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Theoretical Study of the Grain Grinding Process in the Grain Crusher Chamber

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Abstract. One of the tasks currently facing animal husbandry is to preserve and improve the herd and productivity in order to saturate the domestic market with livestock products. The successful completion of this task depends primarily on the creation of a solid food base. This issue can be solved by introducing feed production technologies and rational use of feed, regardless of natural conditions. The effective use of feed in animal feeding is possible only if they are well prepared for and mixed with other components.

The use of feed mixtures makes it possible to expand the use of plant residues and industrial additives, ensure full-fledged eating and digestion of feed, increase animal productivity by 10...26%, reduce feed consumption per unit of production by 15...20%.

Keywords: agriculture, lifestock industry, animal feeding, operation, innovative technologies

Introductıon

One of the tasks facing animal husbandry at the present time is to provide livestock products. The successful completion of this task depends, first of all, on the creation of a solid, high-quality feed base in this industry. It has been established that the use of feed mixtures provides full-fledged eating and digestion of feed, an increase in animal productivity by 10... 26% and a decrease in feed consumption per unit of production by 15...20%.

The preparation of concentrated compound feeds directly on the farm based on industrial additives helps to solve several tasks at once. In the technological processes of preparing a feed mixture, the mixing operation plays an important role and manifests itself in the productivity of these animals. As can be seen, reducing the energy intensity of the mixing process of equipment for the production of full-fledged concentrated compound feeds, improving feed mixtures in the direction of improving their quality is an important urgent problem in agriculture.

In addition, existing machines for the production of compound feeds, along with high productivity, have high energy consumption, and their use in small farms and agricultural enterprises is inefficient. Taking this into account, our goal was to develop a new small-sized installation for these farms, substantiate its parameters and operating modes. In this paper, a constructive and functional - technological justification of the main elements and modes of creating such a device is given.

It has been established that this issue in animal husbandry can be solved by introducing innovative technologies for processing harvested feed, regardless of natural conditions and rational use of feed. The effective use of feed in animal feeding is possible only if they are well prepared for feeding and mixed with other components to supplement it[1,2].

In the technological processes of preparing a feed mixture, the mixing operation plays an important role and manifests itself in the productivity of these animals. However, this operation requires energy consumption, which affects the cost of the final product. It should also be noted that the existing feed mixers do not always fully meet the zootechnical requirements, do not ensure the production of the desired quality feed mixture.

The current state of production of concentrated compound feed in economic conditions.

The main consumers of concentrated compound feeds in our country are poultry and animal husbandry. Poultry farming is almost entirely dependent on concentrated compound feeds. Therefore, such large farms organize their enterprises for the production of concentrated compound feeds. As for cattle, coarse and juicy feeds are the main ones in their diet. However, it is impossible to ensure the required productivity without the use of concentrated compound feeds, whether in dairy or meat production. Feed grain is fed to an animal without preparation for feeding in most cases, especially on small farms, while concentrated compound feeds account for less than 30% of the cattle diet due to their high cost.

Feeding farm animals with full-fledged concentrated compound feeds is much more effective than alternate feeding with certain feed products (1). Alternate feeding of products such as cereals, legumes, cake, chaff, fish meal, etc. to animals and birds is less effective compared to feeding in the form of concentrated compound feeds. Faster weight gain, lower consumption and feed losses when fed in a full-fledged mixture also lead to lower costs for obtaining them.

The main factor of a positive effect in a full-fledged concentrated compound feed is considered not to be a set of grain components, but the ratio and level of nutrients and biologically active substances. Therefore, when concentrated compound feeds with grain composition, available on the farm in limited quantities, are enriched with protein, vitamins, micronutrients and premixes, they become quite rational and economically effective.

The correct construction of the technological process and the choice of equipment ultimately affects the cost of livestock products.

The cost of concentrated compound feeds of the farm's own production is significantly lower compared to compound feeds produced and purchased at a large feed mill. At the same time, it should be noted that concentrated compound feeds produced on the farm itself guarantee the quality and required composition regardless of the manufacturer, the purchase price of grain on the market and changes in the price of electricity.

In the production of concentrated compound feeds on the farm in accordance with zootechnical requirements using its own feed grains and purchased protein, mineral and vitamin supplements, feed resources are used more efficiently, and a high-quality livestock product is obtained at minimal cost.

