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STUDY OF AERODYNAMIC CHARACTERISTICS OF COTTON FIBER IN SEPARATOR OF PNEUMO-MECHANICAL SPINNING MACHINE

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Abstract:

Objective. In this article, the movement of fibers in the air channel and the rotor in the pneumomechanical spinning machine was studied. In the experimental work, the uniformity and stability of the velocity field of each channel for moving fibers in an aerodynamic device were checked. In this case, the airflow speed was changed from 5 m/s to 30 m/s. Differential equations of motion along the OX and OY axis were created taking into account the air resistance.

Methods. When determining the movement of fibers in a conical channel, the total speed was divided into components, constant values were found, and general equations of motion were derived. Also, time-dependent graphs of the movement of fibers in a conical channel along the OX axis on different surfaces, and time-dependent graphs of the movement along the OX axis at different speeds were obtained.

Results. The results of the research showed that the time-dependent graphs of the movement of fibers along the OX axis in the conical channel on different surfaces, and the time-dependent graphs of the speed *s* in the channel were obtained.

Conclusion. The results of the study showed that when the time-dependent graph of the movement of the fibers in the conical channel along the OX axis on different surfaces $S_1=14{,}51$, $S_2=12{,}56$, $S_3=10{,}75$ was obtained, the fibers on the small surface were straight. When the flow rate is high, a good result was obtained at high speed when the time-dependent graph of the speed of $\vartheta_1 = 30 m/s$ $\vartheta_2 = 25 m/s$ $\vartheta_3 = 20$ *m/s* was obtained in the channel.

Keywords: pneumomechanical spinning, separator, air channel, fiber, chamber, cone.

Introduction. The pneumomechanical spinning technique is widely used in the textile industry due to its excellent economic perspective. The rotor is the most important component of the pneumomechanical spinning machine, and its speed has a significant impact on the yarn quality. In the study of Chen and Slater [1], the flow behavior in the rotor changes significantly with increasing speed. Kocyo and Lawrence [2] conducted studies on twisting mechanics and rotor spinning under different operating conditions. The effect of rotor speed and geometrical parameters on airflow was analyzed by Xiao et al. [3] and they found that the angular velocity and the slip angle, the good axisymmetry of the spiral structure in the meridional plane of the rotor is reached.

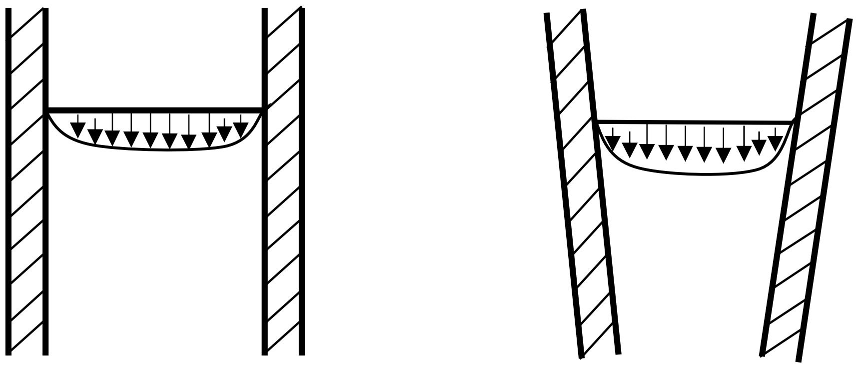
Methods and results. The entire experiment is reduced to measuring force and measuring flow rate, where the flow rate is averaged. The research consists of determining the coefficient of direct resistance S_x, researching the pulling action of cotton fibers, and the effect of density. At the same time, two types of channel shapes were chosen for blowing fibers:

- rectangular channel;
- narrowing channel (confuser type)

Which of the selected channels is the most suitable for the transportation of cotton fibers was compared.

Before the start of the experiments, the uniformity and stability of the velocity field of each channel for blowing fibers in an aerodynamic device were checked. Experiments have shown that the velocity profile in the suspended fiber zone satisfies the conditions of uniformity both in a rectangular channel (Fig. 1a) and in a narrow channel (Fig. 2b).

The airflow speed was varied from 5 m/s to 30 m/s by gradually increasing the fan rotation speed. The measurement range is 30^0 C. The flow rate was determined using a Pitot tube connected to a micromanometer Benetech GM 8903 Thermoanemometer.



a) b)

Figure 1. Fiber channel located in the separator. a) – rectangular channel, b) – conical channel

In the cross-section of the fiber-blowing chamber, the total pressure distribution force was measured using a microtube with an inlet diameter of 6 mm, and the statistical pressure was measured using a statistical pressure tube. At the same time, atmospheric pressure-P_a; ambient temperature -t; relative humidity-Rh was measured.

