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Determination of the angle and speed of interaction of cotton seed rush with the multifaceted screen drum of the separator

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Abstract. An effective separator circuit is recommended for separating cotton seeds. The results of theoretical studies to determine the recommended values of the angle and speed of impact of the cotton seed crusher with the mesh surface of the separator drum are presented. Using the theory of impact, a formula was obtained to determine the angle of impact of the cotton seed crusher on the multifaceted mesh surface of the drum, and an expression was derived for calculating the reaction force upon impact of the crusher. Using a numerical solution, graphical dependencies of the parameters were constructed. The values of the reaction force during the impact interaction of the crushed seeds on the mesh surface of the separator drum are determined.

1 Introduction

Currently, the creation of new scientifically based techniques and technologies and the improvement of production efficiency are one of the main directions of improving the economic conditions of our country.

In our republic, the potential of the developed cotton seed oil industry has been created, and it occupies one of the leading positions among the countries of the Commonwealth of Independent States in terms of capacity. In this direction, it is important for the industry to improve the structure of the Bitter separator machine to obtain effective feed oils from seed waste, to create new efficient structures of working bodies, including the beating shovels for separating the seed pulp into core and shell. Even though there are a number of scientific works on the technique and technology of cotton seed crushing and separation of cotton seed through a separator at oil production enterprises, it is still necessary to justify the working parameters of the separator working bodies that ensure the efficiency of separation and high performance. there is insufficient research on the issues of creating modernized separators that ensure production. There are almost no scientific studies on the study of the laws of movement of the working bodies of the separator that separates the cotton seed, the creation of new effective structures, the justification of optimal parameters, the creation of an effective

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resource-saving separator machine in working modes. Therefore, by improving the construction of the separator that separates the cotton seed husk, it is one of the important issues of the industrial sector to effectively extract the kernel from the seed waste, to produce high-quality feed oils from the extracted seed kernel and to increase its efficiency [1].

It consists of a multi-channel aspiration separator equipped with a bitter separator, an aspiration device, a sieve part with a product receiver and a supporting part, and a device for releasing the product through a fan. At the same time, to increase the productivity and efficiency of sorting the core and husk of seeds, reduce the fat content of the pods and the clumping of the kernel, the aspiration device has a pneumatic channel located next to the device to regulate air flow. The sieve is equipped with a vertical partition installed under the receiver and dividing the mesh part into two sections along the length of the body, under one of which additional sieve plates are installed [2].

One of the disadvantages of this separator design is the low efficiency and effectiveness of separating pods from cotton seed grains.

The main working body of the separator, which is the main working body of the seedbed separator, are two reciprocating mesh sieve bodies, air supply distributors are located under the meshes, and a suction chamber and a settling chamber are located above the sieves. To increase the efficiency of separating the seed mass, the separator has a rotatable movable blade shaft of the hammer, which is installed inside a mesh drum into which air is supplied, and guide baffles are fixed inside the settling chamber. The air distributors are made in the form of a cone with an adjustable longitudinal slot and are installed towards the inlet section in the lower part of the suction part of the upper mesh housing [3,4].

The complexity of the separator design is one of the disadvantages of low productivity. In addition, the addition of core particles to the waste of a large amount of separated cotton seed husks and a decrease in separation efficiency are taken into account.

The design of the Bitter-separator consists of two parts: two parallel slowly rotating cylindrical working drums with a mesh surface and a rapidly rotating shaft with a hammer blade passing through them. In the first part of the separator, the kernels are separated from the pods, and in the second part, the kernels and pods are separated and sorted on a vibrating sieve. Both of these main working parts of the separator are mounted on a common frame [5,6].

One of the main disadvantages of this bitter separator design is the low efficiency of separating bitten grains and the low productivity of the separator.

In another separator design [7] a loading hopper with a product supply device that falls inside the device, a movable board and a guide with the ability to feed the produced product into a dielectric drum are installed, and channels in the form of ditches are made on its surface. Along these corridors there are electrodes with the possibility of connecting to a brush for cleaning of the opposite polarity, and under it there is a receiving part of the separated fractions. In this case, the cleaning brush is designed to be installed on a shaft with a rubber bushing. Each channel located between the electrodes is divided into cells, and these cells are formed in the form of arcs along the channels.

The main disadvantage of the above design is the low productivity of the process of separating cotton ribbons, and this design does not allow its use for separating cotton ribbons [8,9].

