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METHODS AND ANALYSIS OF THE MOVEMENT OF COTTON SEED ON A NET SURFACE DURING THE PROCESS OF CLEANING COTTON RAW MATERIAL

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Abstract: In this article, the interaction between the pile drum and the mesh surface during the cotton ginning process is theoretically studied, and at the same time, the trajectory of cotton movement between the pile drum and the mesh surface is analyzed. During the study, the dynamics of the movement of the cotton gin, in particular, the acceleration states along the X and Y axes, were analyzed. It was found that the acceleration along the X axis initially became negative, and then changed to a positive sign, which is associated with the inertial movement of cotton and the impact of the piles. On the Y axis, the acceleration does not become negative, but gradually decreases over a short period of time. During these studies, it was determined how long the cotton should be in the working zone, and what are the minimum and maximum speeds m/s.

Keywords: Cotton, fine dirt, acceleration, drum with piles, negative, positive, coordinate axis, time, mesh surface.

Introduction. Research and development work is being carried out in the world to modernize the techniques and technologies of cotton ginning enterprises, as well as to introduce them into the production process. In this direction, research is considered a priority, including the development of new techniques and technologies based on the development of mathematical models of cotton drying, cleaning, ginning, fiber cleaning, pneumatic transport, dust collection and free fiber retention, which have a positive effect on the quality indicators of the fiber. At the same time, targeted scientific research is being carried out in such areas as increasing the durability of technological parts of machines at enterprises, introducing reliable modifications based on the creation of new designs with alternative indicators.

The cotton cleaning process is carried out in two stages, first by cleaning from fine and then from coarse impurities. Since our research is focused on cleaning cotton from fine impurities, we will mainly focus on this process. The cleaning process from fine impurities is carried out in machines with working bodies known as a “pair of peg drums and mesh surfaces.” Figure 1 shows a pair of working bodies for cleaning cotton from fine impurities.

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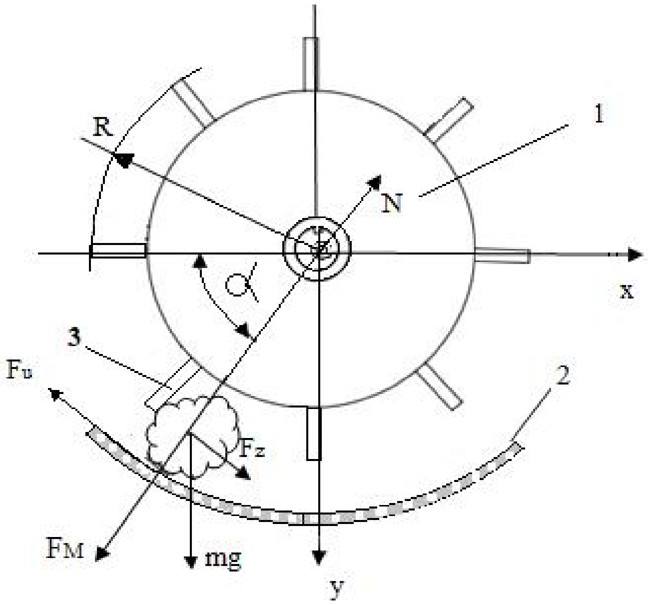

Figure 1. Diagram of the interaction of cotton and piles in a fine-dust cleaning machine.
1-Pile drum, 2-Net surface, 3-Pile.

During the cleaning process, the cotton is affected by the impact force of the pile F_z, the friction force of the mesh surface F_i, and the weight of the cotton mg and the centrifugal force F_m. Also, the reaction force of the surface to the impact of the cotton on the weight mg and the centrifugal force F_m, N [1].

