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Air Density Change Along the Pipe Surface During Pneumatic Transport Of Cotton

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Abstract: This article examines the laws governing the density distribution of cotton and air mixes inside pipes. In the turbulent motion of the cotton and air combination, the connection between the air density and the movement of the air pressure from the tube's opening to the ventilator was investigated.

Key words: air, pipe, speed, volume, weight, friction, damage, pressure, cotton, seed, elbow turn, kristavina

Introduction

Air conditioning, ventilation of rooms and equipment in light industry, transportation of semi-finished and finished goods inside and between workshops, and spinning and weaving of fiber materials are all common uses of aerodynamic, including air transport equipment in the textile industry [1; pp. 22–28].

The laws and useful findings from the research that has been done so far have helped to advance cotton manufacturing science and practice as well as its air delivery to some degree. However, some phenomena that arise during cotton processing and transportation have not yet been completely understood, and some technological tools and machinery, such as aviation transportation equipment, have not yet reached their maximum potential.

According to P. V. Baidyuk [2; 24-98 p.], it was discovered that the loss of air pressure inside the air pipe, which is primarily dependent on the air speed, the diameter of the air pipe, and the size and form of the transported substance, is what causes the process of air transport.

When examining the movement of cotton in the horizontal air pipeline, the majority of scientists engaged in the theory of the transit process in the horizontal air pipeline [3, 4] treated it as a material object with a specific mass and coefficient of aerodynamic resistance. Because of this, the accepted dynamic models were unable to produce estimates with the required degree of precision.

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Through the use of accelerated imaging, Kh. Akhmedkhodjaev [5; 1-186 p.] and Makhametov T.D. [6; 121 b.] examined the motion of a bit of cotton traveling through the air. The distribution of a piece of cotton in a horizontal air duct relies, according to the writers, on the cross-sectional area of the air duct.

The ideas that have been created have mostly dealt with particular issues and parts of an airborne car, and the findings have been inconsistent, at times contradictory.

Methodology

As we previously stated, it is true that the science of shipping cotton by flight has a lengthy past. In specific, the equation connecting the speed of the air flow to the movement of cotton in the flow was created for the first time in 1929. [6; p. 121]:

$$U_x = (1{,}27 \div 1{,}30) \cdot V_м \qquad (1)$$

here: U_x - air speed, m/s; $V_м$ speed of cotton, m/s.

G. Jabbarov [7] proposed the equation for determining the diameter of the air pipe:

$$d = 1.13\sqrt{\frac{G_м}{\mu \cdot \rho \cdot V_м}} \qquad (2)$$

here: $G_м$– material consumption per second weight unit, kg/s;

μ– cross section of the air pipe, m^2; ρ- air density, kg/m^3;

$V_м$– speed of movement of material, m/s.

The ratio of the speed of movement of cotton and air, determined by experiment, is as follows, for individual pieces:

$$\frac{V_х}{U_п} = 0.75 \div 0.85 \qquad (3)$$

For shredded, small pieces of cotton:

$$\frac{V_х}{U_п} = 0.57 \div 0.70 \qquad (4)$$

According to his findings, S. Kadirkhojaev [8] carried out similar experiments.:

a) the speed of movement of cotton depends on the speed of air in different weights and sizes of particles as follows:

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$$V_{ì} = (0,5 \div 0,75)U_{õ} \qquad (5)$$

б) The minimum speed of the air at the mouth of the air pipe is related to the productivity of cotton transportation of the air transport as follows:

$$V_M = 8,5 G_M^{0,4} \qquad (6)$$

here: $G_м$ - productivity of cotton transportation by air, t/h.

в) The absorption rate of cotton is determined by the following expression:

$$U_x = 2,56 \sqrt{\frac{\gamma_n}{\gamma_x} d_n}, \qquad (7)$$

here: γ_n - density of cotton, kg/m ^{3}; d_n - diameter of the cotton ball, м; γ_x - air density, kg/m ^{3}.

