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Theoretical and practical aspects of the air exchange process when feeding cotton into the pipes of the carrier device

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Abstract. The scholarly literature on the transfer of cotton to an air-assisted carrier is thoroughly examined in this article. The theoretical foundation for the procedure of transferring cotton to an air-assisted carrier device was developed based on the findings of nzary and practical work. The movement trajectories of cotton in the distance to the pipe and inside the pipe were measured when raw materials were transmitted to the starting part of the pipe of the carrier device using air at different starting speeds. Cotton moves in the first section of the pipe and then progressively transitions into the rectilinear movement in this instance, as is theoretically demonstrated.

1 Introduction

The RBX brand screw breaker machine is currently utilized for the automated transfer of cotton via air to the carrier device system's pipe at the initial stage of cotton ginning firms' technical processes. A study was conducted at the Namangan cotton ginning mill to assess the RBX garam breaker machine's performance. This machine breaks down the cotton pile and conveys it to a horizontal tape device using the RBX pile milling cutter, subsequently directing air to the carrier device's pipe. The flexibility for both upstream and downstream movements is achievable by positioning a pile milling machine adjacent to it. This capability enhances the efficiency of cotton removal from the garam, making it a recommended practice for optimal operations.

According to the given plan, the cotton is transferred from the garam breaker machine garam in two steps. In the first, a screw breaker machine can travel the entire length of the shaft and distort around 6 meters of it. There are five meters between the stair and the horizontal tape gadget in it [1,2]

In the second stage, the boiler breaker will be able to transmit the remaining 8 meters of the width of the cotton boiler. In this case, a horizontal tape device is installed on the cotton collection pad.

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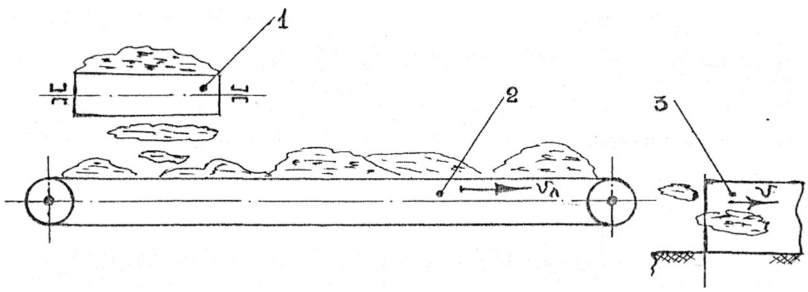
2 Methods and materials

After analyzing the condition of the cotton transported via the heap eliminator, we reached the following conclusion: the milling machine's pegs break the cotton from the pile and transfer it to the tape in a ball-shaped position, resulting in uneven distribution across the tape. Consequently, cotton is unevenly transferred with the assistance of air to the carrier device's pipe. To investigate this further, an experimental device scheme was designed and constructed at the Namangan cotton ginning firm No. 3 (Figure 1). The air-assisted carrier comprises an air-assisted carrier (3), a screw breaker with a horizontal tape device (2), and a curved tape device (1). The horizontal tape device is installed in alignment with the screw breaker placement line.



1 –bias tape devise; 2-horizontal tape devise; 3-a tube which carries the cotton

Fig. 1. Scheme of an experimental device prepared for the study of unevenness in the transmission of cotton.

The apparatus used for the investigation was conditionally divided into ten equal portions of the horizontal transporter's length, which is installed parallel to the fault-breaking alignment line. This is how the study was carried out. The dimensions of the plots were established, the linear speed of movement, the tape's breadth and length, and the scales needed for cotton pulling were ready.

3 Research results and discussion

The transporter's output side is made to send material straight into the pipe. In accordance with the present operating guidelines, the throttle breakers, horizontal transporter, and separator and fan of the air-assisted carrier device were installed. Throughout the investigation, the screed breaker and separator are continuously observed in operation, with particular focus on the cotton transfer procedure. Both the screw breaker and the horizontal tape device were stopped simultaneously after 60 minutes. This causes a cotton spread to form all the way along the tape's length. It describes the condition in which the content that is the source of the spread is disseminated.

On the surface of the resulting spread horizontal tape cut into pieces according to the specified plots.