We find the expression of forces:

The impact force F_z depends on the linear velocity of the drum with the peg and the coefficient of elasticity of the cotton, and we take it in the following form:

$F_z = k\vartheta$ (1)

Friction force:

$$F_i = N \cdot f = (F_m + mg \cdot cos\alpha) \cdot f = \left(m\frac{\vartheta^2}{R} + mg \cdot \cos\varphi\right) f = m \cdot f(\omega^2 R + g\cos\alpha) \quad (2)$$

Centripetal force F_m:

$$F_m = m\frac{\vartheta^2}{R} = m\frac{(\omega R)^2}{R} = m\omega^2 \cdot R = m\frac{\pi n}{30} R = \frac{\pi}{30} mnR \quad (3)$$

We formulate the equilibrium equation of the cotton ball with respect to the coordinate axes:

$$\left.\begin{aligned} m\frac{dv_x}{dt} &= -F_m \cdot \sin\alpha - F_i \cdot \cos\alpha + F_z \cdot \cos\alpha \\ m\frac{dv_y}{dt} &= mg + F_m \cdot \cos\alpha - F_i \cdot \sin\alpha + F_z \cdot \sin\alpha \end{aligned}\right\} \quad (4)$$

Taking into account equations (1), (2) and (3), we change the form of equation (4):

$$\left.\begin{aligned} m\frac{dv_x}{dt} &= -\frac{\pi}{30} mnR \cdot \sin\alpha - mf\left(\frac{\pi}{30} nR + g \cdot \cos\alpha\right) \cdot \cos\alpha + k\vartheta \cdot \cos\alpha \\ m\frac{dv_y}{dt} &= mg + \frac{\pi}{30} mnR \cdot \cos\alpha - mf\left(\frac{\pi}{30} nR + g \cdot \cos\alpha\right) \cdot \sin\alpha + k\vartheta \cdot \sin\alpha \end{aligned}\right] \quad (5)$$

From this we get the following:

$$\left.\begin{aligned}\frac{dv_x}{dt}&=-\frac{\pi}{30}nR\cdot\sin\alpha-f\left(\frac{\pi}{30}nR+g\cos\alpha\right)\cdot\cos\alpha+\frac{k}{m}\vartheta\cdot\cos\alpha\\ \frac{dv_y}{dt}&=g+\frac{\pi}{30}nR\cdot\cos\alpha-f\left(\frac{\pi}{30}nR+g\cos\alpha\right)\cdot\sin\alpha+\frac{k}{m}\cdot\sin\alpha\end{aligned}\right\}\quad(6)$$

The angle α varies depending on the speed of the pile drum, so we adopt the following formula:

$$\alpha=\omega t \quad (7)$$

Substituting, we get the following formula:

$$\left.\begin{aligned}\frac{dv_x}{dt}&=-\frac{\pi}{30}nR\cdot\sin\omega t-f\left(\frac{\pi}{30}nR+g\cos\omega t\right)\cos\omega t+\frac{k}{m}\vartheta_x\cos\omega t\\ \frac{dv_y}{dt}&=g+\frac{\pi}{30}nR\cdot\cos\omega t-f\left(\frac{\pi}{30}nR+g\cos\omega t\right)\cdot\sin\omega t+\frac{k}{m}\vartheta_x\sin\omega t\end{aligned}\right\}\quad(8)$$

The resulting equations cannot be integrated analytically. Their integration can be done numerically, for example, using the Runge-Kutta method on a computer [2].

Initial conditions:

$t_0=0$; $a_0=75^0$; n=500 rpm;
R=200mm=0.2m; m=0.001; 0.0015; 0.01kg;
K=0.1 kg/c; f=0,4;0.8;1.2)

Assuming that the cleaning process ends at time $t=t_s$, after this time $\alpha=75^0$ will be reached, and the cotton will leave the mesh surface.

The analysis of the equations obtained based on the given conditions and indicators is presented in Figures 2-3.

