DEVELOPMENT AND JUSTIFICATION OF THE MAIN PARAMETERS OF THE PROTECTANT OF PUBESCENT COTTON SEEDS

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Abstract

The article presents the results of theoretical studies to substantiate the optimal height of the protrusion of the teeth of the saw cylinder, depending on the required seed productivity, and presents an analytical method for determining the parameters of the seed capture and dragging zone based on the seed equilibrium condition in the space between the teeth of the drum. The parameters of the drum tooth and the height of the tooth protrusion from the grate are recommended, both ensuring the appropriate efficiency of seed etching. The dependencies describing the movement of seeds on an inclined tray are also theoretically considered and derived, and the recommended angles of inclination of the tray depending on the angle of friction of the seeds are given.

Keywords: sowing seeds, etcher, etching, toothed drum, grate (comb), distance, tooth protrusion, productivity, suspension, qualities, tray, friction.

Introduction

The preparation of the seeds is completed after they are etched with a suspension in special machines. In a well-known seed pickler, including a seed hopper, a receiving chamber communicating with it, in which, by means of an axis equipped with a counterweight and a lever, a two-section bucket is installed, and a yoke is mounted on the pump drive shaft, and a bracket is installed on the axis lever to interact with the yoke of the pump drive shaft (Fig. 1 a) [1].

The disadvantage of this pickler is that with a change in the seed supply capacity, it is impossible to ensure the supply of a suspension corresponding to the volume of the supplied seed without re-adjusting the suspension supply. Moreover, the manual adjustment mode reduces the accuracy of the correlation of the seed supply with the consumption of the suspension and the productivity of the seed feeder. If the suspension supply is not adjusted in time, the probability of non-occurrence of the required dose of suspension on the surface of the seeds poured from the bucket increases, which causes their passage without treatment with pesticides, resulting in a decrease in the quality of seed etching.

Development of the etchant design. To increase the quality of etching of pubescent cotton seeds with a suspension of high productivity, a new [2] efficient design was developed (Fig.1b).

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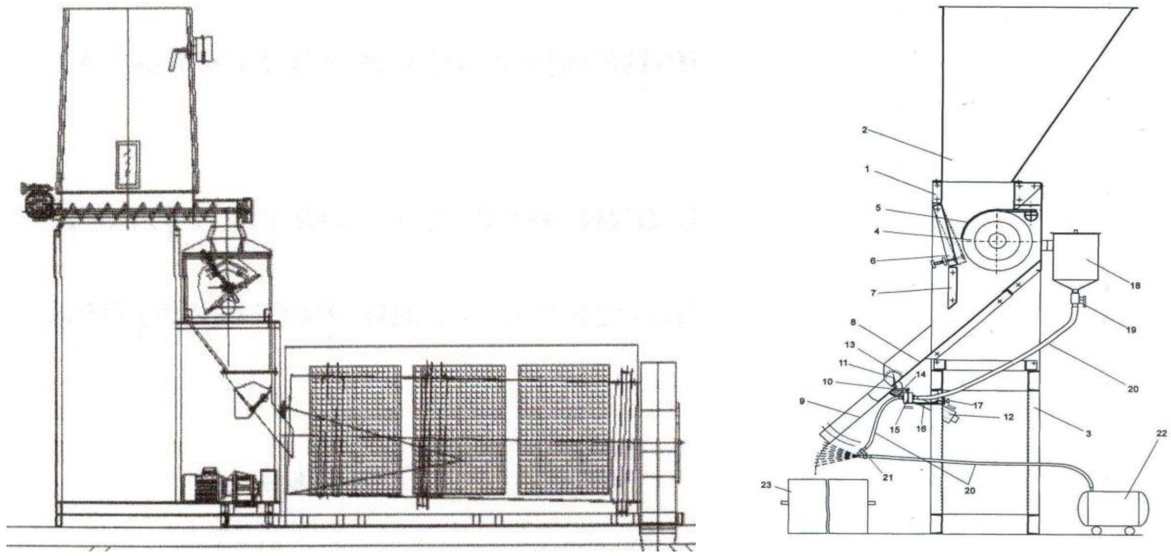
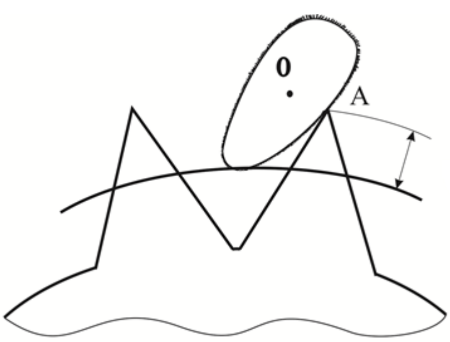