2 Materials and methods

Recommended separator. The essence of the Bitter Separator of the proposed new design is that for the fractionation of cotton seeds, two main rotating working drums with a mesh surface located horizontally are installed in the separator, inside of which there are blade shafts that beat off the bitten seed. The shafts of the forwarding blades are installed eccentrically, and the axes of the working drums with mesh surfaces rotate in the opposite direction. And under the drums there is a vibrating screen. And under the drums there is a vibrating screen. Under the screen there is a movable flat plate for removing the sorted product from the separator, which moves back and forth in the direction of movement of the seed mill. The two sides of the striker shafts are made in the form of an open tube, like a groove, and the strikers are installed in rows on perforated eyes on the outer part of this shaft using rubber bushings and the threaded connection is fixed. In this case, the hammer blades are installed on the shaft horizontally and vertically in rows. In addition, the lugs of snare drums with a mesh surface are divided into three parts, which differ in the sizes of the diameters of the lugs, the size of these holes decreases from beginning to end along the length of the mesh drum, while the holes on the mesh surface of the snare drum are made in the form of a truncated cone. The largest diameter of the conical holes on the mesh surface of the drum is on the outer surface of the drums. The conical shape of the holes is formed by reducing the length of the drum from beginning to end. It should be noted that the drive of the Bitter Separator includes one electric motor, and all working parts receive their movements from this common electric motor [10,11].

Calculation scheme and mathematical model of interaction of cotton seed rushanka with multifaceted screen drum of separator. In the process of operation, the drum beats striking and cutting into parts the cotton seeds at a certain speed direct the parts of the seeds to the mesh surface of the drum [12]. In this case, it is important to study the impact interaction of seed rolls with a flat mesh surface, in particular their impact angles and reflection after impact. Figure 1 shows the computational scheme of interaction of cotton seed roughening with the mesh drum.

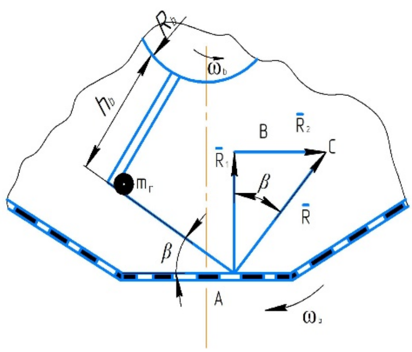


Fig. 1. Calculation scheme of interaction of rushanka of cotton seeds with mesh drum.

Speed of rushanka of seed is determined from expression [13]:

$$V_r = \omega_b (R_b + h_b) \tag{1}$$

Taking into account the centrifugal force and according to the results of [14] we have:

$$F_q = m_r (R_b + h_b)\omega_b^2; \quad R = \sqrt{R_1^2 + R_2^2}; \quad \omega_b = \frac{1 + K_b}{t_i}\cos\beta; \tag{2}$$

where, R_b, h_b - radius of the beater drum and height of the beater, ω_b- angular speed of the beating drum, K_b – the coefficient of recovery of rushanka on impact, β- angle of interaction of the rushanka with the mesh drum, m_r - rushanka mass.

The angle of impact of the cotton seed rush on the mesh surface of the drum is determined from (2):

$$\beta = arcCos\frac{V_p t_i}{(R_b + h_b)(1 + K_b)};\qquad (3)$$

In this case, the greater the angle of interaction, the greater the reaction force $\bar{R}_b$ – leading to intensive separation into parts of the rushanka. With the initial values of the parameters, it is recommended to choose the angle β within (400÷600).

Considering the momentum of the rushanka against the mesh surface R=0.408N according to the calculation results, the reaction force R_1 is determined from the expression [15]:

$$R_1 = \frac{0{,}408 V_p t_u}{(R_б + h_б)(1 + K_в)};\qquad (4)$$

In this case, the initial values of the parameters were taken:

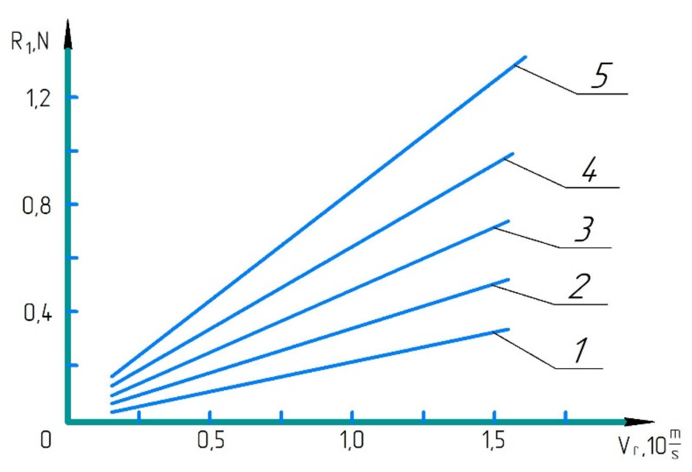
ω_b=7,33c-1; (R_b+h_b)=0,25м; t_i=(0,02-0,03)c; K_b=(0,25-0,35).

