

Friction force determination between the inclined piles of the cotton gin drum from small impurities and seed of the fiber

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Abstract. Comprehensive measures are being implemented in our republic to develop cotton and textile clusters, modernize and re-equip cotton ginning enterprises, increase the profitability of production and primary processing of raw materials, and at the same time increase the competitiveness of products. One of the important issues is to provide cleaning equipment with cotton uninterruptedly and taking into account the heat and humidity regime, that is, the creation of an effective technology for preparing cotton for the cleaning process. Based on the experience of Jaxon, large-scale research and development work is being carried out to improve the technique and technology of primary processing of cotton. In this area, among other things, it is important to create an effective technology for cleaning cotton from impurities, optimizing the moisture-thermal parameters when cleaning cotton, creating resource-saving efficient designs of suppliers, optimizing modes and performance indicators. In this article, a formula is obtained for determining the friction force created by seeding the fiber on the surface of the pile, installed obliquely on the surface of the cleaning drum from small impurities. Based on the analysis of the connection graphs, built on the basis of a numerical solution, the recommended values of the parameters of the pile drum were determined.

1. Introduction

Purification of cotton from small impurities is an important process that largely affects the subsequent stage of its processing, that is, the processes of ginning and fiber cleaning. If fine dirt is not sufficiently cleaned, it changes from passive dirt to active dirt [1,2] and becomes difficult to separate in the fiber cleaner. All cleaners that separate small impurities from cotton work in the same way: cotton is sieved in bulk drums and moves along mesh surfaces. This process is repeated several times and the cotton is cleaned of small impurities. The cleaning efficiency depends on the speed of rotation of the pile drums, their design, the mesh surface and the quality of the cotton.

The speed of rotation of the pile drum is limited by the increase in mechanical damage to the cotton seed, and the surface area of the drum is limited by the transition of the cotton into the dirty mixture.

As can be seen from the design of the pile drum, each pile is attached to the shaft with a threaded lock nut. This complicates the assembly of this drum, setting its static and dynamic balance [3].

In connection with the development of transportation technology, there was no need to hold the threads, and in connection with the delivery of raw cotton to the receiving points in trailers, the same short-haired drums began to be used.

So, the factors that increase the efficiency of cotton cleaners from small impurities are the following [4]:

1. Pile drums increase their angular velocity;
2. Reducing the slope of the installation of drum piles;
3. Ensuring the moisture level of cotton products.

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2. Methods

In the existing pile drums, the laws of movement of the pile drum and interaction with a piece of cotton wool are sufficiently taken into account [5,6]. However, when the drum piles are set at an angle, pieces of cotton wool create a sufficient friction force with the pile, and its movement along its surface is not determined [7]. It should be noted that with an inclined installation of piles, the force for separating pieces of cotton from the main masses is greater and the cleaning efficiency is higher. In the initial part, in the first drum of the cleaner, the force of interdependence of the pieces of cotton is greater; for their separation, it is desirable to make the angle of deviation (tilt) of the pile large. From a theoretical point of view, it is important to determine the force of friction when an inclined pile is exposed to a piece of cotton. Figure 1 shows a design scheme for determining the friction force created by seeding the fiber on the surface of an inclined pile.

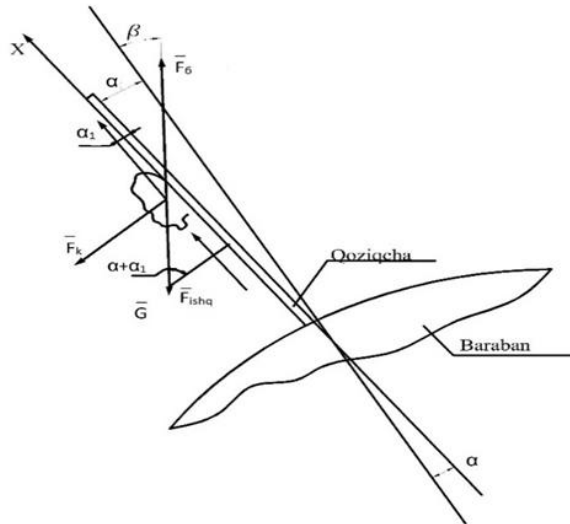


Fig. 1. Calculation scheme of the equilibrium condition of the fibrous seed on the surface of the inclined pile

The shown calculation scheme is mainly influenced by the forces on the surface of the fibrous seed: \bar{G} - gravity; \bar{F}_{ishq} - the frictional force created by the fibrous seed with the inclined surface of the pile; \bar{F}_{δ} - the strength of interlinking of the fiber seed surface with cotton particles; \bar{F}_{nor} - normal force; \bar{F}_{MK} - centrifugal force; \bar{F}_K - inertia force; N - reaction force.

