DETERMINATION OF RATIONAL OPERATING PARAMETERS FOR A VIBRATING DYSK-TYPE GRINDER USEDIN ETHANOL INDUSTRY

ВИЗНАЧЕННЯ РАЦІОНАЛЬНИХ ЕКСПЛУАТАЦІЙНИХ ПАРАМЕТРІВ ВІБРОДИСКОВОЇ ДРОБАРКИ СПИРТОВОЇ ГАЛУЗІ

Ph.D. Yanovich V.P., Assist. Kupchuk I.M.
Vinnitsa National Agrarian University
Tel: +380978173992; E-mail: kupchuk.igor@mail.ru

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ABSTRACT

The article shows a schematic diagram of a vibrating disk-type grinder for chopping corn starch substance in ethanol production, achieving the idea of a combined interaction between vibrational and rotational motion of the working body, a combination of shock and cutting impact of working bodies on the material, which will handle both certified substance and substance materials with a high moisture content without significantly reducing equipment bandwidth and ensuring the timely product withdrawal from the grinding zone.

Also, were determined the rational vibration modes of the disk cutters by experimental evaluation of equipment performance, which resulted in a performance charts depending on the angular speed of the rotor, sieve orifice diameters and humidity.

РЕЗЮМЕ

У статті приведена принципова схема вібродискової дробарки для подрібнення зернової крохмалевмісної сировини спиртового виробництва, яка реалізує ідею комбінованого взаємодії вібраційного і обертального руху виконавчого органу, поєднання ударного і ріжучого впливу робочих елементів на матеріал, що дозволить обробляти як кондиційну сировину так і сировину з підвищеним вмістом вологості без значного зменшення пропускної здатності обладнання та забезпечити своєчасне виведення продукту із зони подрібнення.

Також було визначено раціональні режими роботи вібраційної дискової дробарки, шляхом експериментальної оцінки продуктивності обладнання, в результаті чого було отримано графічні залежності продуктивності від кутової швидкості ротора, діаметра перфорації сита та вологості.

INTRODUCTION

One of the most important and energy-intensive processes in ethanol production is material grinding, which is usually performed by a hammer grinder. Therefore, effective implementation of constructive machines to perform the designated operations and study their parameters determines the relevance of these studies.

Based on the analysis of processes*(Turshatov M.V., 2011; Abramova I.M., 2012; Billomyttcev A.S., Druzhynin E.I., Morachkovsky O.K. 2016; Dudnikov A.A., Belovod A.I., Pasyuta A.G., 2015; Toneva P., Epple P., Breuer M., 2011)*and structural schemes of existing equipment*(Turshatov M.V., 2011; Abramova I.M., 2012; Kuzo I.V., Lanets O.S., Gursky V.M., Shpak Y.V., 2015; Sydorenko I.I., Kushnir A.Y., Baidzhanov S.M., 2015)*for implementing the process of grinding and weight loss, we offer a better way of grinding grain substance for alcohol production, the essence of which is in the development of a fundamentally new grinder scheme, which could achieve a combination of shock and cutting impact of workingbodies on the material, which will handle both certified substance and substance materials with a high moisture content without significant reducting equipment bandwidth and the timely product withdrawal from the crushing zone, by levelling the excessive air circulation on product layer, and consequently reducing specific energy consumption for the mentioned treatment *(Deinychenko G.V, Samoichuk K.O., Ivzhenko A.O., 2016; Wang Y., Wang S., 2007)*.

However, to achieve high rates of energy efficiency, it is necessary to prove rational equipment operation by experimental evaluation of the productivity of equipment developed for the process of grinding starch containing grain materials.

MATERIAL AND METHODS

The experimental part of the work was conducted at the laboratory processes and equipment, processing and food production department in Vinnitsa National Agrarian University and in the "Ovechatske MPD" SE "Ukrspirt" specialized laboratory, using experimental and industrial design of the vibrating disk-type grinder*(PalamarchukI.P., YanovychV.P., KupchukI.M., SolomkoI.V., 2013)*(Fig.1) for which when switching on the motor *5*, torque moment is transmitted through the clutch *6,* to the kinematic shaft *7*andcounterweights*8*, the rotation of which leads to the creation of a combined power and torque placed on the unbalanced axles of rotor *9* and vibrating disk*10*. The material to be grinded continuously goes through the inlet 2 and is crushed due to the rotating and oscillating movement of disk *10*. When particle size decreases, the material is crushed under the influence of centrifugal forces and alternating loads undergo intense classification on the sieve surface: particleswith diameters equal to or smaller than sieve *4*openings aredischarged through the outlet *3*, the rest are re-grinded *(PalamarchukI.P., YanovychV.P., KupchukI.M., SolomkoI.V., 2013)*.

