

Determining the correlation between the throughput capacity of the grinder chamber of the smart corn thresher device

G Fozilov^{1*}, Sh Khudayberdiev² Sh Shodmonov³, G Ravshanova¹ and U Khusanov⁴

¹National Research University “Tashkent Institute of Irrigation and Agricultural Mechanization Engineers”, K. Niyazi str. 39, Tashkent, Uzbekistan.

²Karshi Institute of Irrigation and Agricultural Technologies of the National Research University “Tashkent Institute of Irrigation and Agricultural Mechanization Engineers”, Kashkadarya region, Karshi city, Uzbekistan.

³National Research University “Tashkent Institute of Irrigation and Agricultural Mechanization Engineers”, K. Niyazi str. 39, Tashkent, Uzbekistan.

⁴Termez State University of Engineering and Agrotechnologies, I.Karimov str., 190111, Termez, Uzbekistan

*E-mail golibjon270784@mail.ru

Abstract. This article describes the technological scheme of a new innovative device consisting of a hopper, smart cameras, smart mechanisms that sort the cobs according to length, conveyors, rubber grips, conveyors moving against each other that squeeze the cobs, next to the conveyor there is a disc that cuts the tip and bottom (unnecessary) part of the ear corn. On the surface of the threshing drum there is a threshing rasp bar, and under the drum there is a concave, as well as an auger and an auger base. The device consists of a loader with an elevator for loading seeds, an electric motor, an output shaft. Also, a processor is installed for programming the device's smart cameras and mechanisms. There is a grinder to grind the unwanted tip and bottom of the cob, unfit cobs smaller than 15 cm and the cores left over from crushed cobs as feed. In these studies, the number of holes N_h in the grinding part of the device, their diameter, the permissible size of the gap between the holes, the diameter of the grinding chamber D_h , and the height of the grinding chamber H_h were determined.

1. Introduction

In the world, the production of resource-saving technology and equipment for processing nutritious grains and preparing concentrated feed occupies a key place. "Worldwide 178-183 mln. 968-1065 mln. considering that a ton of grain is ground and concentrated feed is prepared", it is one of the important tasks to develop high-quality and resource-saving equipment and devices for grinding grains. In this regard, great attention is being paid to the development of devices that grind nutritious grains into a uniform composition.

On a global scale, scientific and research work is being carried out aimed at the development of new scientific and technical solutions of resource-efficient technologies for grinding nutritious grains and preparing high-quality concentrated feed from them and the technical means that implement them [1].

In this direction, it is considered one of the important tasks to save energy and resources by first separating the part suitable for seeds from corn bran and grains, and then cutting it to a certain size and then grinding it. In this regard, it is necessary to develop a grinder device as a part of new smart com



thresher device that performs grinding, that is, first grinding, and then crushing with impact, as well as justifying its technological work process and parameters of working parts. Taking into account the development of family animal husbandry and the increase in the demand for concentrated feed with the increase in the number of livestock, extensive work is being carried out on the development of resource-efficient devices and technologies with low metal and energy consumption, which will allow grinding nutritious grains and preparing high-quality fodder for farms.

In the Action Strategy for the further development of the Republic of Uzbekistan in 2017-2021, including "...creating the feed base of livestock, increasing feed production, organizing their breeding, providing livestock with high-quality feeds, bio-supplements, vitamins, macro-micro elements and other nutrients" provision" tasks are defined. In the implementation of these tasks, one of the important issues is the technical and technological modernization of devices that grind nutritious grains with high quality while saving energy and resources. Rittinger, Rebinder, V.L. Kiripichev abroad to reveal the essence of the process of grinding and crushing of corn, rye, oats, wheat and other nutritious grains, to create feed preparation devices and to justify the parameters of their various working parts, to study and apply performance indicators, and then M. M. Gernet, V. A. Goransky and S. V. Melnikov, V. G. Malkov, T. Abiljanov, M.A. Tishchenko, A.V. Yakovlev, V.G. Korotkov, V.N. Shulyatev, V. Sisuev, J. C. E. Quist, S. Kwofie, P. Vaculík, R. R. Iskenderov, V. Shirobokov, O. Fedorov, S. Ivanovs, P. Sobczak, Y. Ushakov, Dabbour M. I., M.M. Studies by Ibrahim, D. Dzicki, F. Liu, M. Thomas, F. Zhu, J. Zhao and other scientists have been carried out. Dz.Alijanov, A.Srojiddinov, K.Astanakulov, F.Karshiev, Sh.Abdurakhmonov and other researchers carried out scientific and research work in the our Republic on the development and improvement of methods and devices for grinding nutritious grains and other nutrients [2-5].

