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RESEARCH OF THE INTERACTION IMPACT FEATURES OF THE COTTON WICKS WHILE HITTING THE GRATES IN THE COTTON GINNING MACHINES

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Abstract: During the cleaning process of the raw cotton, in the saw drum and grate network zone of the cotton ginning machines, the cotton mass is being subjected to the mechanical impact. At this moment, when the cotton wicks hit the grates, the cotton seed is mechanically being damaged and free fibers are being formed. When the cotton seed is mechanically damaged, its maturity decreases, and the formation of free fibers reduces the curvature/spinning ability of the fiber. Keeping the natural quality indicators of raw cotton and taking into account its physical and mechanical features, there is a great demand to conduct theoretical studies and researches for designing new machines. Taking into consideration the elastic properties of cotton wicks during their impact on the grate, the formulas revealing the movement speed of wicks and recovery of wicks coefficient were determined.

The article reveals the possibility of prevention the cotton elements from damage by determining the interaction characteristics of cotton wicks with grates and by adjusting the technological parameters to the equipment before processing.

Keywords: *cotton wick, extraneous impurities, grate, deformation, impact force*

Introduction.

Since the rate of raw cotton harvesting with the help of machines increases with every passing year, the amount of extraneous impurities in it also increases. This complicates the work of ginning machines. There is a need to increase the cleaning effect of the ginning machines in the flow line, no matter those working with batteries and/or the equipment continuously connected to the technological process [1]. Separation of large impurities (such as lint, stalks, stems, thorn, stem fractures etc.) that are in active contact with cotton fibers requires greater responsibility. The main cleaning section of the ginning machines, used for this purpose is called the saw drum-grate network zone [2]. Keeping the natural quality indicators of raw cotton and taking into account its physical and mechanical features, there is a great demand to conduct theoretical studies and researches for designing new machines [8, 9, 11]. The solution of this issue could be possible as a result of the joint effort of scientific research project organizations, as well as machine-building and cotton processing enterprises.

Materials and methods. At all stages of the regulated technological process, the raw cotton is exposed to shock loads, which leads to the mechanical damage of the cotton wicks and the formation of free fibers. As a result of it its maturity and the curvature/spinning ability of the fiber decrease [7, 10].

The impact impulse in the process of ginning/purifying the raw cotton was experimentally studied in the article [4]. In this work the interaction of circular, trapezoidal and elastic working surface grates with fibrous mass was studied in a wide range.

It was shown in research work [5] that the interaction of raw cotton and grates according to a number of factors was a complex process and depended on the reaction of grates during the contact of extraneous mixtures with grates. It was also determined that the friction of the fiber with the surface of the grates activates the fibrous layer, which leads to the weakening of the connection of the external mixtures with the fiber. Grates with different profiles were studied in this work.

It is possible to determine the interaction characteristics of cotton wicks with working parts of the ginning machines, and to prevent damage to cotton elements by adjusting the technological parameters to the equipment before starting the cleaning process.

According to the reporting scheme of the impact process in the grate - wick system (Fig. 1), some relations of the impact process of cotton wicks on the grates were determined.

