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Evaluation of the Efficiency of the Impact Crusher in Order to Improve the Quality of Products for Agriculture

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Abstract. The article presents the parameters used to evaluate the efficiency of the crusher, productivity and specific work for grinding grain. Methodology for conducting experimental studies. The dependence of the performance of the crusher's working chamber on the gap for wheat at various speeds is given, and the dependence of the specific work on grinding wheat grain on the size of the gap of the working chamber at various speeds is given. The optimal value of the gap is given, at which a quality product for agriculture is obtained.

INTRODUCTION

The work aimed at creating new types of resource-saving technologies and technical means of preparing feed by grinding grain raw materials in agricultural production is relevant. The most responsible and time-consuming technological operation in agricultural production is the grinding of feed grain, which is carried out mainly by hammer mills with high energy and metal consumption, and the quality of the crushed product does not always meet zootechnical requirements. Therefore, the creation of a feed grain grinder, which makes it possible to obtain a finished zootechnical product of the required quality while reducing the specific energy consumption and metal consumption, is the most important task. In our Republic and abroad, many scientists have been involved in grain crushing processes for agriculture, but the study of the working processes of an impact crusher, depending on energy costs and product quality, has not been studied enough. In the production of feed and improving their quality, an important role is played by the availability of the necessary equipment for the preparation of feed, it is also important that the technical means in agriculture are used productively, efficiently, and the quality of grinding must meet zootechnical requirements [1-3].

PUTTING THE ISSUE

When evaluating the efficiency of the crusher, the productivity and specific work for grinding grain are used and are determined by the following formulas:

1. 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:

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

Here: N_p - power consumption for grain grinding.

SOLUTION METHOD

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 with a change in the value of the rotor speed. Based on the data obtained, the values of productivity and specific work for grinding grain were determined. The obtained experiments were carried out on soft varieties of wheat and the results are presented in Figure 1. It can be seen from the graph that with an increase in the gap δ and the rotor speed, the productivity increases[4-8].

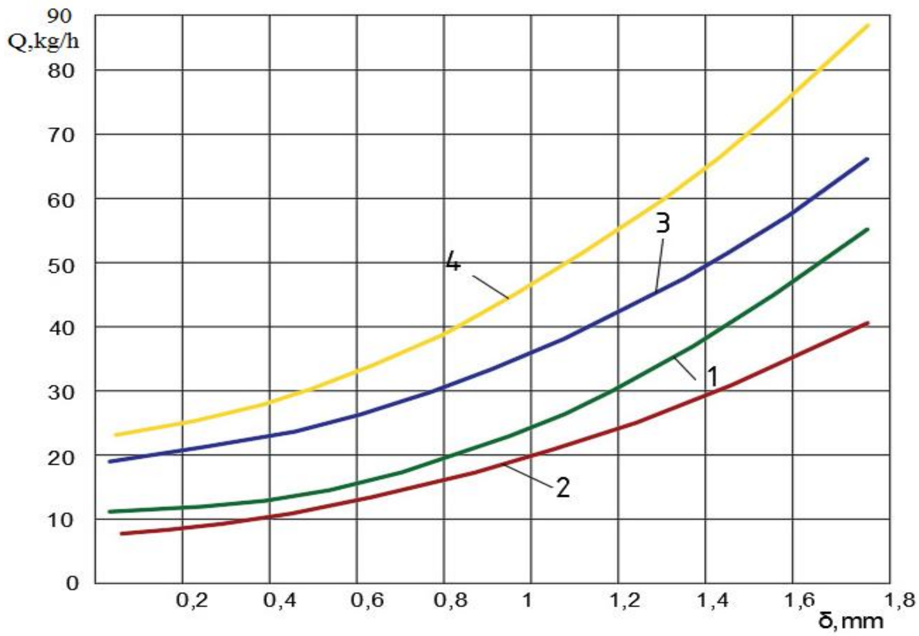

FIGURE 1. Dependence of productivity Q of the working chamber on the gap δ for wheat at different speeds: 1-750 min^{-1}; 2-1000 min^{-1}; 3-1500 min^{-1}; 4-2000 min^{-1}.

The exclusion of representations is the cases of work on small gaps at δ=0.25 mm. At the same time, the minimum performance was obtained in all modes. Observations of the operation of the machine at small gaps (<0.25 mm) showed that in this case, destruction and abrasion become predominant. As a result, heating of the rotor and stator disks occurs, moisture is released from the product (which is especially protection at high grain moisture content) and, as a result, the output flow is compressed and productivity decreases [9-15].