Preprepared protein – vitamin - mineral additives not only simplify the production technology of concentrated compound feeds in the farm, but also create conditions for obtaining high-quality feeds enriched with nutrients. The feed mixture prepared on the farm retains the uniformity of the composition well, and the animals constantly receive fresh feed.

In Europe and America, 40% of concentrated compound feeds are produced directly on farms (2,3,4). Foreign companies produce a set of equipment, machines and installations of various capacities for this purpose. Thus, the companies Art's Way, Gehl, Sudenga (USA), Peruzzo, AGREX (Italy), Toy, Electra (France), Kramer, Tropper, Buschhoff (Germany), Van Aarsen (Netherlands), Nakkiyan Konepaya (Finland), Tropper (Austria) and others produce feed mills, shredders and feed mixers.

The issues of the quality of harvested feed in the conditions of intensification of animal husbandry, their rational use in animal feeding are currently a matter of paramount importance. The effectiveness of the feed is high when it meets the needs of animals in terms of its physical and mechanical properties and the amount of nutrients contained in it [6].

With the intensification of animal husbandry and an increase in its productivity, the number of controlled indicators increases, and with it the requirements for feed quality. High demands are placed not only on the amount of individual nutrients in the feed, but also on their quality and suitability for the body [10,12,15].

In recent years, livestock breeders in our republic have observed positive changes in forage harvesting. Along with an increase in the yield of forage crops, an increase in the area of their next sowing is being carried out, the creation of cultural pastures in many places, the introduction of progressive methods of harvesting forage of plant origin and means of mechanization [10]. Currently, traditional forage crops are grown in the republic in fields of hundreds of thousands of hectares, hundreds of thousands of tons of dry grass, straw and concentrated feed are harvested [1,5]. Currently, haylage, silage and other juicy feeds, full-fledged silage mixture are being resumed in farms that have survived the period of the last recession and occupy a worthy place in the practice of feed production.

However, it is too early to say that animal husbandry in the republic is fully provided with feed. Many peasant farms face a shortage of feed in winter, often the low nutritional value of the feed obtained leads to a decrease in livestock productivity, which in turn leads to unprofitability of farms.

Thus, landowners and livestock farmers engaged in feed production will have to focus on ensuring the nutritional quality of the feed supplied.

The purpose of the study. This is the operation, determination of parameters and modes of a resource-saving plant for the preparation of full-fledged concentrated compound feed.
The object of the study. This is a plant for grinding, mixing and enriching grain of cereals - components for the preparation of concentrated feed.

Research methodology.
To achieve this goal, theoretical and experimental studies will be conducted aimed at obtaining dependencies that help determine the optimal kinematic and technological parameters of a small-sized plant for the production of full-fledged concentrated compound feed. Theoretical research is based on the study of technological processes using methods of classical mechanics, thermodynamics and computer systems. In experimental studies, physical modeling methods will be used for theoretical calculations and verification of the results. Using the reporting and constructive method based on the results of experimental modeling, it is possible to optimize the design and technological parameters of the feed mixer. The results of the study will be performed using mathematical statistics, regression and factor analysis.
The mixing process and its evaluation: In engineering practice, they face problems characterized by consistency or several optimization criteria. There are at least three criteria here: 1) a criterion based on the quality of the technical object (abbreviated as the quality of the technological process); 2) a criterion indicating the economical use of energy or fuel (specific energy consumption, etc.); 3) the criterion of operational productivity or throughput should be taken into account.

Result of ınvestıgatıon.
Our analysis shows that instead of existing methods, crushing of grain crops is carried out in a combined way, that is, both by the method of free slicing and by the method of free grinding – cutting-impact, as well as with sharp serrated knives rotating not around the horizontal axis, but around the vertical axis, under the same conditions and mode, by reducing the torque inertia, idling, including general work and per unit of work, energy consumption can be reduced to at least 6 times compared to existing machines.
So, in the currently available hammer grinding machines, grain crushing occurs by pre-impact, and then rubbing it into a deck or iron mesh, between which there is a very small distance, using a set of multi-mass hammers rotating around a horizontal axis. A set of hammers contains up to 60-280 hammers on a shaft, and they are so tightly packed in discs that are mounted on the shaft in a set of hammers that a set of hammers can theoretically be considered as a rotating drum with an internal filling having a certain radius *r*. According to classical mechanics, the moment of inertia resistance of such a figure is determined by the formula[12].

