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Study of Cotton-Raw Movement in Screw Washer

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ABSTRACT*:* The article presents the results of studies of the movement of raw cotton in a screw cleaner. Considering that when the mass of raw cotton is moving along the trough along the plane with a uniform speed, the equilibrium condition must be met, equilibrium equations are drawn up and mathematical expressions are obtained allowing to calculate the moment of rotation on the shaft of the screw cleaner and the power consumption when processing raw cotton

The design values of the power consumption of the screw conveyor are determined depending on the filling factor and shaft rotation speed and it is indicated that as the duty cycle and shaft speed increase, the power consumption is also increased

KEYWORDS: Cotton raw, torque, power consumption, friction, equilibrium condition, screw cleaner, filling factor.

I. INTRODUCTION.

The constant increase in the requirements of the textile industry for the quality of processed cotton fiber forces the cotton ginning industry to seek new reserves in the technology and machinery for the primary processing of cotton in order to obtain a fiber that meets the requirements of the relevant standards.

In previously adopted regulated technological processes for processing raw cotton, a screw (worm) cleaner 6A-12M was used to clean the material from small litter [1].
The operating principle of the cleaner 6A-12M Fig. 1 is as follows:

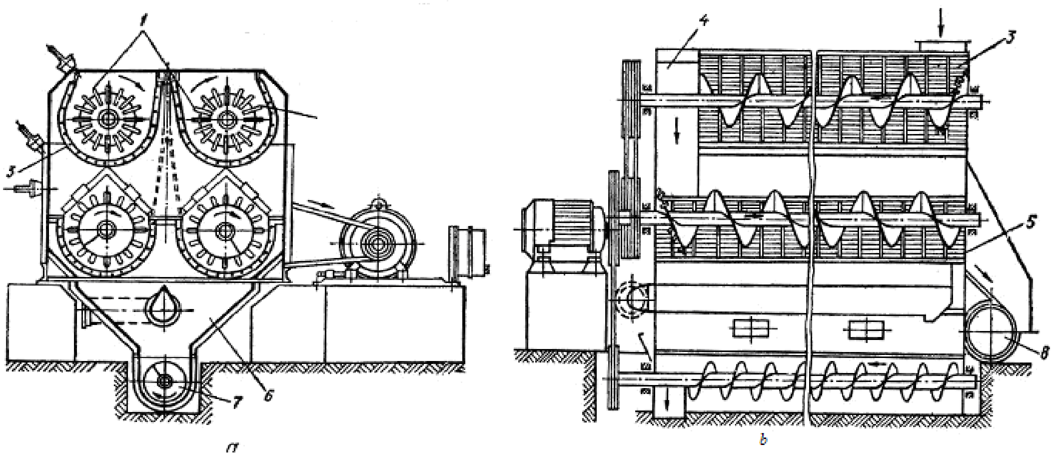

Fig.1. Screw (worm) cleaner 6A-12M for cleaning raw cotton from small litter.

Entering the machine for cleaning, raw cotton is divided into two separate streams and falls under the influence of the rotating upper screw augers. The screw auger drum is a screw, usually used for transportation of raw

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cotton, a screw conveyor with a diameter of 560-400 mm. with feathers pinned 2, which protrude above the circumference of the feathers by 75 mm.
Auger screws, located along the screw line, raw cotton loosen, throw up and at the same time gradually moves to the opposite end of the machine.
In the process of movement and constant shaking of raw cotton, weighed out impurities, which fail through the grate 3, forming a groove of auger. Raw cotton, after cleaning in the upper, parallel augers, enters through the vertical connecting shafts 4 into the same lower screw augers, which again loosen, shake and move the raw cotton, cleared from litter, into reverseside - to the discharge opening 5. Sorbic impurities separated through the grates of the upper and lower sections of the screw augers fall into the hopper b and out of it are diverted by the weed conveyor 7.
Due to the shock effect of the shots on raw cotton during its movement, the excretion of weed is very intense. Each slice of raw cotton is in the chamber 6A-12M on average 30-35 seconds; During this time, it is subjected to a lot of shavings.

The purifier had good technical and technological characteristics, isolated fine minerals, but there were frequent cases of twisting and burning of raw cotton, leading to the formation of such harmful, so-called "soft vices" like flagella and combined flagella. An important negative, in this respect, role was played by a rather long line of cotton processing. Therefore, this machine is currently excluded from the regulated technological process of processing raw cotton.

