

PAPER • OPEN ACCESS

Methods of regulating the work of units at irrigation pumping stations

To cite this article: D Alijanov *et al* 2020 *IOP Conf. Ser.: Mater. Sci. Eng.* **883** 012117

View the [article online](#) for updates and enhancements.

Methods of regulating the work of units at irrigation pumping stations

D Alijanov^{1*}, Sh Abdurokhmonov¹ and N Umirov¹

¹Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Tashkent, Uzbekistan

abduroxmonov.shavkatjon@bk.ru

Abstract. The article shows that the process of grain crushing is not sufficiently studied. A practical way to control the quality of grain grinding. The crushing process was studied by various scientists, but they did not consider the module for the quality of grain grinding in a rotary crusher. The article is devoted to assessing the quality of grain grinding by compiling a module. For a qualitative analysis of the grinding of the experimental crusher, the experimental plan was adopted for various values of the working chamber clearance and rotor rotation frequencies. The experimental results were examined in wheat at 750 rpm and a working chamber gap of 1.5 mm. The results obtained allow us to determine the average size of the grinding particles. For the analytical description of processes according to experimental data, various standard distribution functions of a random variable were used. To determine the appropriate case of the form of the distribution of the discrete function for various gaps. The technique of determining the coefficients of models in the form of linear equations by the least squares method is considered. The technique can also be used to find the coefficients of nonlinear functions. The distribution density of random variables is determined which allows to determine the probability of a random variable falling into the range of values. The degree of correspondence between empirical and theoretical distributions was estimated based on a hypothesis at a significance level. The grinding quality of the experimental machine, with serial hammer crushers shows the average grinding value, the particle density distribution of hammer machines is much lower.

1. Introduction

An analysis of world and domestic experience in livestock breeding shows that only in conditions of a high level of supply of farms with complete feeds and modern machines, the genetic potential of animals and birds can be realized. Without the use of resource-saving machine technologies, highly efficient sets of machines and production lines, it is impossible to solve the vital market problems of modern animal husbandry [1-12].

Recent studies indicate the possibility of a significant increase in the efficiency of feeding concentrated feed by fractionating it during grinding for each animal species. Grinding grain negatively affects the productivity of animals and their health, up to an increase in mortality, significantly worsens working conditions throughout the entire process from preparation to distribution of feed, and also increases the energy intensity of the process [13-17].

One of the promising areas in the field of grain grinding in recent years is the development of centrifugal rotor disk choppers, which are currently widely used.



Zootechnical science recommends crushed feed with particles of a certain size for each type of animal and bird. The size of the entire mass of bulk material as a statistical population is estimated by the content in it of classes or fractions of certain sizes, i.e., by granulometric composition.

The object of research is the process of influencing the operating parameters of a rotary crusher with grains.

An analysis of the works shows that the crushing process was studied by various scientists, but they did not consider the model of the quality of grain grinding in a rotary crusher [18-21].

The aim of the article is to compile a model for assessing the quality of grinding grain.

Putting the issue

Introduction The object of research is the technological process of the influence of the operating parameters of a rotary crusher with grains.

An analysis of world and domestic experience in animal husbandry shows that only in conditions of a high level of supply of full-fledged feeds to farms.

An analysis of the works shows that the crushing process was studied by various scientists, but they did not consider the model of the quality of grain grinding in a rotary crusher.

The aim of the article is to compile a model for assessing the quality of grinding grain.

In practice, sieve analysis is performed using sieve analysis with standard sieve sets. At the same time, the grinding module (average value of grain particle sizes after destruction):

$$M = \frac{\sum x_i \cdot m_i}{\sum m_i} = \sum x_i \cdot p_i$$

Where m_i is the mass of product on i ohm sieve;

$\sum m_i$ is grinding mass total for one sieving;

$P_i = \frac{m_i}{\sum m_i}$ is the relative part of the grinding on the i -th sieve (frequency);

$x_i = \frac{d_i + d_{i+1}}{2}$ is the average value of sieves with diameters of a random particle size between two adjacent holes d_i and d_{i+1} ; it is assumed that the accepted random values x_i correspond to the normal distribution.

