

## JUSTIFICATION OF THE RATIONAL PROCESS AND PRINCIPLE OF OPERATION OF THE MACHINE FOR FINE CRUSHING OF RODS

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The effective use of corn cobs as part of feed mixtures requires appropriate preparation of raw materials, namely their grinding to achieve a granulometric composition, ensuring a reduction in energy consumption for the grinding process. For the effective use of corn cobs as part of fodder mixtures for cattle, the main requirement is their preliminary grinding to particles up to 5 mm in size with a fractional content of at least 70% and the use of a non-metal-intensive machine with reduced energy consumption requirements for the implementation of the process. The principle of operation, construction and geometric parameters of machines for grinding corn stalks corresponding to their particle size composition and physical and mechanical properties are analyzed.

**Key words:** *rod, grinding, mixture, granulometric composition.*

### PROBLEM

In order to increase the productivity of animal husbandry by creating a reliable fodder base based on the principle of resource-saving technology, a complex of technological, technical and organizational measures is envisaged to increase the production of coarse, juicy fodder and fodder grain. The successful implementation of this task becomes possible mainly due to the expansion of corn crops, which in terms of yield of biological mass and grain, versatility of use and nutrition surpasses almost all grain fodder crops and occupies a leading place in the world in animal feed rations [1,2].

### ANALYSIS OF THE LATEST RESEARCH

The technological operation of grinding is the most energy-intensive in the work processes of preparing fodder in the form of hay, silage, grass flour and cuttings, combined fodder and complete ration fodder mixes. As a result of grinding raw materials, they acquire fluidity, thanks to which the operations of loading, transportation, dosing, dehydration, pressing are improved, conditions are provided for the effective performance of canning processes. Along with this, when preparing fodder for feeding, it is necessary to grind it to a certain granulometric size, depending on the requirements for the most complete assimilation of this fodder by individual species of animals of different age groups. The chosen method of grinding, which depends on the physical and mechanical properties of the feed and its purpose, determines the design of the grinding device, its parameters, the mode of operation to ensure the minimum specific energy intensity of the process. Therefore, the consciousness of this work is aimed at studying the regularities of the process of grinding corn stalks, with the analysis of the designs of machines of domestic and foreign production, used at that time for processing raw materials. The performed analysis of the designs of machines for grinding cobs and grain-cob mixture showed that for corn cobs with negligible moisture, their use is impractical due to the expected high energy consumption and insufficient efficiency of the process with a significant metal content of the structures, as well as the lack of a mechanism for operational regulation of the degree of crushing of the product. As a result of the conducted analysis, it was established that all existing designs of machines for grinding rods, grain-rod mixture and corn cobs, regardless of the principle of operation, can be conditionally divided into two groups: the first serves for coarse grinding, the second - for fine grinding of the product into flour or grain. It should be noted that in the existing studies there is practically no data on the

designs of machines intended directly for grinding corn stalks (threshed cobs) and their effectiveness on such basic indicators as specific energy consumption and granulometric composition of the ground product. Data on the physical and mechanical properties of the rods, in particular, on strength under different types of deformations, on the basis of which the selection of the principle of operation of the equipment and the development of the design of the grinding working body should be carried out, are also not given. There are only recommendations for the use for coarse grinding of corn stalks, which are serially produced by the machine industry: cake crushers, which require some reconstruction [3], roller crushers, and some others.

The purpose of this study is to develop a design of a grinder for corn cobs, which provides lower energy consumption and the required degree of crushing, which can be achieved when choosing the principle of operation of the machine and its working organs, based on the data of the physical and mechanical properties of the cobs, their structure and granulometric composition.

## RESEARCH RESULTS

When considering the principle possibility of using hammer crushers for crushing corn stalks, the following must be taken into account. Rods obtained as a result of threshing cobs have a moisture content of 16...18%, after a day it drops to 10...,12%, and during storage it can reach even lower values depending on the relative humidity of the air and the storage period. In addition, as a result of the change in the structure of the rods during the removal of grains from the nests in the process of threshing the cobs, their specific hygroscopic properties and structure, their strength increases significantly and the frictional properties change, in comparison with unthreshed cobs of high humidity, while maintaining the elastic-plastic characteristics that showed anticipatory research and analysis of available data. Taking into account the above, based on the principle of action of hammer crushers, which implement the crushing process due to shock loads during intensive rubbing of the product through the sieve, their use for fine crushing of corn stalks is impractical for the following reasons:

- when grinding rods with increased strength and changed frictional properties;
  - energy consumption for the process and wear and tear of working bodies of hammers and sieves increases;
  - a large number of small particles formed during the destruction of rods of insignificant humidity, capable of creating fire-hazardous concentrations of mixtures with air;
  - puts forward increased requirements for aspiration of the machine and its tightness;
  - lack of a mechanism for operational regulation of the degree of grinding of the product
- of the considered constructions of hammer crushers when crushing kuruza cobs with a moisture content of 30...45% (Table 1.8) indicates their significant energy consumption Nud and metal consumption Mud.