For the study on the technological characteristics of the equipment developed for the grinding process, a series of experiments to change the properties of the dispersed material (maize) under shock-cutting impact in the "vibration force field" were conducted.

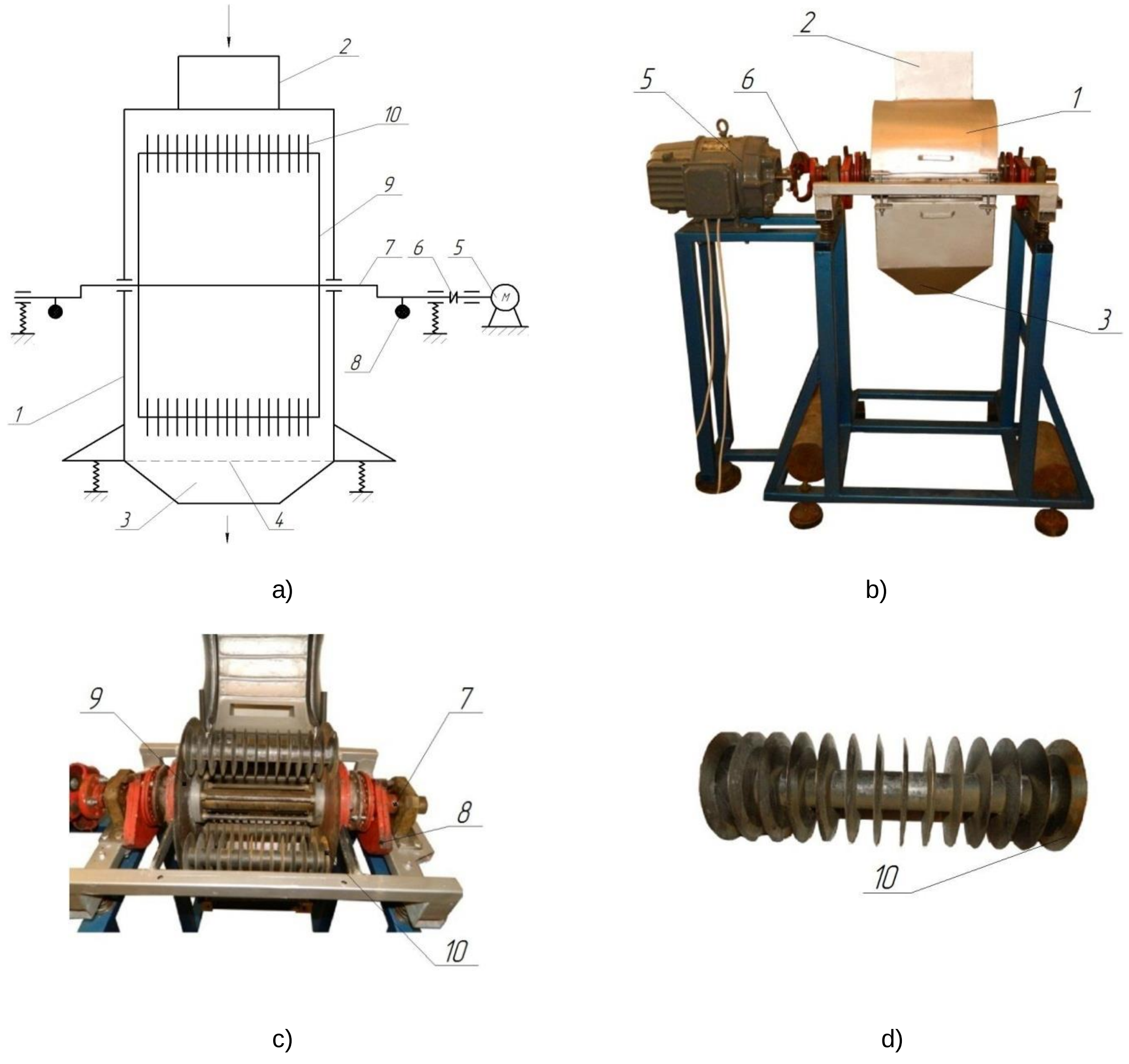

Fig. 1 - Vibration disk-type grinder

a) the basic scheme; b) general view; c) the working body; g) disc beat;
1 - the case; 2, 3 –material inlet and outlet; 4 - sieve; 5 - electric motor; 6 - elastic sleeve;
7 - kinematic shaft; 8 - counterweight; 9 - rotor; 10 –vibrating disk

Performance evaluation was performed by weighing the shredded material that passed through the mill for an hour. To determine the material mass, a BTA-60 / 30-5-T electronic laboratory technical balance (Fig. 2) was used.