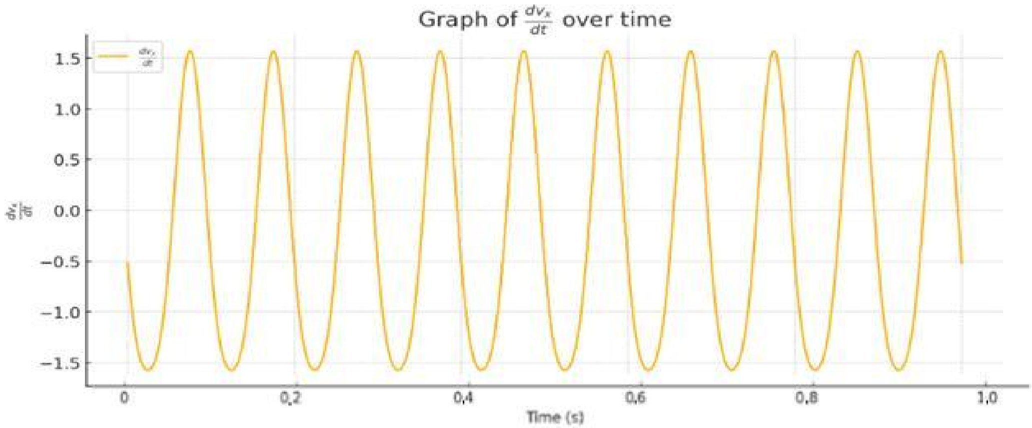

Figure 2. Time variation of the acceleration of a piece of cotton along the X axis in the cleaning zone

If we look at the graphs (Figures 2 and 3), we can see a wave-like change in the acceleration of the cotton ball in the cleaning zone along the X and Y axes with time. Indeed, as a result of the impact of the pegs, the acceleration of the cotton ball increases sharply and decreases as the impact subsides. The maximum value of the acceleration can be used to determine the amount of impact force acting on the cotton ball [3].

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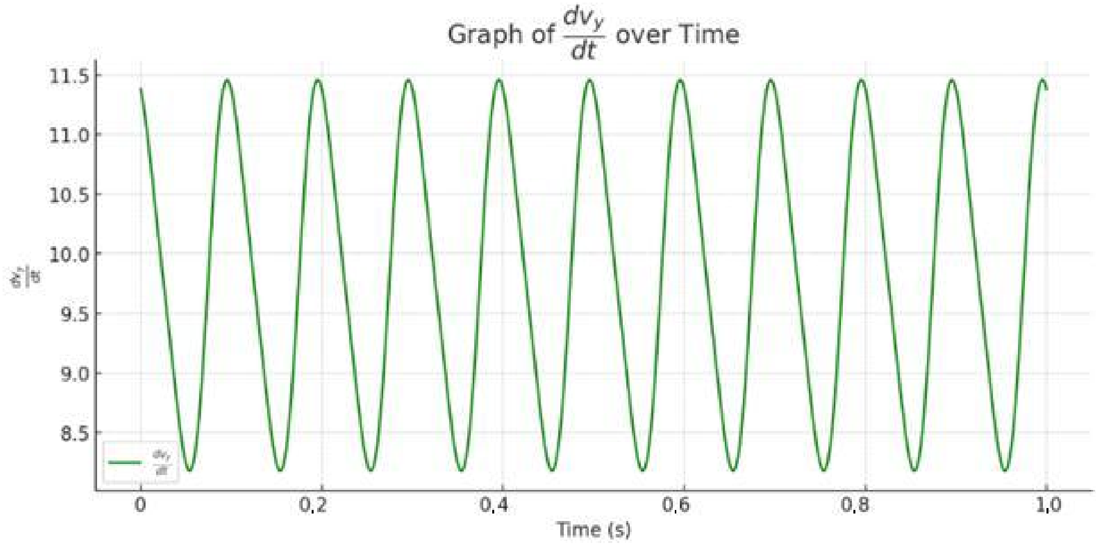

Figure 3. Time variation of the acceleration of a piece of cotton along the Y axis in the cleaning zone

In this case, it is seen that the acceleration along the X-axis initially acquires a positive and then a negative sign. This is because until the impact, the cotton moves with its inertia and has a negative sign, that is, it is in a decelerating motion. After the impact by the kolosnik, its speed increases sharply and, since it is moving in an accelerating motion, its acceleration becomes positive.