Since the results of experiments on x_i and p_i are discrete, the dispersion of the distribution is also determined by the formula [4, 5, 6, 7, 8, 9]

$$D = \sum (x_i - M)^2 \cdot p_i$$

2. Solution method

To analyze the qualitative characteristics of grinding the experimental crusher, we adopted the experimental plan for various gaps of the working chamber and rotational speeds n of the rotor. For the specified clearance, grinding was performed at least 5 times, and the reliability of the p_i results was checked according to criterion 3σ . The processing of the experimental results will be examined using the example of grinding in wheat at a rotor frequency of 750 min^{-1} and a working chamber gap of $\delta=1,5 \text{ mm}$ Table 1. shows the average data of five repeated grindings of the same weights (1 kg each). For the sieve analysis, we took the grinding mass obtained during the stationary operation of the crusher (i.e., the mass obtained during the transitional regime was excluded).

Table 1. Size distribution of grinding particles at $n = 750 \text{ min}^{-1}$ and $\delta = 1.5 \text{ mm}$

Particle size x_i , mm	1.1	1.35	1.75	2.25	2.75
Frequencies, p	0.04	0.06	0.1	0.3	0.5
Sum of accumulated frequencies $F = \sum p_\xi$	0.04	0.1	0.2	0.5	1.0

Given in Table 1, numerical data of a discrete (experimental) distribution make it possible to determine the average value of grinding particles [10, 11, 12, 13, 14]

$$\bar{x} = \sum_1^5 x_i \cdot p_i = 2.35mm$$

and variance

$$D = \sum_i (x_i - \bar{x})^2 \cdot p_i = 0.2415$$

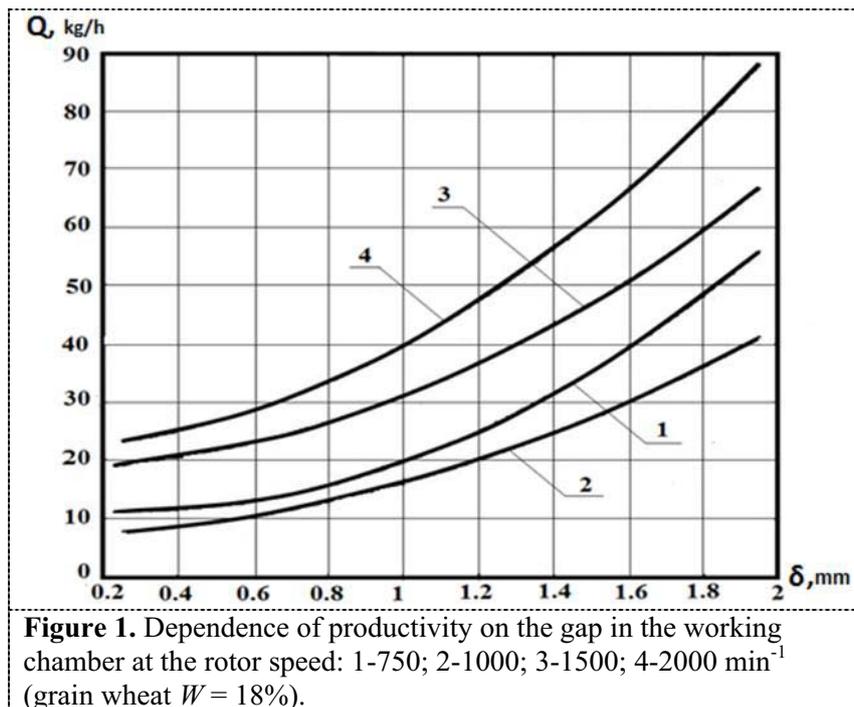
From the table. 1 it also follows that p_i show the probability of equality of a random variable x to a specific value x_i , i.e.

$$P_{\xi} = P(X = x_i)$$

respectively for the accumulated frequencies

$$\sum P_{\xi} = P(X \leq x_i)$$

For the analytical description of processes according to experimental data, various types of standard distribution functions of a random variable are used (normal distribution, gamma distribution, exponential distribution, etc.). To determine the type of distribution suitable for our case, we consider a discrete function $P_i = f(x_i)$ on the graph (Fig. 1), constructed for various gaps.



