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THEORETICAL STUDY OF UNIFORM TRANSFER OF COTTON RAW MATERIALS IN PNEUMATIC TRANSPORT

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ABSTRACT: As a result of the scientific research carried out in this article, a transmission theory was developed that purifies cotton raw materials from small impurities and ensures smooth movement in pneumatic transport. It is scientifically proven that the feed roller and horizontal belt must work together to ensure uniform transport of cotton raw material.
Key words: Feeder, roller, horizontal belt, dirt, cotton ball, product, cotton, movement, pipe, device.

The production of high-quality fiber that meets international standards has posed an important task for specialists and scientists in the field of cotton processing to improve existing equipment and technology. On the other hand, the level of improvement of spinning and weaving equipment is increasing, and attention must be paid to the quality of cotton fiber [1].

The results of monitoring the process of transporting cotton by air showed that this raw material is transferred unevenly through pipes. As a result, the cotton is collected in the pipe and moved in certain pieces.

Uneven supply of cotton into the pipe will lead to wear of the elements of the pneumatic conveying device. As a result, the efficiency of the device that captures heavy impurities from cotton decreases, damage to fibers and seeds increases, blockages occur on the mesh surfaces of the separators, and the likelihood of heavy impurities entering the fiber separators and separators into the exhaust air increases. and we fall into the seed of increase. In addition, due to the poor quality of cotton, the efficiency of drying drums and cleaning machines is reduced [1,2].

For uniform transfer of cotton, an additional feed roller is installed, which ensures uniform transfer of cotton flow and thereby increases the efficiency of cleaning cotton from small and large impurities. Let the speed of the feed shaft be v0 and the piece of cotton wool move with speed v1. Let us accept the following assumptions: let the speed of the feed roller be constant and act on the pieces of cotton in two ways; The length of a stack of cotton balls is equal to l, the cotton balls move along the surface of the mesh surfaces. Theoretically, we measure the movement of cotton particles and the time they remain on the surface of the pile. Therefore,

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we also determine the corresponding angular velocity of movement of the cotton pieces along with the lint.
By placing the coordinate head in the center of the roller, we direct the axis from right to left, and the axis perpendicular to it, from bottom to top (Fig. 2). Suppose a piece of cotton wool moves along the surface of a stack at an arbitrary time t. The angle between the radius of the feed roller and the rolling roller is taken equal to 1.

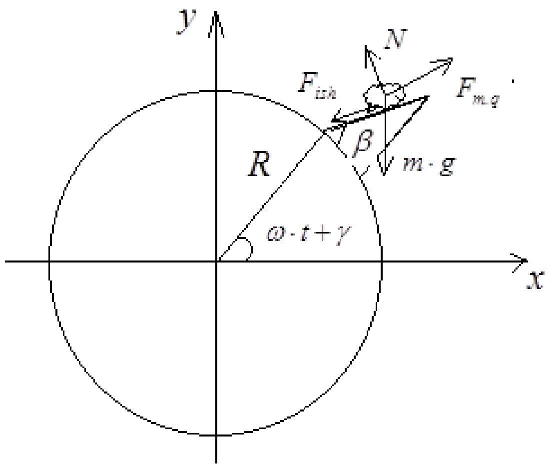

Figure 1. The action is based on the use of rolling rollers that provide cotton particles.

Figure 1 generates the following equation for the trajectory of cotton particles.

$$x = R \cdot \cos(\omega \cdot \mathrm{t} + \gamma) + l \cdot \cos\varphi$$
$$y_0 = R \cdot \sin(\omega \cdot \mathrm{t} + \gamma) + l \cdot \sin\varphi \qquad (1)$$

φ *and* β the angles are obtained depending on the angle of inclination of the rolling tools:

$$\varphi = -\frac{\pi}{2} + \omega \cdot t + \beta + \gamma$$

Thus, the movement of the cotton pieces is determined by (X,Y).

