DEVELOPMENT OF THE ORETICAL MODEL OF COTTON MOVEMENT IN PNEUMOTRANSPORT AND SEPARATION PROCESS

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ANNOTATION

The article focuses on technological processes in cotton ginning enterprises. Also, the productivity of cotton transportation in the pneumatic transport device, the transportation time, the share of the internal volume of the air pipe of raw cotton during transportation, and the views of the air transport system are based on the observations and practical experiences.

Keywords: cotton, pneumatic transport, fan, air pipe, resistance, air, length, mass, density, volume, separator.

INTRODUCTION

The effective operation of the pneumatic transport system used for transferring cotton to technological machines depends on the construction of its constituent elements [1] and the description of the "cotton-air" mixture [2, 3].

In the following years, pipes with a diameter of 300 mm instead of 400 mm began to be used in the cotton pneumatic transport system [4]. As a result, air, energy and material consumption for cotton transportation has been significantly reduced. However, the dimensions of other elements of pneumatic transport remained unchanged. As a result, cotton transportation speeds have increased relatively. Accordingly, cotton is entering the working chambers of the separator faster than before. This situation indicates that the forces of impact on the cotton in the separator will increase, and the cases of damage will increase.

It is known that during the working process, the "cotton-air" mixture enters the working chamber of the separator, and the main part of it moves in the working chamber of the separator, hits its walls, falls to the vacuum valve under the influence of its own weight. The rest is hit on the mesh surface. Circular mesh surfaces are installed on the sides of the separator working chamber in the air flow path. A certain amount of cotton sticks to these surfaces. Cotton is separated from the mesh surface using an elastic squeegee.

When a small diameter pipe is used, the cross-sectional area of the air and cotton flow is reduced, and the cotton with this cross-sectional area, however, enters the separator chamber at a high speed and hits the inner surfaces in one place. In the separator device, the accumulation of cotton in the central part of the vacuum valve and the increase of blockages, as a result of the cotton falling between the vacuum valve blades and the outer shell and being crushed, lead to further deterioration of the product quality indicators. Therefore, it is necessary to study the pattern of movement of the cotton and air mixture inside the inlet pipe of the separator, to develop a structure that allows reducing the aerodynamic resistance of the inlet pipe and ensures that the cotton is evenly distributed across the width of the separator [5-7].

METHODOLOGY

Based on the study of the laws of the movement of cotton in the separation chamber, we will consider the issue of the distribution of cotton along the length of the separator vacuum valve. In this case, we consider cotton as a system of loosely connected pieces [8].

We start studying the movement from the moment when the piece of cotton enters the inlet of the separator (Fig. 1). Let the coordinate head be in the center of the input square. In the Deckard coordinate system, the position of a piece of cotton is determined along three axes: x; y; z.

