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Theoretical Study of Cotton Flow Movement in An Improved Working Chamber of a Saw Gin

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Abstract. In this article, the authors studied the theoretical analysis of a mesh drum installed in the working chamber to reduce the density of the green shaft. According to it, the angles of movement are classified according to the time of changing lumps of cotton to prevent clogging of the working chamber. It is concluded that, knowing the laws of movement of cotton particles, it is possible to determine the efficiency of extracting seeds from them.
Key words: gin machine, working chamber, density, mesh drum, cotton ball, flow of movement, force.

Ginning is the process of separating fiber from seeds. Based on the principle of impact on cotton, ginning is divided into saw and roller ginning. Since our country mainly grows medium-staple cotton, more attention is being paid to improving the ginning process designed to process this type of cotton.

Although the quality of products is formed at all stages of raw material processing, many studies have proven that the aging process has the greatest influence on product quality indicators. That is why we conducted this initial study to evaluate the impact on product quality indicators and determine the reasons [1].

It has been proven that an increase in the productivity of saw gin necessarily occurs along with an increase in the density of the raw material. However, as density increases, performance increases up to a certain limit, after which performance begins to decline. This situation is associated with a decrease in the rotation speed of the raw material under the influence of friction forces in the lateral direction, and it has been proven that the process completely stops at a density of 550÷600 kg/m3. This situation negatively affects the cotton ginning process, causing a decrease in productivity and fiber quality.

To eliminate this drawback, it is necessary to more carefully study the aging process and develop other methods for reducing the density of raw materials. In research conducted in this area, the issue of improving the working chamber of the saw gin by developing effective methods for increasing labor productivity in the ginning process has still not been sufficiently studied [2,3].

To ensure that the seeds, completely separated from the fiber, do not accumulate in the middle of the raw material shaft, a mesh drum is installed in the middle of the working chamber, which serves to reduce the density of the cotton flow in the working chamber. In addition, the holes of the mesh drum have a convex and concave shape, and as a result of the impact of the cotton flow on the surface of this tube, the seeds come out. This serves to uniformly separate the seeds from the cotton flow in the working chamber. As a result of the theoretical analysis of this process, the issue of ensuring uniform density of the cotton flow was seen.

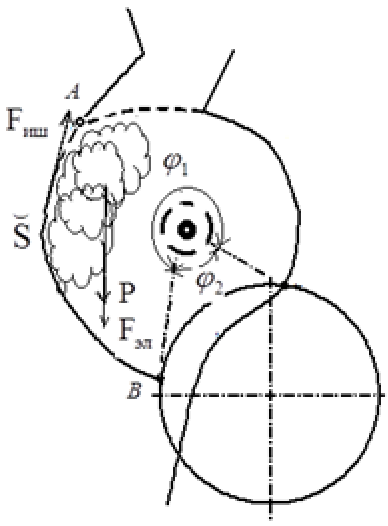

Figure 1. Scheme of the movement of cotton flow in the working chamber

The directions of external forces acting on the flow of cotton in the working chamber are presented $P = m \cdot g$ - the weight of the cotton lump, $F_{эл} = \mu \cdot \left(\vartheta \cdot t - \breve{S}\right)$- the elastic force of the accelerator acting on the cotton hem, where: μ - the elasticity coefficient between the cotton lumps.

$F_{иш} = f\left(\frac{m \cdot \vartheta_1^{\,2}}{R} + m \cdot g\right)$- friction force created by a piece of cotton on the surface of the working chamber.

where: $\frac{m \cdot \vartheta_1^{\,2}}{\mathrm{R}}$ – centrifugal force; f - friction coefficient.

We analyze the position of a cotton ball moving in $A\breve{B} = \breve{S}$ an arc in $\breve{S} = R \cdot \varphi_1$ the working chamber under the influence of external forces. The equation of motion resulting from the impact of the mesh drum on the cotton ball is expressed as follows:

$$m \cdot \mathrm{R} \cdot \ddot{\varphi}_1 = \overline{F}_{эл} + P - \overline{F}_{иш} \quad (1)$$

Using external forces acting on the flow of cotton in the upper working chamber to equation (1), we create the equation

$$m \cdot \mathrm{R} \cdot \ddot{\varphi}_1 = \mu\left(\vartheta \cdot t - \breve{S}\right) + m \cdot g - \frac{f \cdot m \cdot \vartheta_1^{\,2}}{R} \quad (2)$$

(2) in the equation $\breve{S} = R \cdot \varphi_1$ and $\vartheta = \omega \cdot R = \dot{\varphi}_1 \cdot R$ since

$$m \cdot \mathrm{R} \cdot \ddot{\varphi}_1 = \mu \cdot \left(R \cdot \dot{\varphi}_1 \cdot t - R \cdot \varphi_1\right) + m \cdot g - \frac{f \cdot m \cdot \vartheta_1^{\,2}}{R} \quad (3)$$

Equation (3) is integrated under the following initial conditions $\varphi_1(0) = 0$, $\dot{\varphi}_1(0) = 0$. If the working chamber is a circle on the surface $\dot{\varphi}_1 \cdot R$, equation (3) is integrated $t = t_0$ up to the moment where it is determined from the condition $\varphi_1(t_0) = \varphi$

$$\ddot{\varphi}_1 - \frac{\mu \cdot t}{m} \cdot \dot{\varphi}_1 + \frac{\mu}{m} \cdot \varphi_1 = \frac{g}{R} - \frac{f \cdot \vartheta_1^{\,2}}{R^2} \quad (4)$$

