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Ways to Improve Electrical Sorting Devices

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ABSTRACT. In article data on the short analysis of the electric sorting devices and a working hypothesis, a way of their improvement, the schematic diagram and working body advanced power - resource-saving electric sorting devices and the principle of its work, forces of the crops operating on seeds of the trimmed cotton seeds which got on a surface of working body, results of theoretical justification of a corner of a separation from its surface and also size of the enclosed tension are provided to heteropolar electrodes.

KEYWORDS: Seeds of crops, sorting, a dielectric drum, heteropolar electrodes, electric field, power - and resource-saving, the device, the induced electric field, electric field between heteropolar electrodes, electric force

I. INTRODUCTION

By researches of scientists it is established that sorting of seeds of crops needs to be made for receiving high-quality, biologically uniform and full-fledged sowing material not on one sign, and on set of all major physicomechanical properties [1]. Methods of sorting of seeds of a agricultural of cultures in electric field as the essence of electric methods of sorting is that they make electropower impact on seeds in view of their affine meet such requirements and affect them selectively, taking into account set of all physicomechanical properties. As a result, sorting of seeds of agricultural cultures in electric field is carried out not on one sign, and on set of all major physicomechanical properties, i.e. on the weight, the geometrical sizes, density, fineness, electrical resistance, dielectric permeability, etc.

II. SIGNIFICANCE OF THE SYSTEM

In article data on the short analysis of the electric sorting devices and a working hypothesis, a way of their improvement, the schematic diagram and working body advanced power - resource-saving electric sorting devices and the principle of its work. The study of literature survey is presented in section III, methodology is explained in section IV, section V covers the experimental results of the study, and section VI discusses the future study and conclusion

III. LITERATURE SURVEY

Considering the last, scientists it is offered to sort seeds of crops in various electric fields [2, 3, 4]. However, despite a certain advantage of an electric method of sorting in comparison with pneumatic and mechanical methods it did not find still widespread introduction in technological lines of preparation of sowing seeds of crops. It was interfered by some shortcomings of the electric sorting devices, for example, relative humidity and temperature of air have a negative impact on stability and efficiency of technological process of sorting of seeds of crops in the field of the crown category and electrostatic field. Besides, use for power supply of the electrocrown and electrostatic sorting devices of constant voltage about 30-40 kV, complicates their technological service and demands use of special expensive converters.

IV. METHODOLOGY

For widespread introduction of electric methods of sorting in technological lines of preparation of sowing seeds of crops by scientists the dielectric method of sorting is offered [5.6]. The essence of a dielectric method of sorting is that seeds of crops getting between the heteropolar electrodes which are reeled up on the surfaces of the dielectric reel in the form of the two-way screw and connected to the high-voltage power supply, are polarized also

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under the influence of the arising electric force, attracted to them. Depending on a ratio of operating forces and, respectively, physicomechanical properties seeds of crops come off a surface of the rotating working body at various angles of rotation and get to the corresponding compartments of the reception bunker, i.e. to sowing or technical fractions. The carried-out research works in this direction showed that use of a dielectric method for sorting of seeds of crops allows to eliminate above-mentioned defects. At the same time, unlike electrocrown and electrostatic methods, at a dielectric method, sorting of seeds can be made as in variable, and constant electric field, without charging their free electric ions. The last partially excludes influence on technological process of sorting of seeds of environmental conditions and air temperature. However, the developed sorting devices based on a dielectric method also did not find broad application in technological lines of preparation of sowing seeds because of limitation of their functional opportunities.