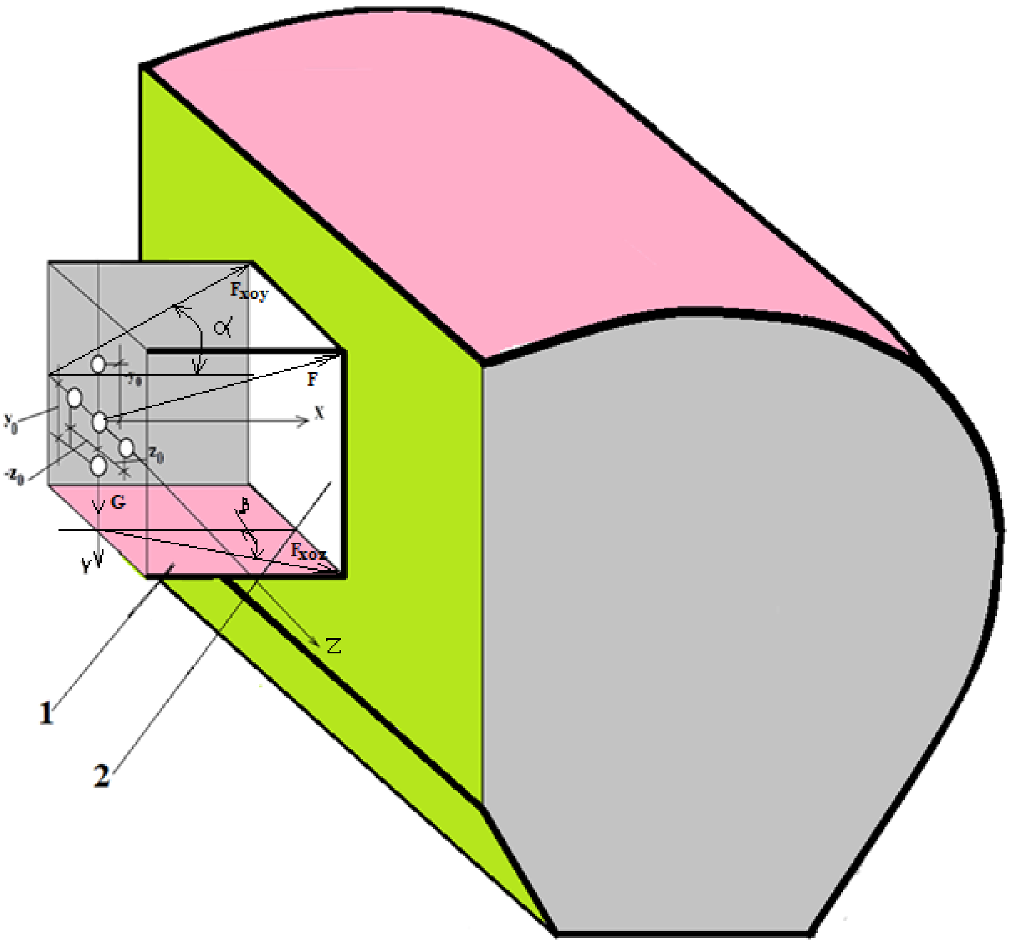

Figure 1. Studying the movement of cotton in the separator chamber.
1-inlet pipe, 2-working chamber

In the plane movement of fibrous materials, it is affected by aerodynamic and gravitational forces. The speed of the cotton particles appears under the influence of the speed of the air flow:

$$v_п = nU, \quad м/с$$

where: U - air flow speed, m/s; vp - cotton speed, m/s; n-delay coefficient, determined in experiments n=0.5-0.75.

The sources of forces in the plane of symmetry are direct resistance (Fx) and lifting force (Fy) and transverse force (Fz). These forces depend on the difference in air and cotton velocities, and they can be expressed at speeds higher than the speed of sound, that is, in the medium of quadratic resistance, and in the form of F = k "v " 2 , at lower speeds, that is, in the medium of linear resistance, in the form of F = kv. Velocities in cotton pneumatic transport are about 10 times lower than the speed of sound, and using a linear connection to study this process, we get the following expressions for the coordinate axes:

$$\left.\begin{aligned} F_x &= k_x v_x \\ F_y &= k_y v_y \\ F_z &= k_z v_z \end{aligned}\right\} \qquad (2)$$

where: kx; ku; kz - aerodynamic coefficients. The direction of the force Fx corresponds to the speed of movement of the body, but in our case it is directed against the speed of movement, since it is a force that hinders the movement. The directions of the forces Fy and Fz are always perpendicular to Fx and to each other.

The generation of lift force and transverse force is somewhat complicated. Due to the fact that the movement of the flow is spatial, even in the zero-angle movement of symmetric bodies, lift force and transverse force are generated, because the air velocity is uneven across the pipe cross-section, more precisely, it is higher in the center of the pipe and decreases closer to the pipe wall, so there are transverse forces that pull the cotton particles towards the center . The vertical direction of these forces is the lifting force, and the force acting on the horizontal plane pulls the object either towards the side walls of the pipe, or, on the contrary, from the wall towards the center of the pipe [9-10].

Regarding the lifting force, it can also be said that some pieces of cotton move at different speeds in the air. In addition, the pieces of cotton do not have a symmetrical shape. However, if they have only one axis of symmetry, in a constant velocity flow, they will turn and move along the flow around their axis of symmetry. In this case, the angle of movement and the lifting force will be equal to 0. However, this situation is not stable, because the cotton bundles under the influence of gravity fall down into the non-symmetrical flow zone, and again lift force appears in it. Thus, it can be concluded that the main reason for the generation of lifting force is unevenly distributed flow [11].

In our example, the air flow after the intake manifold is divided by 2. Half of it goes to the right, and the rest to the left, towards the mesh surfaces. These currents also pull the cotton particles towards the mesh surfaces. However, the bulk of the cotton moves straight on by its own inertia, downwards by gravity and laterally deflected by a complex trajectory and hits the opposite wall. Cotton particles located closer to the side wall from the center of the inlet pipe are more susceptible to the effect of the lateral flow, and these particles also move along a trajectory that descends under the influence of gravity, moves forward under the influence of inertial forces, and is pushed sideways under the influence of air flow, hitting the mesh surface.

