Resource-saving grain husking technology

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Abstract. The paper presents technical solutions aimed at increasing the efficiency of the technological process of grain seed husking by the method of step-by-step removal of fruit and seed coats. For grain seeds, it is not required to perform calibration. The author resource-saving technology and new equipment are described. They involve a multi-stage effect on grain seeds by changing the working technological gap created by the lined elastic material of the inner surface of the body and rotating movable husking hemispheres lined with elastic material, combined into one unit of patented technological equipment. A comparison of the developed resource-saving technology with the technology used for the active action of an abrasive tool by stripping fruit and seed casings is carried out. Key technical solutions were identified. They increase the production efficiency of using a multi-stage process of husking grain seeds by 14%, reduce energy consumption by reducing the amount of equipment used for calibrating seeds by 15%, reduce the amount of waste in the form of bran with a multi-stage resource-saving effect of lined elastic materials for fruit and seed casings by 18%, and increase the yield of uncrushed hulled grain to 91%. The technical devices developed are intended for implementation schemes for processing grain seeds by micro and small farms. The use of the resource-saving technology reduces the cost of grain seed husking by 8-10%, depending on the variety of grain seeds.

1. Introduction

Krasnoyarsk Territory is located in Eastern Siberia. In the north, it is washed by the Kara Sea and the Laptev Sea, and in the south it borders the Republic of Khakassia. The total area of Krasnoyarsk Territory is 2,366,797 square kilometers, while agricultural land is only 2.3% of the total area, and 57.7% are arable land, 14.5% hayfields, 24.7% - pastures, 0.7% - perennial plantations. Agricultural production is carried out in a sharply continental climate, characterized by strong fluctuations in air temperatures. The duration of the period with a temperature of more than +10 °C is less than 40 days in the north of the region, and 110 - 120 days in the south, where the main grain crops with a ripening season of 165 days are concentrated. According to the agricultural portal, the sown area is 133.7 thousand hectares of wheat and 46.6 thousand hectares of barley. As a result of agricultural activities in 2019, Krasnoyarsk Territory harvested 13356.9 cwt of wheat, 3469.4 cwt of oats, 392.6 of rye, 4147.1 thousand cwt of barley. An increase in the sowing areas is due to the fact that grain crops are widely used in the food processing industry and fodder production, and the surplus grain is exported.

An increase in the volume of growing grain crops is due to the increasing number of small farms that specialize in growing grain crops. Farms of Krasnoyarsk Territory with up to 1000 hectares of...
sown area make up 38.2%, from 1000 to 2000 hectares - 18.2%, from 2000 to 3000 hectares - 16.4%, and farms with a sown area from 3000 to 8000 hectares account for 27.2 % [1].

Existing technologies and equipment for processing grain crops are intended for large farms, and small farms are experiencing an acute shortage of small-sized, low-tonnage and energy-efficient resource-saving equipment for processing grain seeds.

Due to the growth in the number of small farms specializing in growing grain seeds (in Krasnoyarsk Territory, their share is 72.8% of the total grain production), it is necessary to develop new resource-saving technological equipment for small farms.

Wheat grain husking technologies are used at grain processing enterprises that have different production capacities depending on specialization and can process up to 100 tons of grain per day. The development of small farms requires scientific and technical research on husking and studies on technical possibilities of using the existing serially produced technological equipment. It was found that the solution to the problem for the further development of farms is the development of new small-sized and energy-saving technological equipment.

The purpose of this study is to develop resource-saving technology and technical means to increase the efficiency of the process of husking grain seeds for micro and small farms.

2. Research Methods
At the initial stage, a comparative analysis of existing and developed technologies was carried out to determine the design differences and identify the inefficiency of existing equipment [2]. To increase the efficiency of the technological process and develop new equipment, the results of patent research carried out in accordance with GOST R 15.011-96 "Patent research" were used. The development and delivery of products for the production of a prototype were carried out by mathematical modeling of the technological process. The research was carried out using a computer, a Microsoft Excel spreadsheet, and a computer simulation program [3].

Tests of an experimental sample of the resource-saving technology of multi-stage husking were conducted in the laboratory conditions of the Institute for Food Production on the basis of regulatory documents “Tests of agricultural machinery. Test program and methods”.