In these studies, the processes of grinding nutritious grains in disc, mill, and rotor grinders were studied, and the grinder, which performs the final grinding of corn bran and grain, wheat, barley, rye, and oat grains step by step with grinder blades, and then grind them with grinder hammers. the issues related to development of the structure and justification of its parameters have not been sufficiently studied. This research was carried out within the framework of the above problem and proposal and decisions.

Moreover, around the globe other researchers have researched that to develop the corncob threshing devices and machines and they investigated the physical mechanical properties and moisture of the corn grain to harvest it [6]. However, almost all of them adapted their researches to remove all grain located on ear corn. Then the seed grain is separated by sieve cleaners and graders according to the size of the seed grain.

2. Materials and Methods

In order to extract quality corn seeds, it is necessary to remove 3-4 cm of kernels from the tip and bottom of the cultivated corn cob for the seed, and then to separate the kernels in the middle of the cob. However, today this process is done by hand. There is no machine or device in the world that separates the tip and bottom of the corn cob, then threshes the seed grains in the middle, and simultaneously grinds the unfit cobs, husks for seed and the core as fodder [7-8].

The main purpose of the proposed invention is to create a new innovative device for sorting the ear cobs suitable for seed with the help of smart cameras, cutting the tips and lower parts of the ears of corn with the help of a cutting disc mechanism, and for threshing and separating its seeds of the exact size.

In this case, in one device, in one process, corn cob is sorted into the required size with the help of a smart camera and mechanisms, its tip and bottom are cut, the grains in the middle of the corn cob are threshed, and the seeds of the correct size are sorted.

This problem is solved by sorting hulled pods of suitable size and using a cutting disc to cut off the top and bottom of the pods, then crushing and sorting the seed kernels in the middle of the pod. In this case, the middle part of the seed is threshed using a threshing drum. Separated pure seed grains are loaded into containers. The principle scheme of the device that sorts the proposed corn stalks in specific sizes, cuts their tops and bottoms, and separates pure seed grain in specific sizes is presented (figure 1).

