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The Influence of the Mode of Movement of the Pieces Cotton When Interacting With a Cotton Grid

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ABSTRACT. The article provides a new effective scheme and principle of operation of a multifaceted grid of cotton cleaner from small waste. The ratios of the reaction forces at impact are presented, as well as the method for calculating the angle of flight of cotton bats before hitting a multifaceted grid. The results of comparative tests of the recommended zone for the purification of a fibrous material from fine waste substantiate the necessary technological parameters.

KEYWORDS: cleaner, raw cotton, grid, multifaceted, elastic support, flight angle, cleaning effect.

I.INTRODUCTION

The main working bodies of cleaning machines from small waste are the spiked cylinder and the grid. The intensity of the cleaning of raw cotton from small waste depends not only on the rational design of the cylinder, but also on the correct choice of cleaning grid, which remove weed impurities from the working zone of cleaning. The requirements for the design of the grid come from the general research strategy, in other words, with the minimum impact on raw cotton - the maximum cleaning effect is achieved.

One of the promising areas for improving the cleaning process is the use of elastic elements in the design of the working organs of cotton ginning machines [1].

It should be noted that the intensification of raw cotton cleaning, the development of improved designs, the definition of effective new ways of cleaning raw cotton from small trash, as well as the activation of stationary working bodies of machines, is an important task of the cotton-cleaning industry.

To increase the effect of cleaning cotton from small waste, it is necessary to intensify the interaction of cylinder spiky on raw cotton, as well as to equip the drainage grid with activating elements. At the same time, it is possible to achieve the necessary cleaning effect with the minimum frequency of cleaning, which allows, not only obtaining high-quality products, but also reducing energy costs. At the same time, domestic and foreign researchers and specialists, in the main, pay great attention to the study and improvement of the spiked cylinder, in particular the design of the hammer. Research and improvement of the design of the grid of cotton cleaners from small waste are not conducted sufficiently. High-frequency interactions of spike with cotton, as well as an increase in the shaking abilities of the grid are one of the main directions for improving the design of the working bodies of cotton cleaners from small waste. Thanks to this method it is possible to separate the small weed impurities, deeply embedded in the fibers of cotton pieces.

Therefore, the development and substantiation of the parameters of a highly efficient drainage new multi-faceted grid on elastic supports of cotton cleaners from small waste, providing a significant increase in the effect of cleaning cotton, reducing damage to cotton fibers and seeds, maximum preservation of the natural properties of cotton fiber is an important task for the cotton cleaning industry.

The main goal of the work is to develop a new, highly efficient design of a new multi-faceted grid above the elastic supports of cotton cleaners from small waste and to justify their parameters based on comprehensive experimental studies.

In the cotton-ginning industry, a mechanical method for cleaning cotton is widely used, in which mechanically affects cotton and thereby loosens the bonds between cotton and waste, while such cleaners make it possible to obtain a relatively not high cleaning efficiency [2].

The choice of the design of the grid of the cotton cleaner is important here. Therefore, the authors have developed an effective design of the grid of cotton cleaner from small waste.

The grid of the cleaner of fibrous material consists of a debris removal grid 1, with holes 2 (Fig. 1.).

