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THEORETICAL STUDY OF THE MOVEMENT PROCESS OF COTTON SEEDS TRANSPORTED ON A SCREW CONVEYOR

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ABSTRACT

In this scientific article, the movement of cotton seeds on a screw conveyor and the forces resisting this movement are studied. Based on the constructed mathematical model, the mechanism of seed mass compaction is formed, the moving force caused by the screw conveyor blades, the seed mass, the force of gravity and the frictional force generated along the entire length of the screw are calculated. As the mass of the cotton seeds increases, the angular dependence of the frictional force generating them with the inner surface of the screw conveyor increases, and vice versa, the angular dependence of the screw surface reaction decreases. This in turn leads to a decrease in the compaction coefficient of the seed mass within the conveyor. As a result, a decrease in congestion inside the conveyor of cotton seeds was observed.

KEYWORDS: *Conveyor, Cotton, Seed, Mathematical Model, Mass, Screw, Weight, Force, Density, Reaction, Coefficient Of Friction, Speed, Acceleration.*

INTRODUCTION

Despite the widespread use of screw conveyors in the cotton industry, not enough attention has been paid to the theoretical study of the transportation of materials using screw conveyors. This is because indicators such as the coefficient of friction of the transported material and the rotational speed of the conveyor shaft have a great influence on the process. In a screw conveyor, the forces that resist the movement of the material consist of the resistance of the seed coat to the surface of the screw shaft and the bearings. In addition, when the value of filling the screw conveyor with seeds is large, in addition, the bending force of the shaft is also affected. The mechanism of seed mass compaction is the resistance caused by the driving force generated by the screw conveyor blades, the seed mass, the gravitational force, and the frictional force generated along the entire length of the screw [1-4]. The coefficient of compaction of the seed mass depends in many respects on the specific load on which it is transported along the screw conveyor shell. When coagulating cotton seeds, the coefficient of resistance changes, which leads to an increase in mass density and the formation of, clogs [5-11]. From this point of view, it is important to study the movement of the seed mass on the screw conveyor.

THE MAIN FINDINGS AND RESULTS

Mathematical modeling

The axial velocity V1 of the cotton seed in the screw conveyor shell is determined by the following formula (Figure 1.1 a):

$$V_1 = \frac{Q}{900\pi(D^2 - d^2)\psi\gamma C_0}, м/сек \quad (1.1)$$

where Q-conveyor working productivity, t / s; Outer diameter of D-conveyor, m; d is the diameter of the inner edge of the conveyor, m; ψ -coefficient of filling the space between the wings; γ_0 - volumetric weight of the transported cargo, t / m^3; S_0 = 0.9$\div$1 load shedding coefficient.

The coefficient of filling of the space between the blades should not exceed the coefficient of load capacity of the conveyor:

$$\psi = \psi_1 \cdot \psi_2 \quad (1.2)$$

where: $\psi_1 -$ is the coefficient of load capacity dependence on the number of conveyor revolutions; ψ_2 is the coefficient of load capacity dependence of the conveyor on the angle of inclination, for a horizontal conveyor $\psi_2 = 1$.

The seed is in the screw conveyor shell $V_a$it is expedient to determine the angle of rise of the moving screw lines so that the seeds touching the shell due to the screw movement at speed. The seed velocity is the geometric sum of the axial velocity $V_1$and the rotational velocity V_a .

It is assumed that the motion of the seed layer is uniform and that the material obeys the laws of point motion. So let's look at the material point of cotton seed.

This can be allowed if the internal friction of the seed is greater than the external friction; at the same time the equilibrium of the material point is considered, and an equation is developed to determine the angle of elevation of the moving screw line of the material point touching the shell.

In the platform, we separate the material point A(Fig. 1.1 b) and it shifts to the position A^1as the screw conveyor rotates. In case A, the equilibrium equation for this particle is:

$$F_k \cos(\theta + \alpha) = mg \sin\beta \sin\alpha - mg \cos\beta \sin\phi' \cos\alpha + F_л;$$

$$P = F_k \sin(\theta + \alpha) + mg \sin\beta \cos\alpha + mg \cos\beta \sin\phi' \sin\alpha;$$

$$F_k = f_1 P; f_1 = tg\rho_1, \quad (1.3)$$

where$F_k$is the force of friction of the load particle on the inner surface of the screw conveyor shell, which is opposite to the velocity vector;