$$J1 = m1r12/2 \qquad (2.1)$$

In the combined technological method proposed by us, grain grinding takes place using thin and narrow rectangular knives rotating around a vertical axis. When rotating a figure with such a radius *r* according to classical mechanics around a vertical axis, its moment of inertia resistance is determined by the formula.

$$J2 = m2r22/12 \qquad (2.2)$$

If we take m1 = m2 = m and r1 = r2 = r, we will see that under the same conditions, the moment of inertia resistance in the first case (existing) in j1: j2 = 6 times greater than in the second case (new). On the other hand, it is known that for an object in rotational motion, the energy consumption at idle A changes in direct proportion to the moment of inertia resistance j and the rotational velocity ω and, accordingly, are determined by the formulas
for the first case

$$A1=j1\cdot\omega1/2 \qquad (2.3)$$

for the second case

$$A2=j2\cdot\omega2/2 \qquad (2.4.)$$

If we assume the same rotation speed for both cases and bring the values J1 and J2 from the formulas ω1=ω2=ω and (2.1.) and (2.2) and put them on formulas (2.3) and (2.4), respectively, then it is theoretically possible to reduce the power consumption at idle in the new proposed installation to 6 One time. Therefore, in this new installation, it can reduce energy consumption per unit of work by up to 6 times.
The process of grinding grain with sharp knives by the method of free slicing occurs as follows.

In such a device, the blades are first cut through or torn, thereby injuring the grain with their sharp blades along A-B (fig.1), after which, at high speed, it cuts into a circular mesh B with small holes placed around the perimeter (fig.1), grain particles that do not pass through the mesh return back under the counteraction of the mesh and the airflow, and then again exposed to such an effect with the next blade, and the process continues in this way until the grain is completely crushed and passes through the mesh. This method allows you to grind the material at any humidity, and also makes it possible to reduce fractions less than 1 mm. Thus, the grain is easily pushed out of the holes of the calibrated mesh under the action of centrifugal force and air flow.

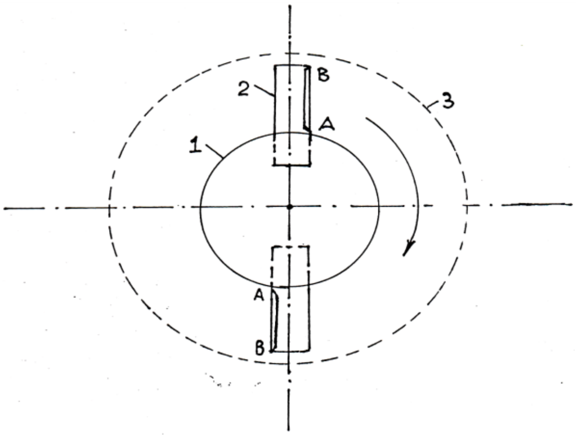

Fig. 1. Diagram of the working chamber of the grain crushing plant by the cutting and impact method: 1- disc; 2- blade; 3- iron mesh.

Figure 2 shows the technological scheme of cutting or tearing in an installation operating on the principle of cutting - impact, followed by impact on an iron mesh and its splitting. Grain from the hopper travels a certain distance from state I to state II. In position II, it comes into contact with a rapidly rotating blade. At this moment, the blade damages the grain shell and cuts, creates cracks, gaps, ruptures, etc., forms deformations in a certain part of the grain and throws the grain into the iron mesh at a speed of υ2. At the moment the blade touches the grain, its speed becomes equal to the sum of two velocity vectors: grain $\vartheta 1$ and blade $\vartheta 2$.

