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Theoretical study of the process of sorting rice seeds under the influence of an electric field

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ABSTRACT: In recent years, special attention has been paid to the cultivation of rice in the Republic of Uzbekistan. As a result, the article presents information about the result of the development of a dielectric sorter device for rice seed sorting, its principle scheme and structure, and the principle of operation. Preliminary experimental research on rice seed sorting in a dielectric sorter device has shown that it is possible to obtain high-quality seed material, which is the key to high yields in the future.

KEYWORDS: rice seed, dielectric sorting device, sorting, working body, polyethylene pipe, counter electrode, electric field, uneven electric field, electric field strength, seed fraction, technical fraction.

I. INTRODUCTION

It is known that the quality indicators of the seeds prepared for planting play a very important role in the production of abundant crops from agricultural crops, along with other agrotechnical measures. Because the use of high-quality seeds for sowing, biological properties close to each other, fertility in laboratory and field conditions, and high potential yield is one of the main factors in increasing the yield of agricultural crops. Sorting of rice seeds allows to reduce the consumption of seeds planted on land, to ensure even and smooth germination of seeds, to increase productivity and to reduce the cost of cultivated products. In order to carry out these works, it is necessary to use energy and resources wisely, to develop technology and technical means that save them.

As a result of the scientific and research work carried out in the following years, various modifications of dielectric devices for sorting the seeds of agricultural crops were developed [1,2,3,4,5,6]. However, the lack of improvement and some shortcomings of the proposed devices prevent their large-scale introduction into technological systems of seed preparation.

Therefore, in order to obtain selected seeds with similar biological properties, high fertility and potential productivity in laboratory and field conditions, it is an urgent issue of today to develop and justify the parameters of an improved energy and resource-efficient universal device that increases the efficiency of seed sorting of agricultural crops. is of great practical importance for the economy.

II. BACKGROUND OR RELATED WORK

The main focus of the article is on the characteristics of the electric sorting device for use in the process of sorting rice seeds in agroclusters and farmers and farms in Uzbekistan. Literature Review Section III, Methodology Section IV, Section V discusses the experimental results of the study and Section VI shows the future research and conclusion.

The dielectric sorter mainly focuses on how it has the characteristics of using the rice seed in the electric field sorting process. The study of literature survey is presented in section III, Methodology is explained in section IV, section V dicusses the experimental results of the study, and section VI shows the future study and Conclusion.

III. LITERATURE SURVEY

In the theoretical study of the sorting process of rice seeds in the electric field generated between electrodes of opposite directions, it was carried out on the basis of mathematical analysis using the laws and rules of theoretical mechanics.

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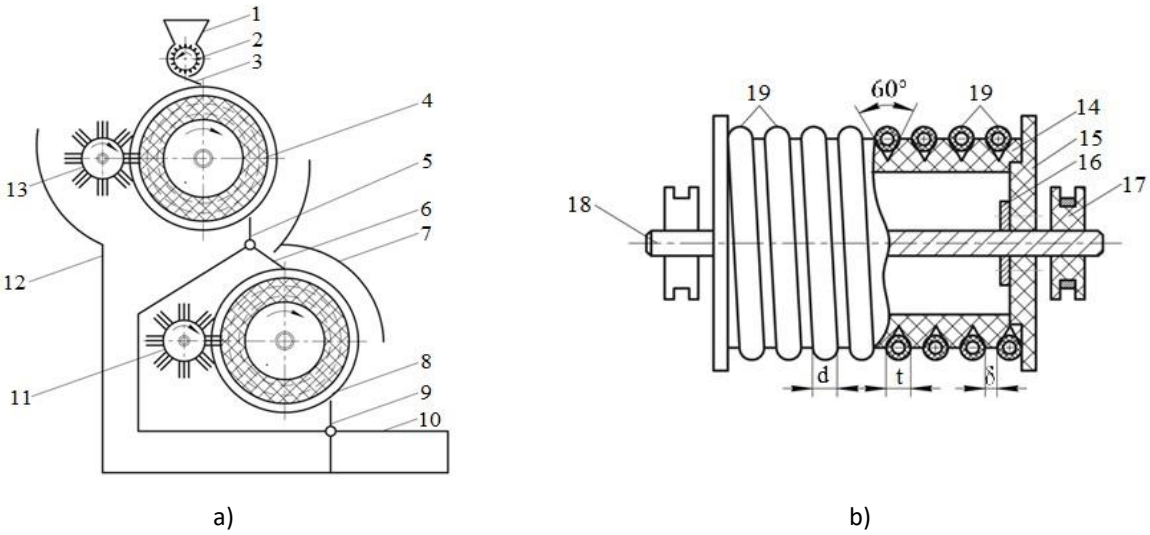
IV. ANALYSIS AND RESULTS

