Gravity grain cleaning machine and its importance in grain logistics and sustainable agriculture

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Abstract. The design schematic of a gravity-based seed cleaning machine was developed, and experimental tests were conducted. The gravity grain cleaning machine (GUTM) demonstrated a cleaning efficiency of 95%, ensuring that seeds met standard requirements in a single cleaning cycle. The compact and lightweight design of the machine, capable of performing the functions of four processing machines, led to a 50-60% reduction in energy consumption and an economic efficiency increase of SUM 1600 thousand/ton. Despite utilizing only one sieve as the primary component, the gravity seed cleaning machine achieved a seed purity level of up to 98.5%, particularly with seed wheat. The device's implementation resulted in a significant 50-60% reduction in production costs, streamlined inter-district transportation, prevented the mixing of elite seed varieties, and lowered loading and electricity expenses.

1 Introduction

In the "decree № PF-5853 On Approval of the Strategy of Agricultural Development for 2020-2030" [1] defined important tasks on rational placement of agricultural crops, further improvement of the farming system, crop rotation, crop rotation, stabilization of grain independence, improvement of soil fertility and yield. In this regard, the development of the impact of the full implementation of the new farming system in the cotton complex on the dynamics of crop yields and other aerobiological indicators is relevant, the scheme of grain: cotton 1:1 on crop rotation is introduced.

Analysis of international experience shows that 200 million people in more than 100 countries. More than 100 thousand hectares are sown with wheat, 729.0 million tons of grain are grown. In this regard, stabilization of food security is considered as one of the most urgent problems on a global scale, as well as the development of farming system, optimal forms and systems of crop rotation. According to the report of the Food and Agriculture Organization of the United Nations (FAO), published in October 2017, the world cereal production showed

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a high result in 2017, reaching 2.612 billion tons, which is 6.8 million tons more than in 2016. winter wheat was sown on an area of 1 million 77 thousand hectares and 7 million 128 thousand tons of grain was grown [2-4].

In this connection, complex measures aimed at gravitational cleaning of grain field seeds are realized in the republic. Up to now in scientific researches on seed preparation researches on development of scientific and technical solutions for sowing seeds on grain fields and substantiation of technical means applied in this process have been carried out insufficiently [5-8]. Particular attention is paid to the results of research to ensure the possibility of gravity cleaning of seeds by low-energy and material-intensive technical means, taking into account biological properties, physical and mechanical properties and quality indicators of seeds [9-12].

According to the world experience of grain farming, it is possible to sow up to the fifth generation of grain. In our country, for humid places it is planted up to the second generation, for arid places - up to the third generation. Seeds imported from Russia for expensive currency are planted for only two years. The reason for this is that as a result of bringing several different varieties to one grain enterprise and sorting all the grain varieties and their progeny in one seed shop, the varieties will mix with each other and in a short time the fertility will be disturbed. According to the rules of seed production, super elite generation seed must be stored in bags, cleaned, sorted and processed according to special methods. We have no possibility to do this. Based on the above, the issue of creating a mini-technology for cleaning, sorting, processing and packaging of primary seeds of high generation of such crops as wheat, barley, rice, mesga, corn and sorghum is relevant [13, 14].

2 Materials and methods

K.D. Astanakulov, F.M. Mamatov, F.Y. Karshiev, A.U. Kuziev, D.K. Khudainazarov are prominent scientists from Uzbekistan who have conducted research on enhancing the efficiency of sorting grain products. Their work focuses on determining the relationship between combine harvester productivity and harvesting height. Additionally, R. Boimatov, Y. Kholyrov, Astanakulov K., and Shokirov K. have contributed to the effective utilization of combines in harvesting grain crops, providing valuable recommendations and suggestions. However, the production of wheat, barley, rice, corn, legumes, and sorghum is primarily carried out by the Research Institute of Grain Legumes, Research Institute of Rice, large farms, clusters, and elite seed farms. Despite this, there are complex issues surrounding the economic efficiency and the application of new technologies for cleaning and sorting seeds of these crops that remain inadequately explored in existing research [15-22].

The process of separating bulk materials, which differ from each other in their geometric features and physical properties, into groups is called. The machines used in this process are called rotary separators.

Roller separators are used at enterprises for storage and processing of grain to clean the main type of grain from foreign impurities differing in linear dimensions (width and thickness); it is used to separate it into separate groups by size in preparation for husking of grain intended for consumption, as well as in sorting grain products and husked grain.

To separate grain products from foreign impurities, they are sieved in separators. In seed mills, corn seeds are sorted by shape and size using sieves.

As a result of sieving, the initial product consisting of different parts is separated into two parts (Figure 1). The part of the mixture that has passed through the openings of the sieve or screen is called the product and the part that has slipped off the surface of the sieve is called the residual product [22-24].

Afterward, we will conventionally refer to separators used for cleaning grain from foreign impurities or separating whole grain into groups as sieves, while separators used for sorting milled or ground grain products based on their geometric dimensions will be called sieves.