a) b)

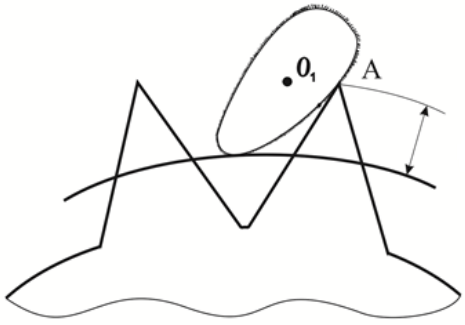
Fig.1. Diagrams of the existing (a) and proposed seed protectant (b)

The mordant (Fig. 1 b) contains a feeder 1, including a hopper 2, a frame 3, a feeding drum 4, grate combs 5, a flap 6, a partition 7, a seed duct 8. An oscillating tray 9 with a shaft 10 consisting of an index arrow 11 and a counterweight with a regulating load 12, a scale 13 is adapted to it attached to the sidewall of the rolling tray, lever 14, valve 15 with a sliding valve, bracket 16 of the screw mechanism 17, suspension tanks 18 with a crane 19, hoses 20, nozzle 21, compressor 22 and drawer 23. The mordant works as follows: The prepared suspension is fed into tanks 18, from where the suspension is fed with uniform free pressure through the crane 19 to the crane 15 with a gate valve. By adjusting the load of the counterweight 12, the oscillating tray with a lever 14, depending on the number of seeds supplied, communicates with the sliding valve 15, glued to the bracket 16 of the screw mechanism 17. The deviation of the arrow on the scale 11 indicates the angle of inclination of the oscillating tray 9, and at the same time characterizes the rate of consumption of the suspension and the productivity of the seed feeder. The productivity of the feeder is regulated by lifting and lowering the grate combs 5 and adjusting the gap between the drum and the flap 6. The adjustment of the required amount of slurry supply is carried out by moving the valve 15 closer to the axis of the shaft 10 of the oscillating tray or further from the axis using a screw mechanism 17. The upper part of the valve valve with an opening is hooked onto the finger of the lever 14. The seeds supplied from the oscillating tray 9, acting on the lever 14 with their weight, open the valve valve 15 and provide a slurry supply, which is directed to the nozzles 21 for spraying on the seeds under air pressure supplied through the compressor 22. After passing the seeds, if the tray is empty, it is arbitrarily set to the initial position 0 (36^0), while the valve of the tap 15 closes the gap and stops the suspension supply. The performance of the feeder and the corresponding slurry flow rate in the device can be determined by the index arrow 11 and the scale 13, showing the angles of inclination of the oscillating tray 9 and the corresponding performance of the seed feeder.