$$x = R \cdot \cos(\omega \cdot t + \gamma) + l \cdot \sin(\omega \cdot t + \gamma + \beta)$$
$$y = R \cdot \sin(\omega \cdot t + \gamma) - l \cdot \cos(\omega \cdot t + \gamma + \beta) \qquad (2)$$

Using the equation of motion, the speed of a piece of cotton is determined using a Cartesian coordinate system. To do this, we take the first-order time derivative from the equations of motion and obtain the following equation.

$$\dot{x} = -R \cdot \omega \cdot \sin(\gamma + \omega \cdot t) + \dot{l} \cdot \sin(\omega \cdot t + \gamma + \beta) + l \cdot \omega \cdot \cos(\omega \cdot t + \gamma + \beta)$$
$$\dot{y} = R \cdot \omega \cdot \cos(\gamma + \omega \cdot t) - \dot{l} \cdot \cos(\omega \cdot t + \gamma + \beta) + l \cdot \omega \cdot \sin(\omega \cdot t + \gamma + \beta) \qquad (3)$$

The degree of freedom of the system is determined, generalized coordinates are selected, and generalized forces acting on the cotton pieces are calculated. The kinetic energy of a cotton

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piece on the surface of the pegs is determined as a function of generalized coordinates and generalized velocities. The derivatives of the required kinetic energy $\frac{\partial T}{\partial \dot{l}_i}, \frac{d}{dt}(\frac{\partial T}{\partial \dot{l}}), \frac{\partial T}{\partial l_i}$ are obtained using the Lagrange type II equation to form the general equation of motion of the cotton piece on the surface of the pegs.
A type II Lagrange equation was created and by calculating this equation, the dependence of the uniform transition to the next process under the influence of the rollers providing cotton pieces on the rotation speed of the rollers was obtained.

$$\frac{d}{dt}(\frac{\partial T}{\partial \dot{l}}) - \frac{\partial T}{\partial l} = Q_l \quad (4)$$

As generalized coordinates, the length of the peg shaft is taken equal to l.
Here is $T = \frac{1}{2} m(\dot{x}^2 + \dot{y}^2)$ - the kinetic energy, Q_l - is the total force, and *m*- is the mass of the cotton piece.
The kinetic energy is determined.

$$T = \frac{m}{2} \cdot (\dot{x}^2 + \dot{y}^2) \quad (5)$$

From the equations of motion of a cotton piece in a Cartesian coordinate system, the first-order time derivative is obtained and the speed of the cotton piece on the surface of the pegs is calculated.

$$\dot{x}^2 = R^2 \cdot \omega^2 \cdot \sin^2(\gamma + \omega \cdot t) + \dot{l}^2 \cdot \sin^2(\omega \cdot t + \gamma + \beta) + l^2 \cdot \omega^2 \cdot \cos^2(\omega \cdot t + \gamma + \beta) - 2 \cdot R \cdot \dot{l} \cdot \omega \cdot \sin(\gamma + \omega \cdot t) \cdot \sin(\omega \cdot t + \gamma + \beta)$$
$$- 2 \cdot R \cdot l \cdot \omega^2 \cdot \sin(\gamma + \omega \cdot t) \cdot \cos(\omega \cdot t + \gamma + \beta) + 2 \cdot l \cdot \dot{l} \cdot \sin(\omega \cdot t + \gamma + \beta) \cdot \cos(\omega \cdot t + \gamma + \beta)$$
$$\dot{y}^2 = R^2 \cdot \omega^2 \cdot \cos^2(\gamma + \omega \cdot t) + \dot{l}^2 \cdot \cos^2(\omega \cdot t + \gamma + \beta) + l^2 \cdot \omega^2 \cdot \sin^2(\omega \cdot t + \gamma + \beta) - 2 \cdot R \cdot \dot{l} \cdot \omega \cdot \cos(\gamma + \omega \cdot t) \cdot \cos(\omega \cdot t + \gamma + \beta)$$
$$+ 2 \cdot R \cdot l \cdot \omega^2 \cdot \cos(\gamma + \omega \cdot t) \cdot \sin(\omega \cdot t + \gamma + \beta) - 2 \cdot l \cdot \dot{l} \cdot \cos(\omega \cdot t + \gamma + \beta) \cdot \sin(\omega \cdot t + \gamma + \beta)$$

the resulting equality is substituted into equation (5) and obtained.