On the y-axis, the acceleration does not change to negative, but this acceleration has the property of slowly decreasing over a short period of time.

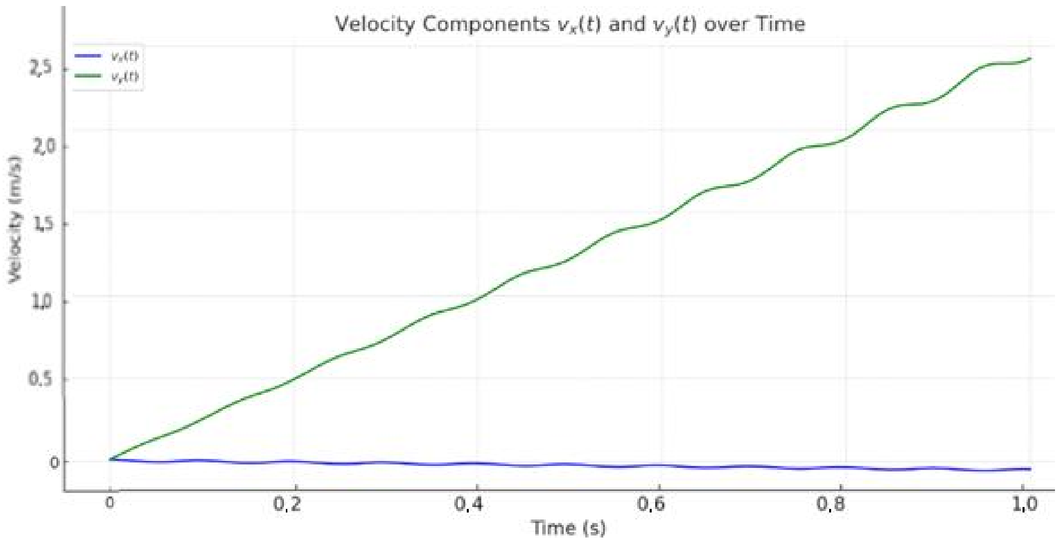

Figure 4. Time variation of cotton ball velocity in the cleaning zone

Blue line *— Vx (t): velocity in the x direction over time.*

Green line *— Vy (t): velocity in the y direction with respect to time.*

m=0.001kg

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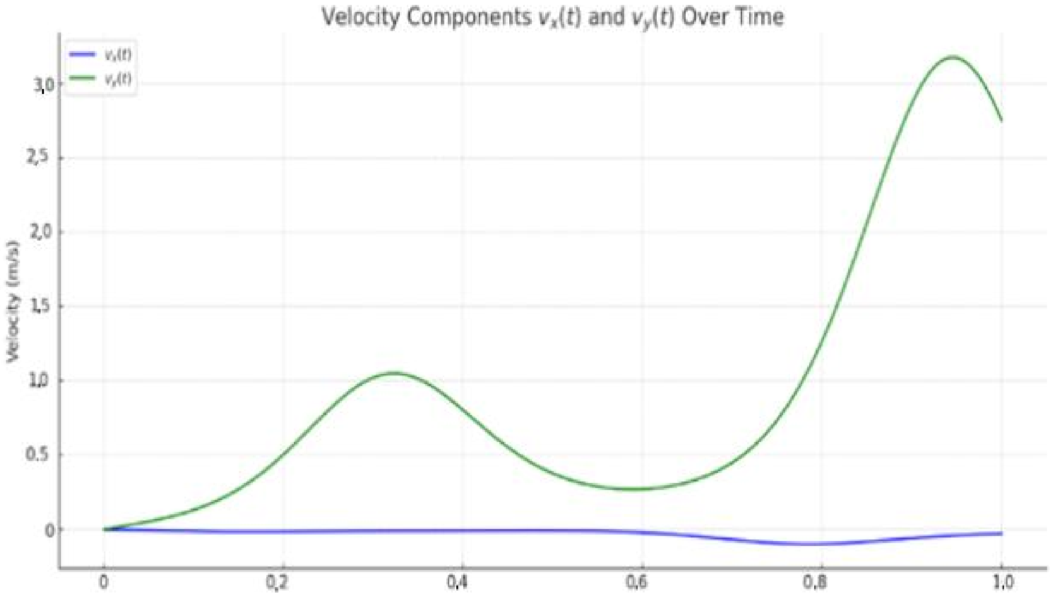