V. EXPERIMENTAL RESULTS

On the basis of the research works which are carried out in recent years for sorting of cotton-raw on previously allocated short meetings and seeds the small seeds of cultures by scientists is offered a triboelectric method [7.8]. Essence of this method are that electric field arises at friction of two dielectric bodies of rotation, i.e. a dielectric drum and the removable (rubbing) brush. The short meetings or seeds the small seeds of cultures which got on a surface of the rotating charged dielectric reel, are polarized and under the influence of the arising electric force are attracted to it. Depending on a ratio of operating forces and, respectively, physico-mechanical properties, they come off the surface of the rotating charged dielectric reel at various angles of rotation and get to the corresponding compartments of the reception bunker. In this regard, at a triboelectric method of sorting, for creation of electric field of high voltage it is not required high-voltage power supplies. The mechanism for implementation of this method is simple on a design, is easy in production, electro and is fireproof also the most important, without additional high-voltage power supply. However, the triboelectric method can be used only when sorting short meetings of cotton-raw and seeds the small seeds of cultures.

Due to the above, on the basis of the analysis of the existing electric methods of sorting of seeds of crops and relying on achievements of chemical industry in recent years, we put forward a scientific hypothesis – to improve the electric sorting devices by combination of electric fields arising in two different conditions i.e. the electric field arising at the friction of two dielectric bodies of rotation and electric field of one working body arising between heteropolar electrodes on a surface [9, 10]. It will allow to increase electric forces of pressing of seeds of crops to a surface of working body that will provide increase in efficiency of their sorting and clearness of division into sowing and technical fractions.

On the basis of the made scientific hypothesis and the conducted preliminary theoretical and pilot researches the advanced electric sorting device is developed.

In figure 1 the schematic diagram and working body of the sorting device offered advanced electric for sorting of seeds of crops is submitted.

The advanced electric sorting device consists of loading bunker 1, feeder 2, the grounded electrode 3, working body 4, reception bunker 5, the removable (rubbing) brush 6, a cattle board 7.

The working body 4 is executed a type of dielectric reel 8 and on which its surface two-way spiral flutes with a hollow corner "φ", with of "t", in distance between them "δ" are cut and heteropolar electrodes 13 are reeled up on them (fig. 1, b). Dielectric reel 8 by means of flanges 9 and side disks 11 made also of dielectric material is fixed on a shaft 12. Heteropolar electrodes 13 via slip rings 10 are connected to the high-voltage power supply.

The principle of operation of the advanced electric sorting device consists in the following. At connection of the device to network by means of the electric motor and a reducer, through chain transfer, feeder 2, working body 4 and a removable brush 6 is given to the rotary movement. At this time from loading bunker 1 by means of feeder 2 and a cattle board 7 the sorted seeds of crops a uniform layer move on a surface of working body 4. The seeds which got on a surface of working body 4 under the influence of the induced electric field and electric field of heteropolar electrodes 13 are polarized and attracted to it.

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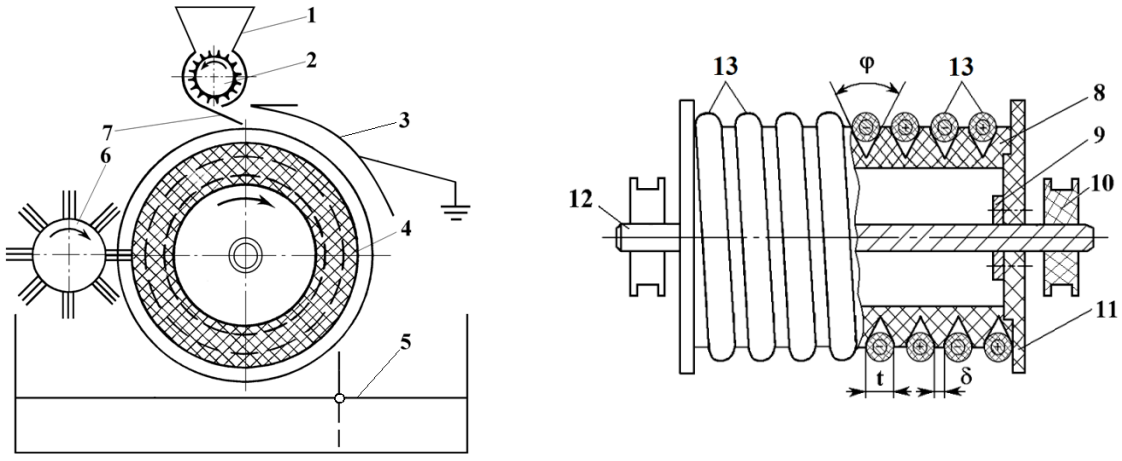

