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Study of the Effect of the Mobile Floor of the Separator Device on the Cotton Section

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Abstract--- *The article is theoretically based on the improved design of the cotton separator, in which the mesh surface in the working chamber of the device is resized relative to previous analogs, it is set in motion and a mathematical model is developed and graphs are constructed.*

Keywords--- *Cotton, Fiber, Air Flow, Separator, Device, Working Chamber, Mesh Surface, Vacuum-valve, Foreign Compounds, Motion.*

I. INTRODUCTION

Today, as in all areas of the world, special attention is paid to improving the quality of products through the introduction of high-efficiency innovations in the field of ginning, the creation of resource-saving technologies, improvement of existing equipment and technologies [1,2].

It is known that pneumatic transport devices are widely used in ginneries for the delivery of seed cotton to processing technologies [3]. This system consists of several devices, the main element of which is the separator device. The main function of the separator is to separate the cotton seed transported from the air stream after delivery to the destination by airflow [4].

II. THE MAIN RESULTS AND FINDINGS

Today, there are many types of separator device and their design has been improved for several years. The most common of these is the SS-15 cotton separator. However, this separator device still has its own shortcomings, and they affect the process of separating cotton from the air stream. The most important of these shortcomings is the damage to the seeds as a result of high-speed impact on the working chamber of the seed cotton separator [5,6]. Also, during the stripping process with the help of a cotton scraper attached to the mesh surface of the SS-15 separator, the fibers are damaged by the seeds and the cotton fiber absorbs air from the mesh surface, which leads to the process of artificial insemination [7,8].

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Therefore, by introducing a new cotton separator to the ginnery, it is advisable to increase the productivity of the cotton separator by eliminating congestion in the working chamber (Figure 1).

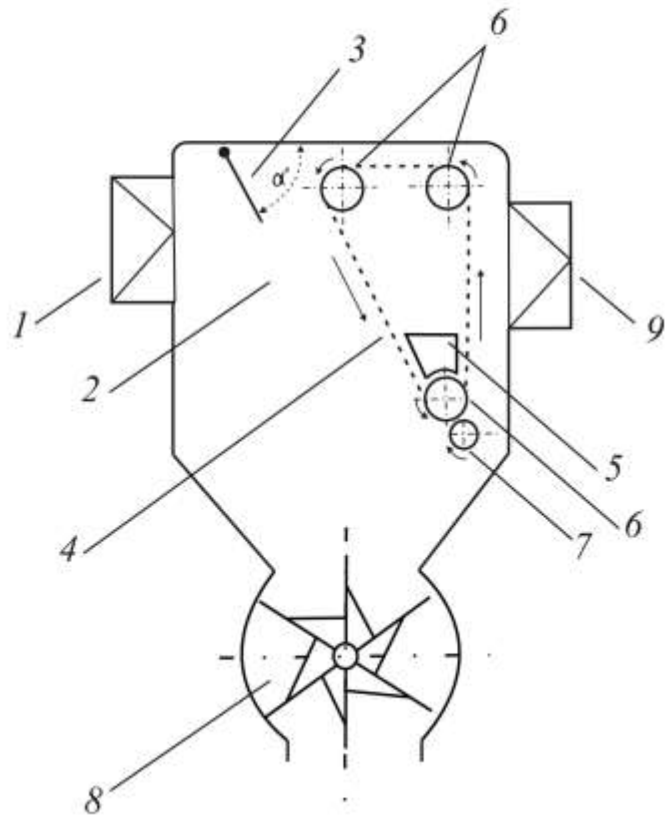

Figure 1: The Proposed Cotton Separator Device

1- inlet pipe, 2 - working chamber, 3- guide, 4 - mesh surface conveyor, 5 - set, 6 - shafts, 7- brush drum, 8 - vacuum valve, 9 - air suction pipe.

Mathematical Model of the Processes that Take Place in the Device

The cotton pieces that enter the separator working chamber along with the air flow are hit by a mesh conveyor belt that forms $\angle \alpha$ an angle with the vertical direction (Figure 2). The cotton pieces move down the surface of the net, due to their own gravity. A certain part of the air flow is sucked through the holes in the mesh surface in its direction. The mesh surface is in the form of a conveyor belt that moves regularly. In the process of separating the cotton pieces from the air, they move along the surface of the net, sticking to it. After the mesh surface and the cotton raw material have traveled a certain distance, the cotton raw material is separated from the mesh surface using a brush drum located at the bottom. The separated cotton raw material is thrown to the bottom of the device and from there it is discharged through a vacuum valve [9,10]. When raw cotton sticks to the surface of the net, as a result of air absorption from the surface of the net, the process of cleaning the passive state of fine impurities in the raw material of cotton takes place. In this process, the angle $\angle \alpha$ formed by the vertical plane of the surface of the mesh is also affected by the process of separation of cotton pieces from the air [11].

