Analysis of the movement of raw cotton in the working chamber of the screw cleaner

O I Rajabov, L P Uzakova and M H Gapparova
Bukhara Engineering Technological Institute, Bukhara, Uzbekistan

E-mail: ozodbek4103@mail.ru

Abstract. The article presents the results of theoretical studies on the substantiation of the parameters of the main working organs of the raw cotton cleaner from fine trash. The article also provides a scheme of interaction between the pile and the raw cotton. The speed and direction of movement of the cotton after the impact are given. This article analyzes the interaction of the laws of cotton volatility with the mesh surface of a cotton cleaner from fine trash. Based on the research, the best values of the frequency of rotation of the spiked cylinder, the number of edges of the spiked and the gap between the spiked cylinder and the net were obtained.

1. Introduction
The main working bodies of fine trash cleaning machines are a spiked cylinder and a mesh surface. The intensity of the cleaning of raw cotton from fine trash depends not only on the rational design of the cylinder, but also on the correct choice of cleaning mesh surfaces that remove the trash from the working area of cleaning. The requirements imposed on the structure of the mesh surface are based on the general research strategy, in other words, with a minimum force impact on the raw cotton, the maximum cleaning effect is achieved [1-4].

It should be noted that the intensification of the cleaning of raw cotton, the development of improved designs, the definition of new effective methods of cleaning the raw cotton from small trash impurities, as well as the activation of stationary working parts of machines, is an urgent task of the cotton ginning industry [5,6].

2. Materials and methods
In a screw cleaner, the process of cleaning raw cotton from small weeds mainly occurs due to: 1) the impact of the spiked on individual portions of raw cotton and 2) friction on the mesh surface of the portions of raw cotton thrown by the spiked through the screw.

Consequently, the intensity of cleaning the raw cotton from small weeds in the auger cleaner depends on the force of the impact of the spiked on the portions of the raw cotton and on the driving force of the spiked, which contributes to the transfer of cotton through the screw.

To clarify the dependence of the impact force and the driving force of the spiked on the parameters of the head screw of the auger cleaner, let us consider the movement of raw cotton in its working chamber. Depending on the nature of the impact on raw cotton of the working organs, the cross-section of the working chamber of the auger cleaner can be divided into two zones [7-10].

A - zone for feeding and throwing raw cotton.
2.1. There is no screening surface in this area

B - working area, in the section of which a sieving surface is located under the spiked screw.

Let us consider the processes occurring during the movement of raw cotton in each of the indicated zones.

Zone for feeding and throwing raw cotton, when raw cotton enters the machine, part of it in the feeding zone meets the spiked of the rotating screw, and the other part is directly directed to the lower zone of the working chamber (figure 1)

The translational speed of a raw cotton (free fall speed $v_2$), which it possesses when meeting the spiked of a rotating screw, is decomposed into two portable components $v_1$, and a relative one $v_R$ (16).

Knowing the speed of falling cotton - raw $v_2 = \sqrt{2gh}$ (h is the height of the receiving shaft), the circumferential speed of the splitting $v_1 = \omega R$ and the angle between the direction of these speeds, we get:

$$v_R = \sqrt{v_2^2 + v_1^2 - 2v_1 v_2 \cos \alpha}$$

(1)

Disregarding friction, the shock impulse of the driving force can be considered directed perpendicular to the splitter.

![Figure 1. Diagram of the magnitude and direction of the absolute speed of a lump of cotton - raw after hitting the head of the auger.](image)

After hitting a lump of raw cotton on a spiked, the tangential velocity acquired by the lump will be:

$$|\vec{U}_Rn| = |\vec{U}_Rn|$$

Where K is the coefficient of recovery of the form of a lump of raw cotton. The normal component will be:
\[ v_{Rn} = v_2 \cos \alpha \]

The angle \( \beta \) can be found from the relation:

\[ \frac{v_R}{\sin a} = \frac{v_2}{\sin \beta} \]

From where

\[ \sin \beta = \frac{v_2}{v_R} \sin a \]  \hspace{1cm} (2)

Therefore, we get

\[ U_{Rn} = K v_R \cos a \]  \hspace{1cm} (3)

Or

\[ U_{Rn} = K \cos \beta \sqrt{v_2^2 + v_1^2 - 2 v_1 v_2 \cos \alpha} \]  \hspace{1cm} (4)

The component of the relative velocity along the splitter does not change upon impact

\( (v_{Rt} = U_{Rt}) \)

Adding the speeds \( U_{Rt} \) and \( U_{Rn} \), we find the relative speed of the cotton ball after the impact \( (U_R) \).