а) *б)*

Figure 1. Schematic diagram (a) and working body (b) advanced electric sorting device:
1 – loading hopper; 2 – feeder; 3 – grounded electrode; 4 – working organ; 5 – receiving bunker; 6 – removable (rubbing) brush; 7-pitched board; 8 – dielectric drum; 9 – flanges; 10 – current collectors; 11– side discs; 12– shaft; 13 – bipolar electrodes

As a result the seeds of crops which got a surface of working body 4 are affected by the total electric force of $F\Sigma$ consisting of the electric force of $F_k$caused by action of the induced electric field on a charge of seeds, electric force of the mirror $F_z$display caused by interaction of a charge of seeds with the charged dielectric reel and the electric force of F_e, caused by action of electric field of heteropolar electrodes 13 on seeds. Except total electric force seeds of crops are also affected by the centrifugal force of F_s, gravity of G, inertia of Fi, friction of Ft and reaction ΣN. In dependences on a ratio of operating forces, the seeds of crops differing in physicomechanical properties come off a surface of the rotating working body 4 at various angles of rotation and get to the corresponding compartments of reception bunker 5, i.e. to sowing or technical fractions. The 4th seeds of crops and other light impurity which stuck to a surface of working body are removed by means of a removable brush 6.

Because of action on seeds of crops of total electric force, the technological efficiency of their sorting and clearness of division into sowing and technical fractions increases. Besides, the functionality of the device as in the induced electric field it is possible to sort seeds the small seeds of cultures and a short meeting of cotton-raw without giving of tension to heteropolar electrodes from the high-voltage power supply extends. When sorting large seeds, such as seeds of a cotton, corn, soy, wheat, rice, etc. from a high-voltage source to heteropolar electrodes voltage about U=500-4000 V moves.

It is also necessary to note that because of performance of working body from dielectric material the metal consumption of the advanced electric sorting device decreases by 1.5-2.0 times, and consumption of electric energy in comparison with the pneumatic sorting devices decreases more than by 34 times.

For check of operability of the sorting device offered advanced electric also pilot studies on sorting of seeds of various agricultural cultures on it were conducted theoretical.

In figure 2 the scheme of forces, acting on seeds of crops at hit on a surface of the rotating working body of the advanced electric sorting device is submitted.

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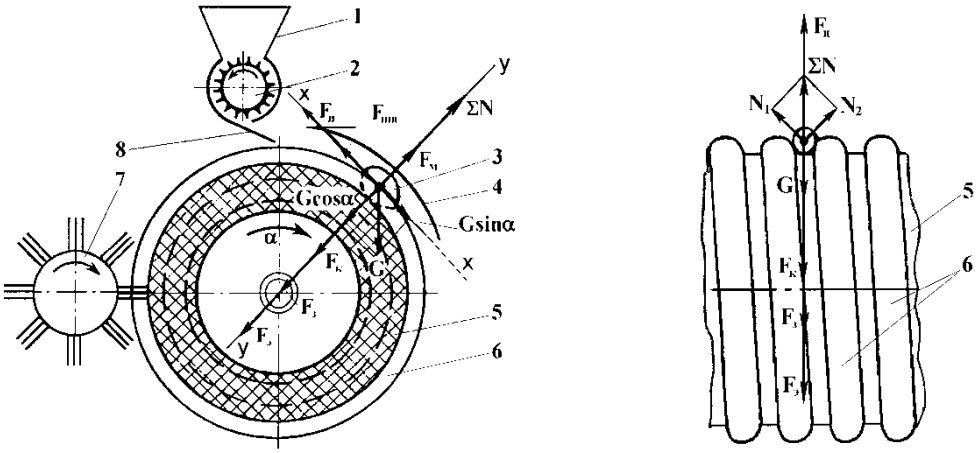

