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ANALYSIS OF COTTON MOVEMENT THROUGH A PIPE IN A PNEUMATIC CONVEYOR.

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Abstract: *In the article , the equations of motion and the trajectory of movement of a piece of cotton in the pipeline of a pneumotransport device are analyzed, in which the laws of the change of the movement of a piece of cotton under the influence of aerodynamic resistance, weight, inertia, impact and reaction forces are derived, and the change of quality indicators of cotton during movement is theoretically based .*

Key words: *cotton, pneumotransport, aerodynamic resistance, air, pipe, movement, flow rate, impact*

Introduction.

Currently, extensive work is being carried out in the cotton ginning industry, which is related to the creation of high-efficiency techniques and technologies for the initial processing of cotton raw materials. Work is being carried out on the introduction of flexible technologies in the initial processing of cotton raw materials in cotton ginning enterprises. In particular, it is important to ensure the preservation of the quantity and quality of cotton raw materials prepared by cotton ginning enterprises, to reduce the consumption of raw materials and energy, and to create techniques and technologies.

When transporting cotton by air, the concentration of the air and cotton mixture has a significant effect on the characteristics of the transport. When the material moves in a straight pipe with air, the magnitude of inertial forces and resistance forces practically do not change. In this case, the transfer of cotton along the axis of the pneumatic conveying equipment creates favorable conditions for the transport process.

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The lack of theoretical development of the selection of optimal conditions for the transfer of cotton to the pipeline raises the issue of studying the process of transferring cotton to the pipe of pneumatic transport equipment from a theoretical point of view. The solution of this problem allows to determine the parameters that ensure the smooth progress of the air transportation process.

Transfer cotton to a pipe and study its movement inside.

A belt conveyor is used to transfer cotton to the pipe of the pneumatic transport equipment (Fig . 1).

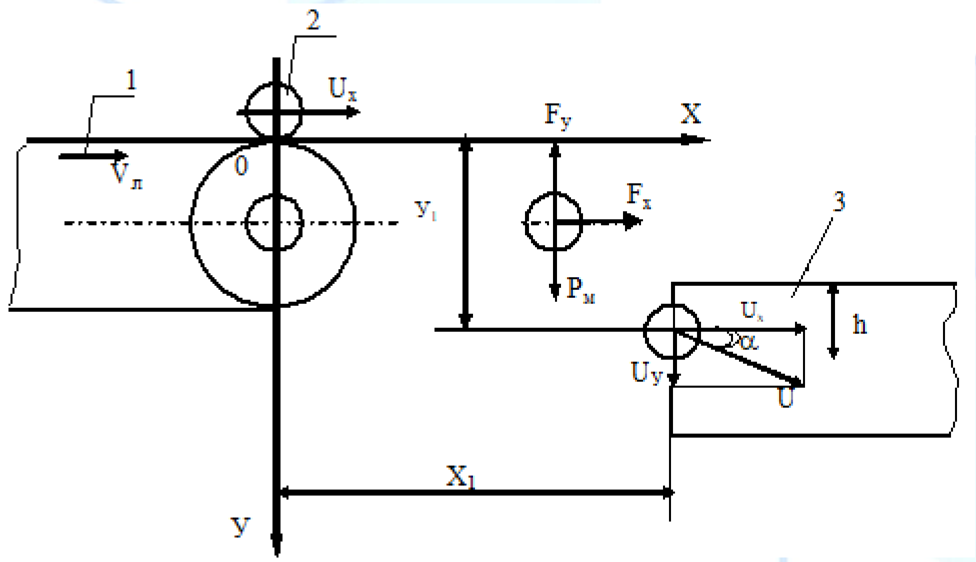

Figure-1 . Cotton using a belt conveyor to the pipe transmission

1-horizontal ribbon cutting ; 2- piece of cotton ; 3rd pipe.

First , we assume that the motion is on a plane and set the coordinate origin at the point where the contact between the tape and the cotton piece is broken. let 's put Let's consider the movement of a piece of cotton along the XOU plane.