At the same time, there is a tendency to increase the share of so-called "hard-to-clean" varieties in the total volume of raw cotton harvest, which are very difficult to clean due to the structure of their fiber and more from the raw adhesion of weed with fiber, although they have certain advantages in such indicators as yield, physical and mechanical properties of fiber, maturity, etc.

Therefore, in the practice of the cotton ginning plant, a fact is often observed: a technological machine (a small litter cleaner or a large litter cleaner) that works well and provides a high cleaning effect on one selection grade of raw cotton, because of the increased strength of the litter attachment to the fiber, not copes with cotton of another variety of raw cotton of various breeding varieties, such as "An-Bayavut", "Sulton", "Porlock" and many others.

On the basis of the foregoing, it can be concluded that the issues of increasing the purifying effect of technological machines in the processing of raw cotton are still very urgent and the purpose of this work is a theoretical study of the movement of raw cotton in a screw cleaner for its further modernization and incorporation into the technological process of cotton processing -consumer.

II. LITERATURE REVIEW

Despite the widespread use of screw conveyors in the industry, insufficient attention has been paid to studying the working process of processing the material with screw conveyors. It is known that the analysis carried out in A. Sultonov's work [2] does not fully disclose the mechanism of interaction of the product with the working parts of the screw conveyor, the theoretical analysis of the value of the width of the blades and the angle of their inclination to the longitudinal axis of the drum has been performed and the problem of defect formation during cleaning raw cotton.

It is noted that when the "" coefficient of filling the screw conveyor with a product changes, there may be a face or a change in the amount of productivity, but the data on how the forces created by the screw on the product and the groove of the screw conveyor are not given.

In addition, questions related to the influence of such parameters as the coefficient of friction of the screw conveyor material, the frequency of rotation of the shaft on the transportation process and the damage to cotton are not sufficiently studied.

In work [3] for transporting and cleaning fibrous material from weed impurities containing screw augers and troughs with perforated holes located under the augers, the spikes on the auger are set in increments of 3.5-4.0 of the screw diameter, however, , their total quantity is sharply reduced, which leads to a decrease in the degree of loosening of raw cotton and the cleaning effect of the machine.

In work [4] results of researches on definition of optimum constructive parameters of the screw conveyor are resulted, which allowed to come up innovatively to the process of designing screw conveyors. It is proposed to change the geometry of the screw conveyor by adding three additional spirals oriented in the same or opposite direction from the screw blades.

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III. EXPERIMENTAL PART

Taking into account the foregoing, let us consider the mechanism of the influence of the mass of cotton on the power consumption of the screw conveyor when transporting to them the mass of cotton.
All the power in the screw conveyor is spent on:

- overcoming frictional forces in the supports of the conveyor shaft M_{tr}:
- overcoming the inertial forces "M_{in}", taking into account that the frequency of rotation of the shaft of the screw conveyor is not very high, we assume that in the work $M_{in} = 0$
- full work, for transportation of raw cotton.

It should also be noted that due to the low rotational speeds of the screw (250-260 min^{-1}), the centrifugal force can be neglected.

Thus, the power consumption can be written as:

$$N=N_1+N_2+N_3 \tag{1}$$

N_1- capacity for useful work;
N_2- power on friction in supports;
N_3- the power consumed by the medium's resistance, that is, the movement of the mass of cotton inside the groove of the screw conveyor.

Consider the relationship between the forces acting on the conveyor screw. Let's unfold the blade of the screw conveyor (Fig. 1) along the average diameter, as a result of which we obtain an inclined plane with a lifting angle equal to the step: In this figure: B this figure:
-F- force of friction when moving cotton on the surface of the screw of the screw conveyor;
-P – the driving force of the cotton mass along the inclined plane of the propeller blade acting on the shaft of the screw conveyor;
-F_1 – force of friction of the mass of cotton on the surface of the trough, preventing the movement of material;
- α - The angle of inclination of the screw blade of the screw conveyor with respect to the axis of rotation.
For the case of the movement of the cotton mass (G) along the trough along the plane with a uniform velocity, the equilibrium condition must be satisfied.