Gills with round openings can hold objects whose width surpasses the diameter of the opening. Therefore, in such mills, the product is separated based on the width of its individual particles or from the grain mixture, which differ in width from the main type of grain.

Holsters with long openings can hold objects whose thickness exceeds the width of the opening. Such sieves can be used to separate the primary product into groups based on the thickness of specific particles or to clean the main grain species from impurities that differ in thickness.

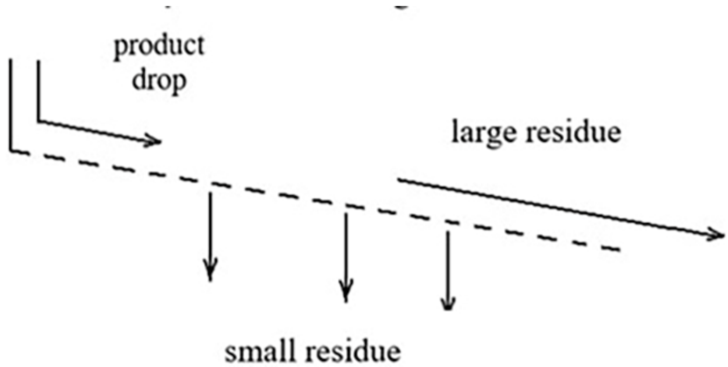

Fig. 1. Separation of the grain mixture in Strainer into two groups.

To evaluate the performance of bubble separators, the following indicators were adopted [17,15,19]:

- productivity Q - the amount of grain entering the machine per unit of time, kg/s;
- efficiency of grain cleaning from impurities E, %; the amount of whole grain in the waste a, i.e. qualitative assessment of the separation process, %.

The efficiency of separators with coils is determined by the results of the product balance and is expressed as follows:

$$Q = G/t; \quad (1)$$

where: G - mass of initial grain entering the machine, kg; t - time of balance acceptance, s.

The efficiency of cleaning grain from impurities is determined by the following formula (%):

$$E = \frac{A - Б}{A}(100 - a) \; ; \quad (2)$$

where: A - the amount of foreign impurities in the original grain to be separated, %; B - the amount of foreign impurities remaining in the grain after cleaning, %;

a - the amount of whole grain remaining in the waste in relation to the mass of mixtures to be separated, %.

In addition, the efficiency of grain cleaning machines can be determined by the following formula:

$$\eta = \frac{A - aA}{B} \cdot 100 \; ; \quad (3)$$

where: A - mass of waste, kg;
B - mass of foreign impurities to be separated in the original grain, kg;
a - relative amount of whole grain in the waste.

The efficiency of grain cleaning is determined by the rules of organization of the technological process. According to him, at the primary cleaning of grain

efficiency should not be less than 65%.

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3 Results and discussion

A design scheme for a gravity seed cleaning machine intended for this purpose was developed, several modifications were made, and then sufficient experimental tests were conducted to continue the improvement work.

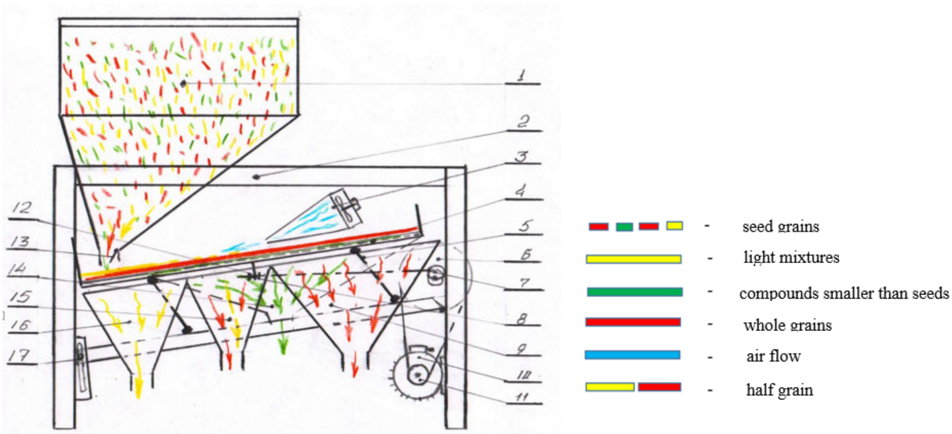

Fig. 2. Technological scheme of the machine for seed cleaning by gravity method: 1st hopper; 2nd housing; 3-fan; 4th sieve; 5-tie carrying the sieve; 6- large pulley; 7-axial central axis; 8- oscillating tie; 9-grain threshing shed; 10-electric motor; 11-rotary pulley; 12-pull shock absorber; 13-grain flow regulator; 14-may garbage disposal; 15-grain threshing machine; 16-lamp mixing unit; 17-sieve inclination change regulator.

