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COMPARISON RESULTS OF GRAIN CRIMPING PRODUCTS WITH ROLLER AND DISC WORKING BODIES

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Abstract

A description of the grain conditioner with disc working bodies and its differences from the industrially produced conditioners with disc working bodies is given. The results of a comparative analysis of the obtained product on both types of working bodies of grinders on barley, wheat, rye, oats, buckwheat and millet are presented. There is information both on the productivity of the used conditioners, and on the amount of power consumed for their drive and specific energy consumption. Unlike the grain roller conditioner, the disc conditioner has a lower capacity. However, energy consumption per kilogram of product is significantly lower.

Key words*: grains, crimping products, roller and disc working bodies.*

INTRODUCTION

In modern industry, a large amount of materials must be shredded. Grinding products are used both in mining to obtain materials for industrial processing (Liu et al., 2018; Yang et al., 2018), in the technology of obtaining construction components (Ostroukh et al., 2018), for chemical production and use (Gladkova et al., 2018; Slimani et al., 2018), for the production of food for humans and animals (Smejtková et al., 2016).

Various designs with different working bodies are used as grinders for lumpy materials (Kupchuk et al., 2019; Iskenderovet al., 2018). In some cases, vibration effects are used to increase the efficiency of the process (Rabat et al., 2018;Vaisberg et al., 2019). The main attention is paid, as a rule, to reducing energy consumption (Stepanenko et al., 2018; Norov et al., 2019) and obtaining a given particle size distribution (Lvov, 2018). For this purpose, theoretical studies are carried out to obtain the necessary equations and establish laws (Sysuev et al., 2017). The obtained mathematical expressions (Sysuev et al., 2016) allow to analyze the process by numerical methods, optimizing its parameters. An increase in the efficiency of the technological process and an increase in productivity are substantiated (Sysuev et al., 2015). In agriculture, the effect of the resulting grinding products on the vital activity of animals and changes in nutrition is also established (Inoue et al., 2015; Miyaji et al., 2017).

The purpose of the research was to establish the influence of the design features of the working bodies (cylindrical and conical shapes of smooth rollers) of the grain conditioner on the quality indicators of the product obtained from the kernels of a number of agricultural crops.

MATERIALS AND METHODS

The research methodology provided for comparative studies of the operation of roller conditioners with a smooth working surface, having a position in the form of cylindrical rollers (Figure 1) and conical disks (Figure 2). In the course of the experiment, for the recommended setting of the conditioners, the following indicators were measured by conventional methods: the average design thickness of the flakes (measured with a caliper 100 flakes); sieve analysis was the weighted average particle size - modulus of grinding; the fraction of the dusty fraction after sieving as the exit from the last sieve with holes of 0.25 mm); sorption coefficient as the ratio of the mass of retained moisture to the crushed

product; the productivity of conditioners as the ratio of the mass of the product passed through to the time of its collection The drive power was measured with a KI-505 device. Energy consumption was defined as the ratio of the consumed power to the productivity. To determine the corrected energy consumption, the grinding modulus value was multiplied by the energy consumption.

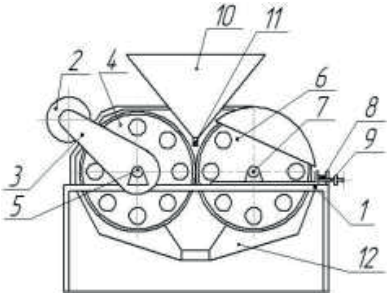
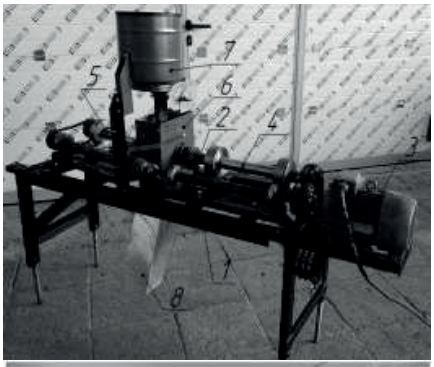


Figure 1 - Design and general view of the roller conditioner (Petent, 2008): 1 - frame; 2 - electric motor; 3 - V-belt transmission; 4 - drive roll; 5, 7 - bearing support; 6 - driven drum; 8 - safety spring; 9 - adjustment screw; 10 - loading hopper; 11 - damper; 12 - unloading tray



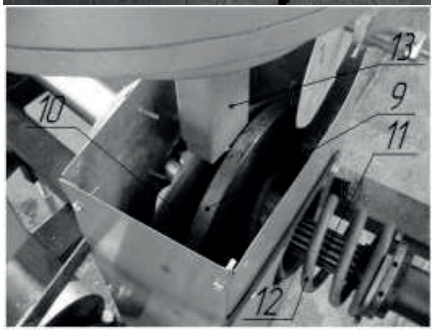


Figure 2 - General view and internal structure of a conical roller conditioner (Patent, 2015): 1 - frame; 2 - drive shaft; 3 - electric motor; 4, 5 - driven shafts; 6 - protective casing; 7 - loading hopper; 8 - unloading tray; 9, 10 - crimping discs; 11 - stock; 12 - spring; 13 - power supply

RESULTS AND DISCUSSIONS

The average values for three replicates of measuring the performance of the conditioner with smooth cylindrical rollers and the conditioner with disc working bodies are presented in Table 1. At the same time, information characterizing the quality of the product obtained is shown in Table 2.