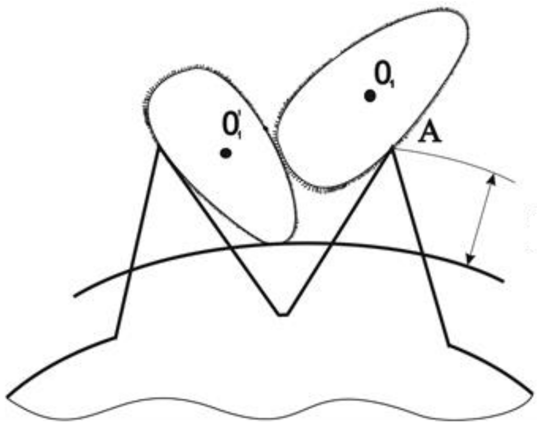
Justification of the protrusion of the teeth of the seed dispenser drum from its grates. The recommended seed protectant provides for regulating the seed supply capacity by changing the values of the protrusion of the drum teeth from the grate of the installation [3]. Figure 2 shows the layout (orientation) of cotton seeds in the space between the teeth when the height of the protrusion of the teeth from the grate is changed. In Fig. 2a and shows the layout of the seed at h<7,0 mm. Considering that the seed size reaches (10,0-12,0) mm and its orientation between the tooth space, two options can be considered. In the first variant, the center of gravity of the seed is located outside the outer circumference of the upper teeth of the drum. In this case, the seeds will not be captured and dragged by a toothed drum. In the second variant, the center of gravity of the seed will be located in the interdental space of the drum. In this case, the seeds will be dragged into the feeding area.Therefore, at h<7,0 to 50%, the seeds will be captured and dragged into the feeding area. In Fig. 2b provides a scheme in which h = 7,0 mm and the seeds will be dragged necessarily in one layer. An increase in the height of the protrusion of the teeth from the grates increases accordingly and the number of seeds being dragged into the feeding zone.



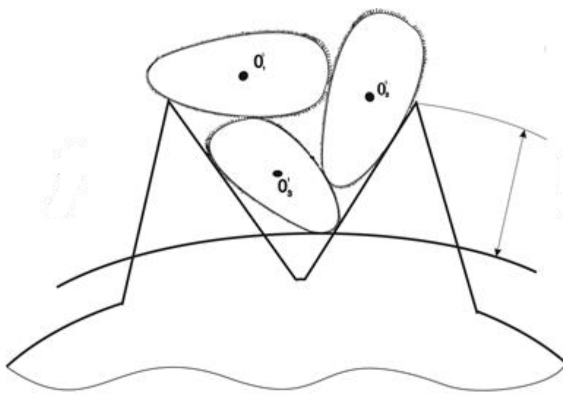
a-with the external height of the teeth from the grate h<7,0 mm;



b - at h=7,0 mm;



v-at h=10,0 mm;



g-at h=13,0 mm;

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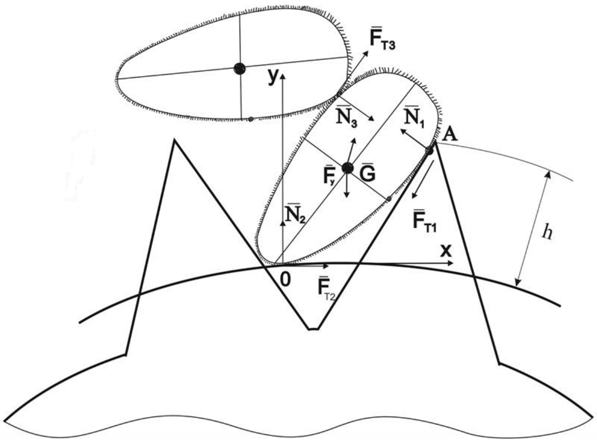

d-calculation scheme of the interaction of the seed with the teeth of the drum

Fig. 2. Diagrams of the arrangement of seeds between the teeth of different values of the protruding teeth of the grate

With an increase in h to 10,0 mm (see Fig. 2 v), the number of seeds being dragged into the feeding zone increases by 1,5 times. An increase in h to 13,0 mm allows the dragging of cotton seeds in two or more layers [4, 5]. It is important to study the process of seizing and dragging the seed with the teeth of the drum. Figure 2d shows the calculation scheme, which shows the forces acting on the seed in a static position.

Theoretically, the condition of seed equilibrium in the interdental space was considered. Let's define the condition for overturning the seed when it is captured and carried by the teeth of the drum. It follows from the calculation scheme (Fig.2.(d)) that the following forces act on it: $\overline{G}$- weight strength, $\overline{N}, \overline{F_{\text{т}_1}}$- reaction forces and friction between the seeds and the surface of the drum tooth; $\overline{N_2}, \overline{F_{\text{т}_2}}$- reaction force and friction force between the seeds and the grate surface; $\overline{N_3}, \overline{F_{\text{т}_3}}$- the reaction force and friction between the seeds and neighboring seeds in the capture zone and dragging into the feeding zone. In addition, inertia and centrifugal force act on the trapped seed. Considering that the seed does not move on the surface of the tooth, the inertia force will be zero. The centrifugal force will be:

$$F_y = m\omega^2 R \qquad (1)$$

where, m-is the mass of the seed, is the angular velocity of the toothed drum, R is the radius of the center of the mass of the seed relative to the axis of rotation of the drum.