3 Results and discussion

Numerical solution of the problem and analysis of the results. By solution of problem (4) graphic dependencies of changing reaction force of collision of rushanka of cotton seeds against reticulate surface of the drum on angle and speed of their interaction were plotted [16].

Figure 2 shows graphical dependencies of changing reaction force of cotton seeds rushanka interaction with reticulate surface of recommended separator on impact velocity of rushanka.

The analysis of produced diagrams shows that with the increase of impact speed of rushanka from 2,5 m/s up to 13,5 m/s when rushanka of cotton seeds against the mesh surface of the drum of the recommended separator from the impact velocity of rushanka.

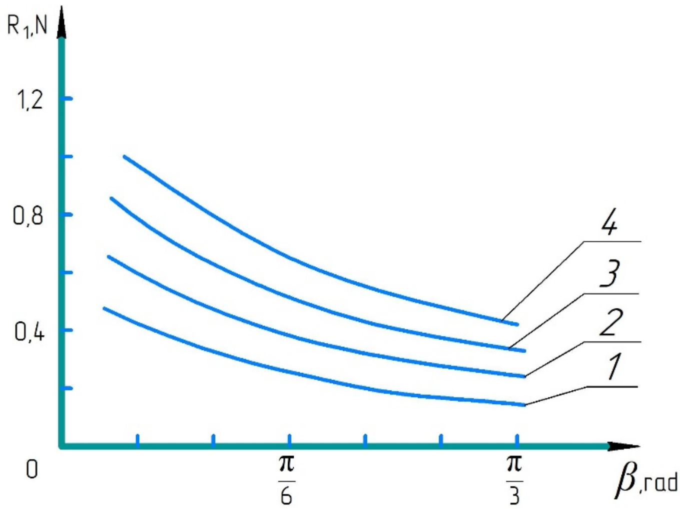


1- (R_b+h_b)=0,20м; 2- (R_b+h_b)=0,25м 3-(R_b+h_b)=0,3м; 4(R_b+h_b)=0,35м

Fig. 2. Graphic dependences of changes in reaction force on interaction.

(R_b+h_b)=0,2m The reaction force from the impact of the rushank R_1 increases from 0.12N to 0.29N according to a linear pattern. Accordingly, with increasing values of (R_b+h_b) up to 0.35m, the value of R_1 increases from 0.18N to 1.22N according to a linear relationship. It should be noted that with increasing values of R_1 also increases the separation of rushanki, especially the core from the skin of the seed of cotton, so the recommended values are: $V_r \geq (1{,}0 \div 1{,}5) \cdot 10$m/s, $(R_b+h_b) \geq (0{,}3 \div 0{,}35)$m.

Figure 3 shows the dependence of changes in the reaction force from the impact of the cotton seeds rush on the mesh surface of the separator drum on changes in the angle of incidence of the rush. Based on the analysis of the graphs we can note that with increasing angle of impact of cotton seeds on the mesh surface of the separator drum the value of the reaction force R_1 decreases sufficiently according to the linear law.



1- ω_b=10s^{-1}; 2- ω_b=7,5s^{-1}; 3- ω_b=6,0s^{-1}; 4- ω_b=5,0s^{-1}.

Fig. 3. Dependences of changes in reaction force from collision of rushanka of cotton seeds on the mesh surface of the separator drum from changes in the angle of incidence of rushanka.

This is explained by the fact that an increase in β leads to a decrease in the vertical component of the force R (see Fig. 1). The recommended values are: β≤(250÷300); ωb≥(6,5÷7,5)s-1.

4 Conclusion

An effective separator circuit has been developed for separating cotton seeds. Based on theoretical studies, formulas have been determined for calculating the reaction force of the crushed seeds interaction, the angle and speed of interaction. Based on the analysis of the constructed graphical dependencies, the values of the impact angle and the reaction force of the crushed seeds on the multifaceted mesh surface of the drum were justified, and the values of the speed of impact of the crushed seeds, row and the angular velocity of the drum were selected.

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