RESULTS AND SAMPLES

The nature of the distribution of experimental performance series (Q) and specific work (A) will make it possible to assume the use of models $Q_m=f(\delta)$ and $A_m=f(\delta)$ in the form of equations:

$$Q_m=a_0+a_1\cdot\delta+a_2\cdot\delta^2 \tag{3}$$

$$A_m=в_0+в_1\cdot\delta+в_2\cdot\delta^2 \tag{4}$$

Below is an example of determining the coefficients of the model $Q_m=f(\delta)$ by the least squares method on PC in the MatLAB system in the direct calculation mode:

x=[0.25 0.5 1 1.5 2]; - $x=\delta$

y_1=[8.02 9.37 15.7 28.1 42.91]; -$y_1= Q_1$(for n=750 min^{-1})
y_2=[11.3 12.65 20 35.14 59]; - $y_2= Q_2$(for n=1000 min^{-1})
y_3=[19.37 21.29 32.7 45.5 70]; - $y_3= Q_3$(for n=1500 min^{-1})
y_4=[23.1 26.6 40.6 60.5 91.9]; - $y_4= Q_4$(for n=2000 min^{-1})

r=[1 1 1 1 1]; k=(x.^2): s=(r; x; k);

pa = s`/y1`- calculation of model coefficients:
pa = 7.2857 - a_0
-0.1035 - a_1
9.0201 - a_3

y_{1m}=7.2857-0.1035·x+9.0201·(x.^2) - Q_m - Q_m – error vector.
ans=0.1964 -0.1190 -0.5023 0.6743 -0.2491 – max{Q_1-Q_{1m}}=0.6743

pa= s`/$y_2$`
pa= 12.7049
-8.6644
15.8749

y_{2m}=12.7049-8.6644·x+15.8749·(x.^2)
y_{2m}= 12.7049 123414 19.9154 58.8757
y_2-y_{2m}
ans= -0.2310 0.3086 0.0846 -0.2868 0.1243 max error 0.3086

pa= s`/$y_3$`
pa=18.7457
-0.5185
12.9393

y_{3m}=18.7457-0.5185·x+12.9393·(x.^2)
y_{3m}=19.4248 21.7213 31.1665 47.0814 69.4659
y_3-y_{3m}
ans=-0.0548 -0.4313 1.5335 -1.5814 0.5341 max error 1.5814

pa= s`/$y_4$`
pa= 21.9833
0.8335
16.9795

y_{4m}=21.9833+0.8335·x+16.9795(x.^2)
y_{4m}= 0.2107 0.4194 0.8374 1.2563 1.6760
y_4-y_{4m}
ans= -0.2084 -0.4167 -0.8333 -1.2502 -1.6668 max error 1.6668

Figure 1 shows the nature of the dependence $Q_m=f(\delta)$ with plotting points of experimental values of Q for different speed modes. The deviation of the curves from the points on the corresponding sections, as well as the numerical values of the error vectors (no more than 5% on the sections for maximum errors) show good convergence of theoretical models with experiment [16-23]. The productivity growth rates are linear:

- Q_{1m}= -0.1030+18.04·δ;
- Q_{2m}= -8.6644+31.75·δ;
- Q_{3m}= -0.5185+25.88·δ;
- Q_{4m}= -0.8335+33.96·δ.

It can be seen from these equations that the most rapid change in productivity is at n=2000 min^{-1}, which is explained by a significant increase in centrifugal forces that contribute to faster movement of particles in the rotor slots. Similarly, the coefficients for the model of specific grinding work (4) were found. However, the obtained errors ($A-A_m$) in all modes turned out to be large, in some cases they reached 10-15% (on sections A). To increase the flexibility of the model, i.e. decrease in the numerical values of the elements of the error vector in each mode, increased the degree of the equation:

$$A_m=B_0+B_1\cdot\delta+B_2\cdot\delta^2+B_3\cdot\delta^3 \quad (5)$$

As a result, the following system of equations is obtained in order of increasing rotational speed:

- $A_{1m}=21.43 - 21.23\cdot\delta + 21.58\cdot\delta^2 - 5.15\cdot\delta^3$ – at $\max\{A_1-A_{1m}\}=0.46$ (8.2%);
- $A_{2m}=17.72 - 28.45\cdot\delta + \cdot19.69\delta^2 - 4.78\cdot\delta^3$ – at $\max\{A_1-A_{2m}\}=0.52$ (5.6%);
- $A_{3m}=17.7528 - 24.9969\cdot\delta +15.4096\cdot\delta^2 - 3.3590\cdot\delta^3$ – at $\max\{A_3-A_{3m}\}=0.69$ (8.3%);
- $A_{4m}=12.51- 23.05\cdot\delta + 15.96\cdot\delta^2 - 4.07\cdot\delta^3$ – at $\max\{A_4-A_{4m}\}=0.16$ (3%)

