The Study of the Movement of the Aero Mixture through the Pipeline During Pneumatic Transportation of Cotton

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Annotation--- The paper presents the results of studies on the movement of raw cotton inside a pipeline with a variable cross-section of a pneumatic conveying system used at ginneries. The patterns of parameter changes during the movement of components inside the pipeline are analyzed, technical solutions to improve the efficiency of the process are proposed.

Keywords--- Raw Cotton, Pneumatic Transport, Air Pressure and Speed, Cotton Fiber, Pipeline, Porosity, Aerosol Mixture.

I. General Concepts of Multi-Component Systems

Uzbekistan is one of the northern cotton-growing countries in the world and produces about 3 million tons of raw cotton per year. There are 98 ginneries of various capacities in the republic. Where, the average capacity of ginneries is in the range of 30 thousand tons of raw cotton per year [1].

The period of cotton picking in the republic is rather short and lasts about 2 months, usually September and October, relatively warm months of autumn. In November, the rain and cold season begins in this region, which prevents the harvest. Therefore, the cotton farms plan to finish the harvest season before November. Moreover, cotton is currently harvested mainly by hand.

Cotton processing at ginneries lasts up to 10 months according to processing plans. Therefore, the cotton processing technology in Uzbekistan provides for the harvesting and long-term storage of cotton before processing. For this, there are cotton harvesting stations where, on a certain area, sites are built with a height of 40-50 cm and a size of 12x25 meters. On each site, trapezoidal piles (or modules) of cotton are formed, manually pressed, 7-8 meters high, weighing 350-450 tons, covered with a waterproof material on top (often use tarpaulin). These piles are called "riot". It should be noted that the formation of rebellion is very difficult, labor-intensive work, requiring certain skills and the amount of labor [2-4]. Cotton is stored in riots until the processing line approaches, and, proceeding from the state (humidity and temperature) of the cotton, technological care is carried out - digging tunnels in riots, measuring temperature, and conducting ventilation as needed.

According to the processing plan, in turn, the riot is taken apart - the cotton is removed from the riot and served for processing. The rebellion is disassembled mechanically, using a special machine called a rebellion breaker or manually. Manual disassembly of the riot and the supply of cotton for processing is also difficult, time-consuming, occupying 0.8 people / hour of labor, occupation. Therefore, although at the same time, there are no material and energy costs and no negative impact on the quality indicators of raw materials, production prefers the mechanical method of disassembling the riot as a safer, more modern and perfect one.

There are several designs and models of riot parsers - RBC, RBA, RP, etc. But their principle of operation is the same. The main working unit of the parser is a rotating milling cutter made of a steel pipe in the form of wheels on which radial pegs are fixed. The cutter is mounted on the end of the boom, 7-8 meters long, mounted with the ability to move both vertically and horizontally. The boom has the appearance of a trunk, inside which a belt conveyor is installed, which communicates with the cutter at the tip of the boom and from the base side with a cotton pick-up

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chamber, under which another, also belt, inclined conveyor is installed to withdraw the cotton from the picker to the side. The parser is mounted on wheels with a propulsion system that allows the machine to move as needed.

Currently, in cotton processing enterprises for transporting it inside the enterprise - from storage to production workshops, from one workshop to another, and also inside the workshops, suction-type pneumatic conveying systems are used. Such installations are notable for their simplicity of design, the possibility of applying the material pipeline regardless of the terrain and terrain, use in any weather conditions, and the ability to create excess pressure inside the pipeline, which helps to attract not only material, but also small weed impurities released in contact with cotton while maintaining sanitary conditions in the workrooms. In addition, studies have identified such positive properties of pneumatic installations as the possibility of cleaning and loosening cotton during transportation under the influence of an air stream. Despite this, there are some disadvantages of pneumatic conveying systems. Their disadvantages include high consumption of air and electricity, as well as a negative impact on the initial quality indicators of transported cotton. In order to increase the positive, eliminate or reduce the negative properties of pneumatic transport, it is necessary to reveal the essence of this process, to establish factors that determine the effectiveness of this process and how to control them by conducting deep theoretical and applied research on this process.

II. Possibilities of Mathematical Modeling of Cotton Pneumatic Conveying Process

These studies are carried out in order to find opportunities to reduce the energy intensity of the process and maintain the original quality of cotton by further improving the process of pneumatic transportation. When pneumatic conveying is operated by a fan, excess pressure and air flow are created inside the pipeline, rushing from the neck of the pipeline to the fan. In this case, the air flow will have a turbulent mode [5–9], which is characterized by a random flow, a pulsating change in parameters, and a relatively high speed. Moreover, the total flow pressure starting from the fan towards the neck of the pipeline is gradually reduced.