Heavy items and cotton are significantly impacted by the walls of the air pipeline in its bottom section when being carried at moderate velocities. Cotton experiences friction with the air duct walls, which causes the strands to roll, clump together, and rip. In this instance, the cotton fiber is harmed as well, and the air pipe's interior surface has corroded. S. Kadirjo'jaev, however, asserted that when cotton is carried at a fast pace in the horizontal section of the air tunnel, the seeds and fibers are not harmed and the process of surface wear slows down. However, because of the material's rapid movement, the air pipe casings' inertial pressures are increased sharply. On the interior of the casing, cotton is struck very hard. As a result, the speed is lost, the strain at the contact site rises, the seed sustains more mechanical damage, and the inner shell surface erodes faster.

Kh. Akhmedkho'djaev and S. Kadirkho'djaev discovered that cotton is spread more uniformly along the cross section of the air conduit when the air flow is higher than 28 m/s. The material enters a suspended form during such transit circumstances. More of the material starts to travel at the bottom of the air tunnel as the air flow velocity drops below 25.0 m/s. When the air flow's velocity falls below 18 m/s, large pieces of cotton fall to the bottom of the air pipe and start to move unevenly by jumping.

The outcomes of watching the airborne transportation of cotton revealed that the raw material is not evenly moved to the pipes for airborne transportation[9,10]. As a result, the cotton travels within the air pipe, becoming concentrated in some areas and split into specific fragments in others.

Elements of the air transit apparatus become less effective as a result of the cotton's uneven transfer into the air conduit. The effectiveness of the device used to remove heavy impurities from cotton declines, cotton fiber and seed are damaged more frequently, there are more blockages on the mesh surfaces of the separators, there are more instances of heavy impurities in the fiber hoppers and in the

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separator, and there are more instances of waste entering the used air increase. Additionally, because the cotton is of low quality, cleaning devices for drying barrels and cotton dryers are less effective.

Conveyors used in cotton ginning facilities today are unable to transfer cotton uniformly. Lack of a scientific and theoretical foundation that adequately describes how cotton interacts with and moves through a mixture of air during the process of moving cotton by air is the primary cause of the dearth of high-performance devices that equally transfer cotton to air transport pipelines.

Incorporating contemporary ideas into cotton's primary features and providing an account of the process of air transport, other studies have also significantly contributed. The majority of these studies noticed a connection between the effectiveness of the cotton processing chain's efficacy and the quality of the cotton supply to the air cargo equipment.

The study of the research and scientific works done thus far reveals that the laws and practical outcomes discovered in them contributed to the advancement of the science and practice of cotton manufacturing, as well as the air conveyance of cotton, to a certain degree. However, some phenomena that arise during cotton processing and transportation have not yet been completely understood, and some technological tools and machinery, such as aviation transportation equipment, have not yet reached their maximum potential. The identified hypotheses primarily addressed particular issues and pneumotransport process elements, and frequently inconsistent, occasionally mutually exclusive findings were obtained.

Based on the foregoing, these studies seek to advance cotton air transportation theory and practice to some degree, preserve the original quality and number markers of cotton products, and provide efficient technological solutions to lower the cost of the finished good.

Results

Air movement, which results from the rarefaction (in suction air transport) or densification (in driver or blower air transport) of air pressure in a confined system, is what causes air transport to happen. Despite being noted in the scientific works completed to date, the degree to which air density changes during flight travel have been examined is unknown. In our efforts, we'll attempt to address this problem.

Let's suppose that the air transportation system in Figure 3.1 has an air pressure gauge on it called a micromanometer. The micromanometer sign displays the manometric (or piezometric) air pressure within the apparatus when the system first turns on. Vacuum or vacuum level refers to the real pressure in the suction portion of the system, and its value is equivalent to the differential between the manometric pressure and the ambient atmospheric pressure:

$$P_{вак} = P_{м} - P_{атм} \,, \qquad (9)$$

Normal air pressure is $P_{атм}$ = 101.325 kPa (or 750mm mercury column) temperature T = 273 K (kelvin) or T = 0^0C, density ρ = 1.29 kg/m^3, under standard conditions $P_{атм}$ = 101.325 kPa, temperature T = 293 K (kelvin) or T = 20^0C, relative humidity w = 50%, density equal to ρ = 1.2

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kg/m^3.