Obviously, the most appropriate is the exponential distribution of the form

$$p_m = A \cdot x^a \cdot e^{bx} \text{ or}$$

here the index m - means the equation of the model, and A , a , b are the coefficients that must be determined on the basis of experimental data.

The methodology for determining the coefficients of models in the form of linear equations by the least squares method is considered. This technique can also be used to find the coefficients of nonlinear functions. To do this, they must be replaced by variables to expressions linear with respect to unknown coefficients. In the table. Figure 2 shows the transformations of some linear functions that

may be useful when performing practical transformations. So, having $z = \ln(P)$; $a_0 = \ln A$, $a_1 = b$, accepted we get the equation $z = a_0 + a_1x$ (this is for the equation $P_m = A \cdot e^{bx}$). The calculation of the model coefficients was performed in the MatLAB system in the direct calculation mode:

```
matrix s=[1 1 1 1 1; 1.1 1.35 1.75 2.25 2.75];
vector z=ln(p);
odds pa=s\z=[a0=-4.9659, a1=1.5867];
coefficient A=exp(-4.9659)=0.007; Since a1 = b, we obtain the frequency model
```

$$P_m = 0,007 \cdot e^{1,5867 \cdot x}$$

The calculation of P_m at x_i gives the vector $P_m = [0.0401 \ 0.00596 \ 0.1125 \ 0.2486 \ 0.5497]$, error vector $P - P_m = [-0.0001 \ 0.0004 \ -0.0125 \ 0.0514 \ -0.0497]$, t.s. the maximum error is 0.0514.

Similarly, we obtain the coefficients of the model of the function of the accumulated frequencies:

$z = \ln(F)$, here is the vector $F = [0.04 \ 0.1 \ 0.2 \ 0.5 \ 1.0]$;

```
matrix s=[1 1 1 1 1; 1.1 1.35 1.75 2.25 2.75];
```

from here

```
odds A=exp(-5.026)=0.0066;
```

$$F_m = 0.0066 \cdot e^{1.8811 \cdot x};$$

F_m at the points x_i gives the vector

$$F_m = [0.0523 \ 0.0836 \ 0.1775 \ 0.4547 \ 1.0646];$$

error vector $F - F_m = [-0.0123 \ 0.0164 \ 0.0225 \ 0.0453 \ -0.0646]$ with a maximum error value of 0.0646.

It is known that the distribution density of a random variable

$$\phi_m = F'_m$$

$$\phi_m = \frac{dF_m}{dx} = 0.0124 \cdot e^{1.8811 \cdot x}$$

The density distribution allows you to determine the probability of a random variable X falling into the range of values $x_1 - x_2$.

$$P(x_1 \leq X < x_2) = \int_{x_1}^{x_2} \phi_m dx$$

If you take $x_1 = 1.1$; $x_2 = 2.75$, then the probability should be equal to one. To check the accuracy of the model, we calculate using the quad file

$(\phi_m, 1.1, 2.75)$ integral $F_m = \int_{1.1}^{2.75} 0.012 \cdot \exp(1.8811 \cdot x) dx = 1.0123$, which is close enough to unity. Accordingly, we obtain the mathematical expectation of a random variable

$$X_m = \int_{1.1}^{2.75} x \cdot \phi_m \cdot dx = 2.5537 MM$$

and variance 2.75

$$D_m = \int_{1.1}^{2.75} (x - x_m)^2 \cdot \phi_m \cdot dx = 0.2393$$

The degree of correspondence between empirical and theoretical distributions was estimated based on the H_0 hypothesis with a significance level of $\alpha = 0.05$