Aerodynamic and gravity forces act on a piece of cotton ejected from the tape . The equation of motion will look like this:

$$\begin{cases} m\dfrac{dU_x}{dt} = -F_x \\ m\dfrac{dU_y}{dt} = -F_y + P_м \end{cases} \qquad (1)$$

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where: m is the mass of the particle, kg; U_x, U_y are the projections of the particle's velocity:

$$F_x = k_p U_x ;\ F_y = k_p U_y , \qquad (2)$$

Where: F_x, F_y - aerodynamic forces opposing the movement of the piece along the coordinate axes; $P_м = mg$ - gravity; g - acceleration of free fall; k_p - aerodynamic drag coefficient of the cotton piece.

the acting forces and developing the system, we get the following:

$$\left.\begin{aligned} \frac{dU_x}{dt} &= -\frac{k_n}{m}U_x \\ \frac{dU_y}{dt} &= -\frac{k_n}{m}\left(U_y - \frac{mg}{k_n}\right) \end{aligned}\right\} \qquad (3)$$

The solutions of equation (3) x, y give the velocities of the cotton ball along the coordinate axes. The solutions are obtained by integrating them once over time $y(t)$ and $x(t)$ - t as a result of excluding time from the solutions $y = y(x)$ - we get the law of change of the movement of a piece of cotton:

$$y = -\frac{m^2 g}{k_n^2} \cdot \left[\ln\left(1 - \frac{k_n \cdot x}{mU_{x_0}}\right) + \frac{k_n \cdot x}{mU_{x_0}}\right] \qquad (4)$$

this rule, we separate the cotton from the surface of the tape and construct the movement trajectory to the pipe (Fig. 2).

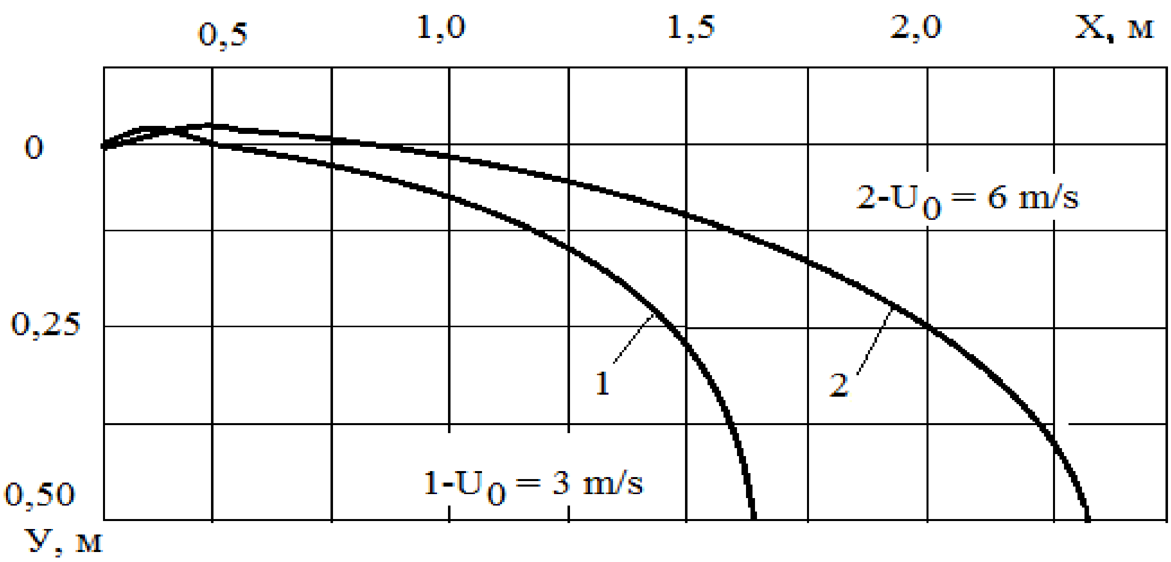

Figure-2. The trajectory of the cotton to the pipe.