As was already mentioned, the most typical fans used in the ginning business generate a pressure between $P_м$= 2.6 – 7.9 kPa. The atmospheric pressure is equivalent to 750 mm Hg, or $P_{атм}$ = 101.325 kPa, under normal climatic circumstances. However, given the climate in our nation, the air pressure is typically 725 millimeters of mercury column, or 98 kPa. In this case, ρ = 1.17 kg/m^3 will be the result of computing the density of air using the gas's equation of state. A 20°C air temperature is acceptable. Because cotton raw materials are primarily processed during the cooler months of autumn, winter, and spring.

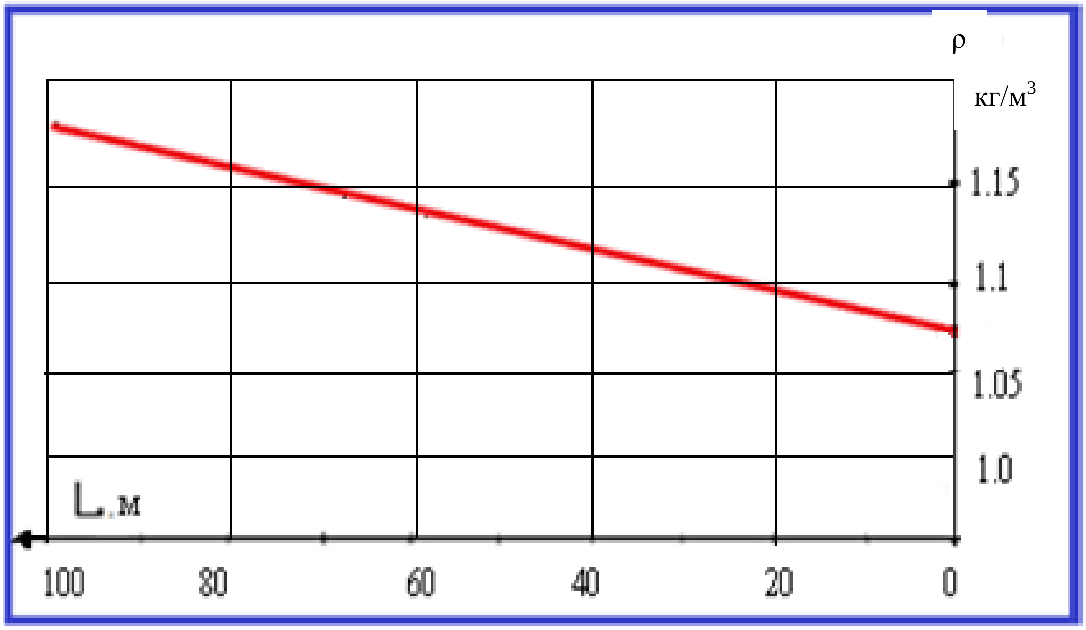

Figure 1. Variation of air density along the length of the air pipe.

According to what has been said, the vacuum level inside the air transport equipment will be equal to the following: $P_{вак}$= (2.6 ÷ 7.9) – 98= – (95.4÷ 90.1) kPa.

If there is a negative indication, air pressure is lower than the vacuum pressure. As a result, the sign cannot be considered in the computations. Now, using the Mendeleev-Clapeyron equation of state for gases, we can use the following equation to calculate the air density inside an aircraft.:

$$\rho = P_{вак} / (RT) = (95.4 \div 90.1) \cdot 10^3 / (287 \cdot 293) = 1.13 \div 1.07 \text{ кг/м}^3.$$

In this scenario, low vacuum and low air density are correlated with high manometric air pressure, and vice versa, with high vacuum and high air density..

Conclusion

On the basis of this, it can be concluded that it was appropriate to accept the density of air at rest in Uzbekistan as ρ = 1.17 kg/m^3 and the density inside the suction part of air transport equipment as

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ρ =1.13 ÷ 1.07 kg/m^3 for the design of aerodynamics and air transport equipment.

As opposed to this, as previously observed, the air density at the air transport pipe's opening is lower than that near the fan (1.07 kg/m^3) and is nearly equal to that of still air (ρ = 1.17 kg/m^3). Without getting too technical, it can be said that in air transport equipment, the air density rises linearly from the fan to the mouth of the air duct and falls in accordance with the linear law from the mouth of the air duct to the fan because the density is directly proportional to the air pressure. (Fig. 1). Calculations show that the difference was 4 ÷ 9 %.

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