RESEARCH ARTICLE | JUNE 17 2025

Some results of experimental study of a multi-faced rotary crusher

D. Alijanov; Sh. Abdurokhmonov; Sh. Turayev; A. Begjanov; J. Ogalikov

AIP Conf. Proc. 3286, 050004 (2025)
https://doi.org/10.1063/5.0279332

Some Results of Experimental Study of a Multi-Faced Rotary Crusher

D. Alijanov[1], Sh. Abdurokhmonov[1, a)], Sh. Turayev[2],
A. Begjanov[3], and J. Ogalikov[1]

[1] *"Tashkent Institute of Irrigation and Agriculture Mechanization Engineers" National Research University, Tashkent, Uzbekistan*
[2] *At JSC "BMKB-Agromash", Tashkent, Uzbekistan*
[3] *Urganch State University Republic of Uzbekistan, Khorezm, Uzbekistan*

[a)] Corresponding author: abduroxmonov.shavkatjon@bk.ru

Abstract. This paper examines a design and technological scheme for a feed grain grinder that is notable for its simplicity in both design and manufacturing. It presents the relationship between the productivity of the grinder's working chamber and the gap size at various operating speeds. Additionally, it illustrates the dependence of the specific work required for grinding grain on the gap size of the working chamber across different speed settings. The paper also includes experimental results and an analysis of a multifaceted impact crusher.

Keywords: Stand, grain, grinding, grinding module, experiment, results, analysis.

INTRODUCTION

Work aimed at creating new types of resource-saving technologies and technical means for preparing feed by grinding grain raw materials in agricultural production is relevant.

For private and small farms, having compact electromechanical tools is crucial for handling labor-intensive tasks related to the care of farm animals and poultry. These tools should utilize low-power single-phase electric motors and feature a simple, reliable design at an affordable market price.

Machines and devices created on the basis of research are used in animal husbandry with certain positive results. However, in these studies, the issues of design development and justification of the parameters of the stator grooves and stator edges were not sufficiently studied, the movement and grinding of grain in the working chamber and the characteristics depending on the operating modes were not studied [1-3].

Presenting the issue

This paper examines one of the design and technological schemes of a feed grain grinder, which is characterized by its simplicity of design and manufacture. Fig. 1 shows a technological diagram of the chopper with a cross-section of the working chamber.

The structure of the machine is clear from the diagram. The work process is as follows. In the initial state, the required gap is established between the top of the conical section of the groove 4 and the surface of the cutting edge of the rotor 5 by moving the stator 3 along the thread. Set the adjusting valve 2 to a certain position depending on the required performance. The grain is poured into the receiving hopper 1, and through the adjusting valve 2 it enters the grooves 4 of the stationary stator 3. In groove 4, the grain, under the influence of gravity, falls down until it comes into contact with the cutting edge of the rotor 5. At the same time, the forces of pressure, reaction and friction create compression, shear and torsion stresses in the particle being destroyed, thereby ensuring the grinding of the grain material. After grinding, the grain mass enters the cavity of the unloading chamber 8 and, using the unloading disk 7, the tray is unloaded.

To study the grinding process, a laboratory setup was made (Fig. 2). The development and manufacture of the grinder was carried out with the goal of creating a machine with a productivity of 50-80 kg/h with a grinding module of 1 - 1.8 mm on feed grain. The introduction of a machine of such productivity into production would make it possible to provide farms with small livestock (15-30 cows), as well as flour for the farmer's family for food purposes [15-17].

VI International Scientific Conference Construction Mechanics, Hydraulics & Water Resources Engineering (CONMECHYDRO 2024)
AIP Conf. Proc. 3286, 050004-1–050004-5; https://doi.org/10.1063/5.0279332

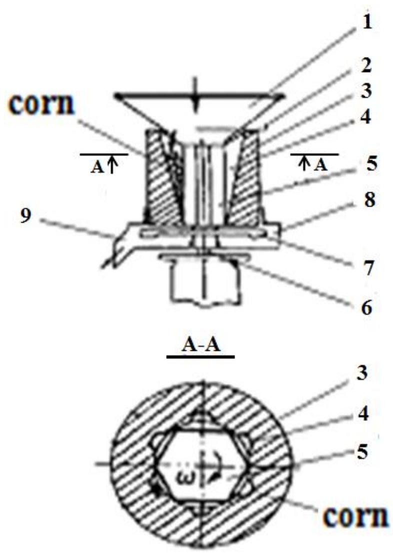

FIGURE 1. Shredder circuit.
1-loading hopper; 2- adjusting valve; 3-stator housing; 4-slot stator; 5-rotor; 6-flange electric motor; 7-unload disk; 8- unloading chamber housing; 9-discharge tray

FIGURE 2. Test bench for hexagonal impact crusher.

Laboratory tests were carried out with the following parameters:

- rotor diameter, mm	63.5
- rotor height, mm	100
- rotor edges, pcs.	6
- hopper capacity, l	4
- width and height of the unloading window, mm	40x20
- size of the working gap between the rotor and stator, mm	0.1
- rotor speed, rpm	130-150

The test program included:

1. Determination of productivity and grinding modulus with a gap between the rotor and stator cone α = 0.5 mm in the rotation speed range of 100...250 rpm.
2. Determination of the reduction ratio [18, 19].
3. Determination of energy indicators in stationary modes.