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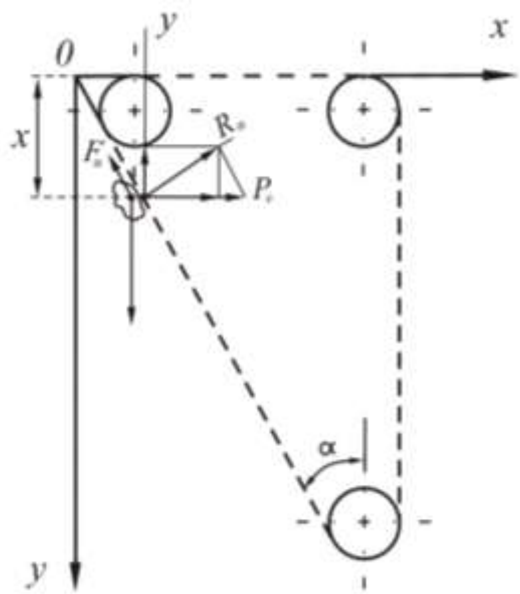

Figure 2: Interaction of Cotton with a Moving Mesh Surface

The process of separation, in which it is important to study the laws of motion of cotton pieces along the mesh surface [12].

The forces acting on the movement of the cotton pieces in the separator working chamber along the mesh surface are as follows (Fig. 3).

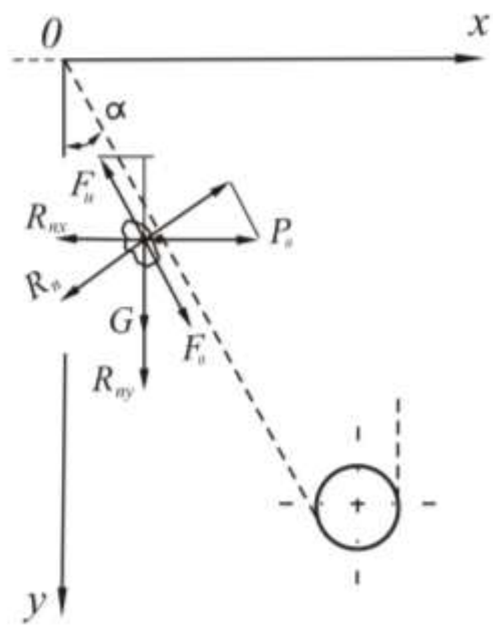

Figure 3: Forces Acting on the Movement of Cotton Pieces along the Mesh Surface

The forces influencing the movement of cotton pieces along the mesh surface are as follows

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$P_0 = CV_0^2$ – aerodynamic lifting force;

$R_n = P_0 \cos\alpha$ – aerodynamic pressure force;

$G = mg$ – gravity of a piece of cotton;

$F_{иш} = f \cdot R$ – friction force between the cotton piece and the mesh surface;

f – coefficient of friction;

F_0 – dragging force of cotton by a conveyor belt with a mesh surface;

We calculate the projections of the forces acting on a piece of cotton on the axes and axes:

$$\begin{cases} F_x = \sum (F_i)_x = -R_{nx} - F_{ux} - F_0 \sin\alpha \\ F_y = \sum (F_i)_y = G + R_{ny} - F_{uy} + F_0 \cos\alpha \end{cases}$$

or:

$$\begin{cases} F_x = -P_0(\cos^2\alpha + 0{,}5 \cdot f_0 \sin 2\alpha) + F_0 \sin\alpha \\ F_y = mg - 0{,}5P_0(\sin 2\alpha - f\cos^2\alpha) + F_0 \cos\alpha \end{cases}$$

If we enter the designation as follows:

$$\begin{cases} \kappa_{11} = \cos^2\alpha + 0{,}5 f \cdot \sin 2\alpha \\ \kappa_{22} = \sin 2\alpha - f \cdot \cos^2\alpha \end{cases} \quad (1)$$