As a result of patent studies, preliminary theoretical and experimental studies, a special device was created for sorting rice seeds in the electric field generated between electrodes with opposite directions [2,3,4]. Figure 1 shows the principle diagram and working body of the dielectric sorter device developed for rice seed sorting.



a) b)

a) schematic diagram of the device; b) body of work
1-loading hopper; 2–supplier; 3, 6 – sliding board; 4, 8-work body; 5, 9–dividing plane; 7, 12–protective walls; 10-receiving bunker; 11, 13–separating brushes; 14-polyethylene pipe; 15-side disks; 16 – flanges; 17-current transmitters; 18-val; 19–electrodes with opposite signs

The working organs of the device are made of polyethylene pipe 14, two-lane winch-shaped canvases with a depth angle of "γ", width of "t_1" and distance between "δ_1"are directed at the surface of the working body located above, and opposite-pointing electrodes with a diameter of d_1, that is, close to the thickness of the rice seed are twisted into them. On the surface of the work organ below, however, two-lane winch-shaped canavas with a depth angle of "γ", width of "t_2", and distance between "δ_2" are channeled, into which are placed opposite-pointing electrodes with a diameter of d_2, that is, close to the width of the rice seed. Two-lane winch-shaped canvas-oriented polyethylene pipe 14 is fastened to val 18 using side discs 15 made of dielectric material and flanes 16. The opposite-signal electrodes are connected to a high-voltage source through 19 current switches 17.

The principle of operation of the device is as follows. When it is connected to the network, the feeder 2, working organs 4 and 8, as well as the detachable brush 11 and 13s through chain transmissions with the help of an electrodvigator and a reducer are driven in a circular motion. At this time, the rice seeds to be sorted are delivered from the loading hopper 1 to the surface of the working body 4 at the same rate through the feeder 2 and the sliding board 3. The seeds, falling on the surface of the rotating working body 4, are placed between the electrodes 19 with opposite directions according to their thickness, and are polarized under the influence of the electric field generated between the opposite electrodes 19, and under the influence of the generated electric field strength is drawn. In addition to the force of the electric field, the seeds are also affected by centrifugal force, weight, inertia, reaction and frictional forces. Based on the ratio of the forces exerted, rice seeds, depending on their physical and mechanical properties, are disconnected from the surface of the working Body 4 at different angles, quality seeds fall on the surface of the lower working body 8, while poor-quality seeds, when turned into large corners, are disconnected or separated using a brush 11, fall.

The rice seeds that are cut off from the surface of the upper working body 4 and fall onto the surface of the lower working body 8 are placed across the width between the electrodes 19 with opposite signs, and the technological process of sorting is repeated. Rice seeds sorted by thickness and width and other important properties are cut off from the surface of the lower working body 8, separated into the seed fraction of the receiving hopper 10, placed in bags and sent for planting.

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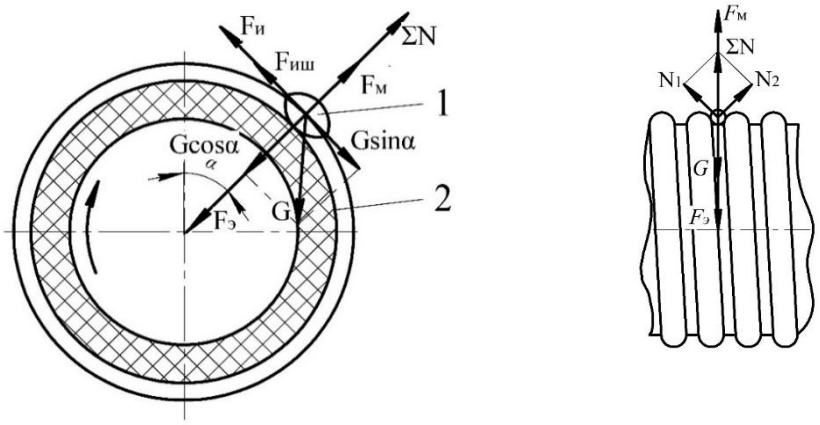
The seeds stuck to the surface of the working body 8 are cut off at large angles or separated with the help of a brush and fall into the technical fraction of the receiving hopper 10.