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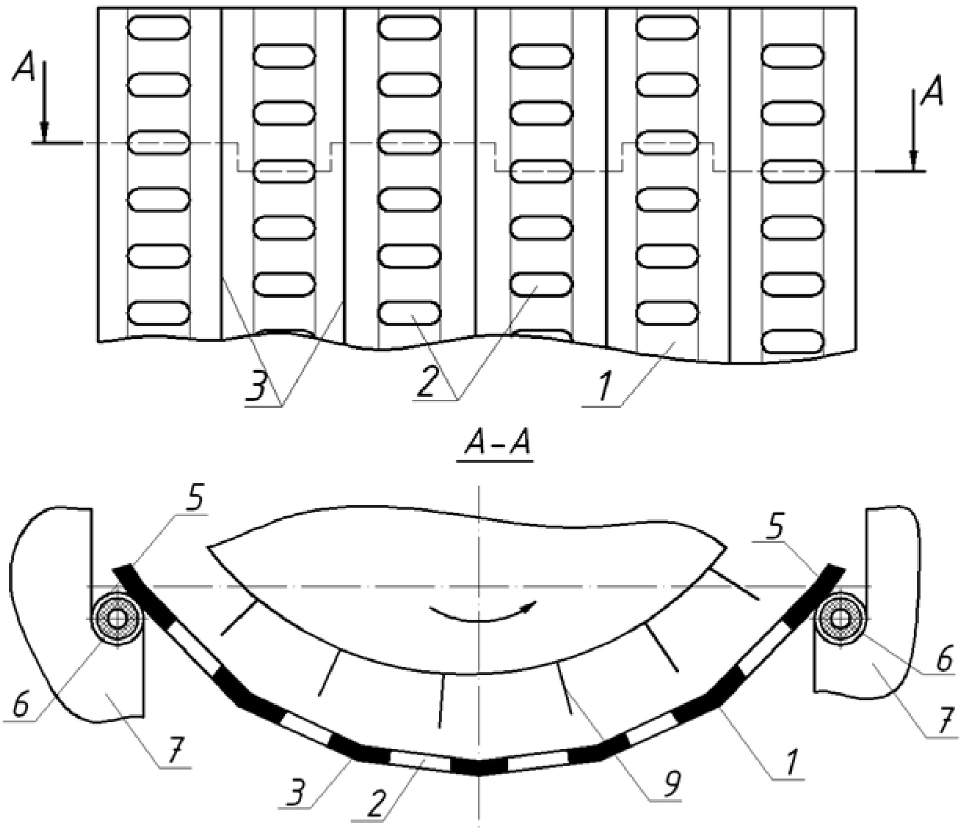

Figure 1. Scheme of a multifaceted grid of cotton cleaner from small waste

The grid is made as part of a multifaceted prism with ribs 3. The holes are made in rows in each face (planes), and between adjacent faces of the hole are arranged in a checkerboard pattern. The lateral grid at the edges in the four corners has rigid sleeves 4 connected to it, which include fingers 5 rigidly connected to the cleaner body 7. Elastic (rubber) bushings 6 are installed between the sleeve and the fingers. A cylinder 8 with spike 9 is installed above the grid 1 in the housing.

In the technology of cleaning raw cotton in a cleaner of small waste when using a multifaceted mesh, it is important to determine the reaction force depending on the angle of interaction and the angular velocity of the cylinder. In fig. 2 shows the design scheme of the cleaning zone. It is known that at the time of departure of the cotton pieces from the end of the cylinder spike, it is mainly affected by centrifugal force. In addition, in the area of free flight, the air resistance and the weight force additionally act on the cotton pieces. Considering that the gap between the ends of the spikes and the mesh surface, small in the first approximation, took into account only the centrifugal one, as the main force and variability of rotation of the spike cylinder we have:

$$F_{цб} = m_л R_к \cdot \left(\omega_{ср} + \omega_о \sin \alpha t\right)^2 \quad (1)$$

Where, $m_л$ - is the mass of the cotton pieces, $R_к$ - is the radius and amplitude of the variable part of the angular velocity of the spike cylinder.

It should be noted that, as noted in the work of G. I. Miroshnichenko [3], the speed of interaction of cotton pieces on a grid is determined from the expression:

$$V_л = \sqrt{\frac{m_л g}{c_1}} \quad (2)$$

Where, g - is the acceleration of gravity, c_1 - is the drag coefficient, $c_1 \approx 0{,}65$.

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But, the expression does not take into account the centrifugal force acting on the cotton pieces. At the same time, taking into account centrifugal force and impulse force, according to [4] we get:

$$\omega_{б} = \frac{(1+\kappa_{в})\cos\alpha}{t_u} \quad (3)$$

Where, $\kappa_{в}$ - is the coefficient of recovery of the blows upon impact, (0.3 ÷ 0.35); α - angle of inclination of the flight speed of the cotton pieces, t_u - time of the pulse interaction (0.015 ÷ 0.030) s.