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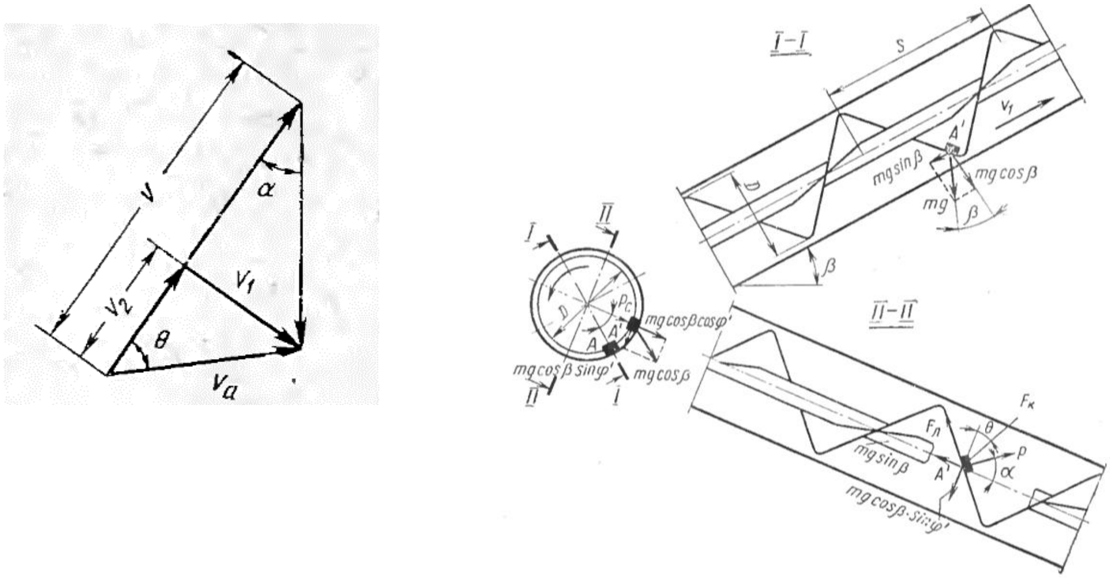


a

b

Figure 1.1. a-velocity triangle; b is the equilibrium scheme of the material point moving from the lowest state A to the state A^1

θ - is the angle of elevation of the material point moving screw line;

α - the angle of rise of the screw line along the outer edge; mg - gravitational force of the load particle; g - free fall acceleration; β is the angle of inclination of the conveyor to the horizon; φ' - angle of rotation of the load particle to the side of the screw rotation; $F_{л}$ -particle friction force on the screw surface; P - screw surface reaction; $f_1 = tg\rho_1$ coefficient of friction of the load particle on the surface of the screw conveyor; ρ is the angle of friction of the load particle on the conveyor surface.

Putting $F_{л}$ and f_1 in the equilibrium equation and subtracting Pforces from it, and taking into account the fact that ginners use mainly horizontal screw conveyors, we give the formula as follows:

$$F_k = \frac{mg\ sin\ \phi'\ cos\,(\alpha+\rho_1)}{cos\,(\theta+\alpha+\rho_1)}; \qquad (1.4)$$

The centrifugal force $P_c$can be expressed as follows:

$$P_c = \frac{2mv_2^2}{D} = \frac{2mv_1^2 ctg\,\theta}{D}; \qquad (1.6)$$

where f_2 is the coefficient of friction of the load on the inner surface of the conveyor shell in motion; D is the diameter of the shell to be taken to be equal to the diameter of the screw.

By aligning the right parts of the equations representing $F_k$and setting the value to P_c, we obtain:

$$\frac{mg\sin\varphi' + \cos(\alpha+\rho_1)}{\cos(\theta+\alpha+\rho_1)} = f_1\left(\frac{2mv_1^2}{D}ctg\,\theta + mg\cos\varphi'\right);$$

$$\frac{2f_2v_1^2ctg^2\theta}{Dg} = \frac{\sin\varphi'\cos(\alpha+\rho_1)}{\cos(\theta+\alpha+\rho_1)} + f_1\cos\varphi'; \qquad (1.7)$$

$$v_1^2ctg^2\theta = \frac{Dg}{2}\left[\frac{\cos(\alpha+\rho_1)\sin\varphi'}{f_1\cos(\theta+\alpha+\rho_1)} + \cos\varphi'\right]$$

From this we determine the velocity of the load axis:

$$v_1 = tg\,\theta\sqrt{\frac{Dg}{2}\left[\frac{\cos(\alpha+\rho_1)\sin\varphi' + \cos\varphi'}{f_1\cos(\theta+\alpha+\rho_1)}\right]} \qquad (1.8)$$

where $\alpha = arctg\dfrac{S}{\pi D}$ is the angle of rotation of the load on the outer edge of the screw conveyor and φ' is the angle of rotation of the load to the side of the conveyor loop, 13 is the screw pitch.