When comparing the expected specific energy consumption for grinding rods and the analyzed equipment with Nud for grinding cobs, it should be taken into account that in addition to lower humidity and greater strength, the rods are also characterized by a lower bulk density, in connection with which the value of Nud for cobs in the comparative analysis should be adopted significantly higher than those indicated in table 1.8. In addition, greater productivity of hammer crushers at a high degree of product crushing is achieved due to a significant rotation frequency of the hammer rotor, which is 3000 min<sup>-1</sup> in DM-8 and DKM-5.0 machines, which creates additional inconveniences during their maintenance and operation, therefore that careful static and dynamic balancing of the rotors is required.

Table 1. Comparative technical characteristics of hammer crushers for grinding high humidity corn cobs.

Indexes	Units of measurement	IRT 165	DM-8	IRM-50	IRM-15	DKM-5	DIS-1M

productivity	t/h	20	8	15	123	82	12
Moisture of cobs	%	43 , 2	43 , 5	46 , 2	30 , 2	33 , 9	45 , 8
Rotor speed	min-1	2000	2950	1610	-	3000	2260
Installed capacity	kW	110	30	90	55	30	22
Specific energy consumption	kW h/t	5 , 5	2 , 7	6 , 0	4 , 5	3 , 7	1 , 8
Mass of shredders	t	5 , 1	0,385	2 , 57	2 , 2	1 , 03	0 , 8
Specific metal capacity	kg h/t	255	89	171	179	125	67
Distribution of crushed particles by fractions, mm	%						
Until 2		42 , 7	39 , 3	35 , 6	48 , 0	41 , 5	7 , 6
2...3		21 , 9	18 , 3	14 , 3	19 , 2	19 , 8	3 , 6
3...4		10 , 4	19 , 0	10 , 6	15 , 8	16 , 6	4 , 7
More than 4		15 , 0	21 , 9	39 , 5	17 , 0	22 , 10	87 , 1
Grinding module, mm		2 , 3	2 , 5	3 , 2	2 , 35	2 , 76	6 , 95

The analysis of technological methods and designs of machines for grinding cobs and corn stalks made it possible to establish that it is rational to develop a two-stage process for grinding the stalks, which includes coarse grinding in toothed crushers and subsequent fine grinding of the stalks to grains with a particle size of 1...5 mm. At the same time, a necessary condition for the effective implementation of the process, along with the achievement of the required particle size composition of the crushed mixture, is its low energy consumption. Preliminary grinding of rods, carried out due to breaking on the side of two-stage toothed discs, must to increase the efficiency of the next grinding of the product by increasing the productivity of the machine that implements the second stage of the process, improving the conditions for particle capture by the feeding device and reducing the specific energy consumption. It should be noted that with the existing technology of grinding the grain-rod mixture from corn, preliminary grinding of the rods in forage harvesters to particles of 3...4 cm in size is also used. The choice of the design of the working organs of the breaker should take into account the linear dimensions of the rods, their configuration and strength at different types of deformations, which will allow, with justified kinematic and technological parameters of the machine, to grind the product with minimal energy consumption. The need for such a choice is due to the fact that the existing designs of machines for coarse grinding are universal, because they are intended for grinding various coarse and fibrous materials that have different structures, geometric dimensions and strength properties, in connection with which the indicators of the technological efficiency of such machines change within wide limits and are not optimal for individual grinding products. For fine grinding of crushed rods (the second stage of the process), it is advisable to use a machine design in which the grinding of the product is carried out due to its repeated cutting by the working bodies while simultaneously stretching and bending in the process of transportation in the working area. This choice of the principle of action of the shredder is due to the characteristic features of the rods, which have considerable strength and have a fairly high elasticity. The material is affected in this way in machines, the working bodies of which are conical toothed discs. At the same time, the most important condition for effective grinding of a specific product is reasonably selected geometric parameters of the cutting elements, their location and configuration.

## CONCLUSIONS

The structural and technological shortcomings of the considered hammer crushers, used for grinding corn cobs with high moisture content, indicate the impracticality of their use in grinding rods. With the chosen principle of operation of the machine for fine grinding of rods, it is necessary to carry out theoretical and experimental studies aimed at substantiation and selection of geometric parameters of the working organs of the grinder. It should be taken into account that the rationality of the proposed two-step process of grinding corn stalks should be confirmed by experimental data on total energy consumption and particle size composition of the ground mixture.

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## ОБГРУНТУВАННЯ РАЦІОНАЛЬНОГО ПРОЦЕСУ Й ПРИНЦИПУ ДІЇ МАШИНИ ДЛЯ ТОНКОГО ЗДРІБНЮВАННЯ СТРИЖНІВ

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Ефективне використання стрижнів кукурудзи у складі кормових сумішей потребує відповідної підготовки сировини, а саме її подрібнення для досягнення гранулометричного складу з забезпеченням зменшення енерговитрат для здійснення процесу подрібнення. Для ефективного використання стрижнів кукурудзи у складі кормових сумішей для великої рогатої худоби основною вимогою є їх попереднє подрібнення до часток розміром до 5 мм з фракційним вмістом не менш ніж 70% і використанням неметалоємної машини з зменшеними потребами енергоспоживання на здійснення процесу. Проаналізовані принцип дії, конструкція й геометричні параметри машин для здрібнювання стрижнів кукурудзи, відповідаючих їх гранулометричному складу й фізико-механічним властивостям.

**Ключові слова:** *стрижень, подрібнення, суміш, гранулометричний склад.*