$$T = \frac{m}{2} \cdot (\dot{x}^2 + \dot{y}^2) = \frac{m}{2} \cdot (R^2 \cdot \omega^2 + \dot{l}^2 + l^2 \cdot \omega^2 - 2 \cdot R \cdot \omega \cdot \dot{l} \cdot \cos\beta + 2 \cdot R \cdot l \cdot \omega^2 \cdot \sin\beta) \quad (6)$$

External forces acting on a piece of cotton moving along the pinning surface of the feed roller are presented in Figure 1. External forces acting on a piece of cotton are taken as a generalized force and determine the sum of their projections onto the surface of the pins. The weight and frictional forces depend on the angle of the pegs relative to the roller and the speed of the roller. Using Figure 1, we find the projections of gravity and friction in the direction of the pile:

$$F_{TP} = f \cdot N$$
$$F_g = m \cdot g \cdot \sin(\omega t + \gamma + \beta) \quad (7)$$

Here: m is the mass of a piece of cotton, N is the normal force acting on a piece of cotton, taking into account gravity, centrifugal and Coriolis forces, it looks like this:

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$$N = 2 \cdot m \cdot \omega \cdot \dot{l} \cdot \cos\beta + m \cdot g \cdot \cos(\omega t + \gamma + \beta) + m \cdot l \cdot \omega^2 \cdot \sin\beta$$

In addition to these forces, centrifugal force also acts on a piece of cotton.

$$m \cdot l \cdot \omega^2 \cdot \cos\beta \qquad (8)$$

where $\omega -$ the angular velocity of movement of a piece of cotton, $\dot{l}$ -is the relative speed. From these connections Q_1 - for generalized forces

$$Q_l = m \cdot g \cdot \omega^2 \cdot \cos\beta - m \cdot g \cdot \sin(\omega \cdot t + \gamma + \beta) - f \cdot N$$

where *f*- is the coefficient of friction between the fiber and the tooth.

From T the kinetic energy $\dot{l}_i$ *and* l_i of a cotton piece, special derivatives are obtained according to the rule of differentiation of a complex function with respect to variables, i.e.

$$\frac{\partial T}{\partial \dot{l}} = \frac{m}{2} \cdot (2 \cdot \dot{l} - 2 \cdot R \cdot \omega \cdot \cos\beta) = m \cdot (\dot{l} - R \cdot \omega \cdot \cos\beta)$$

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{r}}\right) = \ddot{l} \cdot m$$

$$\frac{\partial T}{\partial l} = \frac{m}{2} \cdot (2 \cdot l \cdot \omega^2 + 2 \cdot R \cdot \omega^2 \cdot \sin\beta) = m \cdot (l \cdot \omega^2 + R \cdot \omega^2 \cdot \sin\beta)$$

Substituting the resulting partial derivatives into equation (4), the equation is expressed as a differential equation of motion under the action of a drag force proportional to the speed of motion.

$$\begin{aligned} m \cdot \ddot{l} + m \cdot l \cdot \omega^2 + m \cdot \omega^2 \cdot R \cdot \sin\beta = m \cdot l \cdot \omega^2 \cdot \cos\beta - m \cdot g \cdot \sin(\omega \cdot t + \gamma + \beta) - \\ - f \cdot (m \cdot g \cdot \cos(\omega \cdot t + \gamma + \beta) + m \cdot \omega^2 \cdot l \cdot \sin\beta + 2 \cdot m \cdot \omega \cdot \dot{l} \cdot \cos\beta) \end{aligned} \qquad (9)$$

By dividing both sides of this equation by m mass, the general form of the differential equation of inhomogeneous motion is determined.