3. Results and discussion

Figure 1. The diagram of resource-saving technology for husking grain seeds
According to the author resource-saving technology for husking grain seeds, grain seeds of large geometrical sizes are husked with a minimum number of revolutions of the electric motor. With an increase in the number of revolutions, due to centrifugal forces and movable husking hemispheres, the gap between the lined elastic pads decreases and the process of husking of grains of small seeds begins. It allows for 100% processing of different sized seeds [4]. The technological scheme of the developed resource-saving technology is shown in Figure 1.

To implement the technological process, a new device for husking grain has been developed (Figure 2), patent of the Russian Federation No. 2701802 "Device for husking grain" [4]. Its kinematic diagram is shown in Figure 2.

![Figure 2. The diagram of resource-saving technology for husking grain seeds](image)

The device for husking grain consists of electric motor 1 connected by shaft 2 with coupling 3 and rotating shaft 4. The rotating shaft 4 is mounted on bearings 5, 6 in a housing lined with elastic material 7. The housing 7 lined with elastic material has loading mouth 8 and unloading opening 9. It is mounted on support frame 10. On rotating shaft 4, there are struts 11 with limiting tips 12 installed in glass 13 inside the shelling hemispheres lined with elastic material 14. The shelling hemispheres 14 lined with elastic material have internal holes in the form of glass 15 where spring 16 is installed. It is connected to a rotating shaft at one end, and to a husking hemisphere lined with elastic material 14 at the other end. The discharge opening 9 contains grain cleaning chamber 17 with delivery pipe 18, sieve 19 and outlet 20. In delivery pipe 18, fan 23 is installed. The device for husking grain works as follows: electric motors 1 and 22 are turned on, when electric motor 1 is operating, the torque is transmitted to bulk 2, coupling 3 and rotating shaft 4, mounted on bearings 5, 6 in housing 7 lined with elastic material, installed on support frame 10. Grain is fed into loading mouth 8. When shaft 4 rotates, the torque is transmitted to the mass of shelling hemispheres 14 lined with elastic material, which move along posts 11, to limiting tips 12 installed in glasses 13. When moving shelling hemispheres 14 lined with elastic material, the working gap between the housing 7 lined with elastic material decreases. The movement of shelling hemispheres 14 lined with elastic material is limited by spring 16 installed in glass 15 and connected to shelling hemispheres 14 lined with elastic material and rotating shaft 4. The movement of shelling hemispheres 14 lined with elastic material provides a working gap for husking grain, and with an increase in the number of revolutions, the gap decreases due to centrifugal forces to the limit determined by limiting tips 12. Thus, the required working gap is set.
determined by changing the speed of electric motor 1. When electric motor 22 is operating, the torque is transmitted to shaft 22, which ensures the operation of fan 23 installed in discharge pipe 18, which has sieve 19. The supplied air flow enters the chamber for cleaning peeled grain 17 through discharge pipe 18 passing through sieve 19, while the cleaned grain enters unloading hole 9, light impurities from husking are removed by air through outlet 20.

According to the results, the expected economic effect of the device for husking manufactured according to RF patent No. 2701802 "Device for husking grain"[5] was determined by the methodology for determining the economic efficiency of new technology, inventions and rationalization proposals in the national economy.

The annual economic effect is 7,585,800. It is calculated as the sum of savings of all production resources (labor intensity, materials, capital investments).

4. Conclusion
A comparative analysis of existing technologies for husking grain using an abrasive tool working by husking fruit and seed shells showed that the author resource-saving technology husks grain using lined elastic materials installed on the inner surface of the body and rotating elastic lined materials of movable husking hemispheres regularly changing the technological gap.

A comparison is made between the developed resource-saving technology and the technology used for the active action of an abrasive tool by husking grain.

According to the developed technology, the total yield of husked seeds increases up to 100%, while the aleurone and subaleurone layers and endosperm of grain are not destroyed g due to the coating of the working bodies with lined elastic material, which reduces the yield of bran to 18%, the total metal consumption of equipment used by 20% and energy consumption by 14%.

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