The relationship between speeds V_a, V_1 and V_2 is as follows:

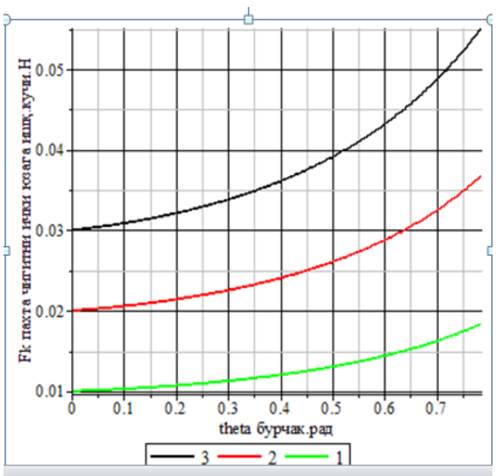
$$V_2 = V_1 \cdot ctg\,\theta \text{ м/сек}; \qquad (1.9)$$

$$V_a = \frac{V_1}{\sin\theta} \text{ м/сек}. \qquad (1.10)$$

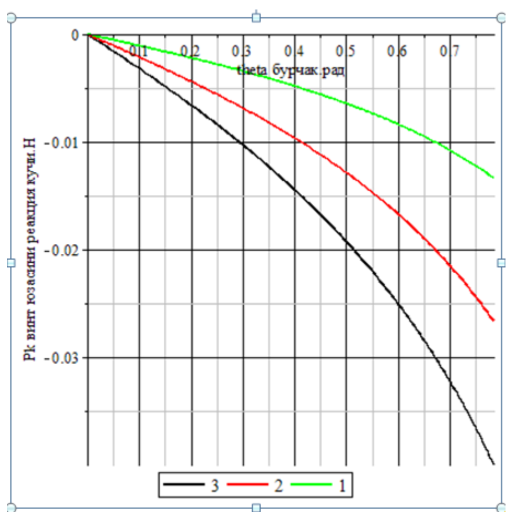
The rotation speed of the outer edge is determined from the velocity triangle (Figure 1.1 a):

$$V_2 = V_1(ctg\,\alpha + ctg\,\theta); \qquad (1.11)$$

Results obtained and their analysis.



a)



b)

Figure 1.2. a) The change in the angular dependence of the friction force on the inner surface of the screw conveyor F_k. b) P - change in the reaction of the screw surface depending on the angle θ.

Figures 1,2,3 in Figure 1.2 a show a θ-angle dependence of the frictional force of the F_k-load particle on the inner surface of the screw conveyor when the mass of the cotton seed is m 0.002 kg, 0.004 kg, 0.006 kg, respectively.

Graphs 1,2,3 in Figure 1.2 b show the θ-angle dependence of the R-screw surface reaction when the mass of the cotton seed is m 0.002 kg, 0.004 kg, 0.006 kg, respectively.

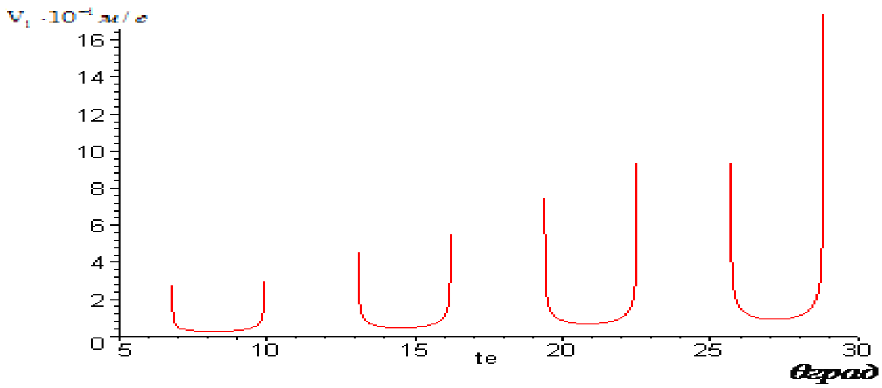


Figure 1.3. Dependence of seed movement speed on angle θ

As the mass of the cotton seeds increases, we can observe that the frictional force generating them with the inner surface of the screw conveyor increases by a value of θ angles. Conversely, we can observe that the screw surface reaction decreases with a value of θ angle dependence.

This in turn leads to a decrease in the compaction coefficient of the seed mass within the conveyor. As a result, cotton seeds reduce congestion inside the conveyor.

In Equation (1.8) the angle θ is of unknown size and is easy to determine by the method of series approximation, and the results of such work are shown graphically in Figure 1.3. As can be seen from the graph, there is uneven and intermittent movement leading to short-term stagnation.

In practice, the diameter of the conveyor screw is 350 mm, the number of revolutions of 225 mm is 80 min-^{1}, the coefficient of friction between the seeds of the conveyor shell is 0.15, using the formula 1.8 - the speed of the seed mass at the bottom of the screw blade it can be calculated that the velocity at the tip is 0.38 m / s. Such a difference in velocities leads to different densities of the mass of seeds transported on the conveyor, and as a result increases the probability of congestion.

CONCLUSION

A mathematical model of the movement of cotton seeds on a screw conveyor was constructed. On the basis of the formed mathematical model F_k- graphs of friction force of cotton seeds on the inner surface of the screw conveyor shell, R - the laws of change of the reaction of the screw surface θ angular dependence are obtained.

As the mass of the cotton seeds increases, we can observe that the frictional force generating them with the inner surface of the screw conveyor increases by a value of θ angles. Conversely, we can observe that the screw surface reaction decreases with a value of θ angle dependence. This in turn leads to a decrease in the compaction coefficient of the seed mass within the conveyor. As a result, the congestion of cotton seeds inside the conveyor is reduced.

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