Figure 2. Diagram of forces acting on seeds when they hit the surface working body of an improved electric sorting device:
1 – loading hopper; 2 – feeder; 3 – cotton seeds; 4 – grounded electrode; 5– dielectric drum; 6 – bipolar electrodes; 7 – removable brush; 8 – pitched board

As appears from figure 2, electric forces of F_q, *Fe* and $F_z$press seeds of crops to a surface of working body of the advanced electric sorting device, the centrifugal force of F_s pushes away them from it, *G* gravity in the top semi-cylinder presses seeds to it, and in the lower semi-cylinder pushes away from it. That seeds of crops came off a surface of working body of the advanced electric sorting device, conditions *N=0* have to be met, i.e.

$$\boldsymbol{F_q + F_з + F_e + G\cos\alpha - F_ц = 0}, \quad (1)$$

where α – a corner of a separation of seeds of crops from the worker's surface a shouting - Ghana, degree.

Substituting instead of forces of F_q, F_e, F_z, G and F_s of their value and having carried out some transformations, we will receive the following expression for justification of a corner of a separation of seeds of crops from a surface of working body of the advanced electric sorting device.

$$\alpha = \arccos\left[\frac{V_c^2}{gR} - \left(\frac{\varepsilon_0 E^2 ab\Phi_3 L}{mg} + \frac{2S_n U^2 \varepsilon_0 \varepsilon_u^2(\varepsilon_c - 1)}{mg(2h\varepsilon_c + l_c\varepsilon_u)^2}\cdot\cos\frac{\theta}{2}\right)\right], \quad (2)$$

whereVc is the linear speed of seeds, m/s;
g – acceleration of gravity, m/s^2;
R – distance from an axis of rotation of working body to the center of gravity of seeds, m;
ε0 = 8.85•10-12 F_m – a dielectric constant;
E – electric field strength, In oil;
a, b is a big and small axis of seeds, m;
m – mass of seeds, kg;
*Sp*is the effective polarized surface of seeds, sq.m;
U – tension attached to heteropolar electrodes In;
ε_i – dielectric permeability of isolation of an electrode;
ε_c – dielectric permeability of seeds;
θ – a corner between a vertical and electric force, degree;
h – thickness of isolation of electrodes, m;
lc is the average length of electropower lines in a seed, m.

here $L = \frac{1}{4}\left(1 + 2\frac{\varepsilon_c - 1}{\varepsilon_c + 2}\right) + \frac{1}{16\pi}\left(1 + 2\frac{\varepsilon_c - 1}{\varepsilon_c + 2}\right)^2$.

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From expression (2) it is visible that if design data and the modes of operation of the advanced electric sorting device are constants, then the corner of a separation of seeds of crops from a surface of working body depends on a square of tension of the induced electric field E and sizes of the enclosed U tension to heteropolar electrodes and also on physicomechanical properties of seeds. In this regard by change of size of tension of the induced electric field and the enclosed tension to heteropolar electrodes it is possible to change a corner of a separation of seeds of crops from a surface of the rotating working body over a wide range.

However it should be noted that in technological process of sorting of seeds of crops the frequency of rotation of working body and a removable brush does not change. Respectively, also the size of tension of electric field arising at their friction the friend about the friend does not change. Proceeding from it, the corner of a separation of seeds from a surface of working body of the advanced electric sorting device can be proved depending on the size of the enclosed tension to heteropolar electrodes.

Using expression (2) calculation for justification of a corner of a separation of seeds of crops from a surface of working body of the advanced electric sorting device, on the example of cotton seeds is made, at the following values of parameters: *Vc =vb =1.05 m/s; m g=9.81 / c2; M R=0.203; ε0 =8.85•10-12 Fm; à = · • 105 In oil; and =9.7•10-3 m; m b=5.4•10-3; F3=0.87; L=0.69; Sp of =67.12•10-6 sq.m; m h=1.05•10-3; εc =7.0; lc =4.48•10-3; εu =4.0; cos(θ/2) = =0.3565; U=3000; 3500 and 4000 V.*

In figure 3 change of a corner of a separation of seeds of a cotton from a surface of working body of the advanced electric sorting device depending on their weight at various sizes of the enclosed tension to heteropolar electrodes is presented.