It is known [8, 9] that a piece of cotton does not move along the y axis. We also consider that the fiber seed moves with the sloping pile as it separates from other adjacent pieces of cotton. It is equal to $\ddot{x} = 0$.

Accordingly, taking the projection of all the acting forces in the direction of the inclined pile, on the axis, we form the following expression [10,11]:

$$m_n \ddot{x} = -m_n g \sin(\alpha + \alpha_1) + F_{ishq} + \frac{G}{2g} \omega^2 D \cos \alpha - F_{\delta} \cos(\alpha + \beta) + F_{nor} \cos \gamma \quad (1)$$

here, m_n - fibrous seed mass;

g - free fall acceleration;

α - angle of inclination with respect to the pile drum radius;

α_1 - the angle of the spatial location of the piece of cotton;

F_{ishq} - friction force;

G - fiber seed weight;

ω - drum angular velocity;

D - drum radius;

F_δ, β - the strength and angle of attachment of the fiber seed to the adjacent cotton pieces;
 γ - the angle of placement of the normal force.

From the received theory (1), we get the formula for determining the friction force between the surface of the inclined pile and the fibrous seed:

$$F_{ishq} = m_n g \sin(\alpha + \alpha_1) - \frac{G}{2g} \omega^2 D \cos \alpha - F_\delta \cos(\alpha + \beta) \tag{2}$$

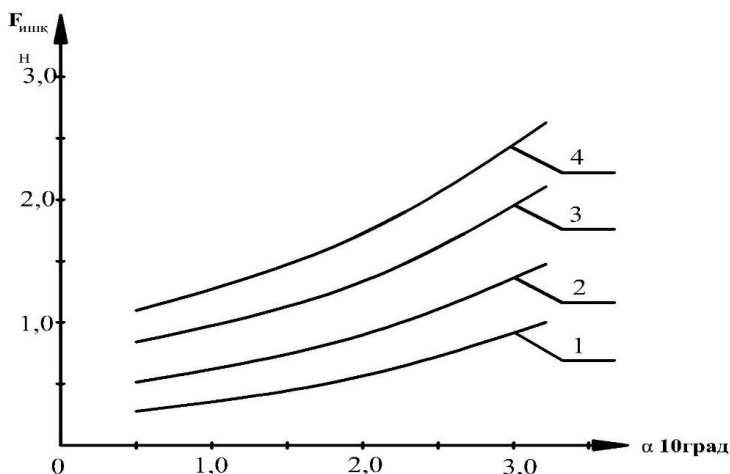
To study the effect of system parameters on the friction force, their values at the starting point were taken into account:

$$m_n = (0,2 \div 0,45) * 10^{-3} \text{ кг}; \quad g = 9,8 \text{ м/с}^2; \quad \alpha = (5^\circ \div 20^\circ); \quad \alpha_1 = (25^\circ \div 35^\circ);$$

$$\omega = (40 \div 45) \text{ с}^{-1}; \quad \beta = (10^\circ \div 25^\circ); \quad F_\delta = (0,8 \div 1,5) \text{ Н}; \quad D = (0,16 \div 0,18) \text{ м}.$$

3. Results and Discussion

According to the results of the numerical solution of the problem, the laws of parameter correlation were determined in the form of graphs. Figure 2 shows graphs of the change in the angle of deflection of the pile of the cleaner drum and the change in the friction force with a piece of cotton on its surface. At the same time, with an increase in the deviation angle of the pile from 5° to 25° , the friction force between the surface of the pile and the cotton fabric changes, at an angular speed of the drum of 50 s^{-1} , the values of F_{ishq} increase non-linearly from 0.52 N to 1.21 N.



1- $\omega = 50 \text{ s}^{-1}$; 2- $\omega = 45 \text{ s}^{-1}$; 3- $\omega = 40 \text{ s}^{-1}$; 4- $\omega = 35 \text{ s}^{-1}$;
Fig. 2. Graphs of dependence of the friction force between the fiber seed and drum piles on the slope angle of the piles

It can also be seen that when the drum speed decreases to 35 s^{-1} , the values of the friction force F_{ishq} slide from 1.31 N to 3.1 N in a non-linear clutch. It should be noted here that the higher the friction force, the more time the piece of cotton wool is on the surface of the inclined pile. This, in turn, has a positive effect on the cleansing effect. Therefore, it is desirable that the piles have an angle of inclination of $(15^\circ \div 25^\circ)$ to ensure high values of the F_{ishq} force at a rotation frequency within $(35 \div 40) \text{ s}^{-1}$.