The main reasons for reducing the total pressure in the pipeline are:

1. Reducing the static pressure of the flow due to losses on overcoming the forces of friction resistance of air on the inner surface of the pipeline;
2. Decrease in static pressure of a stream due to losses on overcoming of local resistance (on shaped parts of an air duct);
3. Decrease in dynamic pressure due to air suction from the outside through cracks, crevices and holes in the walls and joints of pipelines.

In addition, there is a slight decrease in air density due to its vacuum inside the pipeline, which causes a decrease in dynamic pressure from the neck of the pipeline to the fan. This gives the opposite effect, i.e., an increase in the dynamic pressure from the fan towards the neck of the pipeline and partially compensates for the decrease in the dynamic pressure due to air suction.

For guaranteed air transportation, the value of the total pressure at the neck (i.e., at the beginning) of the pipeline is important. With an increase in the duration, i.e., the length of the pipeline, the pressure in its neck decreases and reaches such a critical value of Pkr, after which the transportation is interrupted, i.e., with a further increase in the length of the pipeline (pressure reduction), transportation is not guaranteed, often slaughter occurs material in the neck of the pipeline. The distance from the separator to the neck of the pipeline, where Pkris reached - the critical value of the total pressure, is called the radius of the pneumatic transport, that is, this is the maximum distance from where the transportation of the material is guaranteed.

Often, when transporting cotton from distant storages, the radius of action, i.e., air pressure, will be insufficient to remove cotton from the repository and transport it to its intended purpose. In such cases, it is necessary to connect in series a separate, so-called “transshipment” pneumatic installation additionally. “Transshipments” have the same working elements as the main pneumatic installation: separator, fan, cyclone and connecting ducts. Transshipments are stationary and mobile, installed on sites with wheels. This leads to additional energy and air consumption, due to which the latter is clogged with fibrous dust.

III. Investigation of the Process of Supplying Cotton to the Pneumatic Conveying Pipeline

From the storages, the cotton is fed into the pipeline either manually or mechanically using a horizontal belt conveyor, which is installed parallel to the lines of movement of the cotton riot picker (Fig. 1).

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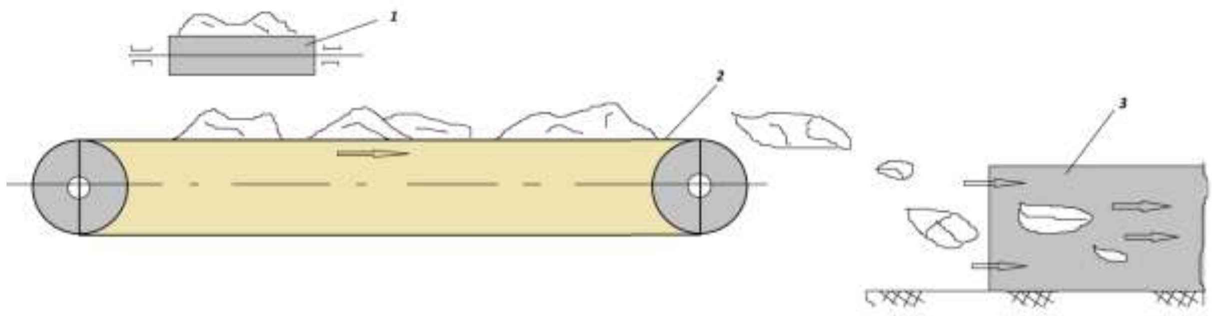

Figure 1. Schematic of an Experimental Setup Designed to Study the Process of Feeding Cotton into Pneumatic Conveying

1. Belt Riot Breaker Conveyor; 2. Horizontal Belt Conveyor; 3. Pipeline Pneumatic Conveying

The process of supplying cotton to pneumatic transport is as follows:

The parser removes the cotton from the riot and feeds it to the horizontal belt conveyor 1 on an inclined belt conveyor 2, on the surface of which a moving layer of cotton is formed towards the pneumatic conveying pipe 3. Upon reaching the conveyor driven shaft, the cotton comes off from the surface of the belt and flies into the airflow zone, which carries the cotton along inside the pipeline 3.

With the arrival of cotton in the pipeline, the aerodynamic regime of the equipment will change. A force appears that draws the material in the direction of air movement, and a vacuum forms behind the material (aerodynamic trail), which also carries air into the pipe (Fig. 2). If you pay attention, in the beginning, cotton particles (discrete medium) pass through the stationary air particles (continuous medium) and fall into the air discharge zone. Here, first of all, the force of the vacuum draws it into the pipe.