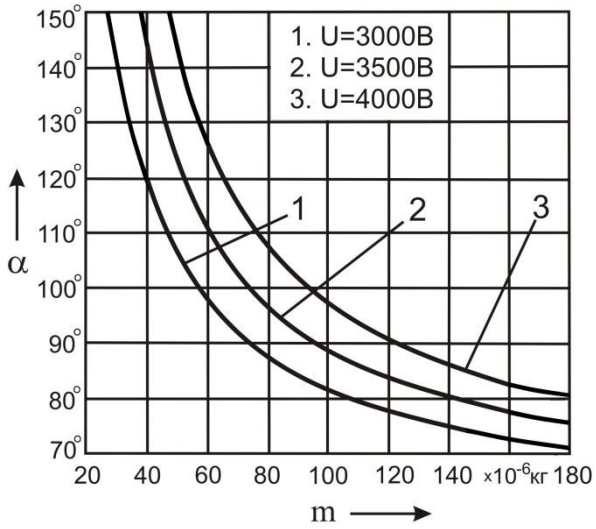

Figure 3. Change of a corner of a separation (α) cotton seeds depending on their masses (m) at various sizes of the enclosed tension (U)

As appears from figure 3, at the same size of the enclosed tension to heteropolar electrodes with increase in mass of seeds of a cotton the corner of their separation from a surface of working body decreases. So, for example, if at size the enclosed tension to heteropolar electrodes of U=3500 V, cotton seeds with a mass of m=40•10-6 of kg come off a surface of working body at the angle of turn α=143 °, cotton seeds the mass of m=160•10-6 of kg come off it at an angle of rotation α=77 ° (figure 3, a curve 2). At the same time with change of size of the enclosed tension to heteropolar electrodes the corner of a separation of seeds of the same weight changes. For example, if at the size of the enclosed U=3000 B tension the corner of a separation of seeds the mass of m=100•10-6 of kg made α=87 °17′ (figure 3, a curve 1), then at the size of the enclosed U=4000 B tension it made α=100 °02′ (figure 3, a curve 3).

I.e. with increase in size of the enclosed tension to heteropolar electrodes

the corner of a separation of seeds of crops of the same weight from a surface of working body increases. It allows to draw a conclusion that with change of size of the enclosed tension to heteropolar electrodes it is possible to change a corner of a separation of seeds of crops from a surface of the rotating working body over a wide range and to operate technological process of sorting depending on their physicomechanical properties.

The analysis of dependences in figure 3 shows that if to consider cotton seeds the mass of less m=100•10-6 of kg low-quality and unsuitable to sowing, then for separation of qualitative seeds from D=400 mm, low-quality with a

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diameter of the worker of body, E=6•105 In oil to heteropolar electrodes it is enough to frequency of its rotation of n=50 mines-1 and size of tension of the induced electric field to give voltage about U=3500 V. At the same time by the correct installation of an axis of arrangement of the dividing plane it is possible to separate qualitative seeds of a cotton from low-quality and to receive high-quality, biologically uniform sowing material with high laboratory and field viability and also potential productivity.

VI. CONCLUSION AND FUTURE WORK

On the basis of the conducted theoretical researches the experimental sample of the advanced electric sorting device is made. Results of pilot studies on sorting of seeds of various crops confirmed correctness of the scientific hypothesis made by us and the conducted theoretical researches. When sorting seeds of various crops on the advanced electric device high-quality, biologically uniform sowing material with high laboratory and field viability and also potential productivity is received. Besides the functionality of the advanced electric device extended, the technological efficiency of sorting and clearness of their division into sowing and technical fractions depending on physicomechanical properties increased.

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