Each piece weighed and the weight of the Cotton was determined for each piece separately and without generalization.

Experiment is repeated 3 times.

The unevenness indicator was developed according to a special methodology:

$$S = \sqrt{\frac{\sum_{l=1}^{n}(k_i - k_{cp})}{n-1}} \quad (1)$$

Here: S- dispersion of material specific density along the surface of the tape; $k = \frac{m}{F_l}$- criterion characterizing the magnitude of the weight of the material corresponding to the belonging area; m- the weight of cotton on the given plot of the tape; F_l - area of the tape plot being seen; n-number of plot *(n=10).*

The transmission productivity of the device is found by the following formula, depending on the mass of cotton on the tape:

$$\Pi = 3.6\frac{m \cdot V_l}{L}, m/s \quad (2)$$

Here: m- the mass of cotton on the tape, kg; *V tape speed*, м/s; L – tape length m.

Table 1. Results of research on the unevenness of the transmission of cotton by air to the carrier device.

Demonstrators					
Cotton sort and variety	**Humidity %**	**Bulk density kg/m³**	**Productivity t/hour**	**Comparative density dispersion kg/m²**	**Breakdowns over 1 hour**
C6524 II type hand picking	9.5	66.6	9.7	1.61	1ʳ
	9.5	75.6	9.5	2.33	1ʳ
	9.5	83.4	9.97	2.74	2ʳ, 1ᶜ
C6524 II type car picking	11.2	69.2	9.2	2.11	2ʳ
	11.2	74.4	9.1	2.62	1ʳ
	11.2	89.7	9.8	3.06	4ʳ, 2ᶜ

When transplanting cotton, there will be a lot of unevenness, as Table 1 shows. This indicator rises in response to both high humidity and an increase in the cotton's volumetric density. The overcompaction of cotton from spinning is the cause of this condition. The cotton cannot be vibrated by the screw breaker machine to the necessary degree. High unevenness causes cotton to settle on the tape's surface like pistols, concealing a portion of the input's cross-section as it enters the pipe. This has been observed. Should the fragments enter the pipe in this manner, there will be a noticeable aerodynamic shadow behind it when it is being transported. Because of the much-reduced air pressure in this area, the item that falls into the pipe sinks to the bottom without gaining the required aerodynamic force. The resistance force created by the cotton soaking into the inner surface of the pipe joins the line of aerodynamic forces here, and the pipe inlet is clamped.

Two times at the entrance and once in the separator chamber during the investigation, cotton clogging in the pipe for an hour at low humidity and not too high a volumetric density was noted. Additionally, there was a blockage at the pipe entry four times and in the separator chamber two times when there was high humidity and volumetric density.

Blockages in the Separator chamber will have a particularly detrimental effect. Depending on how severe the lightness is, it takes an average of 25 minutes of production time to remove obstructions from the separator. It is also possible for the cider vinegar separator to break, in which case replacing it may require more time. In addition, cotton will overflow into the stoneware's working chamber when the separator's chamber becomes clogged with cotton. During production, this is disregarded. This means that just a portion of the cotton is taken up by the air. The last portion leads to the quarry's rock-collecting bunker. The aforementioned makes it evident that reducing the irregularity in cotton transmission is necessary. This presents an opportunity to increase the effectiveness of each piece of equipment that makes up the technical chain involved in cotton processing as well as the air-assisted carrier.

A theoretical framework must be created in order to carry out research on an air-assisted carrier device. This calls for the completion of a more precise investigation that completely elucidates the cotton's collision with all of the carrier device's operational organs through the use of air. Additionally, the device elements' architecture can be improved based on this.

Theoretical verification of the process of transferring cotton to the pipe. The air-assisted transport process represents the flow of air particles moving inside the pipe using the air pressure generated by the fan inside the device, and of solid bodies and particles moving by means of aerodynamic resistance to them and frictional forces. When transporting cotton by air, the concentration of air and cotton mixture has a significant effect on the nature of Transportation.

Resistance forces with inertial forces practically do not change in size at the time when the Material moves in a straight-line pipe using air. In this case, the transmission of cotton along the axis of the pipeline of the carrier device using air creates favorable conditions for the transportation process.