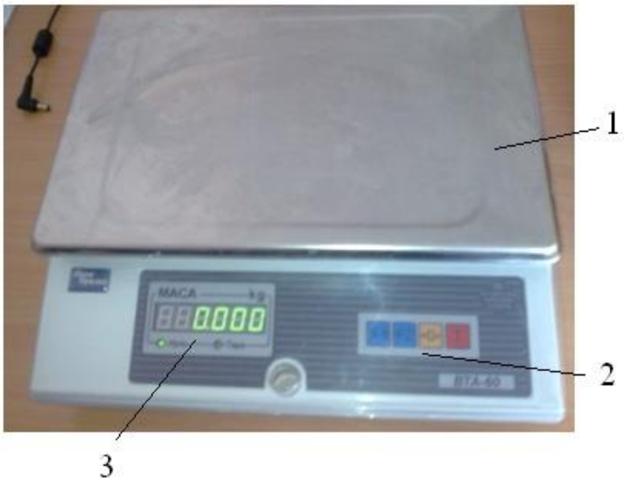

Fig. 2 - BTA-60 / 30-5-T Electronic laboratory technical balance

1 - weighing pan; 2 - panel calibration; 3 - display indicator

Table 1

Technical characteristics of laboratory scales BTA-60 / 30-5-T

Parameter	Range
Maximum weighing, kg	30
The lowest weight, kg	0.02
Readability charging mass, g	1/2/5/10
Operating temperature range	+10 ... +40
Power supply, W	187 ... 242
Power consumption, W	15
Weighing pan dimensions, mm	220 x 340
Weights overall dimensions, mm	325 x 345 x 95

To record the rotational speed of the drive shaft, aUNI-T UT372 wireless tachometer (Fig.3) was used, and its operation principle is described in the technical documentation.

Fig. 3 - UNI-T UT372 Tachometer

1 - laser scanner; 2 - digital display; 3 - control panel

To manage and change the rotation frequency of the motor shaft, an AOSN-20-220-75 autotransformer (Fig.4) is used, which is designed to work with alternating current. It contains current down taking movable contact in the form of graphite roller, allowing infinitely variable voltage from zero to the maximum. Also, the autotransformer has several terminals, through which one can get different current output characteristics.

AOSN-20-220-75 performance laboratory autotransformer enables real-time analysis on performance, power consumption and number of motor revolutions.

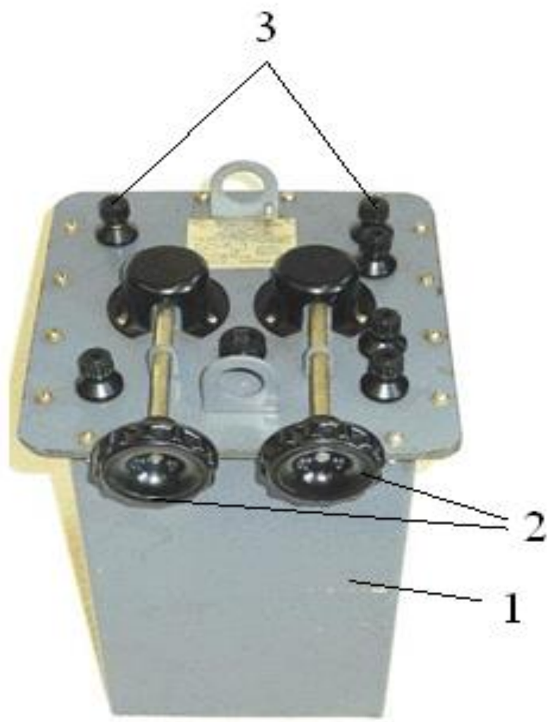

Fig. 4 - AOSN-20-220-7 laboratory autotransformer

1 - outer casing; 2 - voltage regulators; 3 - input and output terminals

To determine the relative humidity of the material, the Wile 55 Moisture analyser (Fig.5) was used, which can measure the relative humidity of various types of grains and seeds, recording the results in the device's memory.

Fig. 5 - Wile-55 moisture analyser

1 - housing cover; 2 - digital display; 3 - control panel; 4 - capacity for sample

Technical characteristics of the device are shown in table 2, the working principle and rules of operation in the technical documentation.