In the separators, a certain amount of air is sucked through the vacuum valve located under the working chamber. This air flow prevents some cotton particles from falling into the vacuum valve and forces them to move towards the mesh surface [12, 13].

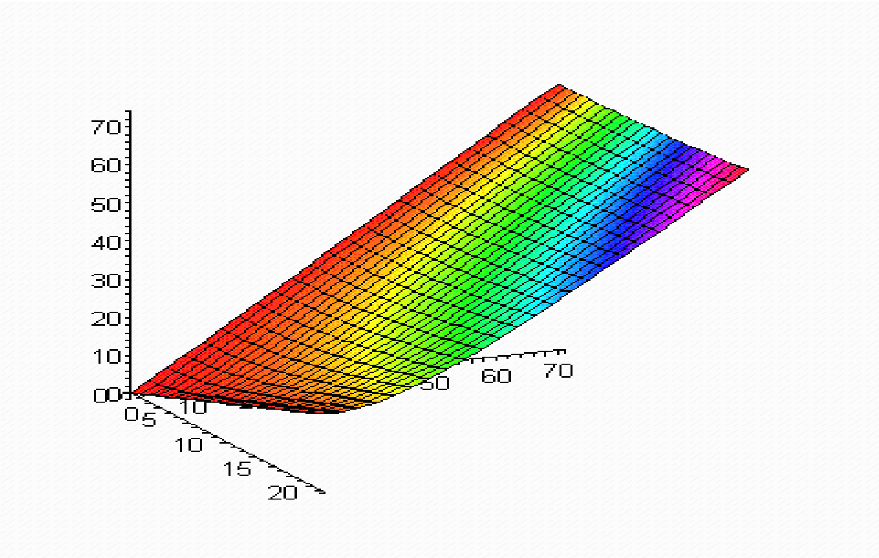

Figure 3. Trajectories of the movement of the cotton ball in the separator eorking chamber
V = 25 m/s,
x_0=0;
y_0=0;
z_0=0

The obtained results are presented graphically in Figures 3 and 4.The displacement of the cotton along the coordinate axes within a unit of time goes with the same intensity. The resulting graphs for all axes are similar to those in Figure 3, with only differences in value. The graphs in Figures 4 and 5 show the movement trajectories of the cotton in one half of the separator. According to them, the displacement along the X-axis is more noticeable. Since the graphs are plotted in a plane, it is difficult to notice the displacements of the trajectories along the U and Z axes.

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Due to the complex nature of the trajectories of the cotton particles, the necessary analysis could not be derived from the three-dimensional graphics obtained on the computer.

Therefore, we analyzed the obtained results into projections on 2 XOY and XOZ planes. and cotton trajectories in the separation chamber are shown.

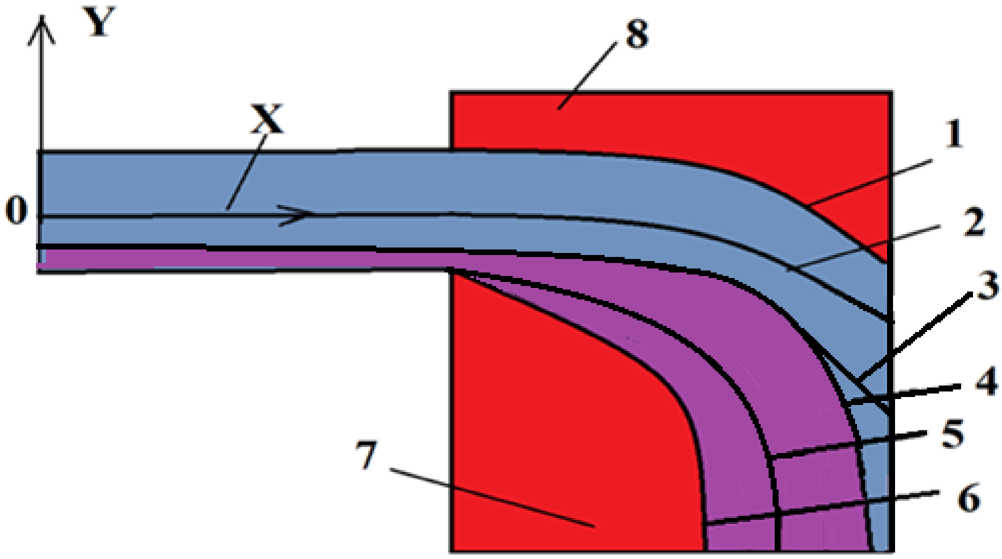

Figure 3. Trajectories of cotton in the separation chamber along the XOY plane. 1-3 – a set of trajectories of cotton pieces hitting the rear wall of the separator and falling down; 4-6 – a set of trajectories of cotton particles directed to the right vacuum valve; 7-8 - cotton-free zone.

