EXAMINATION OF THE WASTE RESULTING FROM SEED COTTON CLEANING

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Annotation. The article presents a dynamic model that explains how impurities pass through cotton's bulk and attach themselves to it elastically. Patterns in the movement of the particles inside and on the surface of the cotton mass because of the forces acting on them have been detected based on the cleaning drum's parameters. The forces exerted on the particle can be expressed by the cleaning drum's radius and angular velocity.

Keywords: friction force, screen bars, angular velocity, fibers, and spiky cylinder.

Known designs of cleaners are based on shock-shaking action on fibrous material [1]. Even though the improvement of purifier designs is an ever-increasing trend, the industry's demand for highly efficient purifiers is not decreasing. It should also be noted that with the improvement of purifier designs, their main working elements remain the same. This, in our opinion, is a consequence of the fact that the essence of the process of cleaning fibrous material from impurities is not sufficiently disclosed; the existing dynamic and mathematical models do not fully correspond to the real cleaning situation. Therefore, any progressive attempts to describe the purification process using the latest scientific advances should be welcomed.

Linear [2], and nonlinear [3] dynamic models of the process of cleaning fibrous material are known. Models have also been developed aimed at separating impurities from the surface of a layer of fibrous material [4], separating debris from fibrous material when layers are shifted [5], and separating debris during their interaction with the working parts of the baking powder [6]. There are also attempts to describe the process with empirical formulas based on experimental material [7]. Even though the models sufficiently solve the problems assigned to them, due to the assumptions made in the development or analysis of the models, some questions were not answered, which led to the development of a dynamic model that takes into account the masses of the speck associated with the fibrous material by an elastic band, the force of dry friction interacting with the surface of the material.

Let the fibrous mass contain a speck of mass m_c, which is connected to it by an elastic element and the force of dry friction. Depending on its location in the fibrous mass, we divide the mote into two types. The first type of specks is located on the surface of the scrap and in contact with the mesh surface. Such specks have an angular velocity equal to the speed of the peg, and in addition, under the influence of centrifugal force, they predominantly move through the mesh hole in the radial direction from the center. We denote the distance from the center to the speck by $r(t)$. We assume that the speck is connected to the fibrous mass through an elastic element with variable stiffness and write the equation of motion of the speck

$$m_c\ddot{r} = m_c g\sin(\alpha + \omega t) + m_c\dot{r}^2 / R - k_c(r - R) \quad (1)$$

where k is the stiffness coefficient of the mote-fiber bundle and depends on the movement $r - R$, i.e. $k_c = k_c(r - R)$, where the function $k_c(z)$ is determined experimentally and has a monotonically decreasing character, and after the separation of the speck from the fibrous mass it becomes zero, i.e. should be taken $k_c(z) = 0$ at $z > z_0$. In particular, this function can be chosen as piecewise constant $k = k_0$ for $z < z_0$ and $k = 0$ for $z > z_0$ or piecewise linear $k_c = k_1(z_0 - z)$ for $z \le z_0$ and $k = 0$ for $z \ge z_0$.

The displacement $r(t)$ satisfies the following initial conditions

$$r = R,\ \dot{r} = R\omega_б^2 \text{ at } t = 0$$

In this case, the time for $t = t_k$ a speck to leave the mesh surface is determined from equations:

$$k[r(t_k) - R] = 0$$

If $t_0 \le t_k$ then the speck manages to leave the surface of the mesh during the contact of the scrap with the surface of the mesh, $t_0 > t_k$ then the speck after the interaction of the scrap with the mesh surface does not leave the scrap and continues to move with it. The results of integration of equation (1) are presented in (Fig. 1)

The second type includes specks that are found in the fibrous mass at a distance r_1 from the center of the drum, and $r_1 < R$.