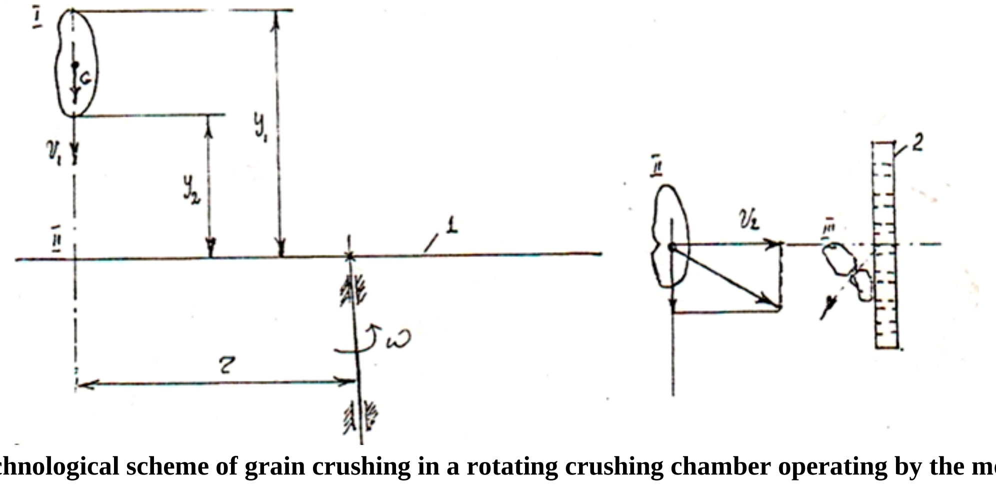

Fig.2. Technological scheme of grain crushing in a rotating crushing chamber operating by the method of free cutting - impact: 1- blade; 2- iron mesh.

Grain hitting the iron mesh at high speed splits at the site of its rupture or other concentrated damage, and particles of crushed grain, whose size is smaller than the diameter of the mesh, are at the same moment ejected from the mesh opening under the action of centrifugal force. Therefore, in this proposed method, the number of grain particles turning into dust, less than 1 mm, will be less.

It should be noted that due to the acceleration of free fall from its length to the distance y1 - y2, the grain repeatedly hits the rapidly rotating blades and receives concentrated blows, crashes into the grid and is crushed again. The process continues in this way until the grain is removed from the grid.

The process of grinding grain in a crushing chamber. The analysis carried out in the first chapter showed that in existing grain crushing machines, the hammer method of grinding grain is mainly preferred. Currently, hammer crushing chambers are used in most machines and installations widely used in production. In these installations, hammers rotating around a horizontal axis have a speed of at least 60-100 m/s, and from the inlet neck they knock out the grain filled on them with a mass of impact and rub it on a circular grid with holes located in it, calibrated according to a grid with small holes. Since the hammer speed in such machines exceeds the limit of 65-100 m/s or more, as a result of the resulting preliminary impact, the grain breaks off and then grinds by friction against a grid or deck. In this mesh chamber, small diameter particles of crushed grain are obtained using hammers, and they exit through holes in the calibrated mesh or deck. Therefore, to grind grains in this way, the grains must be very dry, their moisture content should not be less than 15%. Otherwise, the hammer rotating at high speed heats up from friction against the surface of the deck or grid, resulting in a deterioration in the quality of the crushed grain. Grain grinding is a complex process that depends on the influence of many factors. Practice shows that, despite the number of these factors, the degree of grinding, as well as the energy consumption of the process, is influenced by humidity, grain hardness and other physical and mechanical properties, linear grain sizes, as well as the shape and mode of operation of the working bodies that affect grinding.

Goryachkin V.P. [9], Melnikov S.V. [10], Aleshkin V.P. [11], Belyanichnikov N.N., Smirnov A.U. [12], Makarov A.P. [14], Eliseev V.A. [15], Sirovatka V.I. [16], as well as Azerbaijani researchers Gurbanov H.G. [3], Bagirov B.M.[13], Mammadova G.A. [6-7].

As a result of various theoretical and experimental studies, it is still not possible to determine with complete accuracy the process occurring in the crushing chamber in installations operating by the hammer crushing method. Nevertheless, in the analysis of the operation of hammer crushing plants, all researchers unambiguously take as a basis the theory of impact, developed in the 20 - 30s of the XX century by academician V.P. Goryachkin [19]. According to his theory, the grinding process in a hammer mill or in a device that grinds other materials from each hammer is achieved by an eccentric hammer blow that directs the grain in the direction of impact, after which it crashes into an obstacle and deforms, splits. At the same time, elastic and plastic deformation of the material is observed. The force of the impact leads to the destruction of the material or its flattening. As a result, the material loses its original shape and acquires a new shape. This directly leads to its fragility and an increase in the contact surface. As a rule, in granaries, solid material is crushed, breaks up into smaller pieces and its contact surface increases. This facilitates the assimilation of grain by animals.