The size of the finished product is controlled mainly by the size of the working gap α. Performance is determined by the rotor size and stator speed.

To improve performance, it is necessary to increase the rotation speed, diameter and clearance between them. However, the increase in the values of these parameters will be constrained by the requirements for the following reasons. Rotation speed is the root cause of intense heat generation. Increased temperature, in turn, reduces the baking quality of the resulting flour. When designing small-sized grinders, an unlimited increase in the size of the grinding elements is unacceptable. The size of the gap is determined by the required content of highly dispersed fraction in the finished product [4-9].

SOLUTION METHOD

From the test results (Tab. 1) it is clear that with an increase in rotation speed by 2.6 times, productivity increases by 1.35 times (Fig. 1). Since the productivity of the inlet is 250 kg/h, that is, a constant support of the material is provided in all considered modes, the inadequate rotation speed of the increase in productivity can only be explained by the peculiarity of the dynamic process of moving the mass of grains along the slots of the rotor. The energy intensity of the process does not increase linearly with increasing rotor speed and is an order of magnitude less than the energy consumption for crushing with a grinding module of 1 – 1.8 mm. During testing on wheat in all operating modes, a slight deviation of the grinding module from the set gap value was noted. The yield of flour fraction increases with a decrease in the gap between the disks δ and the rotor speed. This phenomenon is explained by an increase in the work of friction as a result of the backing of the material at the beginning of the working chamber zone [10-14].

The results of statistical processing of the results of the grinding study are given in Table 1.

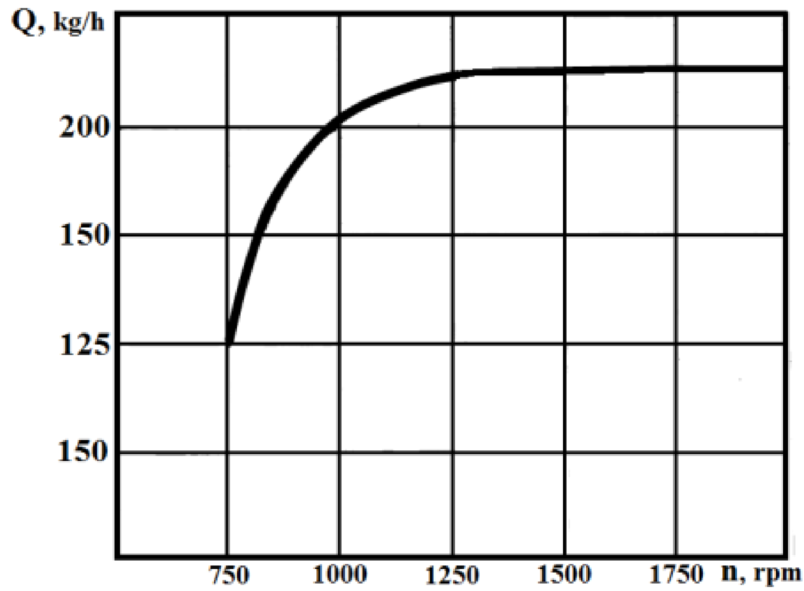

FIGURE 3. Changing the maximum productivity of the working chamber depending on the rotor speed.

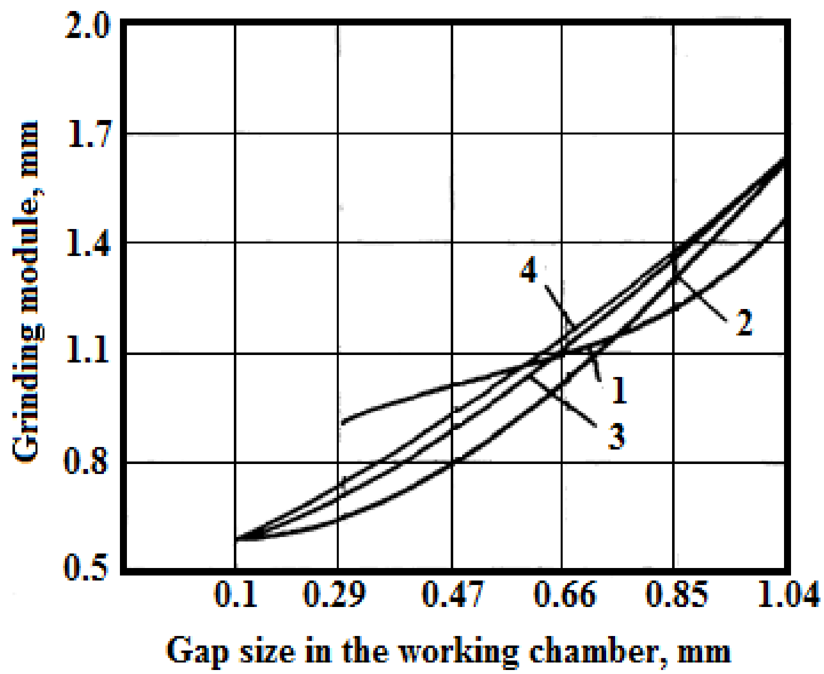

FIGURE 4. Change in the specific power consumption for crushing depending on the size of the gap in the working chamber. 1- at n_1=750 rpm; 2- at n_2=1000 rpm; 3- at n_3=1500 rpm; 4- at n_4=2000 rpm.