3. Results and Samples

Table. 3 shows the results of processing the experimental data, and Fig. 2 shows the dependencies in the form of continuous curves $P_m(x)$ and points of the discrete series $P(x)$. The nature of the curves in Fig. 3 shows a high distribution density for cases 1, 2, 5, 6. So for curves 1,2, all particles (at $P = 1$)

are at a length of 0.98 mm with dispersions $D_1 = 0.082 \dots 0.094$; $D_2 = 0.0408 \dots 0.0339$. For cases of 5.6, the particle weight is on a length of 1 mm with the corresponding dispersions $D_3 = 0.1337 \dots 0.11$; $D_6 = 0.0688 \dots 0.0719$, which indicates a high mass uniformity of grinding. So at $\delta = 0.25$, $\bar{x} = 0.9 \pm 0.2$ about 70% of the crushed mass falls into the range and the possible amount of dust fraction $x < 0.1$ is not more than 3%. The presence of a dust fraction is possible only $\delta = 0.25$; 0.5; 1 mm with large gaps of the dust fraction is not. With an average grinding (with $\delta = 1, 1.5$ mm), a large variation in particle sizes is observed. In particular, at $\delta = 1$ mm, an insignificant amount of dust fraction (not more than 2%) may be present and the dispersion $D_3 = 0.5209 \dots 0.5067$ is the largest in the considered example, and the amount of crushed particles in the range $\bar{x} = 2.05 \pm 0.7$ is about 70%. The difference in the values \bar{x} and δ are explained by the features of the process in the working chamber at the moment of grinding particles from the chamber. At $\delta = 1.75 \dots 2.25$ mm, the average particle sizes are hardly distinguishable, although the distribution density at $\delta = 2.25$ is much higher. This is explained by an increase in the yield of non-crushed particles having a thickness of less than δ . An analysis of similar results for wheat at $n = 1000, 1500, 2250 \text{ min}^{-1}$ shows that there are no significant differences in the quality of grinding for the same gaps δ . It is also impossible to find stable relationships between the model coefficients between themselves or with the distribution parameters x_m, D_m . Comparison of the grinding quality of the experimental machine with serial hammer crushers shows that with the same average grinding values, the distribution density of particles in hammer machines is much lower (1.5 ... 2 times). Also, with any grinding modules, the hammer mill will produce flour fractions, and with fine grinding, the amount of flour fraction can exceed 10%, which violates the zootechnical requirements for the quality of grinding of feed grain.

Table 2. Transformation of some nonlinear functions for determining the coefficients by the least squares method according to experimental data.

Original nonlinear function	What kind of form	Variable Replacement
$Y = A \cdot e^{ax}$	$z = a_0 + a_1x$	$z = \ln Y,$ $a = a_1,$ $a_0 = \ln A$
$Y = B \cdot x^a$	$z = a_0 + a_1u$	$z = \ln Y,$ $u = \ln x,$ $a_0 + \ln a,$ $a_1 = a$
$Y = A \cdot x^a \cdot e^{ax}$	$z = a_0 + a_1 \ln x + a_2x$	$z = \ln Y, a_0 = \ln A,$ $a_2 = a$
$Y = A \cdot x^a \cdot e^{ax^2}$	$z = a_0 + a_1 \ln x + a_2x^2$	$z = \ln Y, a_0 = \ln A,$ $a_1 = a, a_2 = a$
$Y = A \cdot e^{\frac{(x-a)^2}{2\sigma^2}}$	$z = a_0 + a_1x + a_2x^2$	$z = \ln Y, a_1 = \frac{a}{\sigma^2}, a_2 = \frac{1}{2\sigma^2}$
$Y = A \cdot a^x \cdot e^{bx^2}$	$z = a_0 + a_1x + a_2x^2$	$z = \ln Y, a_0 = \ln A, a_1 = \ln a,$ $a_2 = b$

