The Velocity Distribution over the Cross Section Pipes of Pneumatic Transport Installations Cotton

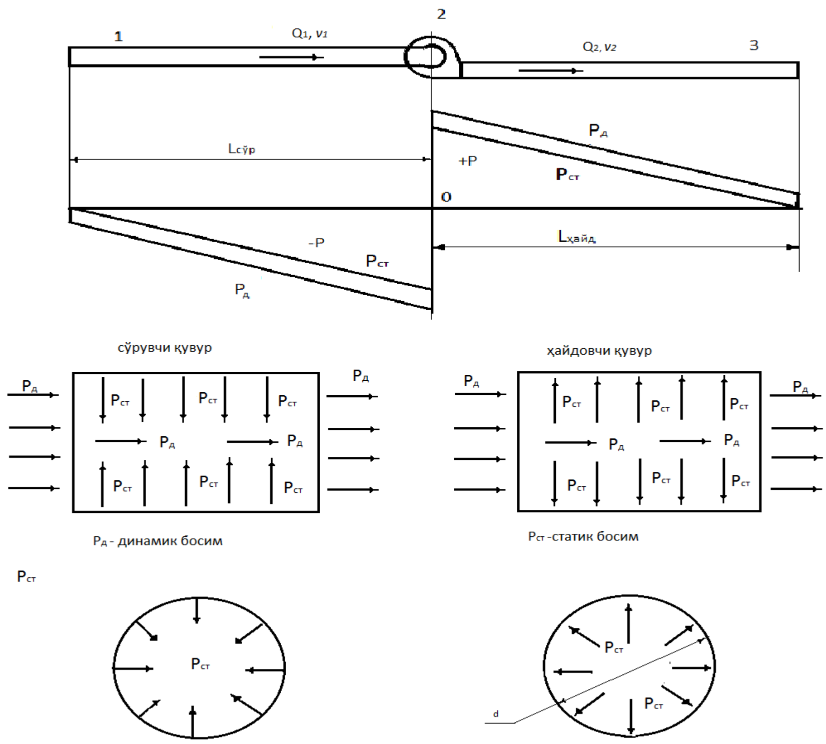
Sarimsakov Olimjon Sharifjanovich, Turg'unov Dilmurod Umarali o'g'li,
Babayeva Malikakhan Nabijon kizi
Namangan engineering-technological institute, Namangan, Uzbekistan

ABSTRACT

The article reflects technological problems and addressing efficient pneumatic conveying raw cotton to ginneries. It gives opinions and proposals for the effective management of the process for air transportation of cotton based on the results of theoretical and applied research.

KEYWORDS: *raw cotton, pneumatic transport installations, the air velocity, the pipeline cross-section of the pipeline diameter, aerodynamic force.*

The process of transporting cotton by air takes place in a closed system isolated from the outside atmosphere. To visualize this process, we adopt the simplest aerodynamic device scheme and first consider the laws of air movement in it (Figure 1). In the picture Suction pipe-1, 2- fan (pump), 3 - drive pipe.



Simple scheme of aerodynamic device and directions of air pressure in pipes.

The fan or pump is located in the middle of the pneumatic pump. When the system is idle, ie when the fan is not running, it is under the pressure of ambient air. In this case, the dynamic pressure is zero and the pressure inside the pipe is equal to the external atmospheric pressure:

$P_д = 0$, $P_{ум} = P_{ст} = P_{атм}$, (1)

When the fan is started, it sucks air from the first half of the equipment and drives it to the second side. As a result, there will be a vacuum environment (sparse air) on one side of the equipment and a compressed air environment (overpressure) on the other side.

The total air pressure that the fan can do $P_{ум}$ static in the pipe $P_{ст}$ and dynamic $P_д$ equal to the sum of the pressures:

$P_{ум} = P_{ст} + P_д$, (2)

However, the pressure to the left of the pipe, i.e. to the fan, is negative – P (vacuum), the pressure after the fan, i.e. on the right, is positive + P has a sign. In this case, static pressure $P_{ст}$ on the suction side from the pipe wall to its center, and on the drive (blower) side from the center of the pipe to its walls. Also, the greatest pressure is at the inlet and outlet holes of the fan, i.e. on both sides of the fan - negative at the inlet, positive at the outlet and decreasing on both sides - towards the pipe ends.