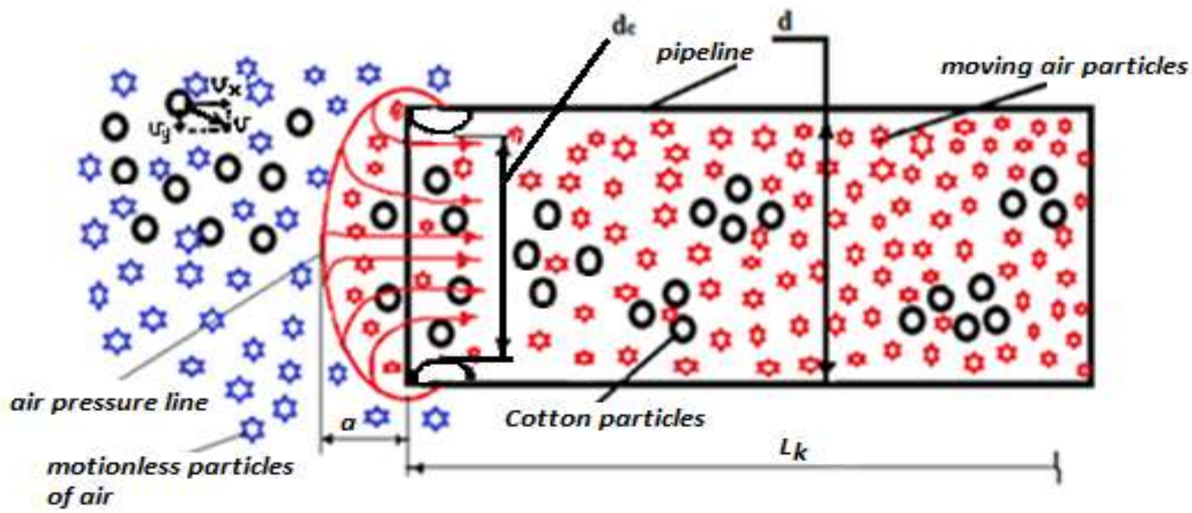

Fig. 2: To the Study of the Movement of a Mixture of Cotton with Air at the Beginning of the Pipeline

In addition, the particles of cotton are affected by the momentum forces of the air particles due to their collision, as well as the friction forces of the air particles with the cotton particles due to their relative motion. In addition, air particles move faster than cotton, because of which, part of the air penetrates into the cotton particles and moving through their pores cause additional friction between the air and cotton particles.

As a result of all the acting forces, the cotton particles mix with the air particles and begin to move to the source of air pressure (vacuum) - the fan.

Most scientists believe that only resistance forces move (move) the body, and model process parameters only depending on air speed. And air velocity causes dynamic pressure. That is, it turns out that the laws of motion depend only on dynamic pressure. However, this pressure is only a smaller part of the total pressure. Most of the

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total is static pressure and it is actively involved in organizing the process of moving both air and material. Evidence of the above is that fans with high air flow and low pressure have less conveying ability. In addition, there are air pumps that create high pressure, but with less air consumption. Analysis shows that their transport capacity is also limited. This shows that for the efficient transportation of the material a certain amount of pressure and air flow are required, moreover, the pressure value can be characterized by static pressure, and the flow rate - dynamic.

According to sources, the total pressure is the ratio of mechanical energy in liquids and gases to a unit of their weight. And kinetic energy is velocity or dynamic pressure equal to half the square of the flow velocity times the density of the medium. The ratio of the sum of the pressure energy and the total potential energy of a state to a unit of weight is called static pressure. Static pressure is a relatively complex physical structure without a clear mathematical expression for a moving gas. It is logical that this pressure is the ratio of the pressure force of the air particles to the surface area of the base and it can be measured.

The study of the movement of the body, including cotton, through the pipeline, depending only on dynamic pressure, does not give a true result. And taking these arguments into account, it is advisable to choose models that take into account the static air pressure when modeling the processes of pneumatic transportation. Moreover, the rational values of static and dynamic pressures for efficient transportation, of course, will be different for each material. And it should be noted that so far no studies have been conducted in this area either abroad or in our country. This is a task for further research.

Pneumatic transportation is a multi-factor, complex process. Therefore, some assumptions and limitations apply in its mathematical modeling.

Air speed is usually higher than body speed. Therefore, in many theories, the body is considered to be motionless, and its air stream bends around. In other theories, on the contrary, it is assumed that the air is stationary, and the body makes a relative motion [10]. In addition, in a number of theories, a body in an air stream is considered as a material point, a sphere or a sphere, or another specific geometric figure. There are also attempts to theoretically describe the motion of bodies and air flow in other branches of science as a two-component medium [11-22].

Depending on the assumptions made and how close the model is to the actual process, the results can also be more or less accurate. The development of science and computer engineering and technology helps to ensure the development of more realistic models while reducing errors in the results. Unlike our previous studies [23-25], we consider the process of transporting cotton in the pipeline as the movement of a two-component medium, moreover, the air flow is a continuous medium, and raw cotton is discrete, having, at a first approximation, the same speed.