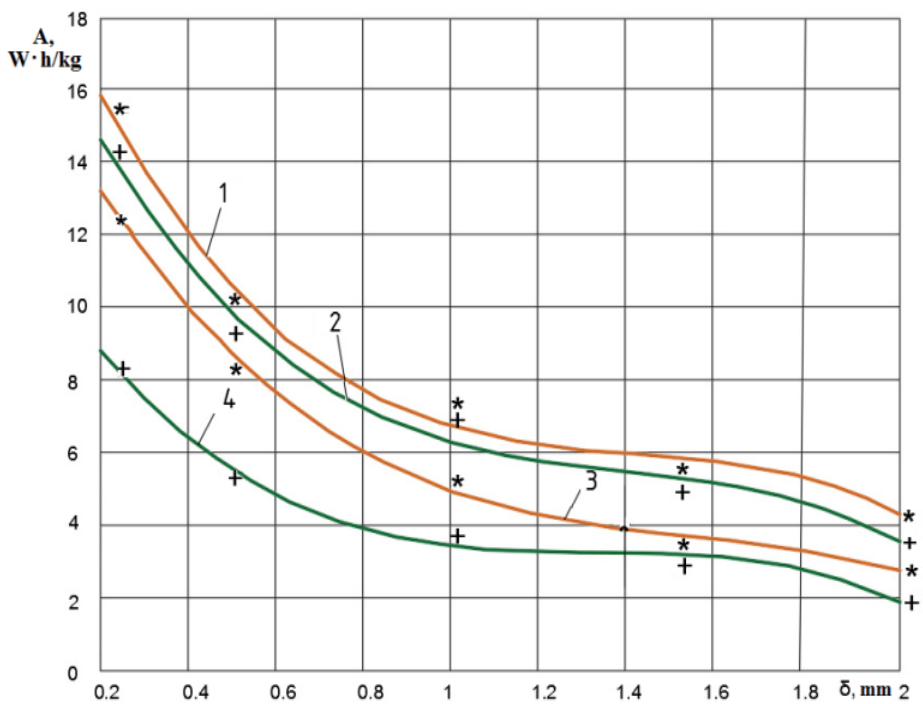

FIGURE 2. Dependence of specific work A on grinding wheat grain on the size of the gap of the working chamber δ at different speed modes: 1-750 min^{-1}; 2-1000 min^{-1}; 3-1500 min^{-1}; 4-2000 min^{-1}.

Figure 2. shows the nature of the dependence $A_m=f(\delta)$ with plotting the experimental values of A in the form of dots, clearly representing the difference between theoretical and experimental values. Further improvement of the model by increasing the degree of Eq. (5), as shown by the calculations, leads to a very slow decrease in the maximum errors. The value of the maximum error does not exceed 9% on specific sections A and the hypothesis H_0 about the correspondence of models to experimental distributions with significance levels $\alpha=0.05$ is confirmed, then the obtained results can be considered quite satisfactory. he nature of the curves in Figure 2 is almost the same, the coefficient b_0 = -1.784 x + 21.43 - changes linearly decreasing with increasing x (here x is the interval between

rotation frequencies: 250 min^{-1} -1; 500 min^{-1} -2; 750 min^{-1}-3) the b_0 ratio decreases. For the remaining coefficients, the patterns of their changes depending on the rotor speed cannot be obtained. This is due to the complexity of the curves, the first derivatives of which are non-linear. The rapid decrease in A_m in the interval δ=0.25-0.8 mm is explained by the reduction in energy losses due to abrasion and heating of the product at the exit from the working chamber. 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 of 1.5 mm. At the same time, the productivity will have a maximum value, and the amount of grinding will be practically absent, which indicates that the quality of the crushed products will meet zootechnical requirements.

CONCLUSION

In the production of feed for agriculture an important role is played by the use of machinery productively and efficiently with good quality indicators that meet the requirements. To evaluate the work of the working chamber of a rotary crusher, the productivity and specific work for grinding grain are used. The productivity of the crusher in the working chamber significantly depends on the size of the gap of the working chamber and the number of revolutions of the rotor. A particularly rapid increase in performance occurs at high speeds.

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