The projections of all the forces acting on a piece of cotton on the axes *ox* and axes *oy* are as follows:

$$\left. \begin{aligned} F_x &= -\kappa_{11} P_0 + F_0 \sin\alpha \\ F_y &= mg + \kappa_{22} P_0 + F_0 \cos\alpha \end{aligned} \right\} \quad (2)$$

In this case, we write the differential equations of motion of cotton pieces along the mesh surface as follows:

$$\left. \begin{aligned} \ddot{x}(t) &= \frac{F_x}{m} \\ \ddot{y}(t) &= \frac{F_y}{m} \end{aligned} \right\} \quad (3)$$

Where: m is the mass of the cotton piece;

(3) - The system of differential equations is integrated under the following initial conditions (4) and obtained the graphs in Figure 4 9 on the basis of the program MAPLE-17 [13,14].

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Prerequisites:

$$\left.\begin{array}{l} x_i(O) = O \\ y_i(O) = O \\ \dot{x}_i(O) = \vartheta_{ox_i} \\ \dot{y}(O) = \vartheta_{oy_i} \end{array}\right\} \qquad (4)$$

Analysis of Results

The graphs in Figure 4.5 show the laws of change of the laws of motion of cotton pieces in the horizontal - *ox* axis and vertical *oy* - directions in relation to time - *t.*

As can be seen from the graphs in Figure 4, the process of separating the cotton pieces from the mesh surface accelerates as the angle $\angle \alpha$ of inclination, which forms the surface of the mesh conveyor in a vertical direction, increases.

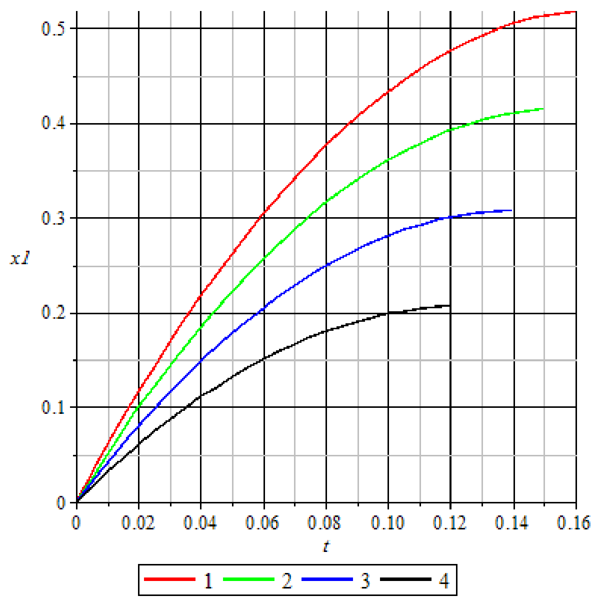

Figure 4: The movement of a piece of cotton in the OX-coordinate direction over time, the law of change at different α - angles.

1) $\alpha = 30^0$, 2) $\alpha = 35^0$, 3) $\alpha = 40^0$, 4) $\alpha = 45^0$.

In particular, if the cotton pieces $\alpha = 30^0$ are separated from the mesh surface at t = 0.14 sec and continue to move in the vertical direction and move on to the next process, this process $\angle \alpha = 45^0$ will occur at t = 0.12 sec.

This, in turn, separates the air from the cotton pieces and accelerates the separation process.

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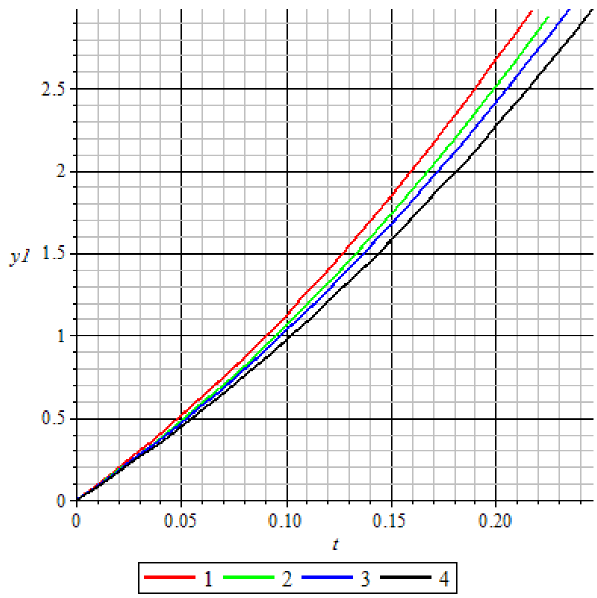

Figure 5: The Movement of A piece of Cotton in the OU-coordinate direction over time, the law of change at Different Angles

$$1)\ \alpha = 30^0,\ 2)\ \alpha = 35^0,\ 3)\ \alpha = 40^0,\ 4)\ \alpha = 45^0.$$

The graphs in Figure 6 show the law of variation of the movement of a piece of cotton in the vertical *oy* -direction depending on the horizontal *ox*- axis direction.