The Study of the Movement of Two-Component Flow through the Pneumatic Pipeline

One of the main indicators of a two-component medium is its volume concentration w and weight concentration μ. The volume concentration is the relative volume of the components in the total volume of the stream:

$$\mathrm{w} = \frac{W_{п}}{W_{п}+W_{х}}, (1)$$

Mass concentration is the relative mass of the components in the total mass of the stream:

$$\mu = \frac{\sigma_{п}}{\sigma_{х}+\sigma_{п}}, (2)$$

Where: the volume of cotton and - air in the total volume of the flow, m^3/s; masses of cotton and air in the total mass of the stream flowing per unit of time, kg/s.

Analysis with the current parameters shows that when using a VS-12M fan with an average productivity of 10 tons of cotton per hour (or 2.78 kg / s), 6.0 m^3/s (or 7.2 kg / s) of air is used, taking attention is paid to the fact that the density of cotton after the riot picker is $\rho п$ = 37.8 kg / m^3, with an air density of ρx = 1.2 kg/m^3 volumetric mass concentration:

$$w = (2{,}78 / 37{,}8) / (6 + 2{,}78 / 37{,}8) = 0{,}012\ m^3/m^3,$$
$$\mu = 2{,}78 / (2{,}78 + 7{,}2) = 0{,}28\ kg/kg$$

These indicators are significantly lower than those used in other industries, such as grain processing, construction, woodworking and mining.

Another indicator of a two-component medium is its average density:

$$\rho = \rho_{x} + w \cdot (\rho_{п} - \rho_{x}), (3)$$

According to the above, the average density of the mixture of cotton and air in actual values is:

$$\rho = 1.2 + (37.8–1.2)\ 0.012 = 1.64\ kg/m^3$$

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Like any conductor, a pneumatic pipe has a certain throughput that determines the performance of the entire pneumatic system.

We analyze the behavior of a two-component medium consisting of a mixture of air and cotton particles at the beginning of the pipeline (Fig. 2).

A mixture of air and cotton is taken as a heterogeneous mixture. The motion of such a mixture can be described by the equations of motion of multi-speed systems proposed by H. A. Rakhmatullin [10], which take into account the dynamic effects arising from the mismatch of the velocities of the components. In this case, we take air as an ideal fluid and determine the internal interaction force through normal pressure, which is common to the whole mixture, directed opposite to the movement of cotton particles. Coordinate axes are installed in the initial section of the pipeline. The axis $0x$ coincides with the axis of the pipeline, the cross-sectional area of which is not constant and varies according to the law $S = s(x)$. We accept the process as stationary. We also accept the following notation $u_0(x)$, $u_1(x)$ speeds, respectively of air and particles of raw cotton, which move in an arbitrary section of the pipeline. When $x = 0$ the moving mass of the mixture is affected by air flow at a speed u_{00}. The one-dimensional motion of the mixture components according to [24.25] can be written by the equations:

$$\rho_0 u_0 s \frac{du_0}{dx} = -\frac{\rho_0}{\rho_0^{(0)}} \frac{d(sp)}{dx} + sk(u_1 - u_0), \tag{1}$$

$$\rho_1 u_1 s \frac{du_1}{dx} = -\frac{\rho_1}{\rho_1^{(0)}} \frac{d(sp)}{dx} - sk(u_1 - u_0) \tag{2}$$

Laws of conservation of masses:

$$\rho_0 u_0 s = u_{00} \rho_{00} s_0 = const, \ \rho_1 u_1 s = u_{10} \rho_{10} s_0 = const, \rho_0 = m\rho_0^{(0)}, \rho_1 = (1-m)\rho_1^{(0)}$$

$$\rho_0 = \frac{m}{m_0}\rho_{00}, \ \rho_1 = \frac{1-m}{1-m_0}\rho_{10} \tag{3}$$

Where ρ_0, ρ_1 - are the and true densities, $\rho_0^{(0)}$, $\rho_1^{(0)}$ - respectively, of air and cotton; m - flow porosity in an arbitrary section of the pipe, k -aerodynamic drag coefficient of cotton, ρ_{00}, ρ_{10} and m_0 - known values of the density of air, cotton and porosity in the section $x = 0$.