Given the seed equilibrium condition, taking the moments from the forces [6] acting on the seed relative to point A, we have:

$$Gh_G + N_3h_3 - N_2h_2 - F_{\text{ц}}h_{\text{ц}} - F_{\text{т}_1}h_1' + F_{\text{т}_2}h_2' = 0 \qquad (2)$$

where, $h_G, h_1, h_2, h_3, h_1', h_2'$- the arms of the corresponding forces are relative to the point A of the alignment of the seed and the surface of the tooth of the drum. In order for the seed to remain in the interdental space, that is, the capture and dragging of the seed takes place, the condition must be fulfilled:

$$Gh_G + N_3h_3 - F_{\text{т}_2}h_2' \geq N_2h_2 + F_{\text{ц}}h_{\text{ц}} + F_{\text{т}_3}h_3' \qquad (3)$$

Considering:

$$G = mg;\; F_{\text{т}_2} = f_2N_2;\; F_{\text{т}_3} = f_3N_3;\; h_2' = h$$

Let's determine the value of the protrusion of the drum tooth from the grate:

$$h \geq \left[\frac{h_2}{f} + \frac{N_3}{fN_2}(f_3 h_3' - h_3) + \frac{m(\omega^2 R h_ц + g h_G)}{fN_2}\right] \qquad (4)$$

In the numerical solution (4), the following parameter values were taken into account: f=0,3; f_3=0,4; m=(0,12÷0,18)•10^{-3} kg, ω=6,28 c^{-1}; R=0,125 m; g=9.8 m/s^2; N_2=(0,4÷0,7) H; N_3=(0,3÷0,5) H. The analysis of the solution of problem (4) shows that with an increase in the number of seeds interacting in the zone of their capture and dragging, the values of N_2 and N_3 can increase by 2,0-3,0 times. When dragging one layer of seeds, N_2 and N_3 reach 0,7 N and 0,5 N, respectively. When dragging a two-layer flow of seeds, N_2 and N_3 reach 1,25 N and 1,0 N, and when (2,5-3,0) a layered flow of cotton seeds, N_2 and N_3 reach 2,0 N and 1,5 N, respectively. In this case, according to (4), the height of the protrusion of the teeth of the drum from the grates with a single-layer seed supply flow is obtained (7,0÷7,5) ×10^{-3} m, with a two-layer seed supply, the height of the protrusion of the teeth is obtained (11,0÷13,0) ×10^{-3}, and with (2,5÷3,0) a layered flow of dragging seeds with the teeth of the drum, the h value should be larger (15,0÷17,0)×10^{-3} m. Taking into account experimental studies [6] at a productivity of (4,0-5,0) t/h, the recommended h values are (7,0-10,0)×10^{-3} m.

Investigation of the movement of seeds on the inclined tray of the pickler

In the recommended design of the seed protectant, it is important to ensure uniform seed supply to the suspension application area. Therefore, it is advisable to study the movement of cotton seeds along an inclined tray. Figure 3 shows the design scheme of the inclined tray of the seed protectant. The seeds in the tray are mainly mixed by the force of their weight. Some of the seeds can be moved by enveloping (rolling friction). The following forces mainly act on the seed located on the surface of the inclined tray: the force of weight G ; the friction force F of the seed against the surface of the tray; N is the reaction force; F and is the force of inertia. If we denote the X and Y coordinate axes, then the seeds will move only along the X axis, and along the Y =0.