The absence of theoretical developments in the selection of favorable conditions when transferring cotton to the pipe puts the issue of studying from the theoretical side the process of transferring cotton to the pipe of the carrier device using air. The solution of this issue ensures the moderate course of the air-assisted transportation process.

Transfer cotton to the pipe and study its movement inside. Let the tape device be used when transferring cotton to the pipe of the carrier device using air (Figure 2):

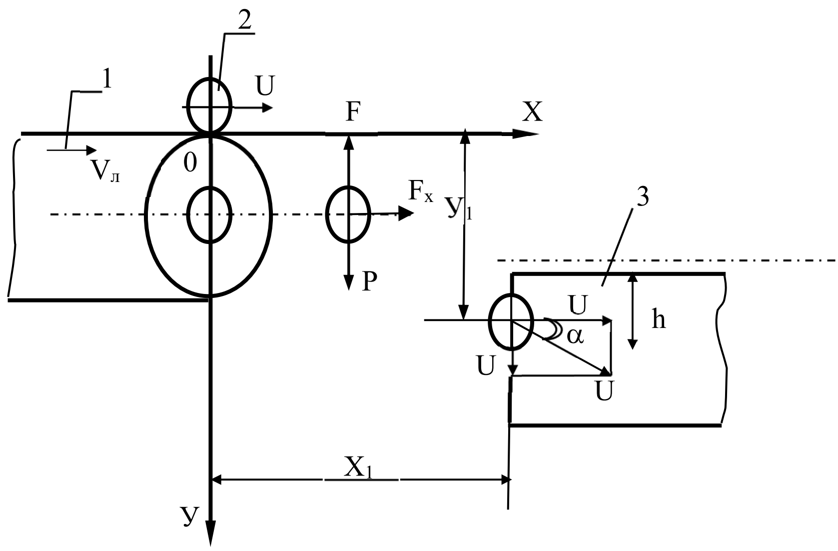


Fig. 2. Transmission of cotton to the pipe of the carrier device using air using a tape device. 1-horizontal tape device; 2-piece of cotton; 3-pipe.

Let us look at the movement of a piece of cotton on the HOU plane. First, we put the coordinate at the point where the contact of the tape with a cotton swab is interrupted.

The slice cut from the tape is affected by aerodynamic and weight forces. The equation of motion will look like this:

$$\begin{cases} m\frac{dU_x}{dt} = -F_x \\ m\frac{dU_y}{dt} = -F_y + P_м \end{cases} \quad (3)$$

Here: m mass of piece, kg; U_x, U_y- the velocity of the slice on the coordinate axes is.

$$F_x=k_nU_x; F_y=k_nU_y, \quad (4)$$

In this: F_x, F_y - aerodynamic forces against the movement of the particle on coordinate axes; $P_м = mg$ - weight force; g - free fall acceleration; k_n - aerodynamic resistance coefficient of a piece of cotton.

Putting the equation of the acting forces and developing the system, we get:

$$\frac{dU_x}{dt} = -\frac{k_n}{m}U_x$$

$$\frac{dU_y}{dt} = -\frac{k_n}{m}\left(U_y - \frac{mg}{k_n}\right) \quad (5)$$

(2.5) solutions to the equation x, y - gives the velocities of a piece of cotton on coordinate axes. By integrating the solutions once in time, one obtains $y(t)$ and$x(t)$ - time from solutions subtracting the results of t $y = y(x)$ - we take the law of change of the movement of a piece of cotton:

$$y = -\frac{m^2 g}{k_n^2} \cdot \left[ln\left(1 - \frac{k_n \cdot x}{mU_{x_0}}\right) + \frac{k_n \cdot x}{mU_{x_0}}\right] \quad (6)$$

By this law, we separate the cotton from the surface of the tape and build a graph of the trajectory of movement up to the pipe (Figure 3).