Currently, two scientific theories of solid state grinding have been formed. One of them is theories that take into account the change in surface, and the other is the change in volume. In both cases, the change is characterized by the rate of increase in the surface or volume of the material during grinding. The first of them for solid technological materials was proposed by Egorov V.A.[12] and Levinson L.B. [19]. These scientists studied for the first time the process of decomposition of rocks extracted from minerals. It turned out that their work in this area can also be used in the process of grinding grain. Even in our proposed device, the grain is subjected to an impact that occurs during the primary incision inside the chamber, the grain that received the primary impact quickly crashes into the surrounding mesh, thereby receiving a second impact, large particles that do not pass through the holes of the mesh hit the rotating blades once again and are crushed again by the impact of the blades that follow it. The grain is repeatedly subjected to such cutting and impact effects until it comes out of the hole in the surrounding iron mesh. When grinding by this method, as in the case of hammer crushers, according to surface theory, the energy spent on grinding changes in direct proportion to the grinding surface. Mathematically, this is expressed as follows.

$$A_n/A_m = n/m \qquad (2.5)$$

where: n and m - the amount of grinding;

An and Am - the energy spent on grinding in quantity n and m.

According to the volume hypothesis, the energy spent on grinding is mainly used to overcome elastic deformation, and the amount of energy spent on changing the material is directly proportional to the changing volume of this material. The mathematical expression of this pattern is written as::

$$A = C \cdot F \cdot L \qquad (2.6)$$

where: C – constant value;

F - the cross-sectional area of the material, cm^2;

L - length of the material, cm.

According to the surface theory mentioned above, a cube with sides a = 1 cm is taken, which is divided into smaller equal parts of the cube. With this division, the surfaces of the parts taken from this cube increase in comparison with the original cube. The pattern of this increase is as follows. More precisely, n is the number obtained after grinding:

- increasing the surface

$$S' = 3s(n-1)$$

- increased energy

$$A' = 3A(n-1)$$

- number of crushed cubes

$$m = n^3$$

where: S and S′ - primary and newly acquired surface, m^2;

A and A′ - energy consumption during the formation of primary and new surfaces, kW;

m - the number of newly obtained cubes, pieces;

n - degree of grinding.

According to the second theory, if we take the initial edge of the cube as *D* and the edges obtained after grinding as *d*, then the umber of crushed cubes *n* obtained from one blow, i.e. at one stage, will be as follows:

$$n = \frac{n^3}{d^3}$$

If the impact is *x* times, then the resulting number of small cubes will be n^x, and it can be written as follows.

$$n^x = \left(\frac{D^3}{d^3}\right)^x \qquad (2.7)$$

Hence, if we log both sides and then find x, then we get.

$$x = (lg\, D^3 - lg\, d^3)/\, lg\, n \qquad (2.8)$$

In this expression, *x* – indicates the number of strokes during the grinding process. According to the volume hypothesis, the energy consumption of each stage - A_m to the previous stage - A_n is expressed as follows [15] .

$$\frac{A_n}{A_m} = \frac{lg\, D^3/d_n^3}{lg\, D^3/d_m^3} \qquad (2.9)$$

The volume hypothesis is fully consistent with the theory of elastic deformations of Hooke's law, one of the basic laws of mechanics. Thus, complete destruction-grinding of dry grain material occurs at the full limit value of elastic deformation.

However, in real conditions on farms, it is more efficient to grind grain not only in the solid state, but also in the wet state. So, in this case, its elasticity decreases in the grain and its plasticity is observed. In this case, hitting the grain with a sharp blade stroke, instead of a blunt one, can ensure that it will be cut or torn with low energy consumption.

In the new method, it is possible to achieve grain grinding at the desired moisture limit and the degree of energy saving. This issue needs to be determined and justified experimentally. To do this, in experimental studies, it is necessary to study the grinding of grain materials at different humidity with a new device and choose an advantageous mode.

Theoretical study of the process of free grain cutting. As a result of the above studies, we have found that it is possible to reduce energy consumption for the process of grinding a single amount of grain when using rotary grain grinders with sharp blades operating by the free cutting-impact method and rotating around a vertical axis instead of a conventional hammer crusher, as well as to grind grain with different humidity, in different operating modes. To determine the physical nature of this issue, let's analyze the process of cutting grain from the impact of a free kick.