When the aerodynamic equipment is completely airtight, the air flow to and from the fan is mutually equal:

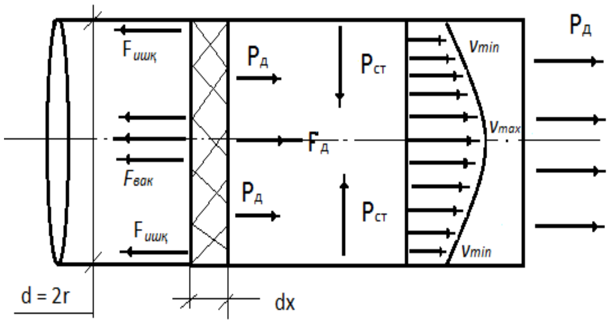
$Q_к = Q_ч$, or $\vartheta_1 f_1 = \vartheta_2 f_2$, (3)

Here: $Q_к$ - entering the system, $Q_ч$ - exhaust air from the system, $м^3$/сек; ϑ_1, ϑ_2 –respectively, the speed of incoming and outgoing air, м/с; s_1 and s_2 inlet and outlet pipe cross section surface, $м^2$.

Accordingly, the dynamic pressure is also constant:

$$P_{дин} = \frac{\rho\vartheta^2}{2} = \frac{\rho\vartheta_2^2}{2} = \frac{\rho\vartheta_1^2}{2} = const\,, \quad (4)$$

To study the movement of air in a pipe, we assume that a piston of dx thickness, flat surface, equal in diameter to the inside diameter of the pipe, is placed inside the pipe (Fig. 2).



PICTURE 2. Air velocity and pressure directions in the pipe.

In this case, the dynamic pressure of the air moving inside the pipe is evenly distributed over the surface of the piston and exerts traction aerodynamic forces. It is an equal influence of forces Fa is equal to:

$F_a = P_\partial \cdot S_n$, (5)

Here, P_∂ -dynamic pressure, Па; S_n – piston cross-sectional area, m2. The cross-sectional area of the piston is equal to the cross-section of the pipe, which in turn depends on the inner diameter of the pipe:

$$S_n = S_қ = \pi \frac{d^2}{4}$$

The dynamic pressure, as we saw above, is proportional to the square of the air velocity $P_{дин}=0.5\,\rho\vartheta^2$. Therefore, the equal effect of aerodynamic force can be found by the following expression:

$F_a = \frac{\pi}{8}\,\rho\,(\vartheta d)^2,$ *(6)*

This force is the maximum force that aerodynamic equipment can generate. Figure 3 shows a graph of the relationship of this power to the relevant parameters.

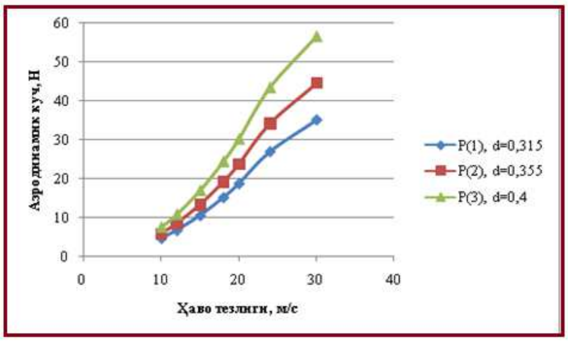


Figure 3. The relationship of aerodynamic force to air velocity.

If we pay attention to the graphs, relatively large aerodynamic forces are generated in pipes with large diameters at the same air velocities. Also, the difference between the magnitude of the force generated as the speed increases increases. This is probably the reason why the industry has switched to pipes with a diameter of 400 - 450 mm. This is because when the pneumatic transport equipment was first used in the industry of our country, the diameter of the pneumatic transport pipeline was 305 mm. Subsequently, as labor productivity in industry and, accordingly, machine productivity increased, there was a need to increase the productivity of pneumatic transport equipment as well, and the industry solved the problem by increasing pipe diameter despite high material and energy consumption. However, in the current context of energy shortages, this solution does not justify itself and the industry is gradually shifting to the use of smaller diameter pipes, and our previous research [1] has theoretically substantiated this measure. It should be noted that aerodynamic force cannot be fully utilized when transporting material in a pipe. This is because the dynamic pressure on the material affects only the part of the material that corresponds to the cross section. Furthermore, since the air velocity is not uniformly distributed across the cross section of the pipe (Fig. 2), the aerodynamic force is not evenly distributed, but just as in the velocity diagram - the force near the pipe wall is the smallest, the pipe has the largest value. (We will discuss this issue in more detail later). This is also greatly influenced by the air flow regime. As air moves inside the pipe, forces appear that impede its movement. One such force is between the air and the pipe surface $F_{ишқ}$ friction force. It would be more accurate to call this force, in the suction part of the pneumatic transport, the original viscosity, the coupling force. This is because the compressive forces in the suction part do not pressurize the air into the pipe wall, but instead pull the wall to the center of the flow. Therefore, there will be no frictional force on the suction side of the pneumatic transport, for example due to the gravitational force of the air. The air is a light gas, compensating for the compressive forces that absorb its gravitational force. However, the coupling forces resist air movement.