Transforming (3) we find:

$$u_0 = \frac{m_0}{m}\frac{s_0}{s}u_{00}, \quad u_1 = \frac{1-m_0}{1-m}\frac{s_0}{s}u_{10}, \frac{\rho_0^{(0)}}{\rho_0} + \frac{\rho_1^{(0)}}{\rho_1} = 1 \tag{4}$$

From (1) and (2), reducing by, we obtain:

$$\rho_0^{(0)} u_0 \frac{du_0}{dx} - \rho_1^{(0)} u_1 \frac{du_1}{dx} = (\frac{\rho_0^{(0)}}{\rho_0} + \frac{\rho_1^{(0)}}{\rho_1})k(u_1 - u_0) \tag{5}$$

From (3) and (4) it follows that the densities and velocities of the components can be expressed in terms of porosity $m(x)$ and velocity exceptions, $u_0(x)$, $u_1(x)$ from equation (5) we find:

$$\frac{dm}{dx} = \frac{F_1(m)}{F_0(m)}\frac{s'(x)}{s(x)} + \frac{F_2(m)}{F_0(m)}\frac{s_0}{s(x)} \tag{6}$$

Pressureis $p(x)$ determined by:

$$p(x) = \frac{s_0}{s}\left[p_0 + u_{00}^2\rho_{00}\left(1 - \frac{m_0}{m}\frac{s_0}{s}\right) + u_{10}^2\rho_{10}\left(1 - \frac{1-m_0}{1-m}\frac{s_0}{s}\right)\right] \tag{7}$$

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Where is p_0 - the pressure of the mixture at $x = 0$

In the process of pneumatic transportation, lateral pressure $q = k_0 p$ (k_0 - the lateral pressure coefficient) from the side of the raw cotton particles acts on the inner wall, which creates a friction force fqL (f - the friction coefficient between the cotton and the pipe surface, $L = l(x)$ - the length of the pipe cross section). We assume that this interaction occurs according to the law of dry friction of Coulone. Then from (1) and (2) it follows:

$$\rho_0 u_0 s \frac{du_0}{dx} = -\frac{\rho_0}{\rho_0^{(0)}} \frac{d(sp)}{dx} + sk(u_1 - u_0) \quad (8)$$

$$\rho_1 u_1 s \frac{du_1}{dx} = -\frac{\rho_1}{\rho_1^{(0)}} \frac{d(sp)}{dx} - sk(u_1 - u_0) - k_0 lfp(1-m) \quad (9)$$

Shortening from $\frac{d(sp)}{ds}$ (1) and (9), we obtain:

$$\rho_0^{(0)} u_0 \frac{du_0}{dx} - \rho_1^{(0)} u_1 \frac{du_1}{dx} = k(u_1 - u_0) + \frac{\rho_1^{(0)}}{s\rho_1}(1-m) lk_0 fp$$

After setting the expressions of derivatives $\frac{du_0}{dx}$ and $\frac{du_1}{dx}$ taking into account dependencies (4), we obtain:

$$\frac{dm}{dx} = Z(m, x, p) = \frac{F_1(m)}{F_0(m} \frac{s'(x)}{s(x)} + \frac{F_2(m)}{F_0(m)} \frac{s_0}{s(x)} - \frac{k_0 fl(x)s(x)m^3(1-m)^3}{s_0^2} p, \quad (10)$$

Where:

$$F_0 = \rho_0^{(0)} u_{00}^2 m_0^3 (1-m)^3 + \rho_1^{(0)} u_{10}^2 m^3 (1-m_0)^3,$$

$$F_1 = -m(1-m)\,[\rho_0^{(0)} u_{00}^2 m_0^2 (1-m)^2 - \rho_1^{(0)} u_{10}^2 m^2 (1-m_0)^2],$$

$$F_1 = m^2 (1-m)^2\, k[u_{00} m_0 (1-m) - u_{10} m(1-m_0)]$$

Adding (6) and (7), taking into account (3), we have:

$$\rho_{00} u_{00} \frac{du_0}{dx} + \rho_{10} u_{10} \frac{du_1}{dx} = -\frac{dp}{dx} - lk_0 fp(1-m)/s.$$

Adding the values of the derivatives $\frac{du_0}{dx}$ and $\frac{du_1}{dx}$ get:

$$\frac{dp}{dx} + Z_0(m, x) p = Z_1(x, m, p) \quad (11)$$

Here: $Z_0 = \frac{l(x) k_0 f(1-m)}{s(x)}$, $Z_1(x, m, p) = F_3(x, m, p) + F_4(x, m)$,

$$F_3 = \frac{s_0^2}{s^2(x)} \frac{Z(x, m, p)}{m^2 (1-m)^2} [\rho_{00} u_{00}^2 m_0^2 (1-m) - \rho_{10} u_{10}^2 (1-m_0)^2 m],$$

$$F_4 = \frac{s_0^2}{s^2(x)} \frac{s'(x)}{s(x)} \frac{1}{m(1-m)} [\rho_{00} u_0^2 m_0 (1-m) + \rho_{10} u_{10}^2 m(1-m_0)]$$