An experimental piece of gravity seed cleaning machine was designed to carry out experiments on seed cleaning machine sizing (Figure 2).

The study of deformation in the cleaning process of the gravity seed cleaning machine can improve its performance and adapt it to all requirements taking into account other factors.

As a result of cleaning under steady-state conditions, tensile, bending and partial torsional deformations occur. Also according to the technological image of the gravity seed cleaning machine, its prototype was developed (Figure 3).

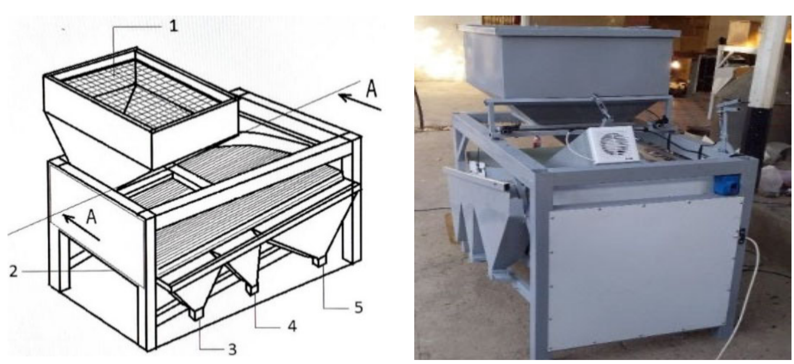

Fig. 3. Experimental instance of gravity seed cleaning machine: 1-seed grains; 2-small mixtures; 3-light mixtures; 4-half grains; 5-grains.

The conditions of tensile, bending and torsional strength were analyzed and permissible strain stresses were determined when seeds were treated for a certain length.

The developed equipment will be transported to Kumkurgan district of Surkhandarya province to the grain cleaning site. The distance from Sherabod district to Kumkurgan district is 40 km. It is necessary to clean 1000 tons of wheat grain in Novo-Sherabod district. Trucks are used to deliver 1000 tons of wheat to the destination.

*L*1 t km*K load*

where:
L=distance of delivery L=75 km
K load= load capacity K load=18 tons
R=1 tkm 1 tkm=2000
75*2000*18=2 700 000

The cost of one-time cargo transportation was 2 700 000 UZS. Now if to calculate on the basis of 1000 tons:

1000/18=55 (flight) trips

A surplus of 2,700,000*55=148,000,000 UZS has been created. Then the Sherabod cluster realized that if they take the amount from each trip, then from 55 trips they will lose 148,000,000 UZS.With this in mind it will be better if they buy a "Gravity Seeding Machine" and this is half of this cost, that it will be compatible.

Note: The benefits of this "Gravity Seed Cleaner" were tested by the Sherabod cluster during the 2022 grain cleaning season and verified that it is indeed an efficient and energy saving technique.

Using the example of Angora district: there is no grain cleaning plant in Angora district, so 4500 tons of seed wheat are brought to Termiz enterprise "Alpomish DMQQKK". Now let's calculate the cost of its transportation.

*L*1 t km*K load*

where:
L=distance of delivery L=35 km
K load=load capacity K load=18 tons
R=1 tkm 1 tkm=2000

*35*2000*18=1 260 000*

The cost of transportation of one-time cargo was 1 260 000 UZS. Now if we calculate based on 4500 tons:

4.500/18=250 (trips) will be available.

For additional travel expenses 1,260,000*250=315,000,000 UZS will be spent.

Another additional cost is loading the grain onto the truck. In production, forklifts are used for loading. Large capacity machines (Lipxer) are used. Costs are incurred even before the goods are loaded onto the vehicles.

4 Conclusion

The device, type and classification of seed cleaning machines, principles of operation are studied. Based on the analysis, the design of the machine for seed cleaning by gravity method is created, and the model and prototype are developed.

The working principle is based on compact, lightweight, low price, very high cleaning ratio, dimensions and operation modes of gravity seed cleaning machine, which can fulfill the functions of four processing machines. According to it, the cleaning effect of the gravity seed cleaning machine (GUTM) was 95% and it was found that the seed could reach the standard requirements in one cleaning. As a result of the compactness and lightness of the presented machine, and the ability to perform the functions of four processing machines, the energy consumption was reduced by 50-60%, and the economic efficiency is 1600 thousand UZS/ton. The theory of longitudinal and transverse movement of seed in the sieve is based. In the course of theoretical and practical research it was found that the sieve is installed at a slope of 27-30 degrees relative to the ground. Despite the fact that only one sieve is installed as a working part of the gravity seed cleaning machine, seed grains, especially seed wheat, for one cleaning are brought to the level of conditioned seeds, that is, it is possible to separate them. up to 98.5%. As a result of introduction of the device the reduction of production cost by 50-60% was achieved. In a word, if we release "Gravity Seed Cleaning Machine": inter-district transportation costs will be reduced, mixing of elite varieties of high generation seeds will be avoided, loading costs and electricity consumption will be reduced.

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