This in turn causes a loss of air pressure.

In the driving (inflating) part of the pneumatic vehicle there is this force-the compressive forces and the gravitational force of the air are directed perpendicular to the pipe wall, and this

because the normal reaction force inversely proportional to the gravitational force of the air also produces a frictional force.

Therefore, in our opinion, the suction device consumes less energy than the blower when delivering the same amount of air at the same distance. However, in any case, when the air flow moves inside the pipe, its wall layer interacts with the fixed wall and loses its energy, speed due to the adhesive properties.

This condition is the tangential (experimental) voltage directed against the air flow in the pipe wall (τ) creates. It is determined by Newton's equation in laminar (quiet) flow for liquids and gases:

$$\tau = \mu \frac{\partial \vartheta}{\partial y}, \quad (7)$$

Here: $\frac{\partial \vartheta}{\partial y}$ - is called the velocity gradient and shows how the velocity is distributed along the radial axis. The velocity distribution in a laminar flow is reminiscent of a parabola directed along a flow (sometimes resembling the shape of a shell). Transportation of cotton by pneumatic transport, as noted above, occurs mainly in turbulent flows. In this case, the velocity is distributed more evenly across the pipe section (Figure 2).

The distribution of velocity across the pipe cross section in turbulent mode has been studied by many scientists [2,3,4]. The following equations can be considered as the most practical and easy to apply of the proposed equations:

$$\vartheta = \vartheta_{max} \left[1 - \frac{y}{r}\right]^{\frac{1}{m}} \quad , (8)$$

$$\vartheta = \vartheta_{max} (y/r)^{n} , \quad (9)$$

Here: $- \vartheta$ - velocity at any point on the radial axis from the center of the pipe, м/с; ϑ_{max} - velocity in the center of the pipe, м/с; y – distance to the point where the velocity is determined (radial coordinate), м; *r* – pipe radius, м; *m* and *n* – experimental endings. Consider

Equation (8). For pneumatic transport processes m = 7 accepted. Therefore, such a distribution of velocity is called the 1/7 degree distribution law.

If , Y = 0 if $\vartheta = \vartheta_{max}$ (velocity in the center of the pipe), $y = r$ if $\vartheta = 0$ (velocity in the pipe wall). This means that the air flow does not flow uniformly along the pipe. The air layer in the center of the pipe flows faster, and the slower it moves away from the center. In this case the average speed of the amount of air flow $\vartheta_{ўрт}$ If not measured by, an error occurs in the calculations. Studies in Altshul have shown that in laminar flows $\vartheta_{ўрт} = 0.5\, \vartheta_{max}$, in turbulent flows y = 0.223 *r* The average speed is:

$$\vartheta = \vartheta_{max} \left[1 - \frac{0.223\, r}{r}\right]^{\frac{1}{7}} = 0.965\, \vartheta_{max} , (10) .$$

It can be seen from Equation that, according to the accepted dependence (3.8), in turbulent flows the velocity at any point of the flow is close to the velocity at the center of the flow. That is, the average speed in a turbulent flow is almost equal to the maximum speed! However, our measurements are as follows

Consider Equation 9. According to Altshul [3]

$$n = 0.9\sqrt{f} \quad , (11)$$

here, f –coefficient of hydraulic resistance. Re = (3.9 ÷5.2) ·10^{-5} for new pipes when f = 0.015 given that around:

$$\vartheta = \vartheta_{max}\left(\frac{y}{r}\right)^{\mathbf{0.11}}, \quad (12)$$