Given the fact that: $F_1 = fN$

Where: f-coefficient of friction of cotton on the chute

N' - The force created by forced oscillation from springs installed in the groove or on the shaft drive drive of the screw conveyor.

We compose the equation of equilibrium of the system of acting forces, which looks like this:

$$P\cos\alpha - (G - N')\sin\alpha = f * N \tag{2}$$

$$N = P\sin\alpha + (G - N')\cos\alpha \tag{3}$$

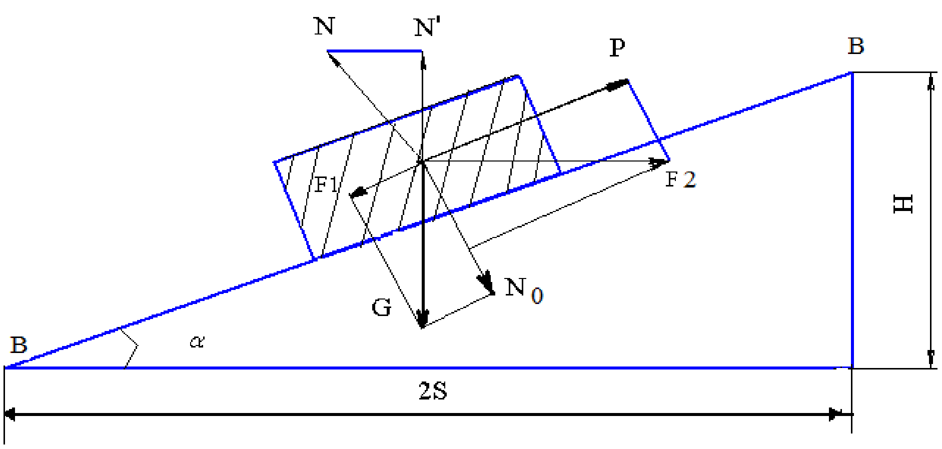

Fig.2. Scheme of forces acting on raw cotton as it moves along the trough.

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Hence: $P\cos\alpha-(G\ -N')\sin\alpha = fP*\sin\alpha + f(G-N')\cos\alpha$

Location: $$P=(G-N')\frac{\sin\alpha+f\cos\alpha}{\cos\alpha-f\sin\alpha} \quad (4)$$

Given that $f=tg\rho$

Where: ρ - angle of friction, you can write down the following:

$$P=(G-N')\frac{tg\alpha+tg\rho}{1-tg\alpha*tg\rho} \quad (5)$$

Solving the equation with respect to the screw rotation force can be written:

$$P=(G'-N')*tg(\alpha+\rho) \quad (6)$$

The torque of the shaft will be determined as:

$$M_{вр}=P*R_{cp}=(G-N')tg(\alpha+\rho)D\eta \quad (7)$$

Where: D - average diameter of the working surface of the conveyor screw

C taking into account equations (6) and (7), we obtain:

$$M_{вр}=\left(G-\mu P\sqrt{1+\frac{4\eta^2*\omega^2}{k}}\right)*tg(\alpha+\rho)*\frac{D}{2} \quad (8)$$

Considering that:

$$F_1=G*f$$

Equation (8) can be written in the following form:

$$M_{вр}=\left(F_1-\mu P\sqrt{1+\frac{4\eta^2*\omega^2}{k}}\right)*tg(\alpha+\rho)\frac{D}{2} \quad (9)$$

Where: G-weight of the cotton in the groove of the screw conveyor in motion. The power consumed by the screw conveyor is calculated as:

$$N=\left(G*-\mu P*\sqrt{1+\frac{4\eta^2\omega^2}{k^4}}\right)*tg(\alpha+\rho)*\omega \quad (10)$$

$$\text{Где: } k=\sqrt{\frac{C}{a}} \quad (11)$$

ω - angular velocity of the screw of the screw conveyor.

The obtained equations (9) and (10) allow to calculate the moment of rotation on the shaft of the screw conveyor and the power consumption during transportation of the cotton mass. From an analysis of the mathematical dependences obtained, it can be seen that the power consumption is largely dependent on the rotational speed of the screw conveyor shaft *K*, coefficient of friction of cotton on the chute and on the blade of the screw of the screw conveyor f and angle of friction ρ, dependent on the structural sizes of the screw.

The calculated values of the power consumption of the screw conveyor depending on the filling factor and the speed of rotation of the shaft are presented in the form of graphical dependencies in Fig.2.