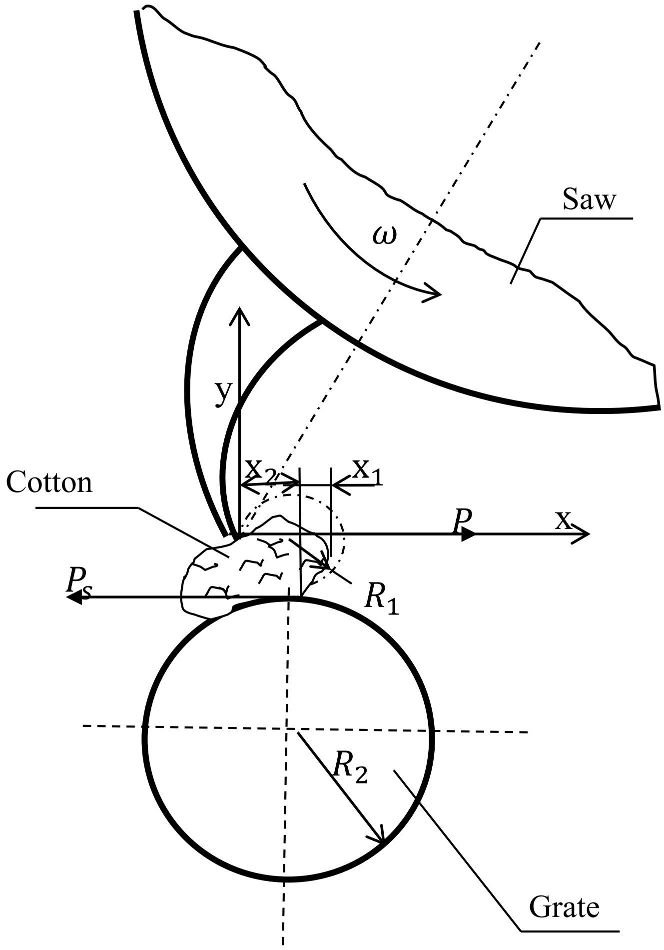

Figure 1. Reporting scheme of the impact process in the grate-wick system

When looking at the process of mutual impact of cotton wicks with grates, we can observe that at certain critical values of impact loads, elastic and plastic deformations occur in the fibrous part of the wick, which means that the process does not obey Hers's law, i.e., it cannot be characterized by Hers's law.

According to the empirical law of Herstner [3], when the elasticity exceeds the limit, not depending on each other when loading, the increasing x deformation consists of x_1 elastic and x_2 plastic components.

In theoretical studies, it is considered that the elastic deformation depends on Hers's law, and the plastic deformation depends linearly on the contact force:

$$x = x_1 + x_2 = kP^{\frac{2}{3}} + m(P - P_s) \qquad (1)$$

where k – is the coefficient characterizing the material (depends on the material property and the configuration of the deformable element); m - is the empirically determined coefficient; P - contact force; P_s – is the value of this force when plastic deformations occur.

In the static loading, the value of x approximation is as follows:

$$x = kP^{\frac{2}{3}} + mP_{\max}$$

where $mP_{\max} = x_{2\max}$ is the maximum plastic deformation.

In the process of unloading, the value of approximation due to plastic deformations remains unchanged. We can determine the k coefficient by equating the inverse coefficient β of the Hers formula.

$$P = \beta x^{\frac{3}{2}}$$

Where

$$\beta = \frac{4}{3}\frac{q_k}{(\delta_1 + \delta_2)\sqrt{A+B}}$$

where q_k is the coefficient; δ_1, δ_2 – elastic constants of objects; A, B – are the coefficients determining the geometry of the colliding surfaces.

For a spherical wick model with radius R_1, $A = \frac{1}{2R_1}$ and for a grate with radius R_2 we can use

$$B = \frac{1}{2}\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

Since the coefficient m cannot be determined analytically, the plastic deformation of the components is calculated experimentally. However, if it is not possible to facilitate the solution of this issue with a certain theoretical approach, it can be solved experimentally.
In the general case, expression (1) can be presented as follows:

$$x = bP^n \tag{2}$$

Where b and n are experimentally determined coefficients.
The deformation work in the contact zone could be as follows:

$$A = \int_0^x P(x)\upsilon x = \int_0^x x^{\frac{1}{2}}\upsilon x = \frac{1}{b^{\frac{1}{2}}} = \frac{n}{1+n}Px$$

Since the total work equals the voltage energy.

$$\frac{1}{1+n}P_{\max}x_{\max} = U_Д = \Delta T \tag{3}$$

where ΔT is the kinetic energy spent on deformation of the wick during impact [3].

$$\Delta T = \frac{m_n}{2}\left[O_0^2 - O_1^2\left(1 + \frac{m_{np}}{m_Л}\right)\right]$$