Calculation of the speed of the flow in different sections was carried out by dynamic measurement of the dynamic pressure P using a pitot tube, and the statistical pressure P according to the static formula [4-8].

$$V = \xi\sqrt{\frac{2k\sin\alpha(h-h_0)\gamma}{\rho}} \quad (1)$$

here

ξ- calibration coefficient equal to 0.98;

k- calibration coefficient of the equipment;

α- micromanometer tube liquid slope angle;

ho- the initial indicator of the micromanometer;
ρ- air density, kg/cm^3;
γ- micromanometer liquid density, g/cm^3;

The density value of alcohol was determined with a simple hydrometer with an accuracy of 0.0001 g/cm3. The relative deviation of density determination for alcohol ranges from 0.800 to 0.820 g/cm3, and is equal to

$$\delta_c = \frac{\Delta\gamma}{\gamma} = \frac{0.001}{0.8} = 0.125\% \qquad (2)$$

The relative error in determining the angle of inclination of the pipe, including the error in the installation of the crossbar, does not exceed 0.2%, and therefore

$$\delta_c = \frac{\Delta \sin\alpha}{\sin\alpha} \simeq 0.2\% \qquad (3)$$

All experiments were performed in triplicate. The required number of measurements was calculated as follows: let δ_s be the systematic error determined by the accuracy class of the instrument or another factor. It is recommended to reduce the random error to such an extent that the error should be less than the systematic one. For this, the value of the absolute error should be smaller than ΔX , δ_s, i.e

$$\Delta\bar{X} \le \frac{\delta_c}{3}; \qquad (4)$$

Taking into account the air resistance, the following expression (1) was created as a differential equation of motion along the OX axis.

Assuming that there is a constant cross-section of the movement channel of the fibers, a coordinate system corresponding to the wall of the movement channel of the fiber on the OX axis was selected.

It was observed that the speed changes in different values of the surfaces over time. The motion of the fibers in the conical tube is integrated with the differential equation along the X-axis. As a result, the speed along the X-axis is determined. It depends on (m) fiber mass, (S_y) drag coefficient, (v_x) air velocity, (S) different surfaces of the conical channel, (α) angle, and (t) time.

$$\frac{dv_x}{v_x^2\cos^2\alpha + v_n^2} = -\frac{C_x S\rho}{2m}\cdot dt$$

$$\frac{dv_x}{v_x^2 + \left(\frac{v_n}{\cos\alpha}\right)^2} = -\frac{C_x S\rho}{2m}\cdot \cos^2\alpha \cdot dt$$

$$\frac{\cos\alpha}{v_n}\, arctg\left(\frac{v_x\cdot\cos\alpha}{v_n}\right) = -\frac{C_x S\rho}{2m}\cos^2\alpha\cdot t$$

$$arctg\left(\frac{v_x}{v_n}\cos\alpha\right) = -\frac{C_x S\rho\cdot v_n\cdot\cos\alpha}{2m}\cdot t$$

$$v_x = -tg\left(\frac{C_x S\rho\cdot v_n\cdot\cos\alpha}{2m}\cdot t\right)\cdot v_n\cdot\cos\alpha \qquad (5)$$

By differentiating the received equation (5) by time, the equation of the movement trajectory of the fibers along the X-axis (6) was obtained. It depends on (m) fiber mass, (S_y) drag coefficient, (r) air density, (v_n) velocity, (S) different surfaces of the conical channel, (α) angle, and (t) time.

$$x = ln\left(\cos\left(\frac{C_x S\rho\cdot v_n\cdot\cos\alpha\cdot t}{2m}\right)\right)\cdot v_n\cdot\cos\alpha\cdot\left(\frac{2m}{C_x S\rho\cdot v_n\cdot\cos\alpha\cdot t}\right)$$

$$x = ln\left(\cos\left(\frac{C_x S\rho\cdot v_n\cdot\cos\alpha\cdot t}{2m}\right)\right)\cdot\left(\frac{2m}{C_x S\rho\cdot t}\right) \qquad (6)$$

Equations for the dependence of breaking force on speeds are derived.

Results.

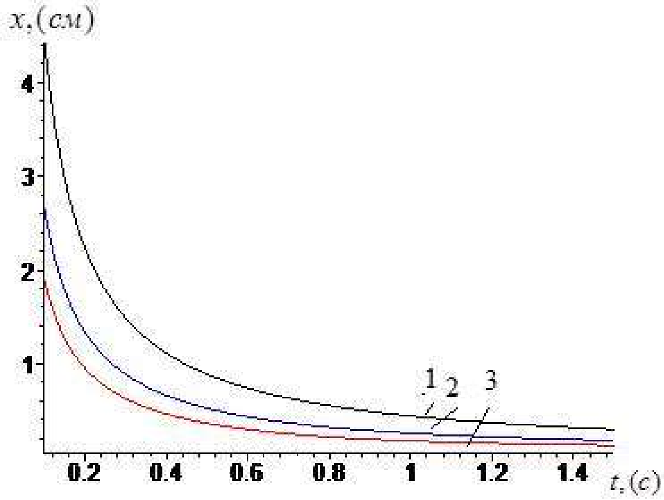


Figure 2. Time-dependent graph of the movement of fibers in a conical channel along the OX-axis on different surfaces S_1=19.6, S_2=12,6, S_3=7.1