Table 2

Wile-55 moisture analyser technical characteristics

Index	Value
Grain and seeds, %	8 ... 35%

Oilseeds, %	5…25
Operating temperature, ^{0}C	0 ... 40
Accuracy,%	± 0.1%
Power, W	9 (IEC 6F22)
Length, mm	120
Width, mm	80
Height, mm	210
Weight, kg	0.8

RESULTS

The data obtained from the experimental studies was processed and interpreted using Microsoft Excel software.

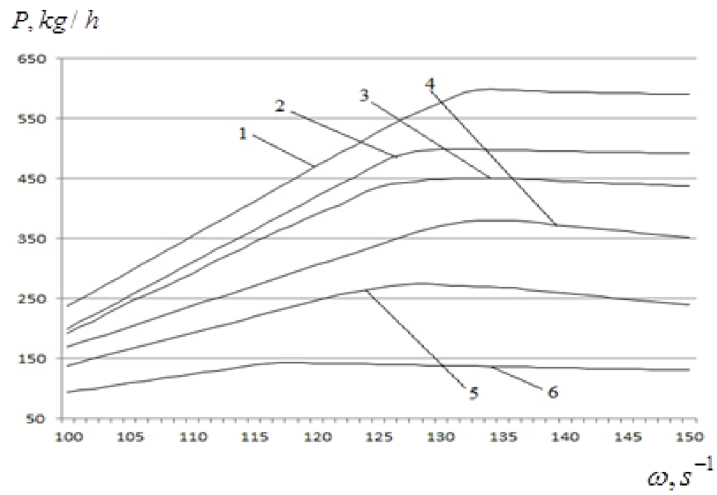

Fig. 6 -Productivity depending on the speed of the rotor and sieve orifice sizes (*d*):
1 - with d = 2 mm; 2 - with d = 1.8 mm; 3 - with d = 1.6 mm; 4 - with d = 1.4 mm; 5 - at d = 1.25 mm; 6 - with d = 1 mm

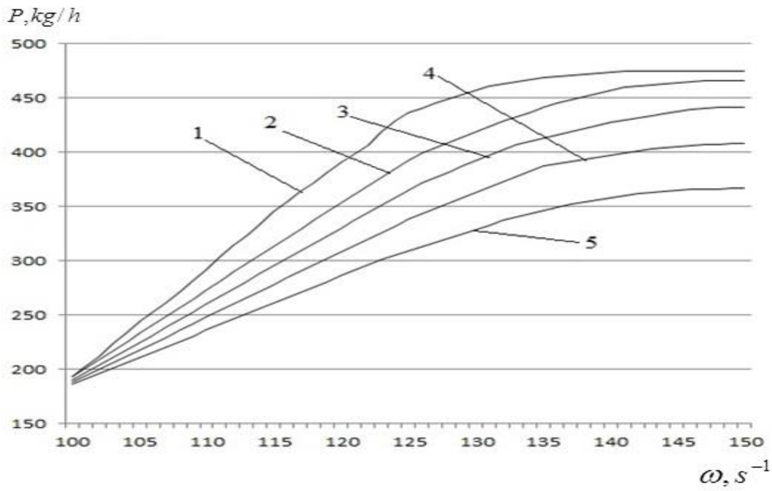

Fig. 7 - Productivity depending on the speed of the rotor and humidity (*H*):
1 - when H = 13 - 14%; 2 - when H = 15 - 16%; 3 - when H = 17-18%; 4 - when H = 19 - 20%; 5 - when H = 21 - 22%.

Fig. 6 shows the change in grinder productivity depending on the angular velocity of the rotor and the diameters of orifices in the separation surface (sieve) of the grinder. The results of experimental studies on changes in equipment productivity depending on the angular velocity of the rotor and the relative humidity of the material are shown in Fig. 7.

CONCLUSIONS

Analysing the dependence charts obtained, we can conclude that the productivity *P* increases with increasing the frequency of rotation, but when reaching the rotation frequency of 125-135 rad/s or more, a decrease of productivity growth is observed. This indicates excessive recirculation of re-grained material and unreasonableness of the machine operation, when the rotor angular velocity is greater than 125-135 rad/s. In addition, it was found that material moisture significantly affects the performance, especially at the same frequency (rad/s), performance decreased by more than 25%, namely from 450 kg/h to 325 kg/h during the grinding of materials with 13- 14%,respectively 21-22% humidity, which allows selecting the optimal flow of material. Productive works should not exceed the experimentally installed capacity ranges of the equipment.

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