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In our proposed small-sized grain grinder on a disk rotating at high angular velocity around a vertical axis, or mounted on a straight axis, knives with a sharp blade strike the falling grain with their weight in a vertical direction and either cut it with sharp knives, or damage it at the first impact and cut the grain into a round grid located on the edge. Pre-deformed, torn grains are very easily torn and crushed.

The process of cutting or tearing grain with a high-speed rotating blade is as follows. Blade 1 strikes at high speed grain 2 with thickness h falling in front of it (figure 3).

Meanwhile, the blade compresses the surface of the resisting grain by its inertia, and the blade enters the grain up to h_s, creating a certain fracture stress σ_d. on its surface. As a result, the cutting or tearing process takes place on the grain surface at this moment.

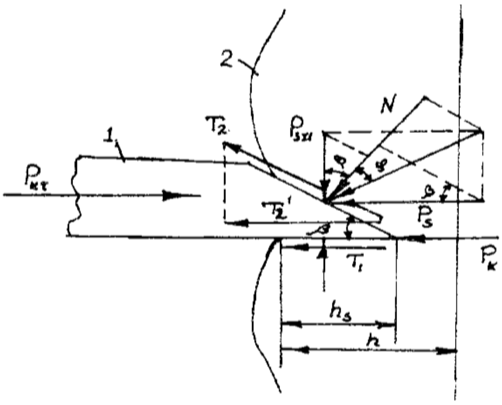

Fig. 3. Forces acting on the knife blade during grain cutting: 1 – knife blade; 2 – grain.

According to the cutting theory of academician V.P.Goryachkin [12], Professor Reznik N.E. [14] when cutting material, the following forces act on the blade of a cutting knife: direct cutting force - P_k acting on the cutting blade directed against the cutting direction; compression force of the blade of the cutting material - P_s. This force is called the resistance force of the material to its expansion to the sides and is estimated as the force applied to the expansion of the material.

From the scheme of cutting grain with a knife in figure 3, it can be seen that the normal force N acting on the sharp side of the blade is equal to the sum of the projections of the forces of the two compressive forces P_s and compression P_{sxl} :

$$N = P_2 \sin\beta + P_{sxl} \cdot \cos\beta \qquad (2.10)$$

This normal acting force creates a friction force on the edge of the blade

$$T_2 = f \cdot N \qquad (2.11)$$

where: f - coefficient of friction.

The coefficient of friction f is called the coefficient of friction of the blade material of the knife on the grain material and is defined as:

$$f = tg\phi \qquad (2.12)$$

In this formula φ is the angle of friction .

There is the following relationship between the normal force - N and the angle of friction φ

$$N = \sqrt{P_s^2 + P_{sxl}^2} \cdot \cos\phi \qquad (2.13)$$

Under the influence of the compression force, a second friction force is created on the back of the knife blade.

$$T_1 = P_{sxl} \cdot f \qquad (2.14)$$

As can be seen from the figure, while the force T_2 forms an angle B with the direction of motion, the friction force T_1 is directed directly against the direction of motion. Therefore, to bring the force T_2 to the direction of motion, it is necessary to write as:

$$T_2^1 = T_2 \cos\beta \qquad (2.15)$$

To determine T_2^1 , we need to put the value of the acting forces in place in the last formula, then we get:

$$T_2^1 = f \cdot N = f(P_s \sin\beta + P_{sxl} \cos\beta) \cdot \cos\beta = f(P_s \frac{1}{2} \sin 2\beta + P_{sxl} \cos^2\beta) \qquad (2.16)$$

The critical force P_{kr} acting on the knife blade at the initial moment of cutting must repel all opposing forces in order for the cutting process to begin, that is, the sum of other acting forces with this critical force from the first moment of the cutting process must satisfy the following inequality condition.

$$P_{kr} \geq P_k + P_s + T_1 + T_2' \qquad (2.16)$$

On the other hand, in cutting theory, it is believed that the shear force P_k should be equal to or greater than the product σ_d of the destructive contact stress on the area of the face of the cutting blade - F_T. Only in this case it is possible to cut the material [92]. More precisely,

$$P_{kəs} \geq F_T \cdot \sigma_d = \delta \cdot \Delta l \cdot \sigma_d \qquad (2.18)$$

where: P_k – shear force;
F_T - the area of the face of the cutting blade;
σ_d - destructive contact voltage;
δ - blade thickness;
Δl - the length of the cutting blade of the knife.