Figure 2 shows the movement trajectory of a piece of cotton before it enters the pipeline of the pneumotransport equipment.

The graph shows that after the fragment is separated from the tape, it moves along an increasing trajectory, where at a low initial speed the fragment enters the pipe at a low speed, and at a high speed it does the opposite.

When studying the motion of cotton in the suction section of a pipe, for convenience, we first set the coordinate at the beginning of the pipe. Let's assume that the motion of the cotton occurs between two infinite walls:
y=0 and *y=d.*

Let us assume that the cotton ball has an absolute velocity when it encounters the air stream and is moving at a certain angle to the axis of the pipe . Then movement equation as follows will be :

$$\begin{cases} mx'' = -k(x'-V) \\ my'' = ky' - mg \end{cases} \qquad (5)$$

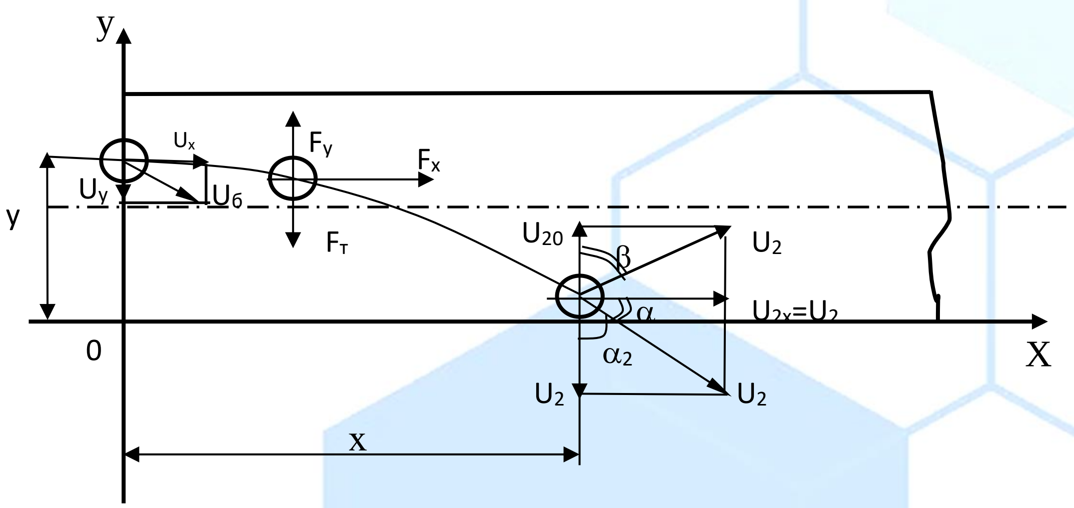

Figure 3. The movement of cotton in the pipe

$U_x = \dfrac{dx}{dt}$ and $U_y = \dfrac{dy}{dt}$, we integrate system (5) at t=0. The solution is as follows:

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$$\begin{cases} x = \frac{m}{k}(U_H \cos\alpha - U)(1 - e^{-\frac{k}{m}}) + Vt \\ y = -\frac{m}{k}(U_H \sin\alpha - \frac{mg}{k})(1 - e^{\frac{k}{m}}) + \frac{mg}{k}t + y_1 \end{cases} \quad (6)$$

This system of equations determines the trajectory of cotton in the xou plane.

At a certain distance (X), a fragment collides with the inner wall of the pipe and is thrown upward under the force of the impact.