If we make transformations in the formula (3), we would get;

$$\frac{n}{1+n}\cdot\frac{x^{\frac{1+n}{n}}}{b^{\frac{1}{2}}} = \Delta T$$

where

$$x_{\max} = \left[\frac{\Delta T b^{\frac{1}{2}} (нп)}{n} \right]^{\frac{1}{1+n}}$$

Accordingly, the maximum value of the contact force during compression would be the following:

$$P_{\max} = \frac{1}{b^{\frac{1}{n}}} x^{\frac{1}{n}} \left[\frac{\Delta T (1+n)}{bn} \right]^{\frac{1}{1+n}}$$

If we integrate the impact equation twice [3], we would write

$$\frac{\partial V}{dt} = \frac{\partial^2 x}{\partial t^2} = -\frac{1}{m_n} P(x)$$

Here, if we write the known values instead of x_{max} and P_{max}, we would get:

$$\frac{2P_{\max}\tau}{m_{uç} V_0} = \frac{1+n}{n} F_1(n) = F_2(n)$$

there, F_1 and F_2 are unique criteria of dynamic similarity during the impact. If we take into consideration the ready values of these functions [3], we would write

$$\frac{V_0 \tau}{x_{\max}} = F_1(n)$$

where τ - is the time of the blow/kick in the active phase.

And in the passive phase, elastic deformations are being restored:

$$x_{\max} = bP^n = (x_1)\max + (x_2)\max = b_1 P^{n_1} + (x_2)\max$$

In the passive stage, the equation of deformation would take the following form:

$$\frac{\partial^2 x}{\partial t^2} = \frac{1}{m_{uç}} P(x) = \frac{1}{m_{uç} b_1^{\frac{1}{n_1}}} \left[x - (x_2)_{\max} \right]^{\frac{1}{n_1}}$$

If we integrate the equation and make certain transformations, we would get

$$\tau_y = \tau + 1{,}65 P_{\max}^{-\frac{1}{6}} \sqrt{m_{uç} b}$$

where τ_y – is the precise impact time.

At the end of the passive phase, the movement speed of the wick during the impact on the grate would be:

$$V_2 = P_{\max}^{\frac{1+n_1}{2}} \sqrt{\frac{2b_1 n_1}{m_{uç}(1+n_1)}}$$

Thus, the recovery coefficient would be determined as follows:

$$\beta = \frac{V_2}{V_0} = P_{\max}^{\frac{1+n_1}{2}} \sqrt{\frac{l_1 n_1}{T_0 (1+n_1)}}$$

If we also take into account the aerodynamic resistance during the impact on the grates, we can take 0.2 [6].

During the report, the value of the n index [6] (dynamic characteristic coefficient) can be taken practically the same for elements of the same shape made of different materials but deformed. The dynamic characteristic coefficient (n) at the speed limit υ = 1.62‒31.0 m / s does not depend on the deformable elements of the material and the impact speed.

The coefficient b depends on the properties of the material and the configuration of the deformable elements and is determined as follows [3].

$b = \frac{b_{st}}{\varphi^{1+n}}$, where φ was the dynamism coefficient and φ = 1.3 is taken. b_{st} – is being determined experimentally at static voltage.

The values of the quantities n and b can also be found from the relation (3), in this case the work of the deformation energy and the kinetic energy of the falling wick are being equalized, provided that one of these equations is determined experimentally or according to the values of V_0 and P [4] and taking from the research work [5], it can be solved by a system of two-variable equations.

Conclusions.

1. When studying a number of characteristics of the impact of the cotton wicks on the grates, it was determined that it is necessary to determine the specific values of these characteristics.
2. Taking into consideration the elastic properties of cotton wicks during their impact on the grate, the formulas revealing the movement speed of wicks and recovery of wicks coefficient were determined.
3. It was determined that it is possible to prevent the damage of cotton elements by determining the interaction characteristics of cotton wicks with grates and by adjusting the technological parameters to the equipment before starting the processing.

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