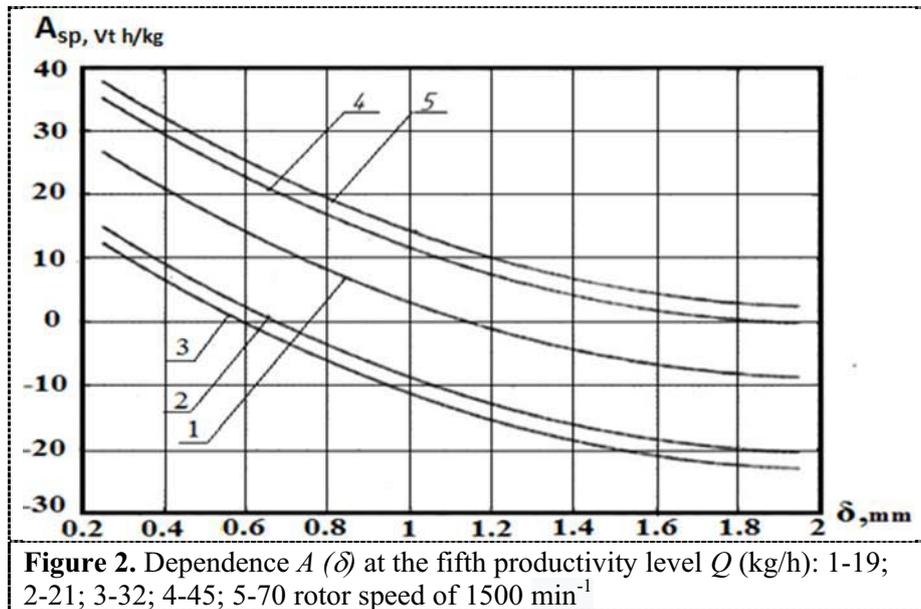
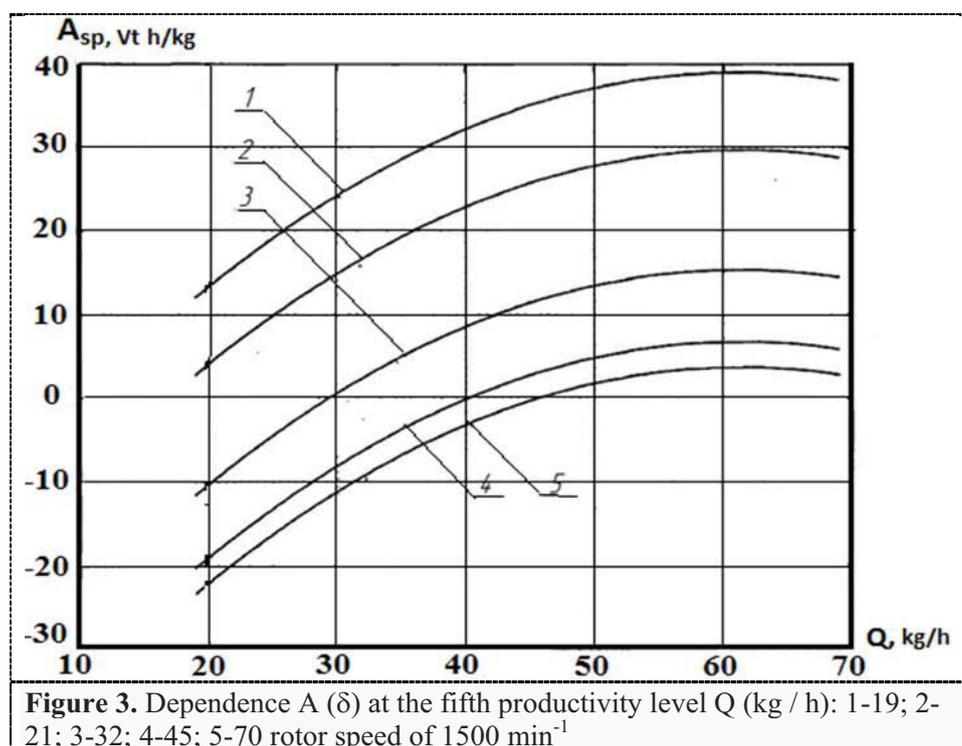


Table 3. Experimental and theoretical distribution of a random value x of particle size after grinding wheat at $n = 750 \text{ min}^{-1}$