If we pay attention to the trajectories of the cotton in the XOY plane in the separation chamber, we see that the cotton pieces entering from points 1, 2 and 3 hit the back wall of the separator and then fall down to the vacuum valve.

It can be said that the trajectories of the cotton particles entering from the intermediate points correspond to this interval and form a set of integrated trajectories.

The cotton particles entering from points 4, 5 and 6 on the vertical plane are directed to the right vacuum valve without hitting anywhere, and the cotton particles entering from the points between these points are also

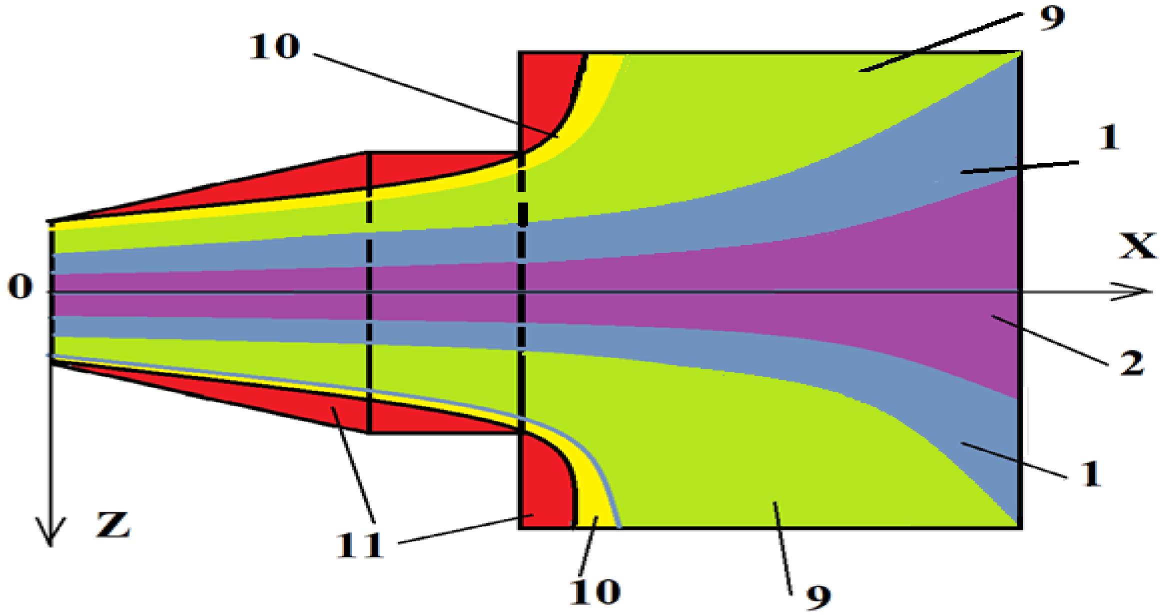

Figure 4. Trajectories of the cotton in the separation chamber along the plane of the XOZ. 1- a set of trajectories of cotton particles directed to the right vacuum-valve; 2 – a set of trajectories of cotton pieces hitting the rear wall of the separator and falling down; 9-10 – a set of trajectories

of cotton particles hitting a straight mesh surface, including cotton particles at the extreme point of pipe 10; 11 – cotton-free zone.

Conclusions: The analysis of the scientific research conducted on the improvement of the operation of moving pneumatic transport devices showed that its installation causes an increase in the amount of energy consumed in the transportation of cotton and a deterioration in the quality of cotton.Therefore, uneven distribution of cotton along the length of the working chamber and vacuum valve in the separator was eliminated.

As a result of theoretical studies, the movement of cotton entering the separator was studied in a 3-dimensional coordinate system, and trajectory equations and graphs of cotton were obtained.In order to solve the problem of uniform distribution of cotton along the length of the vacuum valve, the design of the profile of the inlet manifold was determined in an experimental way, and as a result, the problems of uniform distribution of cotton along the width of the separator and prevention of air accumulation in the pipe are solved.

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