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OPTIMIZATION OF THE BASIC PARAMETERS OF THE CRUSHER CHOPPER WHEN PREPARING ROUGH FEED

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Annotation. *The design of the working body was substantiated theoretically and experimentally. In the course of research, it was revealed that crushers should have such a shape that would reduce the centrifugal force, which increases energy consumption and leads to rapid wear of the working body as a whole. The new shape of the grinder, implemented in the roughage chopper body, improves the main technical parameters of the chopper, while performing the cutting and chopping processes.*

Key words: *grinder-dispenser, angle of installation of the rotor crusher, hopper rotation frequency, throughput, rotor, crusher, organ, power, degree of crushing.*

Introduction. The process of preparing feed consists in crushing them to the same particle size, and further contributes to their better mixing and prevents self-sorting of particles in the finished product during transportation to the consumer [1, 2].

Roughage is one of the essential components in the diet for cattle, sheep, horses and in small doses for pigs and poultry. So, the most valuable is hay, and in case of its lack - straw, the amount of which in the diets of animals on small and medium-sized farms exceeds 25% [1].

In recent years, straw in the feed balance and animal nutrition has been used not only in our country, but also in countries with developed animal husbandry (Russia, Canada, Holland, etc.). The bulk of the straw (80 ... 90%) is hard-to-translate fiber and nitrogen-free extractives [1]. Recently, in many countries, straw is used for livestock feed after pretreatment, which increases its nutritional value and digestibility. Recently, in many countries, straw is used for livestock feed after pretreatment, which increases its nutritional value and digestibility. The first group of methods affects taste and provides a higher attendance. These include mechanical and thermal processing: grinding, granulating, mixing with other components, steaming, etc. The second group, which includes chemical and biological processing, while improving the palatability, increases the nutritional value of roughage [1]. So shredding is the simplest way of mechanical processing, which allows to increase the attendance of straw, reduce losses, improve dosage, transportability and miscibility with other components. In accordance with the zootechnical requirements, the cutting size should be: for cattle - 40 ... 50 mm, for horses - 30 ... 40 mm, for sheep - 20 ... 30 mm with splitting along the fibers. When steaming straw and preparing briquetted feed mixtures, the particle size should be 20 ... 30 mm. The amount of crushed particles for cattle less than 20 mm in length should not exceed 15%, and particles 35 ... 45 mm in length should be at least 80% with splitting along the fibers at least 85% [1, 3, 4].

The mechanical properties of the crushed roughage make it possible to dose and distribute them more efficiently into the feeder, exclude clogging of the beaters and other working organs of the feed dispensing and transporting devices. Therefore, grinding roughage is the main operation in preparing them for feeding. In this regard, it is necessary to develop highly efficient crushers for spruce, capable of processing feed, harvested both in bales, rolls, and loose, normal and high humidity, which is especially important for the conditions of the Karshi region. For grinding roughage in our country, more than fifty types of spruce grinders are used, differing in the principle of grinding, grinding apparatus, method of feeding the material for grinding and removing the finished product. Most of them are energy and metal consuming, unreliable in operation, inoperable when processing straw with high humidity [4].

Rough feed grinders must meet the following basic requirements: provide crushing of loose and compacted material, including high moisture content, have a high throughput with low specific energy consumption, have an even granulometric composition of the finished product, ensure rapid removal of the crushed product from the grinding zone, have a high durability of working bodies, to be simple in design and easy to maintain. The most promising are hammer grinding bodies with counterweights, which grind the material along and across the fibers. They can be successfully used for crushing high humidity stem material. Grinding apparatus with articulated hammers (in drum grinders) creates conditions for increasing the overall stability of the movement of the dynamic system. Crushers with articulated hammers, the so-called crushers, make it possible to obtain a finished product with a high degree of disintegration of particles, are simple to use, reliable in operation, and versatile in relation to the processing of feed with various physical and mechanical properties [3].

Along with the indisputable advantages of hammer crushers, there are also disadvantages, the main of which is the high energy consumption of grinding, although, as studies have shown [4], if we attribute the energy consumption per unit of the newly formed surface, then hammer grinders have specific energy consumption less than other types of working bodies (knife, pin). As the disadvantages of hammer crushers of stalk feed crushers, we note: uneven granulometric composition of the resulting product; increased content of over-crushed particles, leading to the occurrence of a circulating load and an increase in energy consumption; significant wear of working bodies due to high peripheral speeds of hammers.