TABLE 1. Results of statistical processing of the results of the grinding study.

	n, rpm	**U_x, V**	**I_x, A**	**N_x, W**	**U_p, V**	**I_p, A**	**N_p, W**	**Q, kg/h**	**T_{cp}**	**A_{ud}, Wh/kg**
H=17 mm	1150	188	0.8	0.1504	188	1.6	0.3008	38.71	46.5	0.01398
	900	153	0.8	0.1224	153	1.6	0.2448	45	40	0.00979
	650	123	0.6	0.0678	113	1.6	0.1808	52.94	34	0.00768
	400	70	0.6	0.042	70	1.2	0.084	63.71	28.2	0.00237
H=13.75mm	1150	188	0.8	0.1504	188	1.4	0.2632	31.55	57.	0.01286
	900	153	0.8	0.1224	153	1.6	0.2448	35.64	50	0.01236
	650	123	0.6	0.0678	113	1.6	0.1808	43.90	41	0.00926
	400	70	0.6	0.042	70	2.4	0.168	51.42	35	0.00882
H=9.5 mm	1150	188	0.8	0.1504	188	1.6	02672	30.12	58	0.01637
	900	153	0.8	0.1224	153	1.6	0.2344	30.45	52.5	0.01586
	650	123	0.6	0.0678	113	2.4	0.2088	31.80	47	0.01276
	400	70	0.6	0.042	70	2.8	0.196	45.32	40	0.01232

RESULTS AND SAMPLES

Analysis of experimental studies (Fig. 3-4) shows that the productivity value increases with increasing rotor speed and the size of the working chamber gap. At the same time, in general, a certain generalized character is observed. As the gap in the working chamber increases, productivity increases, but when the gap reaches 0.8 - 0.85 mm, productivity increases sharply. This is explained by the fact that as the gap size increases, the friction forces sharply decrease.

During testing on wheat and in all operating modes (Fig. 3-4), a slight deviation of the grinding module from the set gap value is noted. The yield of flour fraction increases with decreasing gap and rotor speed. This phenomenon is explained by an increase in the work of friction as a result of the support of the material at the beginning of the working chamber, as well as an increase in shock impulses when the particles of the product are destroyed during grinding in the grooves.

Analysis of the specific power consumption for crushing shows that with increasing gap in the working chamber, the specific power consumption for crushing in all modes steadily decreases.

CONCLUSIONS

1. The developed design and technological scheme of the hexagonal rotary crusher allows for significant variation in the operating modes, characteristics of the working elements during both stages of grinding, process energy, and grinding quality
2. The design permits wide-ranging adjustments to the amplitude-frequency characteristics of the working elements, process energy, and grinding quality.
3. Further research on the system dynamics requires experimental studies of grinders that utilize various methods for processing grain materials.
4. Analyzing resonance phenomena when the rotor is stopped helps assess the maximum amplitudes of both the rotor and the working chamber housing, and evaluate the impact of resonance on machine performance.

REFERENCES

1. Zhang M, Sword M L and Buckmaster D R 2003 *Transactions of the ASAE* **46(6)** 1503-11
2. 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
3. Momin M A, Wempe P A, Grift T E and Hansen A C 2017 *Transactions of the ASABE* **5(60)** 1551-60
4. Umirov, N.T., Abdurokhmonov, Sh.X. *AIP Conference,* 2022, 2762, https://doi.org/10.1063/5.0128396
5. Alijanov, D., Abdurokhmonov, Sh., Umirov, N. IOP Conference Series: Materials Science and Engineering, 2020, **883** 012117
6. Alijanov, D., Abdurokhmonov, Sh., Jumatov, Y., IOP Conf. Series: Materials Science and Engineering **883** (2020) 012155
7. D. Alijanov, Sh. Abdurokhmonov and Kh. Ismaylov, ICECAE 2020, IOP Conf. Series: Earth and

Environmental Science, **614**, 012110 (2020).
8. 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
9. Borotov A 2020 *IOP Conference Series: Materials Science and Engineering* **883** 012160
10. Zhang M, Sword M L and Buckmaster D R 2003 *Transactions of the ASAE* **46(6)** 1503-11
11. Borotov A 2021 *IOP Conference Series: Earth and Environmental Science* **868** 012035
12. *Sh* Abdurokhmonov, *N* Umirov, and *K* Ismaylov E3S Web of Conferences **486**, 05003 (2024)
13. M. Thomas and W. H. Hendriks, 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, 11-21 (2018).
14. O. V. Nanka Methods of mechanical influence when grinding fodder grain and their energy evaluation, Agrotechnics and energy supply, **1**, 204-209 (2014).