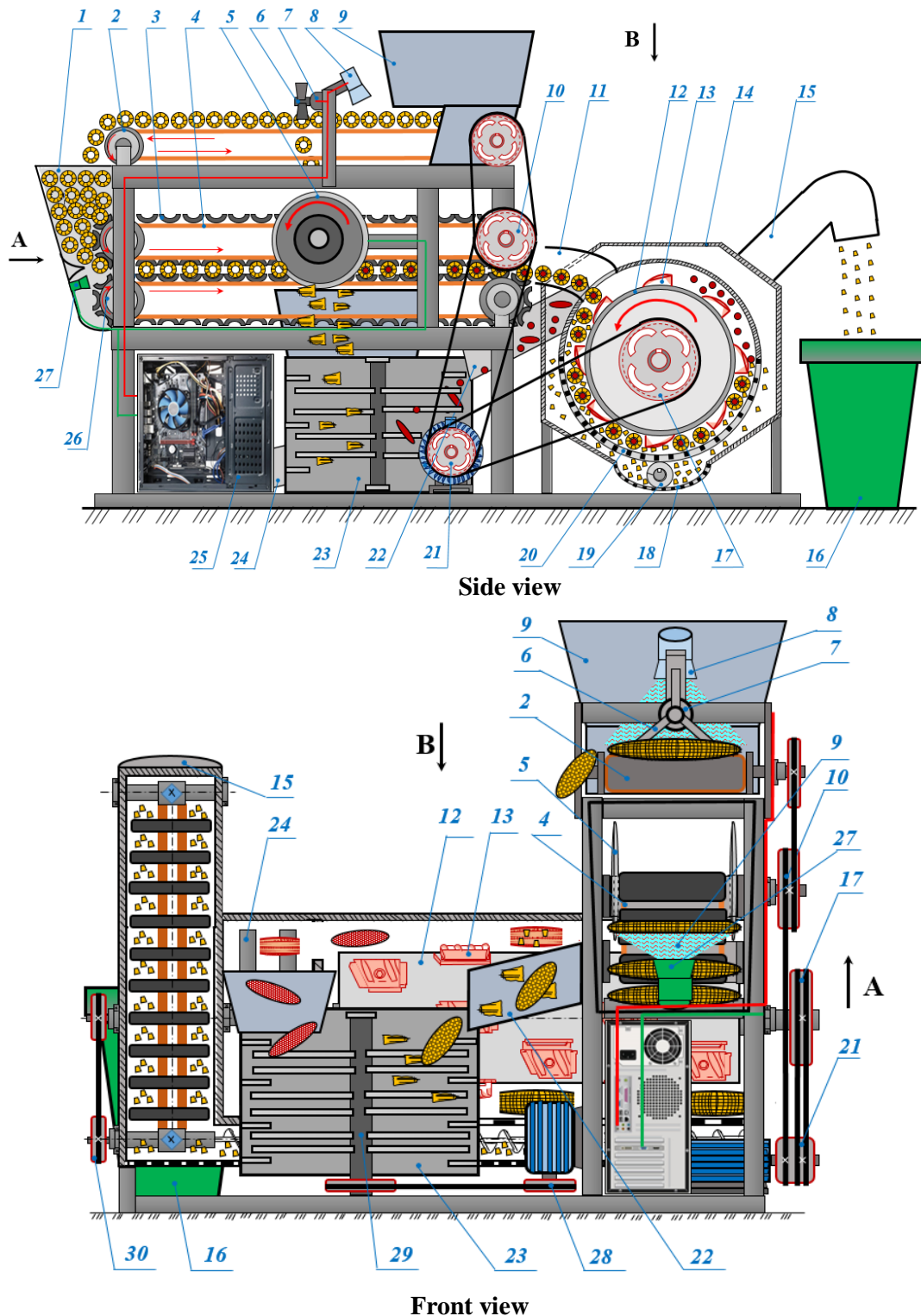


Figure 1. Schematic diagram of the device that cuts the tip and bottom of the proposed corn cobs and separates the seed grain to the exact size

The device that threshes and separates pure seed grain of corn into exact size consists of 1-bunker, 2-upper conveyor, 3-rubber gripper, 4-conveyor, 5-cutting disc, 6-smart sorting mechanism, 7-smart motor, 8-seed sorting smart camera, 9-hopper, 10-upper conveyor pulley, 11-cut straw transfer hole, 12-

threshing drum, 13-threshing rasp bar, 14-body, 15-grain loading pipe, 16-pure seed grain container, 17-drum pulley, 18-auger base, 19-auger 20-concave, 21-electric motor pulley, 22-chop core rod, 23-grinder, 24-grinder shaft, 25-smart mechanism processor, 26-lower conveyor pulley, 27-smart camera for adjusting the cutting disc, 28-electric drive for the grinder motor, 29-grinding rotor and blades, 30-screw and the loading consist of a pulley that moves the transporter.

The technological process of the device is carried out as follows: husked corn cobs are put into the hopper 9. From there, the corn cobs are transferred to bunker 1 using conveyor 2. During the movement of the corn cobs on the conveyer 2, the smart camera 8 determines the size of the corn cobs than 15 cm in length, gives a signal to the smart motor 7, and the motor moves, and with the help of the smart sorting mechanism 6, the corn cobs smaller than 15 cm are separated, they fall along the rod 22 to the grinder 23, and the grinder rotor and it is ground as fodder under the influence of its blades. Corncobs longer than 15 cm continue to move on conveyor 2. At the next stage, the corn cobs falling into the hopper 1 are pulled towards the cutting disc 5 in a compressed state under the influence of the rubber gripper 3 installed on the surface of the conveyer 4 moving against each other.

There, the upper and lower parts of the concobs are cut. At the next stage, the cut middle part of the comcob is threshed by the threshing rasp bar 13, which is mounted on the surface of the threshing drum 12. After that, the threshed seed of exact size passes between the openings of the grain concave 20, is pushed under the action of the auger 19, and is loaded into containers through the grain loading pipe 15. Small impurities other than seed grains fall down between the holes of the auger base 18. The separated core of the corncobs, the upper and lower parts of the core exit through the rods 22 and fall into the grinder 23 and are ground as fodder. The device's smart sorting mechanism 6, smart motor 7 and corncob sorting smart camera 8 and corrector camera 27 that adjusts the cutting disk to smudge sizes are programmed using the smart mechanisms processor 25. The device is driven by electric motors 21 and 28.

3. Results and Discussions

The offered device that separates the seeds of corn into the exact size has a very simple design, and with the help of a smart camera and mechanisms, as well as a cutting disc, it allows to cut the part of the corn in the exact size of the grain, and to sort the pure seeds with minimal labor and energy consumption. In the technological working process of the grinder device, a certain amount of grain product sent for grinding must be ground in time, and the ground grain product must leave the grinder in time. If the product is not ground in time, product accumulation and clogging occur in the grinding chamber.

In this case, the following ratio should be ensured during the operation of the grinder [9-11]:

$$q_f = q_g = q_m, \quad (1)$$

where q_f , q_g , q_m – respectively, the amount of feed being transferred to the grinder and being ground and the amount of feed leaving the chamber after being ground, kg/s.

The work output of the grinder can be determined as follows

$$q_{gr.} = q_{com} D_{gr} H_{gr}, \quad (2)$$

where q_{com} – relative productivity of the crusher-crusher, kg/s·m²;

D_{gr} – diameter of the grinder working chamber, m;

H_{gr} – height of the grinder working chamber, m.

