiency. To determine specific energy consumption, the ratio of energy consumption Np to efficiency Q. Temperature increase Δt, Co, grain after processing in a machine can also be used as an indirect indicator. A large number of input factors and their complex influence on the output indicators make it difficult to provide an exhaustive description of the process under study.

Therefore, there is currently not enough complete data in the literature for the calculation and design of blade machines for surface treatment of grain of various products. The trajectory of grain movement inside the machine can be estimated based on the analysis of the process of grain movement captured by the rotor blades. At the same time, recommendations are taken into account, which make it possible to establish that a number of forces act on the mass of grain, which is transported in a limited annular volume of the working area of the blade machine, which divide it into the following groups:

- dispersing forces between moving grains;
- tangential and normal repulsive and braking forces arising from resistance inside - the grain: normal reaction forces of the drill shell;
-tangential forces that resist the movement of grain on its surface (external friction forces); normal forces acting on the grain from the side of the working surface of the rotating blade during its relative movement in the grain mass;
-normal forces resisting the movement of grain across the working surface of the blade;
- tangential forces of resistance to grain movement; forces arising due to inertia in the coordinate system in which the trajectory of grain movement is considered.

The analysis of the considered forces showed that their joint action creates the necessary conditions for the radial-axial movement of grain. If a particle in constant motion rotates around an axis and at the same time performs translational movement around this axis, then the trajectory of such a particle is called helical. The type of trajectory is determined by the design features of the working area, the filling coefficient and the frictional properties of the mixed grain. The particles located at the bottom of the blade, when moving towards the shell, move along helical trajectories located on non-cylindrical surfaces. In this regard, a model has been adopted in which grain is transported along a rotating parabolic surface with an increasing radius-vector r of variable pitch t along helical trajectories of decreasing size.

The analysis of trajectories suggests that their individual sections are a family of quadratic curves that correspond to the angle of rotation of the blade with a simple $d\psi$, and that the grains located on the leading edge move along the plane of the blade towards the trailing edge. In this case, the type of trajectory of relative motion varies depending on the point of impact on the plane of the blade, which is characterised by the value of the available radius r.

Conclusions and prospects for further research. The analysis of the acting forces made it possible to find that their joint action creates conditions for the radial-axial movement of grain and causes the process of grain peeling by the working surface of the organs of action on the grain.

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ПІДГОТОВКА ЗЕРНОВОЇ ФРАКЦІЇ ДО ПРОЦЕСІВ ВИРОБНИЦТВА КОМБІКОРМІВ

Анотація

Підготовка зернових компонентів з метою подальшого виготовлення комбікормів, є актуальною задачею для виробництв, що забезпечують кормами тваринницький сектор АПК. Компоненти зернових кормів це важливе джерело енергії, вони містять практично всі речовини, необхідні для нормального функціонування організму людини, тварин і птиці.

Анатомія та складова зернових має плівку оболонки, яку в багатьох технологічних процесах необхідно видалити з поверхні, не руйнуючи при цьому ядро зернівки.

Доцільність і необхідність видалення квіткових, плодових і насіннєвих оболонок із зернових культур для виробництва комбікормів, круп та інших продуктів, визначається вимогами до отримання продукту, що відповідає сучасним стандартам якості продукції.

Теоретичною та методологічною основою досліджень є діалектичний метод пізнання фізичних явищ, системний підхід, базові основи проведення технологічних операцій, наукові розробки вітчизняних та закордонних вчених з питань підготовки сировини для виготовлення якісної кінцевої продукції

Для реалізації поставлених завдань використовувались: монографічний метод – при опрацюванні джерел наукової спеціальної літератури, ДСТУ та інші нормативно-правові документи відносно проведення технологічних операцій з підготовки зернової сировини в умовах переробних виробництв АПК, а саме процесу очищення ядра зерна від поверхневих оболонок; абстрактно -логічний метод – при аналізі наукових думок та обґрунтуванні *концепцій удосконалення проведення технологічного процесу обробки зерна; системний підхід – при вивченні базових технологічних передумов для виконання процесів переробки зернової сировини.*

Визначення граничного силового навантаження зерна, яке забезпечує ефективне відділення оболонок в процесі лущення при мінімальному руйнуванні ендосперму і подрібненні, а також врахування міцності зерна та його структурних складових.

Отримано необхідний підхід для визначення транспортуючої здатності робочого ротора при використанні фрикційної машини, надані геометричні та кінематичні параметри роторно-лопатевої машини для забезпечення ефективної її роботи.

Ключові слова: *комбікорм**,** зернівка, плівка, сили, лущення.*

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