IV. Analysis of Research Results

Initial conditions for determining the porosity of cotton and pressure: at

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$$x = 0 \; m = m_0 , \;\; p = p_0 = \rho_{00} u_{00}^2 / 2 \; .$$

The equations were processed by the Maple program for a constant section pipeline and graphs were obtained with the following parameters: $m_0 = 0.4$ $u_{00} = 20 м / с$, $\rho_{00} = 1.2 кг / м^3$, $Q_0 = 10000 кг / час$, $\rho_{10} = 38 кг / м^3$ $s = s_0 = \pi D^2 / 4$, $l = \pi D$, $k_0 = 0.6$.The current coefficient of porosity of the mass of cotton $m = 0.6$, and the boundary values of the interaction coefficient: $k_n = 50 Нс / м^4$, $k_n = 100 Нс / м^4$, $k_n = 200 Нс / м^4$, $k_n = 300 Нс / м^4$.

To determine the effect of the coefficient f of friction on the process of pneumatic transportation, calculations were performed at various values f . When f=0, the movement of the clap occurs at any value $k > 0$. And, at f>0, the movement occurs only at $k \geq k_n$, (here is k_n - the boundary value of the coefficient k.For example, at $f = 0.05$, $f = 0.1$, $f = 0.2$ and $f = 0.3$ $k_n = 8.7 Нс / м^4$, $k_n = 16.8 Нс / м^4$, $k_n = 35.4 Нс / м^4$, $k_n = 50.5 Нс / м^4$.

When $k < k_n$ in some sections of the pipeline the pressure may be zero, then there will be no movement [26-30]. This model does not work in such cases. In other cases, the equations correctly describe the pattern of motion of a two-component mixture.

The analysis shows that porosity (Fig. 3) increases uniformly at large k_n (graph on the right) and relatively smaller (graph on the left) and is about 0.85. And when $k = 400 Нс / м^4$ the growth rate is much higher at the beginning of the process, and after passing a distance of 24-25 meters, the growth rate decreases.

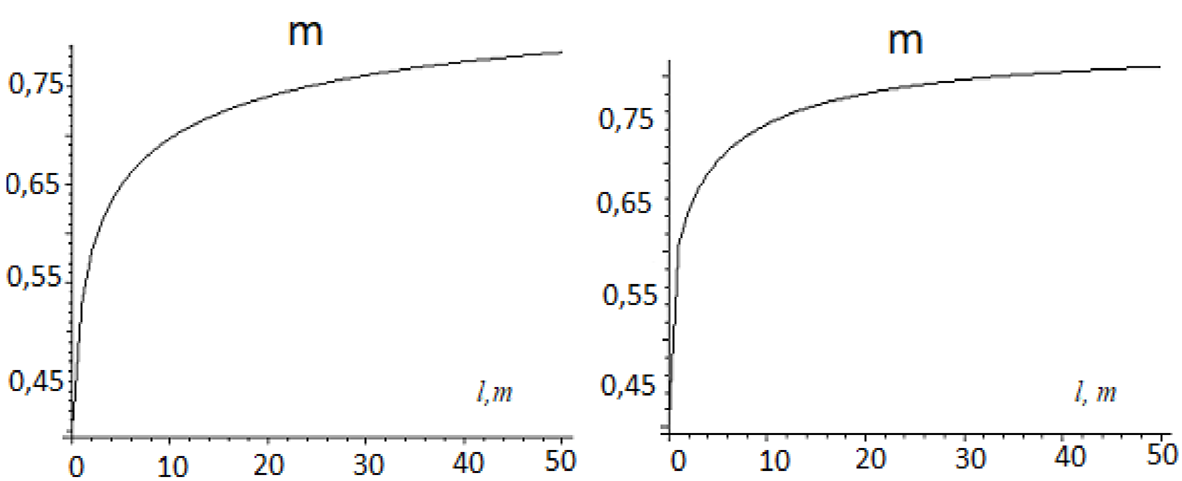

Fig. 3: Change in Porosity of Cotton along the Transport line

$$k = 40 Нс / м^4 \;\; k = 100 Нс / м^4$$

On the pressure graph (Fig. 4): the pressure at the beginning of the pipeline is about 75 Pa at lower values k_n (graph on the left), 95 Pa (graph on the right) for large. However, the pressure P at lower values k_n at the beginning (1-2 meters) of the pipeline decreases markedly, and at 20 meters the intensity drops, the pressure remains relatively constant. At large k_n pressure P decreases constant intensity.

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Air velocity (Fig. 5) decreases with the same intensity at any value k_n . At 50 m, air speed drops to 14-12 m / s, then remains relatively constant. And the speed of cotton (Fig. 6) has a growth pattern at any values k_n .