Table 1. Performance indicators of conditioners

View grains	Roller conditioner			Disc conditioner working bodies		
	Q, kg/h	P, kW	Y, kWh/t	Q, kg/h	P, kW	Y, kWh/t
Barley	208	2.01	9.66	183	0.96	5.25
Wheat	321	2.13	5.27	216	0.98	4.54
Rye	340	1.8	5.29	206	0.96	4.66
Oats	83	1.6	19.2	76	0.88	11.5
Buckwheat	295	1.92	6.51	187	0.97	5.19
Millet	605	1.7	2.81	360	0.93	2.58
Crop average	*308.7*	*1.9*	*8.1*	*204.7*	*0.9*	*5.6*

Table 2. Indicators of crimped grain

Grain type	Roller conditioner				Disc conditioner working bodies			
	a, mm	G	M, mm	υ, %	a, mm	G	M, mm	υ, %
Barley	-	1.04	2.07	four	1.00	1.23	3.23	0.8
Wheat	1.02	0.9	2.43	3	0.98	0.96	2.91	0.6
Rye	0.98	1.02	2.90	2.5	1.01	1.08	2.65	1.4
Oats	0.83	1.24	2.55	2.9	0.89	1.29	3.3	0.6
Buckwheat	-	0.73	0.86	24	0.6	0.76	2.13	8
Millet	-	0.86	1., 8	18	-	0.89	1.59	11
Crop average	-	*0.97*	*2.02*	*9.1*	-	*1.04*	*2.64*	*3.7*

Table 3. Percentage of change in the performance of the disc conditioner relative to the cylindrical rollers

	Q, kg/h	W, kW	Y, kWh/t	Yk, kW*h* mm/t	M, mm	a, mm	G	υ, %
Barley	-12.02	-52.24	-45.65	-15.20	56.04	-	18.27	-80.00
Wheat	-32.71	-53.99	-13., 85	3.16	19.75	-3.92	6.67	-80.00
Rye	-39.41	-46.67	-11.91	-19.50	-8.62	3.06	5.88	-44.00
Oats	-8.43	-45.00	-40.10	-22.49	29.41	7.23	4.03	-79.31
Buckwheat	-36.61	-49.48	-20.28	97.45	147.67	-	4.11	-66.67
Millet	-40.50	-45.29	-8.19	14.05	24.22	-	3.49	-38.89
Crop average	*-33.69*	*-49.10*	*-30.82*	*-10.04*	*30.77*	-	*7.25*	*-58.82*

Comparing the numerical values of the indicators, the percentage of their change was revealed, shown in Table 3.

Considering that one conditioner had cylindrical, and the second conical rollers, and the presence of differences in their geometric parameters, then for an objective comparison, a comparison of the obtained indicators was used.

The performance of conditioners is determined by the length of the conditioning zone and the rotational speed of the rollers. The gap between the rollers, which is either forced or dependent on the performance of the device and associated with the condition of ease of gripping the material, also affects. So, due to the lower initial productivity of the disc conditioner, its average productivity on crops is 33-34% less (Figure 3). In this case, the influence of the properties of the material being flattened also affects. The smallest decrease in the performance of conditioners is observed on such a cohesive mass as oat grain - (-8.4%). Apparently, the improvement of conditions for the capture of oat material by the large diameter of the conditioner discs affects. At the same time,

the modulus of grinding increases by 29.4%, and the thickness of the flakes increases by 7.2%. At the same time, the greatest decrease in productivity on such a fluid material as millet seeds is (-40.5%). Similar, but slightly lower values are for rye, buckwheat and wheat seeds, which have less fluidity and larger sizes. In this case, the grinding module increases accordingly by (-8.62%; 147.67%; 19.75%), and the thickness of the flakes increases by 3% in rye, and in wheat it decreases by 3.9%. Buckwheat does not form flakes due to its high fragility. A significant difference in the quality properties of the product requires its separate consideration.

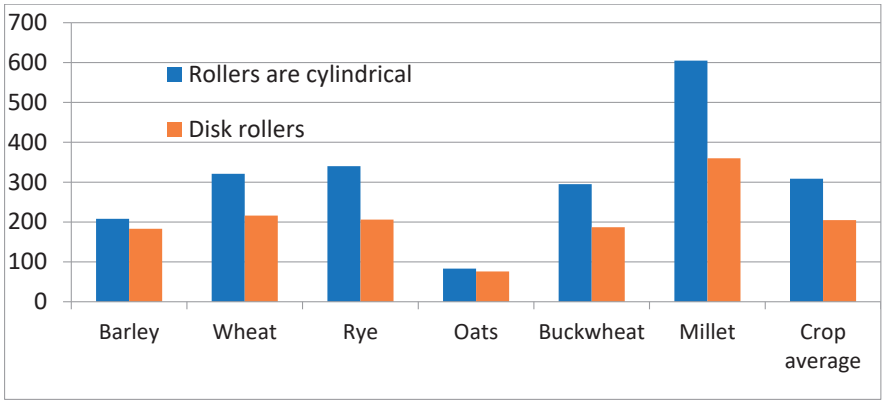


Figure 3 - Histogram of comparison of productivity values Q (kg/h) of disk and cylindrical roller conditioners