3 - in the picture from the diagram following equality we find :

$$tg\alpha = tg\left(\frac{\pi}{2} - \alpha_2\right) = ctg\alpha_2 \text{ or } tg\beta = \frac{ctg\alpha_2}{n} \quad (7)$$

here : n - again recovery coefficient .

analytical h calculations come out of the blow of the next piece of cotton speed expression and coordinate axes (x, y) according to we determine the location :

$$\begin{cases} U_x == (U_{20x} - V)l - \frac{k}{m}(t - t_1) + V \\ U_y = \left(U_{20y} - \frac{mg}{k}\right)l\frac{k}{m}(t - t_1) + \frac{mg}{k} \end{cases} \quad (8)$$

$$\begin{cases} X = \frac{m}{k}(U_{20x} - V)\left(1 - l - \frac{k}{m}(t - t_2)\right) + V(t - t_2) \\ Y = \frac{m}{k}\left(U_{20y} - \frac{mg}{k}\right)\left(1 - l\frac{k}{m}(t - t_2)\right) + \frac{mg}{k}(t - t_2) \end{cases} \quad (9)$$

This on the ground : $U_{20x} = (U_n \cos\alpha_1 - V)\frac{k}{m}t_2 + V \; U_{20y} = U_{20x}x \cdot tg\beta$

Equations (8) and (9). pipe to the wall a piece of cake first on the stroke condition determines This is a critical point enough and down falls If , the vertical coordinate of the critical point size pipe diameter big if , then piece by piece high to the wall It is hit . Its next condition enough accuracy with (8) and (9) of the form equations with determination can Only , from the blow next initial speed direction into account received in case to the signs change is included .

By removing time from expression (9) , we can obtain the equation of the trajectory of a cotton ball along the pipe diameter and length: *ty=f(x)* , the graphical representation of which is shown in Figure 4.

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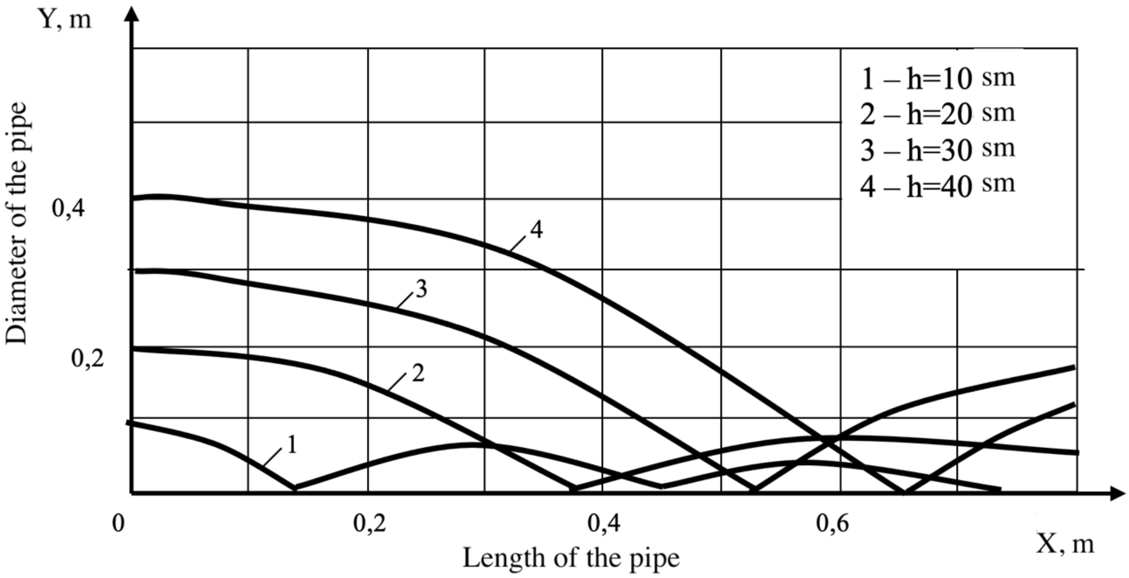

Figure 4. The trajectory of the movement of the particle in the pipe.

An interesting phenomenon can be observed from the results, namely, when a piece of cotton moves in a pipe, even without taking into account the turbulence of the flow, longitudinal, transverse and circulation forces, the cotton collides with the pipe wall with an impact. The higher the speeds, the faster and more intense the impact. It was found that this negatively affects the initial quality indicators of cotton.

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