The clearance in the working chamber	Experiment Results	Arithmetic mean \bar{x}	Dispersion D	Theoretical models	Mathematical expectation x_m	Dispersion D	Error value
$\delta = 0.25 \text{ mm}$	Particle size $x = [0.12 \ 0.325 \ 0.75 \ 1.1]$;			$P_m = 0.0387 \cdot \exp(2.4653 \cdot x)$;			$\max\{P - P_m\} = 0.064$;
	Frequencies $P = [0.05 \ 0.1 \ 0.2 \ 0.65]$;			$F_m = 0.0439 \cdot \exp(2.8591 \cdot x)$;	0.8501	0.082	$\max\{F - F_m\} = 0.065$;
	Distribution function $F = \sum P_i = [0.05 \ 0.15 \ 0.35 \ 1]$;	0.9035	0.094	Density distribution $\phi_m = F_m' = 0.1255 \cdot \exp(2.8591 \cdot x)$;			$(\bar{x} - x_m) = 0.0534$;
							$(D - D_m) = 0.012$
$\delta = 0.5 \text{ mm}$	Particle size $x = [0.12 \ 0.325 \ 0.75 \ 1.1]$;			$P_m = 0.0052 \cdot \exp(4.5572 \cdot x)$;			$\max\{P - P_m\} = 0.038$;
	Frequencies $P = [0.01 \ 0.02 \ 0.15 \ 0.82]$;	1.022	0.0339	$F_m = 0.0061 \cdot \exp(4.6192 \cdot x)$;	0.9801	0.0408	$\max\{F - F_m\} = 0.018$;
	Distribution function $F = \sum P_i = [0.01 \ 0.03 \ 0.18 \ 1]$;			Density distribution $\phi_m = F_m' = 0.0282 \cdot \exp(4.6192 \cdot x)$;			$(\bar{x} - x_m) = 0.042$;
							$(D - D_m) = -0.007$
$\delta = 1 \text{ mm}$	Particle size $x = [0.12 \ 0.325 \ 0.75 \ 1.1 \ 1.35 \ 1.75 \ 2.25 \ 2.75]$;			$P_m = 0.0138 \cdot \exp(1.2877 \cdot x)$;			$\max\{P - P_m\} = 0.086$;
	Frequencies $P = [0.01 \ 0.02 \ 0.05 \ 0.6 \ 0.12 \ 0.15 \ 0.2 \ 0.39]$;	2.05	0.5067	$F_m = 0.074 \cdot x^{0.9856} \cdot \exp(0.5999 \cdot x)$;	2.1081	0.5209	$\max\{F - F_m\} = -0.044$;
	Distribution function $F = \sum P_i = [0.01 \ 0.03 \ 0.08 \ 0.14 \ 0.26 \ 0.41 \ 0.61 \ 1]$;			Density distribution $\phi_m = F_m' = 0.0444 \cdot x^{-0.0144} \cdot \exp(0.5949 \cdot x)$;			$(\bar{x} - x_m) = -0.058$;
							$(D - D_m) = -0.0142$



4. Conclusions

1. The process of destruction of indicators by grain materials and the resulting model of positive intervals of $Q(\delta)$ and (Q, δ) values and non-positive intervals of Q and δ values.
2. The method of determining the coefficients of models in the form of linear equations by the least squares method can also be used to find the coefficients of nonlinear functions.
3. The grinding quality of the experimental machine, with serial hammer crushers shows the average grinding value, the particle density distribution of hammer machines is much lower.