Reaction forces according to fig. 2 we determine from the expressions for the elastic interaction of the cotton pieces with the grid:

$$\overline{F_1} = \overline{F_1'} + \overline{F_2}\ ;\ \overline{F_2} = \overline{F_2'} + \overline{F_2''}\ ;\ \overline{F_3} = \overline{F_3'} + \overline{F_3''}\ ;\ \overline{F_4} = \overline{F_4'} + \overline{F_4''}$$

or $F_1' = F_1\cos\alpha_1;\ F_2' = F_2\cos\alpha_2;\ F_3' = F_3\cos\alpha_3;\ F_4' = F_4\cos\alpha_4;$

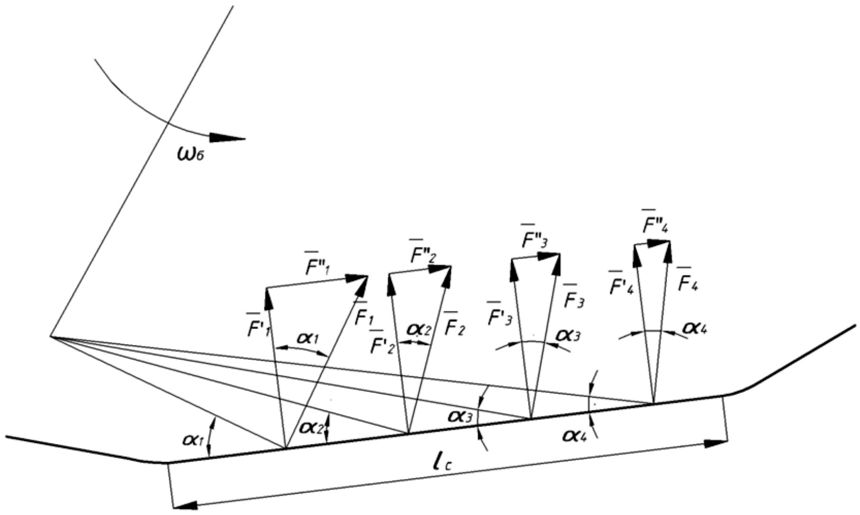

Figure 2. The design scheme of the zone of cleaning cotton from small waste

It is known that, at the linear velocity of the cotton pieces, during interactions with the grid, it should not exceed 11.5 m / s, at which the damage to the seeds and fibers of the cotton significantly increases [5]. Therefore, it is considered expedient, taking into account (1) and (3)

$$\alpha_i \geq \arccos\left[\frac{(\omega_{cp} + \omega_o \sin\alpha t)t_u}{1+\kappa_{в}}\right] \quad (5)$$

To ensure condition (5) with the initial values of the parameters of the cleaning zone, the angle α_i is obtained within:

$$\alpha_i = \left(\frac{2\pi}{9} \div \frac{\pi}{4}\right) \quad (6)$$

Based on the recommended parameters of the cotton cleaning zone using a multifaceted grid surface, a prototype of the cleaner was manufactured. There were comparative tests in a ginning factory. In figure 3 shows the recommended multi-faceted grid (still image)

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Figure 3. A prototype of a multifaceted grid surface mounted on the UGC cotton ginning unit.

When testing, the recommended design of the upgraded section of the UGC cleaning unit showed high reliability. The test results showed that the cleaning effect in comparison with the existing option in the recommended design of the cleaner increases by an average of 7.3%, mechanical damage to seeds decreases by 0.04%, free fiber in the cotton raw material decreases by 0.07%. Due to the additional vibrations, the grid ensures effective isolation of weed impurities and eliminates the process of inhibition of cotton.

The results of comparative technological tests on production lines of cleaning with serial and experienced designs of sections of cleaning units UGC are shown in table 1.

Table 1.

Indicators	After the serial unit in the 1st line UGC	After the upgraded section of the unit in the 2nd line UGC
Original raw cotton		
humidity	8.5 %	8.5 %
Mass fraction of weed impurities	3.0%	3.0%
After cleaning the cotton		
humidity	8.5 %	8.5 %
Mass fraction of weed impurities	0.57	0.45
Cleaning effect of the machine	81%	88.3%
Mechanical damage to seeds	1.35 %	1.31 %
Loose fiber	0.195	0.124

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II. CONCLUSION

An effective design of the multifaceted grid of the cotton cleaner from small waste has been developed. The problem of the shock interaction of cotton pieces with a grid surface is solved. The recommended values of the system parameters are recommended.

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