The destructive contact voltage - σ_d has a certain value for each material, and it is determined experimentally.
The definition of compressive P_s and compressed forces $P_2^{'}$ can be carried out as follows. If we take the equality condition in formula (2.17), then this formula can be written as:

$$P_{kr} = P_k + P_s + T_1 + T_2' \qquad (2.19)$$

If we look at the compressive P_s and compressed $P_2^{'}$ forces as elementary forces acting on the material, we will see that the forces of each ΔP_s and $\Delta P_2^{'}$ change depending on the fact that the blade enters the material, mainly increasing.
With each insertion of the blade into the material at a distance of Δx, the stress in this material increases. In this case, the relative stress can be written as follows, depending on the parameters of the blade's entry into the material:

$$E_s = \frac{h_s}{h} \qquad (2.20)$$

where: E_s - relative compression;
h_s- the distance by which the material is compressed by the blade during cutting, mm;
h - the normal thickness of the material,

It was found that this relative compression ratio can also be expressed as $E_s = \frac{\sigma}{E}$ [92]. Where is σ the stress of the critical rupture, and E is the coefficient of elasticity of the material. With increasing voltage $\sigma = P_s/F$, the relative compression also increases. This happens when the blade of the knife is continuously inserted into the material under the action of force P_s.. However, studies have found that the rate of increase in voltage, as a rule, lags behind the rate of increase in force from the compression effect. This is due to the fact that

$$h_s \prec \frac{b}{tg\beta} \qquad (2.21)$$

where: b - blade thickness, mm
The contact area of the cutting blade F_x from the action of the compression force - P_s can be determined by the following formula

$$F_x = \Delta l \cdot h_s \cdot tg\beta$$

The ratio of the compression force P_s to the contact area in cutting - F_x varies disproportionately. Professor N.E. Reznik [11] explains this by the fact that in agriculture all materials undergoing cutting have an elastic-sticky character. According to his method of determining this value, the change pattern of the compression force P_s depends on the relative compression E_S, and in its definition, the strain is taken against the force of compression P_s to the area of first contact F_s.
To simplify the report in accordance with the above, the expression $E_s \cdot E = G^n$ assumes that n=1. (In fact, not as shown in real conditions, n≠1). Therefore, the force of elementary compression dP_s per unit area dF is written as follows for variations of unit length and elementary width (figure 2.4), [14,15,17].

$$dP_S = E \cdot E_S \cdot dh_s \cdot tg\beta \qquad (2.22)$$

If we put the E_S value in place in this formula, we get:

$$dP_S = E_S \frac{h_s}{h} \cdot dh_s \cdot tg\beta \quad (2.23)$$

$$P_S = \frac{E}{h} tg\beta \int_0^{h_s} h_s \cdot dh_s = \frac{E}{2h} h_s^2 \cdot tg\beta \quad (2.24)$$

Thus, the compression force P_S varies proportionally to the square of the compression height hs, the graph of which is a square-parabola [12].

The relative deformation of E_l is determined by the following formula depending on the degree of compression E_S:

$$E_l = E_S \cdot \mu \quad (2.25)$$

where: μ - Poisson's ratio.

The Poisson's ratio is measured by the ratio of the longitudinal deformation of a material to the transverse deformation under tension or compression. When cutting compacted materials with knife blades, it is taken within the range of μ =(0.08...0.3) in coarse and concentrated feed materials.

If we deduce the value of E_S from formula (2.20) and put it in its place in formula (2.25), we get:

$$E_l = \mu \frac{h_s}{h} \quad (2.26)$$

Conclusıon.

In small-sized installations designed for farms with a small height of the hopper, it is more advisable to supply grain with its own flow. When feeding grain from the hopper to the crushing chamber, a retractable dispenser can be used as a dispenser. The installation defines the shape and parameters of the grinding chamber: - the side of the iron (metal) mesh is round, the diameter of the drum is 220 mm, the height of the drum is 30 mm, the diameter of the calibration holes of the spindle of the iron mesh and its pallet is 3 mm more efficient. This ensures that grain is crushed at different humidity into fractions that meet agrotechnical requirements, which can be used for all types of animals and birds. The number of fractions less than 1 mm is 5-8%.

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Data availability

– manuscript has no associated data

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