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Ensuring the operation of the impact crusher with the lowest energy costs

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Ensuring the operation of the impact crusher with the lowest energy costs

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Abstract. The article presents the indicators that determine the performance and energy costs ofthe impact crusher and the methodology for conducting experimental studies. During the test,the measurements were carried out at different values of the gap of the working chamber and thespeed of the rotor. Results of experimental studies. Theoretical models of the dependence ofproductivity and specific work on the gap in the working chamber of an impact crusher are obtained. Graphic dependences of the gap in the working chamber on productivity and specificwork in various speed modes. High-quality crushed products with the lowest energy costs andcorresponding to the zootechnical requirements for this, it is necessary to have a gap in the working chamber within 1.5 - 2.5 mm.

1. Introduction
Measures to develop highly efficient technical means with low energy consumption, which allow providing livestock farms with complete high-quality feed, is an important task. The leading place in improving the efficiency of livestock production by providing high-grade nutritious feed is occupied by the use of new resource-saving technologies and technical means. In this regard, much attention is paid to the creation of new types of resource-saving technologies and technical means for preparing feed, by grinding grain materials with minimal specific energy costs in livestock farms and corresponding to zootechnical requirements. Many scientists have dealt with the processes of crushing grain for the preparation of feed, but the study of the working processes of an impact crusher, depending on energy costs and the quality of products that meet zootechnical requirements, has not been studied enough. In the production of feed for livestock farms and improving their quality with the lowest energy costs, it plays an important role. It is necessary to have equipment for forage harvesting, it is also important that the technical means in agriculture are used with the least energy costs, the productivity and quality of the crushed products must meet zootechnical requirements [1, 2, 3, 4, 5].

2. Materials and methods
When determining the operation of the crusher with the lowest energy costs, performance indicators are used and the specific work for grinding grain is determined by the following formulas:

- Performance, kg/h

$$Q = \frac{G_g}{t} 3600, \text{kg/h} \tag{1}$$

- Here: G_g is the mass of crushed grain, kg;

t - time, seconds.

2. Specific work, W·h / kg

$$A_{ud} = \frac{N_p}{Q}, \text{ W·h / kg} \tag{2}$$

- Here: N_p - power consumption for grain grinding.

The tests were carried out in accordance with the developed methodology with the necessary instruments and equipment. During the test, the measurements were carried out at different values of the gap of the working chamber and the speed of the rotor. Based on the results of experimental data, the values of productivity and specific work of the impact crusher were determined. On the basis of experimental data, theoretical models of the dependences of productivity Q_m and work A_m on the gap into the working chambers δ were obtained in five speed modes. Here, the error estimates in percent took the modulus of its magnitude. The analysis of theoretical models $Q_m(\delta)$ shows that at δ=0 there should be Q_m=0. But, for example, at δ=0 Q_{1m}=-4.7628, that is, it is in the negative region (which is impossible from a physical point of view), and Q_m=0 at δ=0.2295 mm (the second root - 2.6325 is not applicable). For Q_{2m}, both roots lie in the negative region (δ_1=-2.22; δ_2=-0.13). In figure 1 dependences on the value of the working gap δ are shown. The solid lines represent the equation of the models for different speed modes of the rotor. The experimental data are plotted as dots. It can be seen from the figure that the productivity in all modes increases in the direction of increasing δ, and the rate of its growth also increases with increasing δ. The largest relative displacement of the experimental points relative to the theoretical curves is in the section at δ=3 mm. In percentage terms, they are insignificant and their numerical values are indicated above [6, 7, 8, 9, 10].