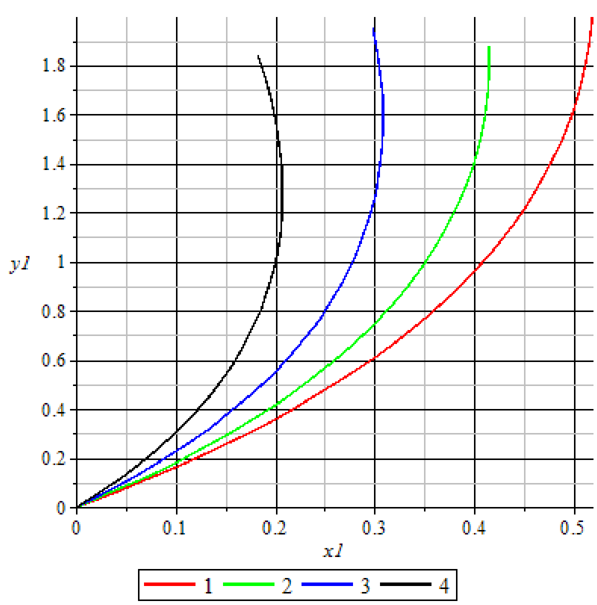

Figure 6: The law of variation at different α-deflection angles, depending on the motion of the cotton piece in the *oy*-coordinate direction and in the *ox*-coordinate direction

$$1)\ \alpha = 30^0,\ 2)\ \alpha = 35^0,\ 3)\ \alpha = 40^0,\ 4)\ \alpha = 45^0.$$

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When there is an angle $\angle\ \alpha = 30^0$ of inclination of the conveyor belt surface vertically,

$$\begin{cases} x_y = 0{,}4\text{м} \\ y = 1\text{м} \end{cases}$$

although the cotton piece separates from the mesh surface and moves on to the next process $\alpha = 45^0$

$$\begin{cases} x_y = 0{,}2\text{м} \\ y = 1\text{м} \end{cases}$$

As long as this process happens. That is, increasing the angle $-\alpha$ accelerates the process of separation of cotton pieces from the air.

The graphs in Figures 7 and 8 show the laws of change of horizontal and vertical velocities of a piece of cotton in time - *t*, respectively.

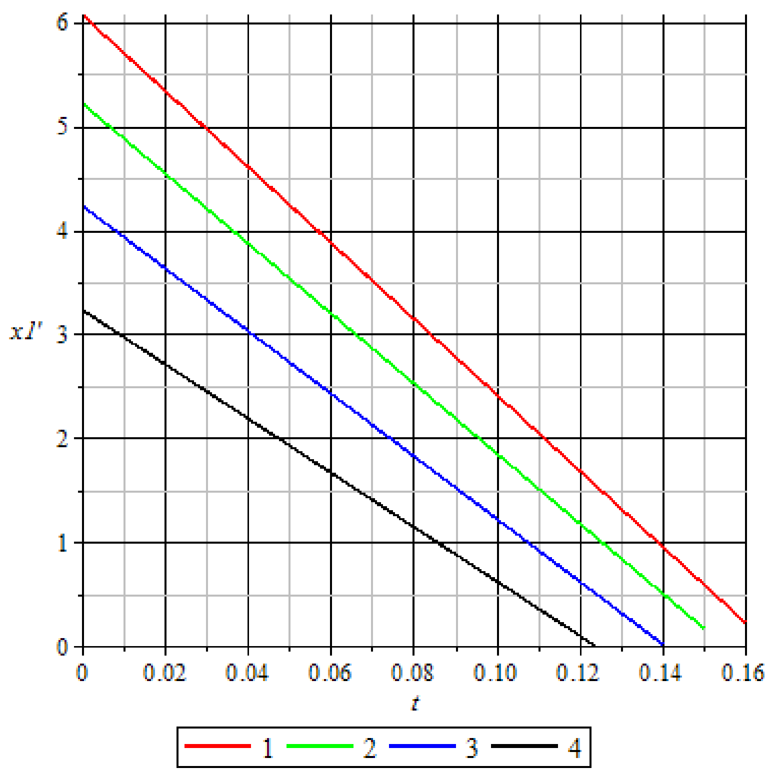

Figure 7: The law of change of the speed of movement of a piece of cotton in the direction of *OX*-coordinates over time, at different α-deflection angles

1) $\alpha = 30^0$, 2) $\alpha = 35^0$, 3) $\alpha = 40^0$, 4) $\alpha = 45^0$.