Figure 3 shows graphs of the dependence of the friction force created by the seed of the fiber and the surface of the pile, on its mass in the zone of cotton cleaning from small impurities.

It is known that in the area of the starting drum of the cleaner, the pieces of cotton do not separate, do not tear. Therefore, larger pieces of cotton with a greater mass are placed on the surface of the heap than single seeds with fiber. That is, according to the analysis of the graphs, with an increase in the mass of cotton balls from $0.25 * 10^{-3} \text{ kg}$ to $0.75 * 10^{-3} \text{ kg}$

and a pile angle of $\alpha = 0$ (the design of the existing series), the friction force is non-linear from 0.215 N to 0.73 N increases, respectively, the F_{ishq} values increased from 0.52 N to 1.26 N at an angle of $\alpha = 5^\circ$, and the F_{ishq} values increased from 1.46 N to 3.26 N in a non-linear relationship with the pile inclination angle increased to 20° . Therefore, increasing the deflection angle piles of drums at the entrance, the greater the mass of pieces of cotton wool, the greater the friction force. Therefore, the higher the separation of the pieces of cotton into individual fibers, the greater the angle of deflection of the pile is recommended to increase the friction force.

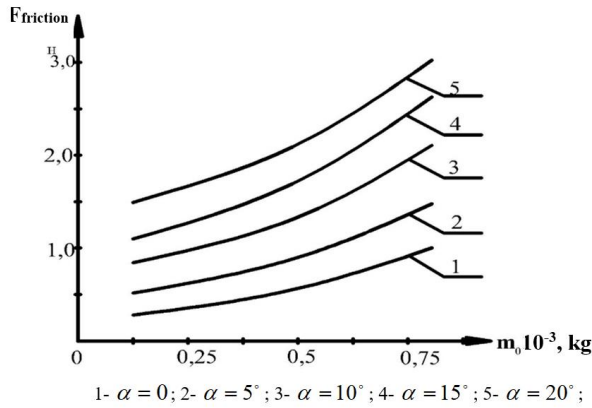


Fig. 3. Graphs of the friction force generated by the fiber seed and the surface of the pile in the cotton cleaning zone as a function of its mass

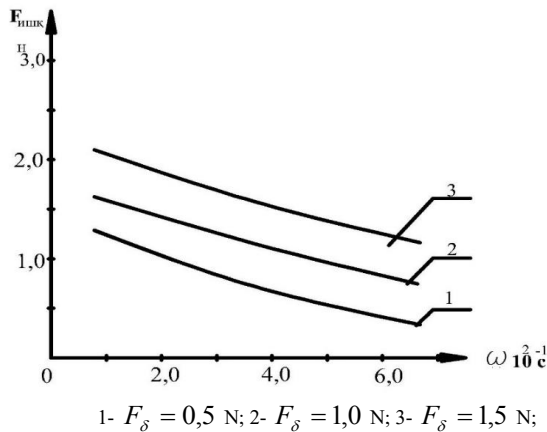


Fig. 4. Graphs of the dependence of the friction force generated by the fiber seed and the pile surface on the drum angular speed in the cotton cleaning zone

Figure 4 shows graphs of the dependence of the friction force created by the seed of the fiber and the pile surface on the angular velocity of the drum in the cotton cleaning zone. As a result of the analysis of the constructed bond graphs, it was found that the increase in the angular velocity of the drum with pile increases as the friction force between the surface of the pile and a piece of cotton goes according to a non-linear law. sample. In particular, with an increase in the values of ω from $1.6 \cdot 10^2 \text{ s}^{-1}$ to $5.8 \cdot 10^2 \text{ s}^{-1}$, the force of connecting a piece of cotton with the rest of the pieces of cotton was 0.5 N, and the values of Force F_{ishq} ranged from 1.34 N to 0.33 N, a decrease in the nonlinear relationship is seen. With an increase in the values of the adhesion force F_δ to 1.5 N, the values of the friction force between the

surface of the pile and the cotton fabric decreased from 2.89 N to 1.21 N with a non-linear connection. Therefore, it is desirable to reduce the angular speed of the drum in order to keep the wool on the surface of the inclined pile for a sufficient period of time, it is recommended to have values of $\omega \leq (35 \div 40) \text{ s}^{-1}$.

4. Conclusions

To remove small impurities from cotton raw materials, the design of the drum with inclined piles is recommended. On the basis of theoretical studies, a formula was obtained for determining the friction force of the fiber seed on the inclined surface of the pile, and on the basis of the analysis, the optimal values of the parameters were determined.

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