With a decrease in average productivity by 33.7%, power costs are reduced by 49% (45-54%). That is, the energy consumption of the process decreases. The average decline is 30.8%, and varies by crop from 8 to 46%. Taking into account the change in the particle grinding modulus, the energy consumption was considered taking into account the particle grinding modulus. In this case, the adjusted values of energy consumption are reduced by 10% (Figure 4). Oats have a decrease of 22.5%, rye of 19.5%, barley of 15.2%. At the same time, a number of crops require an increase in energy consumption: buckwheat by 97.5%, millet by 14%, wheat by 3%. Thus, in terms of energy performance, disc working bodies should be recommended for crushing oats, rye, barley, and wheat. For crushing millet and buckwheat grains, preference should be given to cylindrical rollers.

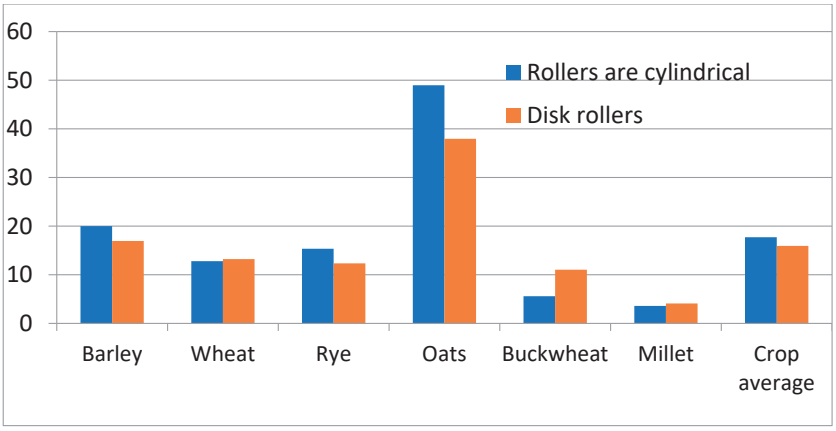


Figure 4 - Histogram of the comparison of the values of the corrected energy consumption Y (KWt mm/t) for disc and cylindrical roller conditioners

It should be noted that although there is an increase in the grinding modulus of almost all seeds of the studied crops (Table 2), as well as a slight increase in the thickness of the flakes in oats and rye, the quality properties of the resulting product improved in all crops: moisture adsorption by the grain product increased (Figure 4) by 7.3% on average. In barley, wheat and rye, the improvement was over 6%. No deterioration of these properties was observed. The growth of the dusty fraction contributes to an increase in the loss of material from dusting, and also contributes to the deterioration of animal respiration. The disc conditioner shows a decrease in dust fraction on all crops, and on average is 59%. The

smallest decrease in dusting was observed in millet and rye.

This phenomenon is explained by the different rate of change in the size of the medial roller space of the conditioners when the rollers are turned. As a result, a relative shift of individual layers of caryopsis occurs between each other, leading to the formation of cracks and microcracks inside the caryopsis. The presence of cracks promotes the adsorption of liquids (for example, gastric juice, which improves the digestibility of the product, which is a positive reaction). The high shear value promotes the formation of deep cracks that destroy the flakes. Chipping off small particles contributes to the growth of the dust fraction. In barley, millet, and buckwheat, the flakes (at least half of the caryopsis) disintegrated into microflakes on cylindrical rollers, remaining on the disk set.

CONCLUSIONS

In contrast to the comparable cylindrical grain roller conditioner, the experienced disc conditioner has 33.7% lower capacity on average. The power consumption is, on average, 49% less. At the same time, the grinding modulus increases by 30.8%. However, adjusted for the modulus of grinding, the energy consumption per ton of product is significantly lower. Average values of corrected energy consumption are reduced by 10%. Oats have a decrease of 22.5%, rye of 19.5%, barley of 15.2%. At the same time, a number of crops require an increase in energy consumption: buckwheat by 97.5%, millet by 14%. Thus, in terms of energy performance, disc working bodies should be recommended for crushing oats, rye, barley, and wheat. For crushing millet and buckwheat grains, preference should be given to cylindrical rollers.

The quality properties of the product obtained on the disc conditioner improved in all crops: the moisture adsorption of the grain product increased by an average of 7.3%. In barley, wheat and rye, the improvement was over 6%. The deterioration of these properties was not observed in any culture. The disc conditioner shows a decrease in dust fraction on all crops compared to cylindrical rollers, and on average is 59%. The smallest reduction in dusting was observed in millet and rye. In barley, millet, and buckwheat, the flakes were broken into microflakes on cylindrical rollers, remaining on the disk set.

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