By changing the value of the voltage applied to the opposite signal electrodes, it is possible to change the angle of disconnection of rice seeds from the surface of the working organ, as well as the amount of separation to the seed and technical fraction. To do this, it is necessary to correctly select the coordinates of the axis of the plane of being of the receiving bunker.

The correct selection of the coordinates of the axis of the dividing plane of the receiving hopper allows to accurately separate the rice seeds cut at different angles from the surface of the working body into seed and technical fraction. This can be achieved by theoretically justifying the value of the voltage applied to the electrodes with the opposite direction and the angle of breaking the rice seeds from the surface of the working body.

Figure 2 describes a scheme of forces acting on rice seeds that have come to the surface of the working organ of the proposed dielectric device.



a) b)

Figure 2. Scheme of forces acting on rice seeds: 1-rice seed; 2-working body

As can be seen from the picture, the following forces affect the rice seeds falling on the surface of the working body with opposite electrodes:

1. The electric field strength generated by the electric field created between electrodes of opposite sign [7]

$$F_э = \frac{2S_y \cdot U^2 \varepsilon_0 \varepsilon_u{}^2 (\varepsilon_y - 1)}{(2h\varepsilon_y + l_y \varepsilon_u)^2} \cdot \cos\frac{\theta}{2}, \qquad (1)$$

where S_y is the effective polarized surface of the seed touching the electrodes, m^2; U - the voltage supplied to the electrodes, V; ε_0 = 8, 85·10^{12} F/m-Electrical constant; ε_u and ε_y - insulation of electrodes and dielectric absorption of seeds; h – thickness of electrode insulation, m; l_y – average length of lines of force in seeds, m; θ – the angle between the electric field forces and the vertical plane, degrees.

2. Centrifugal force

$$F_м = \frac{mV_y^2}{R}, \qquad (2)$$

where m - is seed mass, kg; V_y – linear speed of seed, m/s; R - the distance from the center of rotation of the work body to the center of gravity of the seed, m.

3. Gravity

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$G = mg,$ (3)

where g - is the acceleration of free fall, m/s^2.

4. Inertia force

$$F_и = \frac{mdV_y}{dt}.$$ (4)

5. Reaction force ΣN.

6. Frictional force

$F_{иш}=f\Sigma N,$ (5)

where f is the coefficient of friction of rice seeds on the surface of the electrodes.

As shown in Figure 2, the electric field force pulls the Fe rice seeds to the surface of the working body, the centrifugal force pushes it, the gravity force presses on it in the first half quarter, and pushes it away in the second half quarter. Therefore, depending on the ratio of the forces acting on the rice seed, it is possible to base them on the angles of separation from the surface of the working body and the value of the voltage applied to the electrodes.

According to the scheme shown in Figure 2, ΣN=0, i.e., this condition must be met in order for the rice seeds to break off from the surface of the working body.

$F_э - F_м+G\cos\alpha=0,$ (6)

where α - is the angle of rotation of the seeds from the surface of the working body, degrees.

(6) by substituting the forces Fe, Fm and G in the expression and making some modifications, we obtain the following expression to find the break angles of rice seeds from the surface of the working organ of the dielectric sorting device

$$\alpha = arccos\left[\frac{V_y^2}{gR} - \frac{2S_y \cdot U^2\varepsilon_0\varepsilon_u^2(\varepsilon_y - 1)}{mg(2h\varepsilon_y + l_y\varepsilon_u)^2}\cdot\cos\alpha\frac{\theta}{2}\right]$$ (7)

As can be seen from the last expression, when the constructive dimensions and operating modes of the working body are constant, it turns out that the angle of disconnection of the rice seeds from its surface depends on the square of the value of the voltage-to the opposite-sign electrodes, as well as their self-physicochemical properties (S_y, ε_y, m).