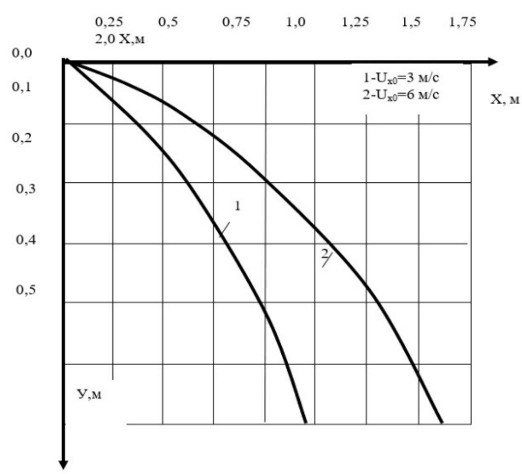


Fig. 3. The trajectory of movement of cotton to the pipe.

Figure 3 depicts the trajectory of the movement of a piece of cotton prior to its arrival in the pipe of the carrier device using air. The graph shows that the piece moves along the ascending trajectory after separating from the surface of the tape, in which, at a small initial speed, the piece comes to the pipe with a small speed, at a large speed –on the contrary.

At the time of studying the movement of cotton in the pipe absorber, so that it is convenient, we first put the coordinate at the beginning of the pipe. Let's assume that the particle is moving between two infinite walls:

y=0 and *y=d.*

Let us assume that a piece of cotton during a meeting with an air flow has an absolute speed, moving it at a certain angle relative to the pipe axis. Then the equation of motion becomes:

$$\begin{cases} mx'' = -k(x' - V) \\ my'' = ky' - mg \end{cases} \quad (7)$$

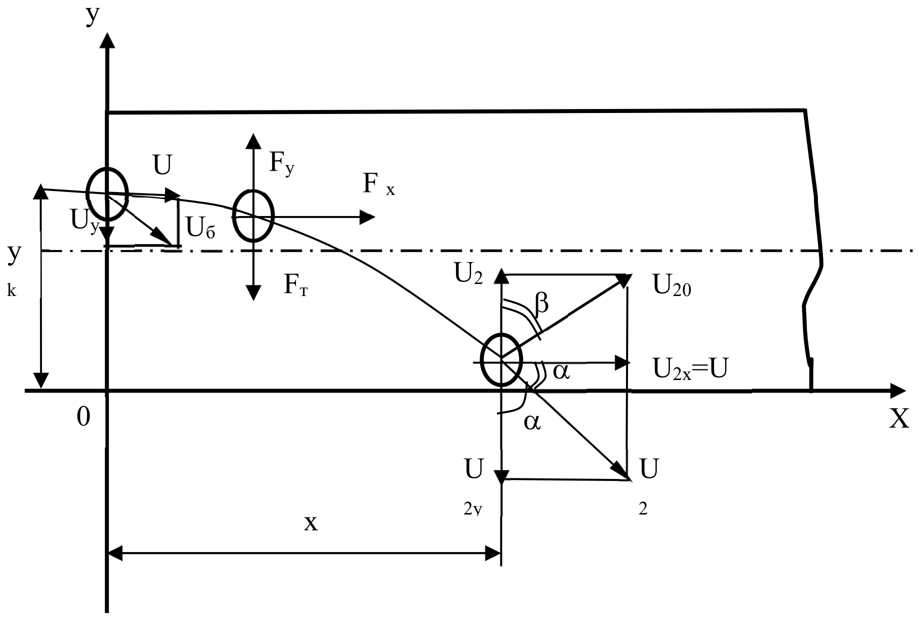


Fig. 4. Movement of cotton in the pipe.

$U_x = \frac{dx}{dt}$ and considering the $U_y = \frac{dy}{dt}$, (7) we integral the system under condition t = 0. The solution would be:

$$\begin{cases} x = \frac{m}{k}(U_H \cos\alpha - U)(1 - e^{-\frac{k}{m}}) + Vt \\ y = -\frac{m}{k}(U_H \sin\alpha - \frac{mg}{k})(1 - e^{\frac{k}{m}}) + \frac{mg}{k}t + y_1 \end{cases} \quad (8)$$

This system of equations determines the trajectory of the cotton to settle in the Hou plane.

At a certain distance (X), the piece collides with the inner wall of the pipe and is fired upwards under the influence of shock force.