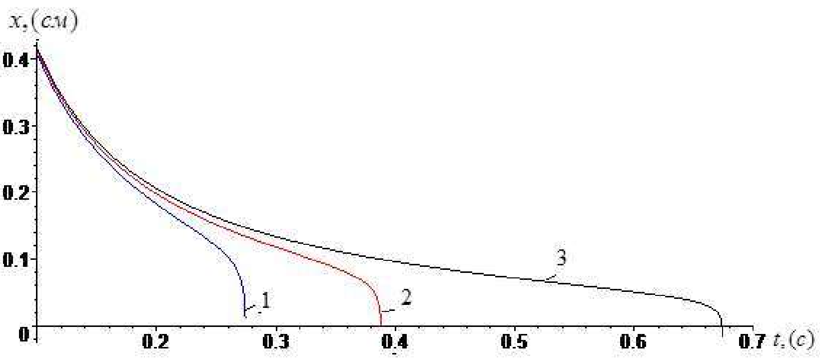


Figure 3. Time-dependent graph of the movement of fibers along the OX-axis in a conical channel at different speeds of $\vartheta_1 = 30$m/s $\vartheta_2 = 25$m/s $\vartheta_3 = 20$ m/s

Conclusion. In the research work, the movement of fibers in the air channel and the rotor in the pneumomechanical spinning machine was studied. In the experimental work, the uniformity and stability of the velocity field of each channel for moving fibers in an aerodynamic device were checked. In this case, the airflow speed was changed from 5 m/s to 30 m/s. Taking into account the air resistance, differential equations of motion along the OX axis were created. When determining the movement of fibers in a conical channel, the total speed was divided into components, constant values were found, and general equations of motion were derived. Also, time-dependent graphs of the movement of fibers in a conical channel along the OX axis on different surfaces, and time-dependent graphs of the movement along the OX axis at different speeds were obtained. The results of the study showed that when the time-dependent graph of the movement of the fibers in the conical channel along the OX axis on different surfaces *S_1=14,51, S_2=12,56, S_3=10,75* was obtained, the fibers on the small surface were straight. When the flow rate is high, a good result was obtained at high speed when the time-dependent graph of the speed of $\vartheta_1 =$ *30m/s* $\vartheta_2 =$ *25m/s* $\vartheta_3 =$ *20 m/s* was obtained in the channel.

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RESEARCH OF THE MOVEMENT OF FIBERS IN THE CONFUSION BETWEEN THE AIR CHANNEL AND THE ROTOR IN A PNEUMO-MECHANICAL SPINNING MACHINE

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Abstract:

Objective. In this paper, we conducted research based on a new experimental approach to describe the airflow in a rotor-spinning machine experimentally. This article studied the movement of fibers in the air channel and the rotor in the pneumomechanical spinning machine. In this case, the airflow speed was changed from 5 m/s to 30 m/s. Differential equations of motion along the OX and OY axis were created considering the air resistance.

Methods. When determining the movement of fibers in a conical channel, the total speed was divided into components, constant values were found, and general equations of motion were derived. Also, time-dependent graphs of the movement of fibers in a conical channel along the OY axis on different surfaces, and time-dependent graphs of the movement along the OY axis at different speeds were obtained.

Results. The results of the study showed that the movement of fibers in the conical channel along the OY axis is a time-dependent graph on different surfaces $S_1=14,51$, $S_2=12,56$, $S_3=10,75$, in the channel time-dependent graphs at a speed of $\vartheta_1 = 30 m/s$ $\vartheta_2 = 25 m/s$ $\vartheta_3 = 20\ m/s$ were obtained.

Conclusion. The results of the study showed that when the time-dependent graph of the movement of the fibers in the conical channel along the OY axis was obtained on different surfaces $S_1=14,51$, $S_2=12,56$, $S_3=10,75$, the fibers on the small surface were straight. When the velocity is high, the time-dependent graph of the speed of $\vartheta_1 = 30 m/s$ $\vartheta_2 = 25 m/s$ $\vartheta_3 = 20\ m/s$ in the channel was obtained at high speed.

Keywords: pneumomechanical spinning, separator, air channel, fiber, chamber, cone.

Introduction. Some studies have been done on the airflow in the rotor-spinning machine's confusor. Lawrence and Chen [1, 2] used a high-speed camera

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