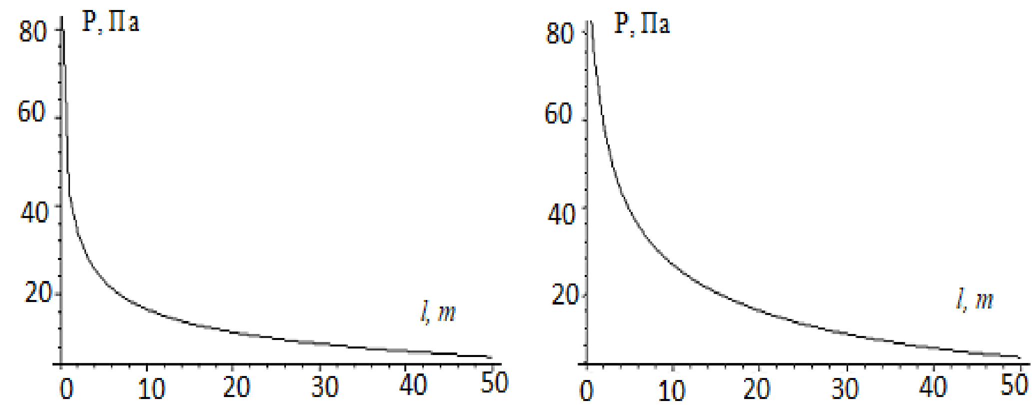

Fig. 4: Air Pressure Change along the Transportation Line

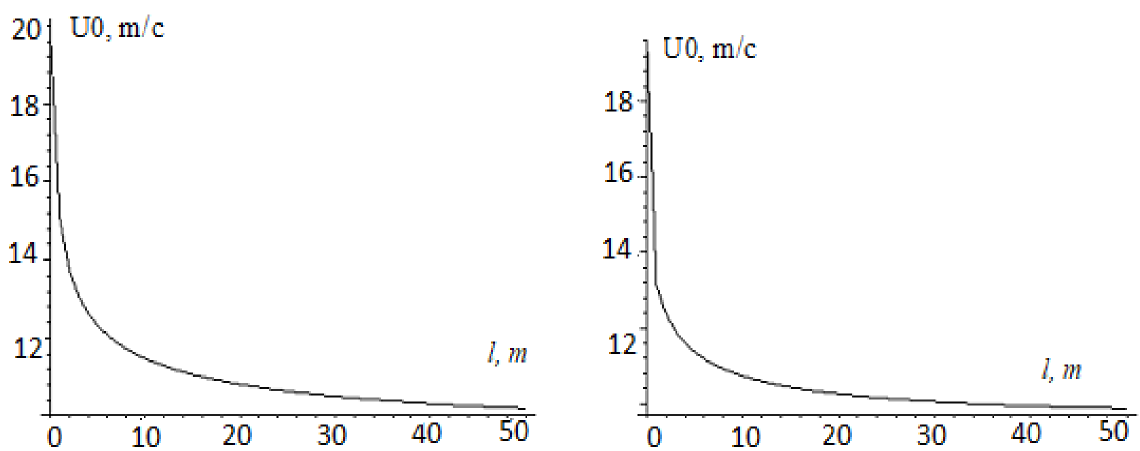

Fig. 5: Change in Air Speed along the Transportation Line

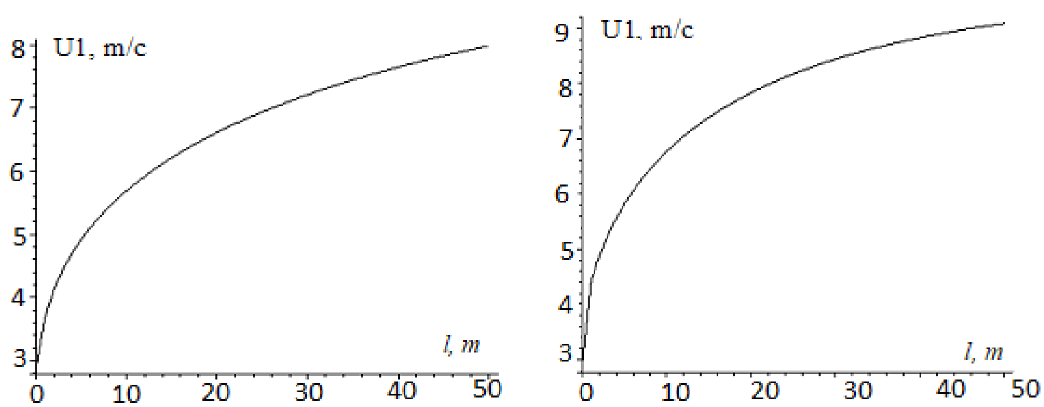

Fig. 6: Change in cotton Speed along the Conveyor Line

And, at 50 meters it is relatively stabilized within 7-8 m / s.At high values, the nature of the change in the parameters is preserved, but with a different intensity of change. Figure 7 shows the change in the porosity of cotton, which shows that in both cases, at 50 m it is about 0.75-0.80.