From the scheme in Figure 4 we find the following equality:

$$tg\alpha = tg\left(\frac{\pi}{2} - \alpha 2\right) = ctg\alpha_2 \quad \text{or} \quad tg\beta = \frac{ctg\alpha_2}{n} \quad (9)$$

here: n - recovery coefficient.

Based on analytical calculations, the expression of the velocity of the post-impact cotton swab and the coordinate axes (x, y) let's determine the location on:

$$\begin{cases} U_x == (U20x - V)l - \frac{k}{m}(t - t1) + V \\ U_y = \left(U20y - \frac{mg}{k}\right) l \frac{k}{m}(t - t1) + \frac{mg}{k} \end{cases} \quad (10)$$

$$\begin{cases} X = \frac{m}{k}(U20x - V)\left(1 - l - \frac{k}{m}(t - t2)\right) + V(t - t2) \\ Y = \frac{m}{k}\left(U20y - \frac{mg}{k}\right)\left(1 - l\frac{k}{m}(t - t2)\right) + \frac{mg}{k}(t - t2) \end{cases} \quad (11)$$

here: $U_{20x} = (U_n \cos\alpha_1 - V)\frac{k}{m}t_2 + V \qquad U_{20y} = U_{20x}x \cdot tg\beta$

(10) and (11) the equations determine the position of the splitter at the first stroke on the pipe wall. In this, the slice reaches the critical point and goes down. If the vertical coordinate magnitude of the critical point is greater than the diameter of the pipe, then the piece will hit

the upper wall. Its subsequent state can be determined with sufficient accuracy by equations of the Form (10) and (11). Only, modifications are made taking into account the direction of the initial speed after the stroke [195].

(11) time from expression subtracting the results of t

$y = y(t)$ - the law of change of the trajectory of a piece of cotton on the diameter and length of the pipe is graphically illustrated.

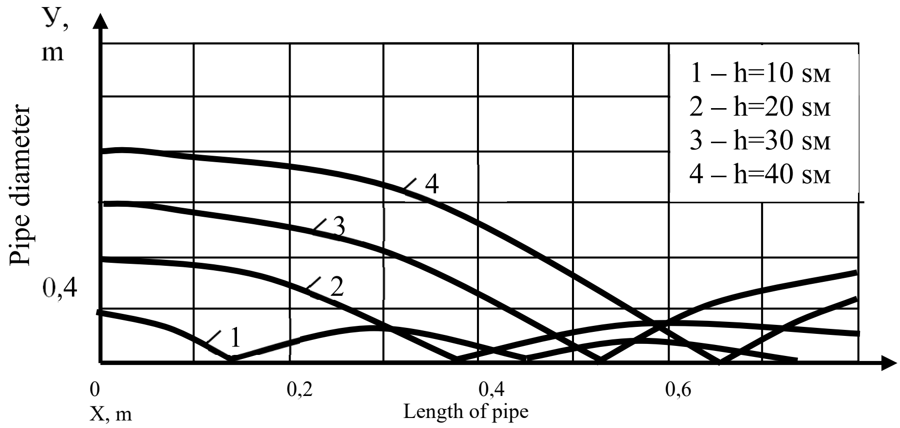


Fig. 5. The trajectory of movement of a piece in a pipe.

An interesting case can be observed from the results. During the movement of a piece of cotton in a pipe, a collision of a piece with a blow to the wall of the pipe occurs, even without taking into account the turbulence of the flow, longitudinal, rotating and other forces. The larger the velocities in this, the faster and more intense the shock.

4 Conclusion

After conducting a comprehensive theoretical and empirical investigation, complemented by a thorough review of scientific literature on cotton transfer to air-assisted carriers, we have reached the following conclusions.

A theoretical basis has been established for the technique of transferring cotton to an aerial apparatus.

Movement trajectories of cotton in the vicinity of and inside the pipe were measured during the transmission of raw materials to the starting portion of the carrier device pipe using air at varying initial speeds. This revealed that cotton commences the pipe with hops and gradually transitions to a straight-line movement.

An equation has been developed to determine the influence of cotton transmission speed on air pressure required for acceleration, based on the hypothesis of cotton movement at the pipe's commencement. The findings suggest that cotton can be accelerated with less energy at higher starting speeds.

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