Figure 5. Time variation of cotton ball velocity in the cleaning zone

Blue line — *Vx (t): velocity in the x direction over time.*

Green line — *Vy (t): velocity in the y direction with respect to time.*

m= 0.0015 kg

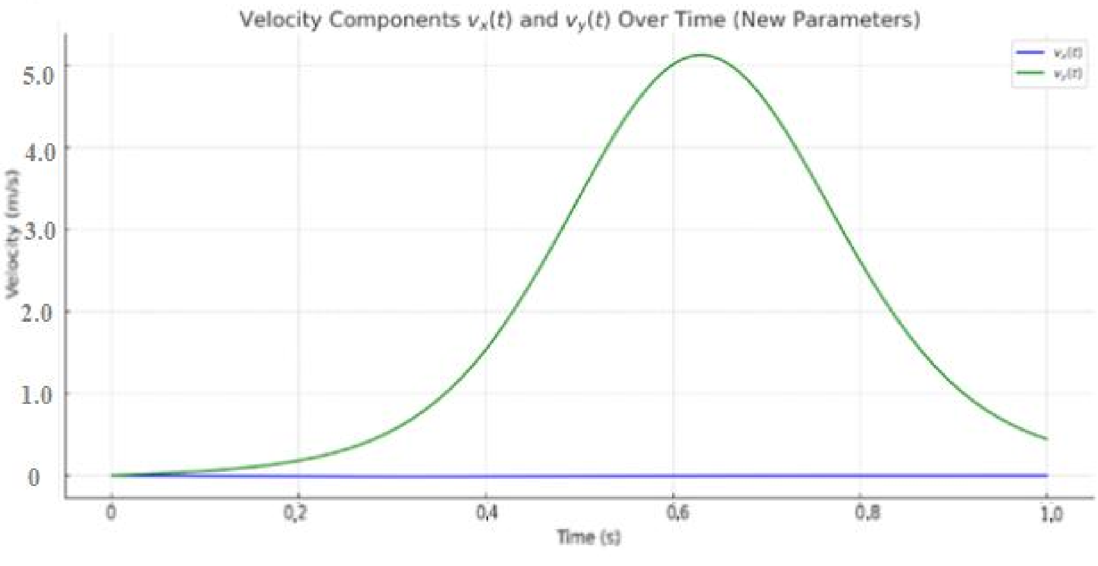

Figure 6. Time variation of the velocity of a cotton ball in the cleaning zone

Blue line — *Vx (t): velocity in the x direction over time.*

Green line — *Vy (t): velocity in the y direction with respect to time.*

m= 0.01kg

In Figures 4, 5 and 6, we see the change in the speed of a cotton ball in the cleaning zone with time. Here, Vx(t): the speed in the x direction has the property of continuously increasing with time, while Vy(t) the speed in the y direction with time does not change much [4].

Conclusion. According to the graphs, an increase in the mass of cotton leads to an increase in its speed. For example, when the mass of cotton is 0.1 kg, it initially increases and the speed reaches 5 m/s, and then the speed begins to decrease and decreases to 0.3 m/s within 1 second. Also, an increase in the mass of a cotton ball leads to an increase in its speed. The expressions obtained allow us to determine the speed of cotton balls during the cleaning process and, through it, the performance of one cleaning section of the cleaner.

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