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$k = 200 Hc / м^4 \quad k = 400 Hc / м^4$

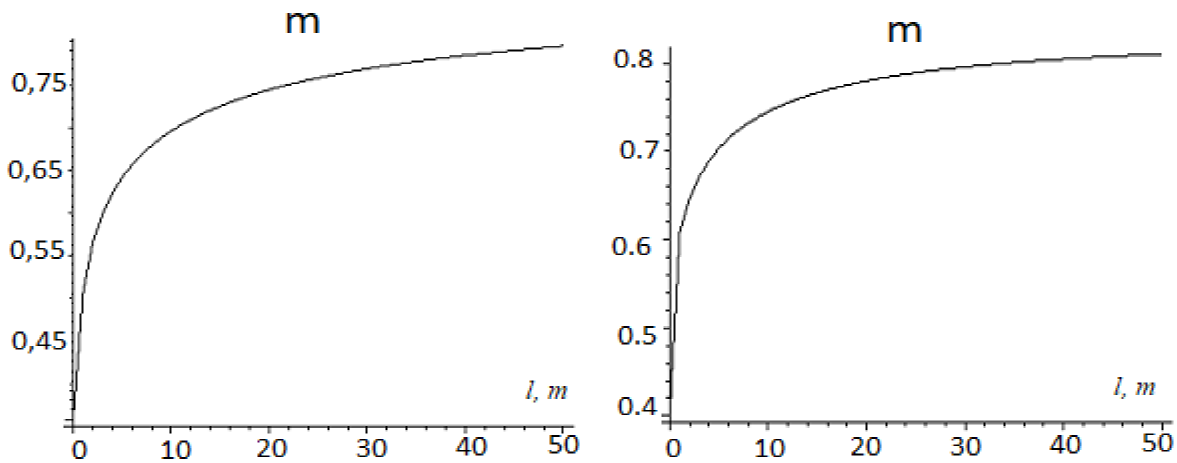

Fig. 7: Change in Porosity of Cotton along the Transport Line

At large k, the growth of porosity by 10–20 m occurs much more intensively, but when it reaches 30 m, the change noticeably stabilizes. The change in air pressure in the pipeline, on the contrary, decreases with smaller k more intensively than with large k. This statement leads to the conclusion that k negatively affects the strength of cotton's resistance to air movement, that is, with increasing k, the resistance force decreases, and with a decrease, on the contrary, [5,6].

For both values of k, the air velocity decreases with almost the same intensity. In the first case, the air velocity stabilizes at the level of 9-10 m / s, and in the other, the air velocity remains unchanged when the speed reaches 15 m / s

a, the speed of cotton at lower values of k increases more intensively than relatively high, and when it reaches 30 meters, the speed of cotton almost stabilizes. In this case, the speed is about 9-10 m / s. The air speed at a distance of 40-50 meters is about 14-15 m / s, i.e., the air is ahead of cotton with a relative speed equal to the difference in their speeds.

The ratio of the speed of cotton to air speed is the coefficient of delay of the speed of cotton versus air speed, which in our case is k = 0.7 - 0.75 and is equal to the tabulated values of this coefficient [7-10]. The fact of the equality of theoretical and tabular values that are established experimentally shows the correspondence of the established theoretical regularity with the natural regularity of the movement of the cotton-air mixture in the transport pipelines of pneumatic installations. This will make it possible to suggest the obtained dependences for their use in the calculations [28-30] for the design of pneumatic conveying systems used for transporting cotton.

The resulting model is universal and can be used in the calculation of pneumatic transport with pipelines of variable cross-section.

V. Conclusions

1. Studies have established patterns of change in air velocity and pressure, as well as the speed and porosity of cotton during pneumatic transportation.
2. An analysis of the equations obtained shows that in the initial 20–25 meters of the pipeline, the porosity of the transported cotton is greatly increased. This shows the susceptibility of cotton to tensile deformation due to the difference in air and cotton speeds, proves why cotton is loosened during pneumatic transport, becomes more fluffy and weed impurities are separated from it.
3. The entry of cotton into the pneumatic transport pipeline leads to a sharp decrease in pressure and air velocity, and the speed of cotton in the initial 15 - 20 meters of the pipeline increases significantly, then with a more moderate intensity.
4. The multi-speed model of movement in the pneumatic conveying pipelines of the cotton-air mixture as a heterogeneous medium more correctly describes the process of moving air and material during pneumatic conveying, which makes it possible to suggest its use for calculations and design of pneumatic conveying systems.

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