(4) let's create a differential equation by introducing the notation into the equation $\mathrm{n} = -\frac{\mu \cdot t}{2 \cdot m}$, $k = \sqrt{\frac{\mu}{m}}$

$$\ddot{\varphi}_1 + n \cdot \dot{\varphi}_1 + k^2 \cdot \varphi_1 = 0 \quad (5)$$

We define the solution to homogeneous equation (5) as follows $\varphi_1 = \mathrm{e}^{\lambda \cdot \mathrm{t}}$:

$$\lambda^2 + n \cdot \lambda + k^2 = 0 \quad (6)$$

$\lambda_{1/2} = -\mathrm{n} \pm \sqrt{\mathrm{n}^2 - k^2}$ from the definition $\mathrm{k}_1 = \sqrt{\mathrm{n}^2 - k^2}$ and $\mathrm{n} < \mathrm{k}$ when the solution to equation (5) is

$$\varphi_1 = \mathrm{e}^{-\mathrm{n} \cdot \mathrm{t}} \cdot (C_1 \cdot \sin(k_1 \cdot t) + C_2 \cdot \cos(k_1 \cdot t)) \quad (7)$$

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In expression (7) we determine the initial and limiting values of the constants C_1 and C_2.
$\varphi(0) = \varphi_0;\ \dot{\varphi}(0) = 0$

$$\dot{\varphi}_1 = -n \cdot e^{-n \cdot t} \cdot (C_1 \cdot \sin(k_1 \cdot t) + C_2 \cdot \cos(k_1 \cdot t)) + e^{-n \cdot t} \cdot (C_1 \cdot k_1 \cdot \cos(k_1 \cdot t) - C_2 \cdot k_1 \cdot \sin(k_1 \cdot t)) \quad (8)$$

using the above initial conditions is $C_1 = -\frac{\varphi_0}{k_1},\ C_2 = \varphi_0$ We put these values into equation (7).

$$\varphi_1 = e^{-n \cdot t} \cdot \left(-\frac{\varphi_0}{k_1} \cdot \sin(k_1 \cdot t) + \varphi_0 \cdot \cos(k_1 \cdot t)\right)$$

The calculation results are presented on φ graphs of the rotation angles of φ_1 cotton balls in the table for removing jams in the working chamber.

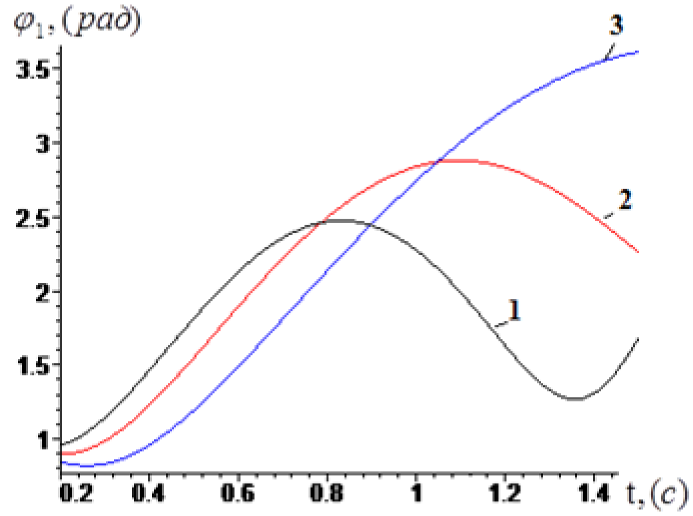

Figure 2. Graphs of changes over time at different values of rotation speed of $n_1 = 125 rot/min$ $n_2 = 100 rot/min$ $n_3 = 75 rot/min$ cotton lumps along the surface of the working chamber AB.

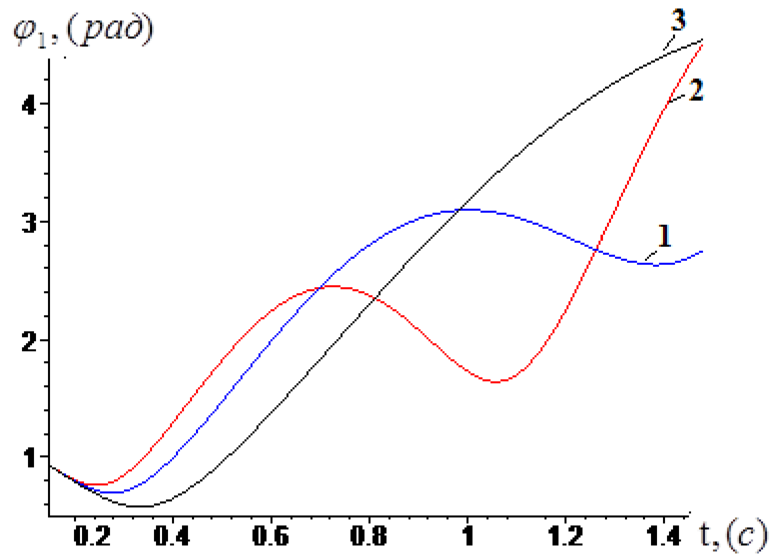

Figure 3. Graphs of changes in the values of $m_1 = 0.6\ гр$, $m_2 = 1.6\ гр$, $m_3 = 2.6\ гр$ masses of various cotton particles along the surface of the working chamber of the AB saw gin.

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At the same time, the angle of change of clap is complemented by preventing jamming in the working chamber. Knowing the laws of movement of cotton balls, you can determine the effectiveness of extracting the seed from them.

Conclusion

The differential equation obtained as a result of a theoretical study of the process of interaction between the raw shaft of the improved working chamber and the saw cylinder showed the possibility of reducing the density of the raw shaft due to the torque of the drum mesh on the axis of rotation of the raw shaft.

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