\[ U_R = \sqrt{U_{Rn}^2 + U_{Rt}^2}, \quad U_{Rt} = U_R \sin \beta \]

\[ U_R = \sqrt{K^2 v_{Rn}^2 + v_{Rn}^2} = \sqrt{K^2 v_R^2 \cos^2 \beta + v_R^2 \sin^2 \beta}, \quad U_R = v_R \sqrt{\sin^2 \beta + K^2 \cos^2 \beta} \]

\[ U_R = \sqrt{(\sin^2 \beta + K^2 \cos^2 \beta)(v_2^2 + v_1^2 - 2 v_1 v_2 \cos \alpha)^2} \]  \hspace{1cm} (5)

The relative velocity \( (U_R) \) with the tangential velocity \( (U_{Rn}) \) forms an angle \( \gamma \), which is determined from equation \( \frac{t_{gr}}{t_{gb}} = K \), i.e.

\[ \tan \gamma = K \cdot \tan \beta \]  \hspace{1cm} (6)

To find the absolute speed \( U \) of the coma after hitting it against the screw spiked, we add the relative speed \( (U_R) \) after the impact with the portable speed \( v \).

In this case, the formula for determining the absolute velocity \( (U) \) of the raw cotton ball after impact can be expressed as follows:

\[ U = \sqrt{v_1^2 + U_R^2 + 2 v_1 U_R \cos \gamma} \]  \hspace{1cm} (7)

Impact impulse of force acting on a lump of raw cotton is determined from the expression

\[ \vec{S} = m \Delta \vec{v} \]  \hspace{1cm} (8)

Where

\[ \Delta \vec{v} = \vec{U} - \vec{v}_2 \]

Then the average value of the impact force will be

\[ T_{im} = \frac{\vec{S}}{\tau} \]  \hspace{1cm} (9)

Where \( \tau \) is the impact time, which is determined by the normal speed of movement of the cotton ball and the amount of crushing of the cotton on the path \( \lambda \) when the splitter is hit.
Knowing the value of the speed of the raw cotton (U) and its direction after the previous blow, it is possible to find, using the same formulas, the direction and magnitude of the speed at subsequent encounters of the cotton with the spiked of the rotating auger in any place of the working chamber of the machine.

The state of the lump of raw cotton after the impact will depend on the magnitude of the impact force ($T_{im}$), which is in direct proportion to the circumferential speed of the spiked screw.

If the magnitude of this force turns out to be equal to or greater than the adhesion force between the slices or flaps, then the lump of raw cotton that has entered the machine will be loosened into slices or flaps.

In this case, the forces of adhesion of the trash to the raw cotton will be weakened and part of the trash will fall out through the mesh or grate.

More impact will occur directly on the weed impurities and its force will be equal to or greater than the force of the cord with fiber cord, then the weed impurities can be released from the cotton.

Thus, in all cases, the blows of the spiked on the cotton will contribute to the release of small trash impurities. However, the magnitude of the impact force should not exceed the force at which the seeds are destroyed.

2.2. Working won (B)

In addition to the impact force, which determines the cleaning effect, the value of the latter is also influenced by the repetition of throwing cotton - raw from the lower layers of the chute through the screw, which is facilitated by the force applied to the portion of cotton - raw by a screw spike when it moves together with the lump in zone B along the sieving surface.

$\tau = \frac{\lambda}{v_{Rn}}$

$\rho_{air}$ - air density;
$v_{air}$ - air speed.

Friction force $F_2$, which arises when the pressure of a portion of cotton - raw on the spiked and if the coefficient of friction of cotton - raw spiked is $f_2$ then:

$$F_2 = f_2 N_2$$
The force of action of the splitter $P_{ac}$, which moves the portion of raw cotton into the upper zone of the working chamber of the cleaner and promotes the transfer of the portion through the screw, thereby achieving multiple cleaning. We find the magnitude of this force from the condition of relative rest of a portion of raw cotton, i.e. when it moves with the rotating spiked.

For the relative rest of a portion of raw cotton, it is necessary that the sum of the projections of all acting forces on the moving coordinate axes $Ox'$ and $Oy'$ is $= 0$, i.e.:

Axis $Ox'$

$$m\omega^2 R + mg \cos \alpha - N_1 - F_2 = 0$$ (10)

Axis $Oy'$

$$P_{ac} - P_{imp} - mg \sin \alpha - F_1 - N_2 = 0$$ (11)

Normal pressure of cotton - raw on the screening surface, which is found from equation (10)

$$N_1 = m\omega^2 R + mg \cos \alpha - F_2$$ (12)

The frictional force $F_1$ caused by normal pressure will

$$F_1 = f_1 N_1$$ or

$$F_1 = f_1(m\omega^2 R + mg \cos \alpha - F_2)$$

Where $f_1$ is the coefficient of friction of the raw cotton on the screening surface. On the other hand, from equation (12) we find the value

$$F_1 = P_{ac} - P_{imp} - mg \sin \alpha - N_2$$

Hence,

$$f_1(m\omega^2 R + mg \cos \alpha - F_2) = P_{ac} - P_{imp} - mg \sin \alpha - N_2$$ (13)

From here

$$P_{ac} = f_1(m\omega^2 R + mg \cos \alpha - F_2) + P_{imp} + mg \sin \alpha + N_2$$ (14)

Transforming equality (14), we obtain:

$$P_{ac} = f_1 G \left(\frac{v_1^2}{gR} + \cos \alpha\right) + P_{imp} + G \sin \alpha + N_2(1 - f_1 f_2)$$ (15)

The equality of both sides of formula (15) is derived from the equilibrium conditions, in which the portion of raw cotton captured by the spike moves with it to the upper zone of the working chamber of the screw cleaner, which is a necessary condition for creating multiple cleaning.