References

- [1] Alijanov D Abdurokhmonov Sh Makhatov Sh 2018 Simulation of grain movement in the working chamber "European science review" *Journal* № 5–6 May–June (Vienna) pp 251-257
- [2] Alijanov D Abdurokhmonov Sh Amonov M 2016 Theoretical models of the mass of parts of rose hips based on experimental studies *Journal "European Applied Sciences"* № 11 (Germany) pp 21-25
- [3] Alijanov D Abdurokhmonov Sh 2019 About the Destruction of Grain in the Working Chamber of the Crusher *International Journal of Innovative Technology and Exploring Engineering (IJITEE)* ISSN: 2278-3075 Volume-9 Issue-1S November pp 436-438
- [4] Gurinenko L A Ivanov V V 2012 Semenikhin A M Geometric parameters of the work area of the disc pair of a stead grinder *Bulletin of Agricultural Science of the Don* No 4 (20) pp 10-16
- [5] Birkov S V Pilyugin K A Sabiev U K 2017 Grinders corn grain New science: *Theoretical and practical view* Vol 1 No 4. pp 10-13
- [6] Sabiev U K Sadbekov D Zh Roleder A I Akhmetov S G 2020 Advantages and disadvantages of some domestic grain crushers. In the collection The role of students' research work in the development of the agro-industrial complex *Collection of the All-Russian (national) scientific-practical conference* pp 249-255
- [7] Sivachenko L A Derman E I 2016 Universal grinder with multi-blade working bodies. In the collection: *Scientific technologies and innovations electronic collection of scientific reports of the International scientific and practical conference* pp 190-194

- [8] Lopatin L A 2018 Comparative studies of the process of grinding grain with hammer and disk working bodies. In the collection: *Resource-saving technologies in the storage and processing of agricultural products materials of the XIV International Scientific and Practical Seminar* pp 177-181
- [9] Nanka O V 2014 Methods of mechanical influence when grinding fodder grain and their energy evaluation *Agrotechnics and energy supply* No 1 (1) pp 204-209
- [10] Kazakov V A 2013 Cereal movement in the work area of the two-stage grain drainer *Bulletin of the NIIEI* No 12 (31) pp 36-42
- [11] Savinykh P A Isupov A Yu Ivanov I I 2019 Results of the centrifugal-rotor grain grinder research. *Bulletin of the NIIEI* No 8 (99) pp 18-33
- [12] Bulatov S Yu Nechaev V N Shamin A E 2020 Results of assessment of quality of grinding of grain crusher DZM-6 *Bulletin of the NIIEI* No 3 (106) pp 21-36
- [13] Savinykh P Kazakov V Moshonkin A Ivanov S 2019 Investigations in feeding device of grain crusher.. In the collection: *Engineering for Rural Development* pp 123-128
- [14] Yalpachyk E Budenko S 2013 Balance of power and energy efficiency grain crusher *Praci Tavria State Agrotechnological University* Vol 13 No 1 pp 218-226
- [15] Yalpachik O 2013 Ground of parameters and operation modes grain-growing crusher of direct blow *Praci Tavria State Agrotechnological University* Vol 13 No 7 pp 42-56
- [16] Gvozdev A Yalpachik A 2012 Experimental researches of distribution of grain on chamber of crushing of crusher with vertical rotor *Praci Tavria State Agrotechnological University* Vol 12 No 3 pp 102-108
- [17] Thomas M Hendriks W H 2018 van der Poel A.F.B. Size distribution analysis of wheat, maize and soybeans and energy efficiency using different methods for coarse grinding *Animal Feed Science and Technology* 240 pp 11-21
- [18] Yanovich V P Kupchuk I M Kovalchuk O S 2016 Theoretical studies of energy parameters of vibration-disk crusher starch containing substance *S World Journal* T j1110. № 11 pp 17-25
- [19] Shi F Kojovic T Esterle J S David D 2003 An energy-based model for swing hammer mills *International Journal of Mineral Processing* T 71. № 1-4 pp 147-166
- [20] Marczuk A Blicharz-Kania A Savinykh P A Isupov A Yu Palitsyn A V Ivanov I I 2019 Studies of a rotary-centrifugal grain grinder using a multifactorial experimental design method. (*Sustainability*) **11** № 19 pp 5362
- [21] Tang C A Xu X H Kou S Q Lindqvist P A Liu H Y 2001 Numerical investigation of particle breakage as applied to mechanical crushing-part i: single-particle breakage. *International Journal of Rock Mechanics and Mining Sciences* **38** № 8 pp 1147-1162