A sharp decrease $\angle\ \alpha -$ in the horizontal velocity can be observed with increasing angle of deflection. However, this process can be observed to increase in the vertical direction and vice versa.

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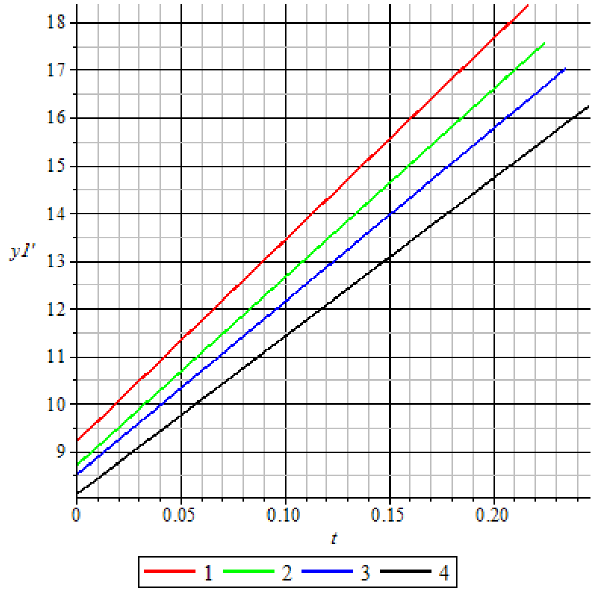

Figure 8: The law of change of the speed of movement of a piece of cotton in the direction of *OY*-coordinate over time, at different α -deflection angles

1) $\alpha = 30^0$, 2) $\alpha = 35^0$, 3) $\alpha = 40^0$, 4) $\alpha = 45^0$.

The graphs in Figure 9 show the law of change of a piece of cotton - $V_y(t)$ the vertical speed - $x(t)$ – depending on the coordinate.

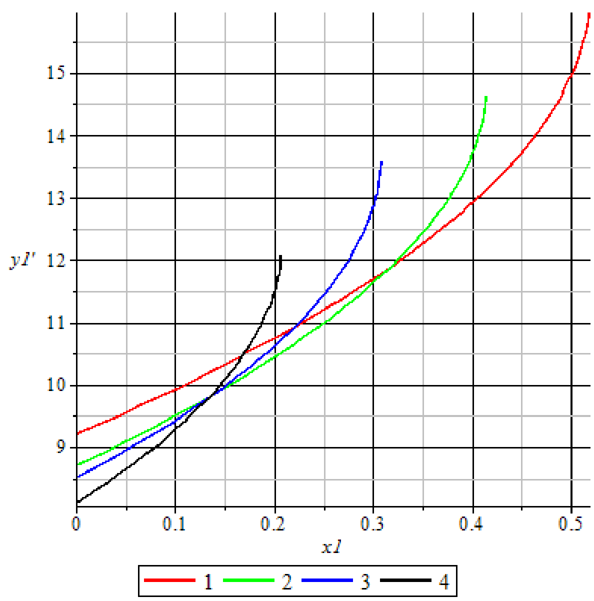

Figure 9: The law of change of the speed of movement of a piece of cotton in the *OY*-coordinate direction in the horizontal direction, at different α-deflection angles.

1) $\alpha = 30^0$, 2) $\alpha = 35^0$, 3) $\alpha = 40^0$, 4) $\alpha = 45^0$.

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In this case, the velocity intensity $V_y(t)$ - is faster at a $\angle \alpha$ large value and slower at a small value.

III. CONCLUSIONS

1. Differential equations of motion of cotton pieces along the surface of the lattice are constructed.
2. Graphs of the laws of change of the law of motion $\angle \alpha$ of the cotton piece in the horizontal and vertical directions at time - *t* at the angular value of the deflection of the mesh surface were obtained.
3. Similarly, the laws of change of cotton pieces over time were obtained, and graphs of their values of the angle of inclination of the mesh surface were constructed.
4. The self-movement of the mesh surface, partly accelerating the process of separation of cotton pieces and cleaning the fine impurities in it, is also partially realized.

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