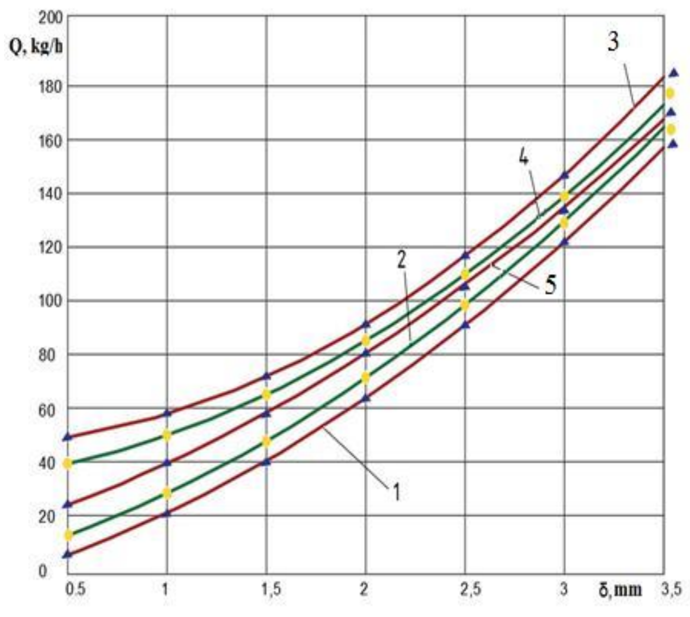

Figure 1. Dependence of productivity (Q) of the working chamber on the gap (δ) for corn at different speeds 1-750 min^{-1}; 2-1000 min^{-1}; 3-1500 min^{-1}; 4-2000 min^{-1}; 5-2500 min^{-1}.

In figure 2 the dependences of the specific crushing work on the working clearances δ are shown for various speed modes. The positions of the experimental points relative to the theoretical curves emphasize the fairly high accuracy of their convergence. Theoretical models are more consistent with the physical process, since as δ→0, A_m→∞ due to Q tending to zero. In this case, all the energy is spent on the destruction of the material, heating the material and working bodies. With an increase in δ, the specific work at the moment of stopping the destruction of the grains turns into work on moving the whole grain in the working chamber from the moment of entry to the moment of exit.

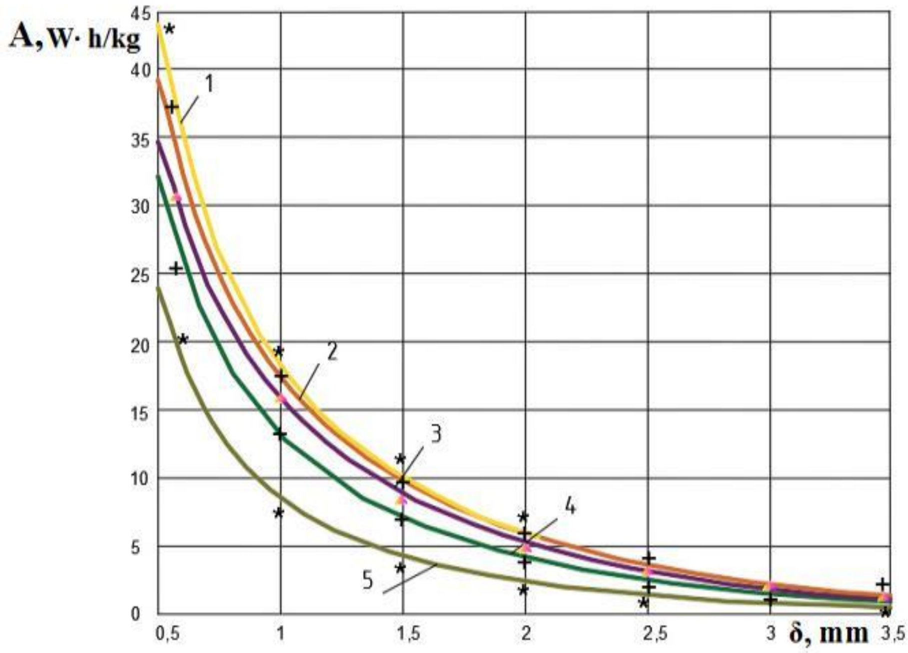

Figure 2. Dependence of specific work (A) on the clearance of the working chamber (δ) for corn at different speeds 1-750 min^{-1}; 2-1000 min^{-1}; 3-1500 min^{-1}; 4-2000 min^{-1}; 5-2500 min^{-1}.

Experimental data are marked with dots [11, 12].