In this case, these types of specks move for some time in the area inside the fibrous mass, and the movement of the specks relative to the shred is predominantly in the radial direction. To compile the equation of motion of a mote, we assume that the mote is acted upon by the force of connection between the mote and the fibers, as well as the frictional force on the surface of their contact as a result of the movement of the mote relative to the fibrous mass. We assume that the friction force is directed tangentially to the trajectory of the mote, and the mote makes an angular movement together with the piece of fibrous mass.

We set the origin of the coordinate in the center of the drum and determine the position of the speck by coordinates (x, y) in the plane $x0y$.

$$x = r(t)\sin\theta,\ y = r(t)\cos\theta \quad (2)$$

Let's create equations for the kinetic energy of a speck

$$T = \frac{m_c}{2}(\dot{x}^2 + \dot{y}^2) = \frac{m_c}{2}(\dot{r}^2 + r^2\dot{\theta}^2) \quad (3)$$

The following forces act on the mote with projections along the axes $0x$ and $0y$

1. Gravity of a speck

$$X_1 = 0,\ Y_1 = -m_c g \quad (4)$$

2. The strength of the binding of the mote to the fibers, depending on the distance $r - R$

$$X_2 = -k_c(r-R)(r-R)\sin\theta,\ Y_2 = -k_c(r-R)(r-R)\cos\theta 5)$$

3. Dry friction force on the contact surface of the speck with the fibrous mass

$$X_3 = -mgf\frac{\dot{x}}{\sqrt{\dot{r}^2 + r^2\dot{\theta}^2}},\ Y_3 = -mgf\frac{\dot{y}}{\sqrt{\dot{r}^2 + r^2\dot{\theta}^2}} \quad (6)$$

We accept the coordinate r as a generalized one and find the generalized force

$$Q_r = (X_1 + X_2 + X_3)\frac{\partial x}{\partial r} + (Y_1 + Y_2 + Y_3)\frac{\partial y}{\partial r}$$

Using expressions (3.12.4) - (3.12.6), we obtain

$$Q_r = -k_c(r-R)(r-R) - \frac{mgf\dot{r}}{\sqrt{\dot{r}^2 + r^2\dot{\theta}^2}} - mg\cos\theta \quad (7)$$

Let us now compose the Lagrange equation of the second kind

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{r}}\right) - \frac{\partial T}{\partial r} = Q_r$$

Putting expressions for kinetic energy (3) and generalized force (7), we compose an equation to determine the variable r

$$m_c\ddot{r} = m_c\dot{\theta}^2 r^2 - k_c(r-R)(r-R) - \frac{m_c gf\dot{r}}{\sqrt{\dot{r}^2 + r^2\dot{\theta}^2}} + m_c g\sin\theta \quad (8)$$

Equation (8) for a known angular displacement of the scrap $\theta = \theta(t)$

integrates under initial conditions $r = R,\ \dot{r} = R\omega_б$ at $t = 0$

From the results, it is clear that this parameter plays a significant role in the process of removing the speck. At small values, the speck is quickly removed from the composition of the scrap. For example, if we assume that the separation of the speck from the scrap occurs when the stretching value is reached $\delta = 0.02$, then the weight of the speck for which the parameter ω_{**} takes values $\omega_{**} < 1000$, then they are removed from the fibrous mass. The remaining specks are where $\omega_{**} > 1000$, then the initial speed of the speck will be insufficient for them to be removed from the mass. If the drum speed is accepted, $\omega_б = 120\ сек^{-1}$ then specks with the parameter $\omega_{**} = 1000$ will also be removed.

Similar mathematical models have been compiled and used in other cotton processing processes when dismantling the reel and supplying cotton for processing, ginning cotton, and during pneumatic transportation of fibrous material [8] – [18].

Conclusions. As a result of the analysis of the dynamic model of the interaction of trash impurities with the fibrous mass in the presence of an elastic connection between them, the dependence of the parameters of the movement of trash on the angular velocity and radius of the working drum of the cleaner was established, which can be used in the development of cleaners for raw cotton.

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