As can be seen from formula (15), the force contributing to the repeated transfer of a portion of raw cotton through the screw has a direct dependence on the square of the circumferential speed of the spiked screw ($v_1^2$) and inverse to its diameter $D_1$.

Consequently, all other things being equal, the greater the peripheral speed of the spiked screw and the smaller its diameter, the greater the possibility of throwing over the screw will receive a portion of raw cotton and thus will undergo repeated cleaning, which will increase the cleaning effect of the screw cleaner.

In addition, under the action of the driving force ($P_{ac}$) at the moment of movement of a portion of raw cotton together with a splint, a centrifugal force of inertia acts on it:

$$C = \frac{mv_1^2}{R}$$ (16)

With an increase in the peripheral speed and a decrease in the diameter of the head screw, the magnitude of the centrifugal force increases, under the action of which the portion of the raw cotton is pressed more against the sieving surface.
At the same time, the driving force increases, contributing to the transfer of a portion of raw cotton through the screw. Under the influence of the pressing force and the driving force, the portion of the raw cotton is subjected to friction and the path it travels along the screening surface increases, which can also improve cleaning.

3. Conclusion
Therefore, increasing the peripheral speed and decreasing the diameter of the bell screw in terms of enhancing the cleaning of raw cotton is a useful measure.

However, an excessive increase in the peripheral speed and a decrease in the diameter of the head screw, increasing the pressing of a portion of raw cotton, can slow down the speed of its movement so much that this will entail an increase in the filling of the working chamber with raw cotton and thereby reduce the intensity of its cleaning.

Therefore, it must be assumed that an increase in the cleaning effect of a screw cleaner is possible only up to a certain limit of an increase in the peripheral speed of the head screw and a decrease in its diameter.

Reference
[1] Abdugaffarov Kh J, Sadoev A A and Murodov O J 2020 Improving the quality of lint by strengthening the cleaning of cotton seeds from waste IOP Conf. Series: Materials Science and Engineering 862 032026
[2] Abrorov A, Kuvoncheva M, Rajabov O, Mukhammadova M and Jumaev S 2020 Method of thermal treatment of saw disk teeth of fiber – processing machines by laser quenching IOP Conference Series: Materials Science and Engineering 862(2) 032034
[3] Shodiyev Z, Shomurodov A and O Rajabov 2020 The results of the experimental nature of the vibrations of the grid cotton cleaner IOP Conference Series: Materials Science and Engineering 883 012169
[4] Rajabov O I, Fazliddin F A, Gapparova M H and Shakhrillo J 2020 The influence of the location of the cells on the allocation of weed impurities for cleaning raw cotton from fine waste IOP Conference Series: Materials Science and Engineering 734(1) 012073
[5] Ozod Rajabov, Ziyodullo Shodiyev, Ikrom Inoyatov and Mastura Gapparova 2020 Analysis of the Technological Process of Cleaning Raw Cotton from Small Trash International Journal of Emerging Trends in Engineering Research 8(9) 6022-9
[6] Rajabov O I, Abrorov A S, Mirzaqulova N I, Zaripov G B and Ziyodullaev Kh S An experimental study of the location of the grid bars cells installed under spiked cylinders in a cotton cleaner from small waste IOP Conference Series: Materials Science and Engineering 734(1) 012073
[7] Jurayev A, and Rajabov O 2019 Experimental study of the interactional of multifaceted and cylindrical spiked cylinder in cotton cleaner from small waste International Journal of Advanced Research in Science, Engineering and Technology 6(3) 8376-81
[8] Rajabov O I 2019 The influence of the mode of movement of the pieces cotton when interacting with a cotton grid International Journal of Advanced Research in Science, Engineering and Technology 6(3) 8455-81
[9] Ozod Rajabov and Ziyodullo Shodiyev 2019 Analysis of Small Fluctuations of a Multifaceted Mesh under the Influence of Technological Load from the Cleaned Cotton - Raw, International Journal of Advanced Research in Science Engineering and Technology 6(10) 11396-9
[10] Anvar Djuraev and Ozod Isroilovich Rajabov 2019 Substantiation of the main parameters of the cylinder with multifaceted spiked of the cotton cleaner from small waste International scientific and practical conference Innovative ideas of modern youth in science (USA) 149-51