The comparative performance of existing grain grinders is the grinding working part, namely hammer or blade $V_b=45-55$ m/s speed is determined and $q_{com} = 2 \div 3 \frac{\text{kg}}{\text{s} \cdot \text{m}^2}$ [12].

We determine the diameter of the grinding rotor using this permissible speed of the grinding blades

$$D_r = \frac{60V_b}{\pi n_r}. \quad (3)$$

If we receive as $V_b=45$ m/s, $n_r=2600$ rpm, then we will find out the diameter of the grinding rotor $D_r=0,33$ m

Based on the diameter of the grinding rotor, we determine the diameter of the grinding chamber

$$D_{gr} = D_b + S_{cl} = \frac{60V_b}{\pi n_r} + S_{cl}, \quad (4)$$

бунда S_{cl} – clearance between the grinder blade and the chamber wall, m.

Previous studies have recommended that the clearance between the grinder blade and the chamber wall be as small as possible. Then if we receive the clearance $S_{cl}=5$ mm, diameter of the grinding chamber must be $D_M=0,38$ m.

The cobs that are sent for grinding must be cut in the grinding chamber into pieces no more than one corn kernel length, namely 20 mm long.

If we assume that the pieces are in the form of a cube with all sides equal, then the number of pieces that can be separated when grinding one corn cob

$$N_p = \frac{V_c}{V_p}, \quad (5)$$

where V_c – total volume of the cob, m³;

V_p – required volume of one ground piece, m³.

We determine the total volume of the corn cob using the following expression

$$V_c = \frac{1}{3} \pi l_c (R_c^2 + R_c r_c + r_c^2), \quad (6)$$

where l_c – length of the corn cob, m;

R_c – the large radius of the corn cob, m;

r_c – the small radius of the corn cob, m

In that case according to (6), (5) will be as following

$$N_p = \frac{1}{3} \left[\frac{\pi l_c (R_c^2 + R_c r_c + r_c^2)}{l_{con}^3} \right], \quad (7)$$

where l_{con} – conditional length of the sides of a piece of ground corn cob, m;

If the average length of the corn cob is $l_c=172,3$ mm, large radius $R_c=20,75$ mm, small radius $r_c=13,4$ mm considering that, then it turns out that in the process of work, one corn cob is divided into 137.5 cubic pieces with sides of 20 mm.

From this, it was found that when grinding one piece of corn cob, under ideal conditions, holes with a diameter of 20 mm $N_p=137.5$ are required for the ground pieces to leave the grinding chamber.

In grain grinders, a round-eyed grinder is used. The sieve surface of a round-eyed sieve corresponding to one hole is defined as follows [12]

$$F_h = (d_h + m)^2 \sin \frac{\pi}{3}, \quad (8)$$

бунда d_m – hole diameter, m;

m – the permissible size of the gap between the holes, m;

In this case, the surface of the grinder is a cylindrical hole that fits all the holes

$$S_{con.} = N_h \cdot F_h = N_h (d_h + m)^2 \sin \frac{\pi}{3}, \quad (9)$$

According to the diameter of the grinding chamber and the surface of the spherical hole, its height is as follows

$$H_{gr} = \frac{S_{con.}}{D_{gr}} = \frac{4N_h (d_h + m)^2 \sin 60^\circ}{D_{gr}}, \quad (10)$$

If the number of holes $N_m=140$ pieces, diameter $d_h=20$ mm, the permissible size of the gap between the holes $m=5$ mm, diameter of the grinding chamber $D_{gr}=0,33-0,38$ m considering that, the height of the grinding chamber we determine that it should be between $H_{gr}=0,2 - 0,23$ m.

4. Conclusions

According to the performed researches, it can be concluded that in order to extract the seeds of the correct size from the corn cobs grown for seed, it is necessary to first cut 3-4 cm from the top and bottom of the cobs, and then separate the pure seed grains from the middle part of the corn cob. However, in this case, if we use them as animal fodder without destroying the parts of grains and grains that are not suitable for seeds, it will increase the productivity of the device even more. For this purpose, in order to ensure the specified performance of the grinder, the diameter of the grinder rotor is $D_r=0.33$ m, the diameter of the grinding chamber is $D_{gr}=0.38$ m, the height of the grinding chamber is $H_{gr}=0.2 - 0.23$ m, and for the output of the ground product the face of its perforated concave $S_{con.}=0.076-0.089$ m² is required. The rotation speed of the grinder rotor required for grain grinding depends on the grinding resistance of the grain to be ground, the impact surface of the grinder rotor and the cross-sectional surface of the grain will be determined during our next research processes.

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