Methodology. In the laboratory of NIIMSH, various hammer designs and their effect on the performance of the grinder were studied. The main element of a hammer mill is a rotor with articulated or rigidly fixed hammers mounted on it. Crushers with articulated hammers are preferred due to their low sensitivity to the presence of foreign bodies in the feed (pieces of ice, snow, strapping material), the possibility of preventing accidents and the ease of replacing hammers. When hammers are hinged, the braking effect of external working resistances is transmitted to the drum shaft and is partially compensated by a decrease in its moment of inertia caused by the deviation of the hammers from the radial position. The displacement of the hammer suspension point from its longitudinal axis facilitates sliding cutting, which increases the efficiency of the grinding process [2].

To reduce the load on the rotor shaft and reduce wear and, accordingly, the energy consumed, it is proposed to use a hammer of this design, which has a face located at a certain angle of installation of the hammer rotor α. Thus, the process of "cutting-grinding" is obtained, while the cutting will be sliding. The rotor is installed in such a way that its axis is deflected from the vertical position. It consists of discs 1, on the axes 3 of which hammer working bodies 2 are installed. In this case, the working face of the hammer is set at an angle α = 22 °, in relation to the radius vector of the rotor. The guide of the rotor body is made along a logarithmic spiral, along it, the crushed material is removed to the animal feeder due to the kinetic energy of the rotor, and partly due to the resulting air flow of the material.

The loading device consists of a side mounted on a frame with the possibility of rotation around a horizontal axis. The opening and closing of the hydraulic side is carried out by means of a hydraulic cylinder.

Insignificant coefficients were excluded from the model; after excluding each insignificant coefficient, the mathematical model was recalculated. As a result, the following mathematical models were obtained:

$$Э=1,225 - 0,278 \cdot x_1 + 0,142 \cdot x_2 + 0,097 \cdot x_1 \cdot x_2; \quad (1)$$

$$P=15,889 + 1,483 \cdot x_1 - 1,878 \cdot x_2 - 1,6 \cdot x_{22}; \quad (2)$$

$$ƛ=3,452 + 0,158 \cdot x_1 + 0,432 \cdot x_2 + 0,335 \cdot x_{12}; \quad (3)$$

$$Q=4,019 + 1,02\ x_1 - 1,268\ x_2 - 0,468\ x_{22}. \quad (4)$$

The specific energy consumption of the grinding process (1) is most influenced by the factor x_1 - bunker rotation frequency (b_1=-0,278). Specific energy consumption of grinding decreases with an increase in the frequency of rotation of the bunker. The power consumed by the grinder-dispenser (2) is most influenced by the factor x_2 - the angle of installation of the hammer rotor (b_2=1,878). As the tilt angle increases, the power decreases. The degree of grinding (3) is significantly influenced by the factor x_2 (b_2 = 0,432). As the factor x_2 increases, the degree of refinement increases. Analysis of the mathematical model Q (4) shows that the angle of inclination of the hammer rotor has the greatest influence on the optimization criterion (b_2=-1,268). With a decrease in the angle of inclination α, and an increase in the factor x_1 (b_1=1,02) – hopper rotation speed, throughput increases. The determination of the optimal values of the factors was carried out using two-dimensional sections. Two-dimensional sections of the response surface are presented in the coordinates: hopper speed and tilt angle of the hammer rotor. Analyzing the cross-sections of the response surface, we can conclude that the minimum specific energy consumption E =1.45 kW• h / (i.e., st.meas.) Is achieved at a bunker rotation frequency n_b=9 min^{-1}, and an angle of installation of the hammer rotor α . From the analysis of two-dimensional sections it can be seen that the minimum power consumed by the grinder P = 15.8 kW is achieved at a bunker rotation frequency n_b = 5 min^{-1} and an angle of installation of the hammer rotor α = 32°. The maximum value of the degree of grinding ƛ = 5.2 is achieved at a hopper rotation frequency n_b = 9 min-1 and an angle of installation of the hammer rotor α=32°. From the analysis of two-dimensional sections it can be seen that with a decrease in the angle of inclination of the hammer rotor and an increase in the frequency of rotation of the hopper, the throughput increases from 2.1 to 6.1 t / h.

Conclusion. In the course of solving the compromise problem of optimizing the parameters of the working process of the mobile grinder-dispenser, its optimal parameters were determined: the frequency of rotation of the bunker n = 9 min^{-1}, the angle of inclination of the hammer rotor α = 22° In this case, the throughput of the unit is Q=5.4 t / h; specific energy consumption E = 2.0 kW • h / (unit of st.meas.); power consumption P = 17kW; the degree of grinding - ƛ = 3.8.

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