At the same time, in the proposed dielectric device, by changing the value of the voltage applied to the opposite electrodes, depending on the physico-mechanical properties of rice seeds, by widely changing the angles of their separation from the surface of the working body, sorted rice seeds It is possible to change the quantity and quality of separation into two fractions, i.e. seed and technical fraction.

Using the expression (7), we calculate the angles of separation of rice seeds from the surface of the working body of the dielectric device at the following values of the parameters: $V_y=V_б$=0,92 m/s; g=9,81 m/s^2; R=0,178 m; S_y=46,26·10^{-6} m^2 and 75,86·10^{-6} m^2; $\varepsilon_и$=4,0; ε_y=10; h=0,675·10^{-3} m; l_y=2,05·10^{-3} and 3,26·10^{-3} m; m=10; 20; 30; 40 and 50 mg; U=1000; 1500 and 2000 V.

Figure 3 shows graphs of changes in the angle of separation of rice seeds from the surface of the working body depending on the mass at different values of the voltage applied to the electrodes.

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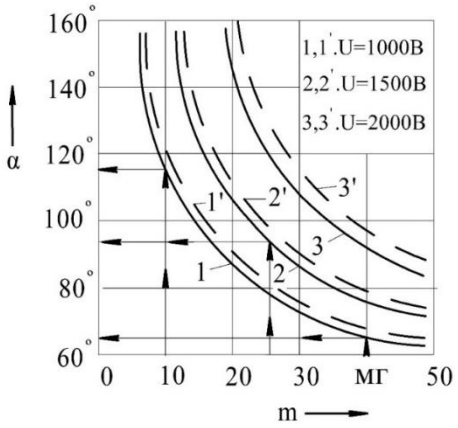

Figure 3. Graphs that change the mass(m) associated discontinuity angles(α) of rice seeds at different values of voltage(U):

———— – for the working body located above;
— — — – for the work body below.

From the curves depicted, it can be seen that when the value of the voltage applied to the electrodes is the same, as the mass of the rice seed changes, the angles of disconnection from the working body are changing. For example, when a voltage of about 1000 V is applied to the electrodes, a rice seed with a mass of 10 mg breaks off when it is turned at an angle of 117°30' from the surface of the working body, while a rice seed with a mass of 40 mg breaks off from its surface at 65°33' breaking when cornering (Fig. 3, curve 1). That is, when the value of the voltage applied to the electrodes does not change, as the mass of rice seeds increases, it is observed that the angle of separation of them from the surface of the working body of the dielectric device decreases.

At the same time, the change in the value of the voltage applied to the electrodes with the opposite direction leads to a change in the breaking angles of rice seeds of the same mass from the surface of the working body. For example, when a voltage of about 1000 V is applied to the electrodes, a rice seed with a mass of 25 mg breaks off from the surface of the working body at an angle of 75°20' (Fig. 3, curve 1), when a voltage of about 2000 V is applied to the electrodes, it breaks when it turns 122° (Fig. 3, curve 3). So, with an increase in the value of the voltage applied to the electrodes, it is observed that the angle of separation of the rice seeds from the surface of the working body of the dielectric device increases. From this, it can be concluded that by changing the value of the voltage applied to the opposite electrodes, it is possible to control the technological process of sorting rice seeds in a dielectric device.

The analysis of the curves depicted in Figure 3 shows that if the rice seeds with a mass of less than 25 mg are considered to be of poor quality and unsuitable for planting, it is sufficient to apply a voltage of about 1500 V to the electrodes of the opposite direction to sort them in the dielectric device. (See Figure 3, curve 2). Increasing the value of the voltage applied to the electrodes over 1500 V increases the angle of breaking rice seeds from the surface of the working body and the transfer of quality seeds to technical fractions, while decreasing it causes the reduction of the angle of breaking rice seeds from the surface of the working body and poor quality seeds. causing the seed to mix into the fraction.

V. CONCLUSION

For sorting rice seeds in a dielectric device, when the diameter of the working body is 350 mm and the number of revolutions is equal to 50 min^{-1}, it is enough to apply a voltage of about 1500 V to the electrodes with opposite signs, and clearly separate them into the seed and technical fraction. and allows to obtain high-quality seeds for planting, biological properties close to each other, fertility in laboratory and field conditions, and high potential yield.

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