3. Results and discussion

We have obtained three-dimensional models of the specific work $A_m(\delta, Q)$ for the entire range of speed modes:

- at n_1=750 min^{-1} A_{1m}= 41.67-31.4 δ+7.64 δ^2+3.19 δ^{-2}+0.035 Q-0.05 δ Q,
- max error 0.3836 or 3.5% (A_1=10.86);
- at n_2=1000 min^{-1} A_{2m}= 56.9-84.39δ+19.04 δ^2+1.1 δ^{-2}+1.26 Q-0.35 δ Q,
- max error 0.0126 or 0.2% (A_2=5.48);
- at n_3=1500 min^{-1} A_{3m}= 32.63-56.29 δ+14.01 δ^2+1.96 δ^{-2}+0.85 Q-0.25 δ Q,
- max error 0.3044 or 6.5% (A_3=4.65);
- at n_4=2000 min^{-1} A_{4m}= 21.62-26.85 δ+6.17 δ^2+2.72 δ^{-2}+0.32 Q-0.09 δ Q,
- max error 0.3513 or 9.5% (A_4=3.65);
- at n_5=2500 min^{-1} A_{5m}= 7.43-15.37 δ+4.45 δ^2+3.57 δ^{-2}+0.23 Q-0.08 δ Q,
- max error 0.01940 or 5.3% (A_5=0.36);

The resulting models describing the dependences Q(δ), A(δ) and A(δ, Q) have high adequacy within the limits of the experiment and can be recommended for engineering calculation of this type of crusher working chambers. Thus, in order to obtain high-quality crushed products with the lowest energy costs and corresponding to zootechnical requirements, it is necessary to have a gap in the working chamber within 1.5 ... 2.5 mm. At the same time, the productivity will have an optimal value, and the amount of grinding will be practically absent, which indicates that the quality of the crushed products will meet zootechnical requirements [13, 14].

4. Conclusions

It is necessary to have equipment and technical means for the preparation of feed, with the lowest energy costs, productively and the quality of the crushed products must meet zootechnical requirements. In the production of feed for agriculture, an important role is played by the use of equipment productively, with the lowest energy costs and quality indicators that meet the requirements. To determine the indicators of energy costs, it is necessary to use the productivity and specific work for grinding grain. The performance of the crusher increases with the increase in the rotor speed and the gap in the working chamber. The specific work for grinding grain decreases with an increase in the rotational speed and the gap in the working chamber. To ensure favorable operation of the impact crusher, it is necessary to have a gap in the working chamber within 1.5 ... 2.5 mm.

References

[1] Borotov A 2021 *IOP Conference Series: Earth and Environmental Science* **868** 012035
[2] Zhang M, Sword M L and Buckmaster D R 2003 *Transactions of the ASAE* **46(6)** 1503-11
[3] Ball M A, Shaver R D, Jirovec A G, Shinners K J and Coors J G 2000 *Article in Journal of Dairy Science* **6(83)** 1264-73
[4] Momin M A, Wempe P A, Grift T E and Hansen A C 2017 *Transactions of the ASABE* **5(60)** 1551-60
[5] Li A, Sultanov B, Sharipov Z and Umirov N 2021 *AEGIS 2021* **868** 012008
[6] Sivachenko L A and Derman E I 2020 *IOP Conf. Series: Materials Science and Engineering* **883** 012117 doi:10.1088/1757-899X/883/1/012117 10
[7] Shaymardanov B, Borotov A and Jumatov Y 2020 *IOP Conference Series: Materials Science and Engineering* **883** 1-9
[8] Nanka O V 2014 Methods of mechanical influence when grinding fodder grain and their energy evaluation *Agrotechnics and energy supply* **1(1)** 204-9
[9] Sattarov N, Borotov A, Ashurov N, Sattarov M, Yunusov R and Abduganiev A 2020 *IOP Conference Series: Earth and Environmental Science* **548** 1-5
[10] Yalpachyk E Budenko S 2013 Balance of power and energy efficiency grain crusher *Praci Tavria State Agrotechnological University* **13(1)** 218-26
[11] Alijanov D, Abdurokhmonov Sh, Jumatov Yo and Bozorboyev A 2020 Reducing the energy capacity of the cutting of stem fodder *IOP Conf. Series: Materials Science and Engineering* **883** 012155 doi:10.1088/1757-899X/883/1/012117
[12] Alijanov D, Abdurokhmonov Sh and Ismaylov Kh 2020 Forces affecting the grain movement in the working chamber of the rotary crusher *ICECAE 2020 IOP Conf. Series: Earth and Environmental Science* **614** 012110 doi:10.1088/1755-1315/614/1/012110
[13] Borotov A 2020 *IOP Conference Series: Materials Science and Engineering* **883** 012160