Analysis of the results shows that with increasing the number of revolutions of the conveyor screw, the power consumption increases. So, for example, if the filling factor ψ =0,27 and number of turnovers in n=200 min^{-1} power consumption is N=2,8 kW, then with an increase in the number of revolutions of the screw up to n=260 min^{-1} The power consumption is also increased to N= 3, 3 kW, that is on 11,8%.

An increase in the filling factor also leads to an increase in the power consumption. Tick, for example, if the coefficient of filling

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ψ =0,27 and number of turnovers in n=200 min^{-1} The power consumption is N=2,8 kW, then with an increase in the fill factor up to ψ =0,5, The power consumption is also significantly increased to N= 4,1 kW.

By the nature of the change in the power consumed by the conveyor, we can conclude that the dependence of the change in power is apparently natural for bulk bodies having similar elastic properties and viscosity as raw cotton.

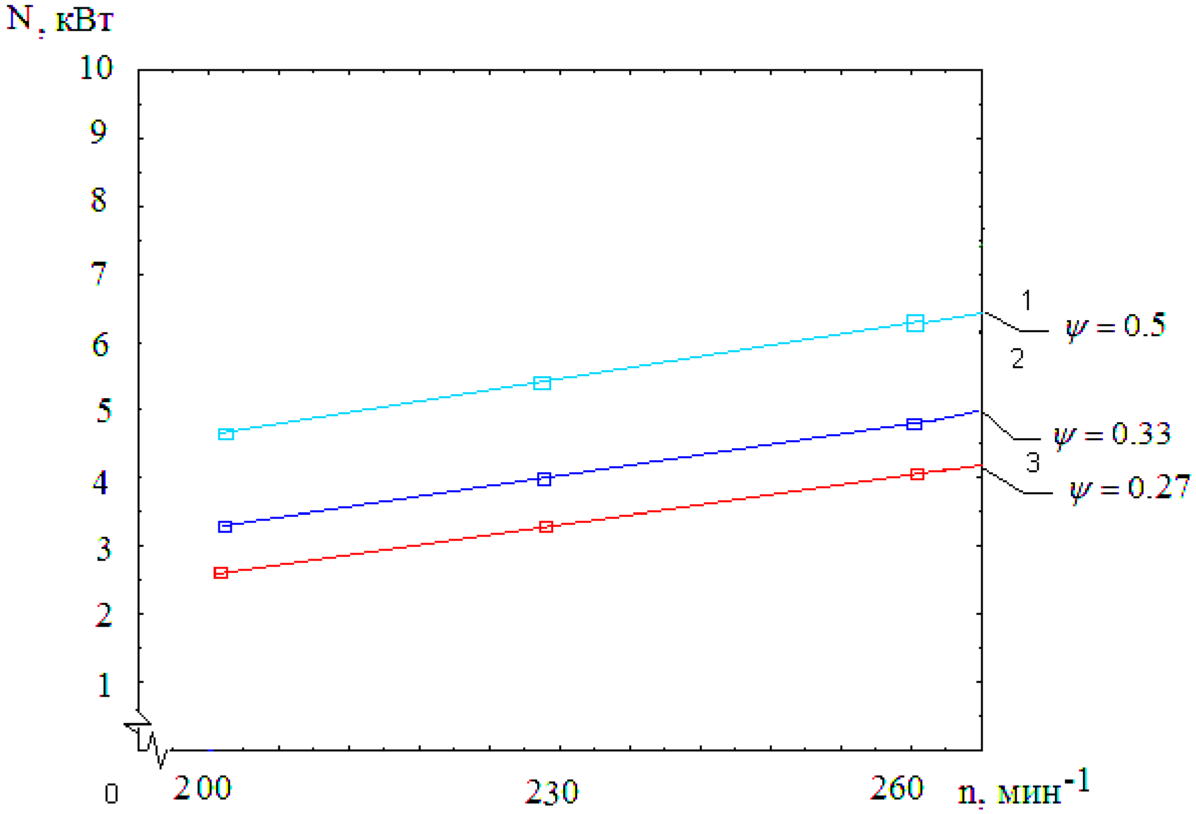

Fig.3 Graphs of the dependence of the torque on the ratio of the conveyor at various rotational speeds of its screw

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