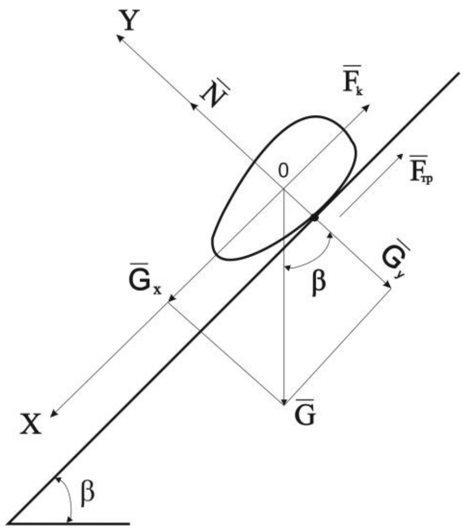

Fig. 3 Calculation diagram of the forces acting on the seeds being moved on an inclined tray

In this case, the equations of motion of the seed along the axes according to [7, 8] will be:

$$m_c\ddot{x} = Gsin\beta - fGcos\beta$$
$$m_c\ddot{y} = N - Gcos\beta \qquad (5)$$

where, m_c is the mass of the seed; (0,124÷0,130)×10^{-3} kg; acceleration of gravity, g=9,81 m/s^2; angle of inclination of the tray, β=45^0; coefficient of friction of the seed along the tray surface, f=0,3. Considering y=0, N=Gcosß. B the initial moment

$$x_0 = 0, y_0 = 0; \ \dot{x} = \dot{x}_0 cos\beta; \ \dot{y} = \dot{y}_0 sin\beta$$

The first equation of the system of differential equations (5) will be:

$$m_c\ddot{x} = G(sin\beta - fcos\beta) \qquad (6)$$

Integrating the differential equation (6) twice, we obtain:

$$\dot{x} = gt(sin\beta - fcos\beta) + C_1, \ \ x = \frac{gt^2}{2}(sin\beta - fcos\beta) + C_1 t + C_2 \qquad (7)$$

Considering the initial conditions for t=0; C_1=0; C_2=0, we have:

$$\dot{x} = gt(sin\beta - fcos\beta); \ \ x = \frac{gt^2}{2}(sin\beta - fcos\beta) \qquad (8)$$

According to the obtained dependencies in Fig.3, the coordinate of the seed drops on the tray surface along the x axis, as well as the length from the cylinder axis to the suspension zone of the inclined tray 0,5 × 10^{-3} m, determine the distance of the seed movement along the inclined tray, (0,67÷0,70) m. This is the maximum distance of movement of the seed located in the rightmost position on the surface of the tray. On average, this distance will be within (0,47÷0,50) m.

From the second equation of the system (8), we can determine the time of movement of the seed along the tray:

$$t = \sqrt{\frac{2x}{m_c g(sin\beta - fcos\beta)}} \qquad (9)$$

Then substituting (9) into the first equation of the system (8), we obtain an expression for determining the seed velocity at the end of the inclined tray of the cotton seed protectant:

$$\dot{x} = \sqrt{2xg(sin\beta - fcos\beta)} \qquad (10)$$

The numerical solution (10) is performed at the following initial parameter values: x = (0,47÷0,50) m; β=40^0÷50^0; g=9,81 m/s^2, f=0,3. Figure 4 shows the graphical dependences of the change in seed velocity at the end of the inclined tray of the seed protectant on the change in the angle of inclination of the tray with a variation in the coefficient of friction between the seed and the surface of the tray.