$$\begin{aligned} \ddot{l} + 2 \cdot f \cdot \omega \cdot \cos\beta \cdot \dot{l} - \omega^2 \cdot (\cos\beta - f \cdot \sin\beta) \cdot l = -g \cdot (\sin(\omega \cdot t + \gamma + \beta) + \\ + f \cdot g \cdot \cos(\omega \cdot t + \gamma + \beta)) - \omega^2 \cdot R \cdot \sin\beta \end{aligned} \qquad (10)$$

Using the following notation: $\gamma(\mathrm{t}) = \omega \cdot t + \gamma + \beta$, $n = f \cdot \omega \cdot \cos\beta$, $c = \cos\beta - f \cdot \sin\beta$, $a = c \cdot \omega^2$, $b = R \cdot \omega^2 \cdot \sin\beta$ let us reduce equation (9) to the following form.

$$\ddot{l} + 2 \cdot n \cdot \dot{l} - a \cdot l = b - g \cdot (\sin(\gamma(t) - f \cdot \cos(\gamma(t))$$

A differential equation is formed. This equation consists of a second-order inhomogeneous linear differential equation with constant coefficients, the solution of which is equal to the sum of the general solution l_1 of the homogeneous equation and partial solutions l_2 of equation (10).

$$l = l_1 + l_2$$

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The general solution of the equation is sought in the following form.
Equation (10) is integrated over the interval $l = l_1,\ \dot{l} = 0,\ t = 0$ in terms of $0 < t < t_1$, where $t_1 = \dfrac{L}{\omega}$; L - is the length of the arc of the pin in contact with a piece of cotton wool. The solution to equation (10) satisfying the above conditions is as follows:

$$l = Ae^{k_1 t} + Be^{k_2 t} - \frac{b}{a} + A_0 \sin(\omega t + \beta + \gamma) + B_0 \cos(\omega t + \beta + \gamma)$$

Where

$$A = \frac{c_1 k_2 - c_2}{k_2 - k_1};\ B = \frac{c_2 - k_1 c_1}{k_2 - k_1};\ c_1 = b/a - A_0 \sin\gamma_1 - B_0 \cos\gamma_1; c_2 = -\omega(A_0 \cos\gamma_1 - B_0 \sin\gamma_1);$$

$$k_1 = -n + \sqrt{n^2 + a}; k_2 = -n - \sqrt{n^2 + a};\ B_0 = g\frac{\omega^2 + a + 2n\omega f}{\Delta}; A_0 = g\frac{\omega^2 + a - 2n\omega f}{\Delta};$$

$$\Delta = (\omega^2 + a)^2 + 4n^2\omega^2;\ \gamma_1 = \gamma_0 + \beta.$$

(10) Here k_1 and k_2 are constant values, if $k > 1$, then a piece of cotton will be separated from the surface of the pegs faster, if $k = 1$, then a piece of cotton will be separated from the surface of the pegs with a uniform movement.

The general solution to the equation of motion is determined by placing all the fixed constants into the general equation.

$$l = \frac{c_1 k_2 - c_2}{k_2 - k_1} \cdot e^{k_1 \cdot t} + \frac{c_2 - k_1 c_1}{k_2 - k_1} \cdot e^{k_2 \cdot t} - g\frac{\omega^2 + a - 2n\omega f}{(\omega^2 + a)^2 + 4n^2\omega^2} \cdot \sin(\omega t + \beta + \gamma) + g\frac{\omega^2 + a + 2n\omega f}{(\omega^2 + a)^2 + 4n^2\omega^2} \cdot \cos(\omega t + \beta + \gamma)$$

This equation (11) of the movement of the roller feeding cotton pieces onto the surface of the pegs depends on the rotation speed and linear speed of the roller. From this equation, the roller rotation speed, which provides optimal values of the recommended parameters for the purpose of uniform transfer of cotton, is equal to $n_1 = 8\min^{-1}; n_2 = 10\min^{-1};\ n_3 = 12\min^{-1}$ values and linear speeds $1 - \vartheta_1 = 5.6\, sm/\min$; $2 - \vartheta_2 = 7\, sm/\min$; $3 - \vartheta_3 = 8.4\, sm/\min$ values analyzed the movement of the cotton piece. The figures show graphs of changes in the linear speed of movement of cotton pieces and rotation speed.