y = 0.223 r when

$$\vartheta_{\breve{y}pm} = 0.848 \cdot \vartheta_{max}, \quad (13)$$

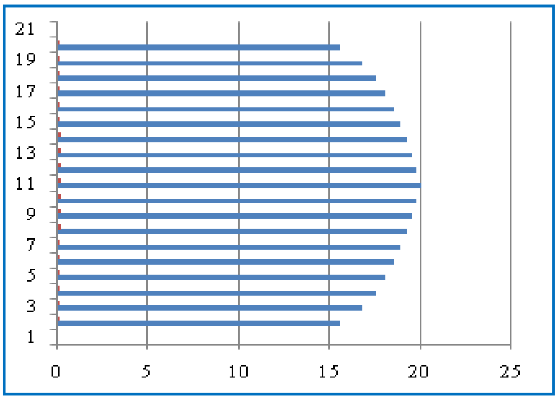
This value is relatively close to reality. This is because our initial measurements showed that the average speed to maximum speed ratio was 0.8 - 0.9. We will discuss this issue in more detail in the experimental research part of the work. Figures 3 and 4 show a graphical analysis of Equation (12).

If we look at the graphs, the velocity in front of the pipe wall in a small diameter pipe is greater than in a large diameter pipe when the (maximum) velocity at the center of the pipe is the same, i.e. the air velocity in turbulent flows in small diameter pipes is relatively evenly distributed across the pipe cross section. Also, the average air velocity depends on the (maximum) velocity in the center of the pipe, and as the pipe diameter increases, the difference between the maximum and average velocities increases, and as the diameter decreases, the velocity difference decreases.

From what has been seen, it can be concluded that the velocity in the pipes is not evenly distributed along the cross section of the pipe due to the influence of resistance forces on the air by the pipe walls. Therefore, it is required to use the value of the average air velocity in the calculations of the pneumatic transport process.

Based on the analysis, we can draw the following conclusions:

1. At relatively the same air velocities, relatively large aerodynamic forces are generated in pipes with large diameters. Also, the difference between the magnitude of the force generated as the speed increases increases.
2. Due to the influence of resistance forces on the air in the pipes by the pipe walls, the air velocity is uniformly distributed across the cross section of the pipe, resulting in the aerodynamic force serving to transport products in the pneumatic transport is not evenly distributed, but the force near the pipe wall is smallest . Therefore, it is required to use the value of the average air velocity in the calculations of the pneumatic transport process.
3. In turbulent flows, the average velocity of air in the pipe depends on the (maximum) velocity at the center of the pipe and the diameter of the pipe is increased



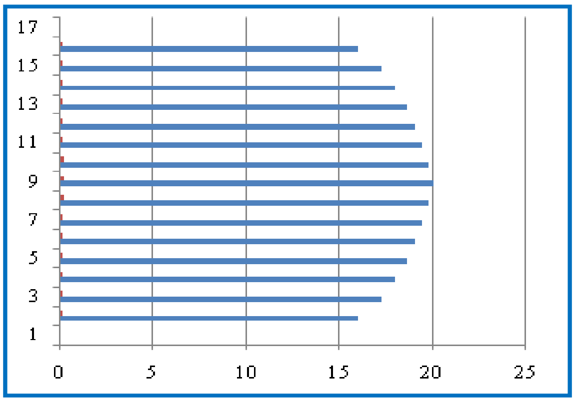


Figure 4 Maximum air speed Figure 5. Maximum air speed

v_{max} = 20 м/с, pipe diameter d = 0.4 мv_{max} = 20 м/с, pipe diameter d= 0.315 м

when the air velocity tube when the cross section of the pipe on the cross section distribution air velocity on distribution the difference between the maximum and average velocities increases, and the smaller the velocity difference decreases, i.e. in small diameter pipes the air velocity is distributed more evenly along the cross section of the pipe.

Sources of information used:

1. Мурадов Р., Саримсаков О., Хусанов С. Внутризаводская пневмотранспортировка хлопка-сырца: состояние, проблемы и перспективы. Журнал «Механика муаммолари», 2014, №2
2. Черный Г.. Газовая динамика. Москва. Наука, 1988.
3. Альтшуль А.и др. Гидравлика и аэродинамика. Стройиздат, 1987.
4. Лойцянский Л.. Механика жидкости и газа. Москва, Дрофа, 2003.
5. A.Salimov, O.Salimov, Sh.Khusanova, I.Khakimov"The problems of natural fiber and textile materials on fire resistance" Saarj journal Akademicia: an international multidisciplinary research jurnal april-2020.
6. Theoretıcal Analysıs of the Movement of Raw Cotton ın Unıform Feeder Feed ın the New Installatıon. International Journal of Advanced Science and Technology Vol. 29, No. 7, (2020), pp. 7970-7974.
7. Theoretical study of the process of cleaning cotton before piling up. *ISJ Theoretical & Applied Science,* (2021). *10 (102),* 801-806.