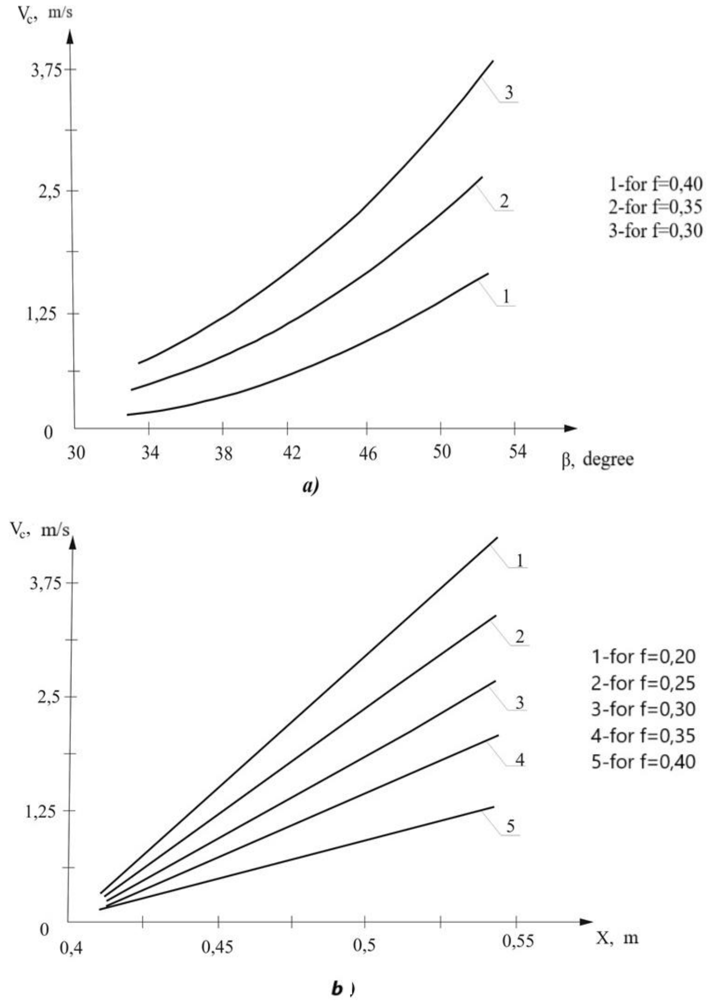

Fig. 4. Graphical dependences of the change in seed velocity at the end of the tray on the change in the angle of inclination of the tray (a) and on the value of the seed movement.

Thus, with an increase in the angle β from 33^0 to 53^0, the seed velocity increases from 0,22 m/s to 1,64 m/s with a coefficient of friction of the seed on the tray surface of 0,40, and at f = 0,3, the Vc velocity increases from 0,63 m/s to 3,67 m/s. Therefore, in order to increase the seed supply to the suspension zone, it is necessary to increase the tilt angle of the tray or reduce the coefficient of friction between the seed and the tray surface. The recommended parameter values are $\beta=40^0\div45^0$, f=0,25÷0,30, at which the productivity of the seed protectant is provided in the range of (4,0÷5,0) tons. Fig.4b shows the graphical dependences of the change in the seed velocity in the discharge zone on the increase in the x coordinate at different values of f. It can be seen from the graphs that with an increase in the x coordinate from 0,407 m to 0,53 m at f = 0,4, the seed velocity at the end of the tray reaches 1,235 m/s, and at f= 0,2 the velocity increases to 3,84 m/s. To ensure the productivity of the cotton seed protectant in the range of (4,0-5,0) t, the recommended value of the x coordinate is less than (0,48-0,52) m at a rotational speed of the gear drum of 60 rpm.

Conclusion

Based on the analysis of the location of seeds in the interdental space, a formula was obtained for calculating the values of the distance of the protrusion of the drum tooth from the grate. To ensure the productivity of the seed protectant within (4,5-5,0) t, the value of the tooth protrusion from the grate is recommended within (7,0-10,0)•10^{-3} m. The equations describing the movement of the seed along the inclined tray of the mordant are obtained. A formula has been derived to determine the mixing time of the seed obliquely on the mordant. Graphical dependences of the change in the seed velocity in the tray on the change in the angle of inclination and on the value of the seed movement are constructed. To increase the seed supply to the suspension zone, it is necessary to increase the tilt angle of the tray or reduce the coefficient of friction between the seed and the tray surface. The recommended parameter values are: $\beta=40^0\div45^0$, $f=0{,}25\div0{,}30$, $x\leq(0{,}48\div0{,}52)$ m, at which the productivity of the seed protectant is provided within (4,0÷5,0) t.

The use of this device for the pickler improves the quality of seed pickling, which in turn ensures high safety and germination of cotton seeds. The device is convenient for setting up by maintenance personnel.

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