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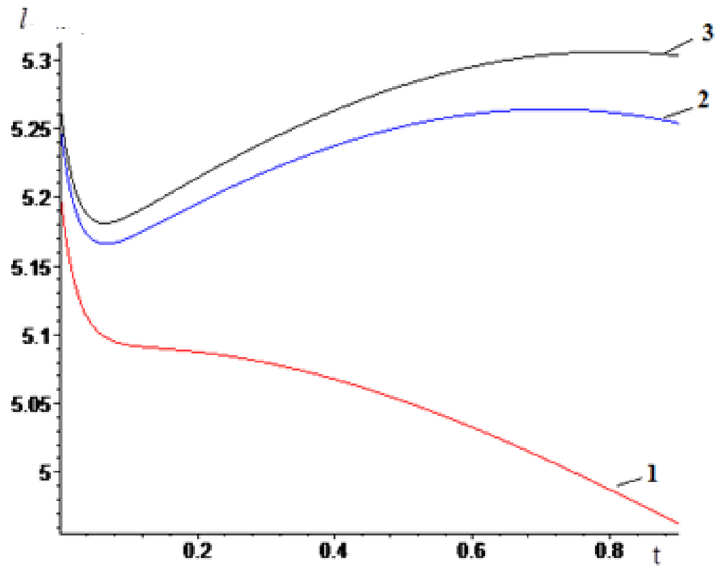

$1 - n_1 = 8\min^{-1}$, $2 - n_2 = 10\min^{-1}$, $3 - n_3 = 12\min^{-1}$

Figure 2. Graphs of the movement of cotton balls with different angular velocities over time $t(\sec)$ along the surface of the peg $l(m)$

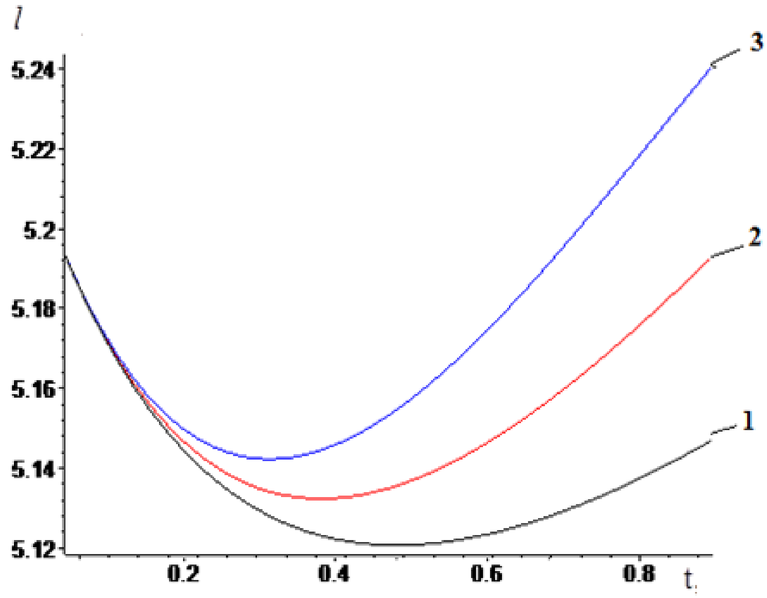

Figure 3. Graphs of the movement of cotton pieces of different masses $t(\sec)$ along the surface $l(m)$ of the pegs in time:

The following values were taken in the calculation:

$$R = 0.2м,\ c = 0.001Нс/м,\ v_0 = 10м/с,\ \omega = 20c^{-1},\ f = 0.2,\ \beta = 15^0$$

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The calculation results and graphs of the change over time of cotton piece $l(t)$ are presented in Figures 2-3.
Finally, the effect of pegs on cotton pieces was studied theoretically.

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