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«THEORETICAL STUDIES ON SCREW CONVEYOR FOR TRANSPORTATION AND CLEANING OF LINTER AND DESIGN OF CONSTRUCTIVE PARAMETERS OF TRANSMISSIONS»

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THEORETICAL STUDIES ON SCREW CONVEYOR FOR TRANSPORTATION AND CLEANING OF LINTER AND DESIGN OF CONSTRUCTIVE PARAMETERS OF TRANSMISSIONS

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Abstract:

Objective. The article presents theoretical studies on the basis of structural parameters of screw conveyors and transmissions that transport and clean fluff. An analysis of the laws of change of the angular speed of the conveyor screw shaft was obtained. Connection graphs are built based on processing laws of screw motion. Based on the analysis of the connection graphs of the parameters, the limit values of the height of the screw waves, which ensure sufficient cleaning efficiency and high productivity, have been determined. Determination of the parameters of the fluff-carrying and cleaning screw conveyor based on theoretical studies

Methods. In system dynamic analysis studies, all rotating masses of the equipment are attached to the screw shaft. In the studies, the mechanical dynamic characteristics of the electric motor were mainly taken into account. The kinetic energy of the system was determined using Lagrange's II-order equation, and a system of differential equations representing the motion of the machine unit for the screw conveyor was derived.

Results. Based on the solution of the problem, the law of movement of the screw of the screw cleaner was obtained. The pitch of the screw, the height and pitch of the wave on the surface of the screw, and the

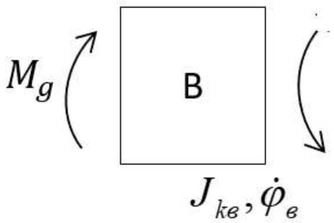
angle of elevation were taken into account. Based on the analysis of the received laws, it was determined that the amplitude of the angular speed fluctuation in the movement of the screw shaft depends mainly on the height of the wavy surface on the screw surface, without changing the resistance and friction from the foam.

Conclusion. Dynamic and mathematical models representing the dynamics of a single-mass machine assembly of a screw conveyor were developed taking into account the mechanical dynamic characteristics of the electric drive, inertial parameters, and technological and frictional resistances. the laws of change of angular speed of the screw shaft were obtained, graphs of dependence were constructed and recommended parameters were developed.

Keywords: Screw conveyor, pressing machine, transportation, construction, fluff, waste, screw shaft, noise, chain transmission

Introduction. Calculation scheme and mathematical model of the screw conveyor machine unit

After saw jin machine, the linter is separated from the seed with the help of linters machines. Screw conveyors are used to transfer the waste in the obtained linter to the pressing machine [1]. Available screw linter carrier will transport shaft linter (with blade) along gutter. In the screw cleaner that we offer, the screw blade is made wavy, which increases the fluffiness of the linter being transported, as a result, the waste in the linter is separated and then it goes out of the shell slots in the grid fast. In addition, the movement of the wiper blade is transmitted to the screw shaft from an electric walker through a reducer and a coupling. In this case, in theoretical studies, the system can be considered as a single-mass machine unit. However, in order to reduce noise, adequately adjust the cleaning mode and ensure efficiency, we proposed to transfer the movement to the screw shaft through a chain drive. Here, belt elements were used in the construction of the chain transmission used [2]. A dynamic model for a single-mass machine unit is presented in Figure 1.



$$M_{вс} = M_{в_1} + M_{в_0} \sin \omega t \pm \delta M_{в_1}$$

Figure 1. Screw machine for linter transportation and cleaning, dynamic model for a single mass machine unit

In system dynamic analysis studies, all rotating masses of the equipment are brought to the screw shaft. In the studies, the mechanical dynamic characteristics of the electric motor were mainly taken into account. A.E. Levin proposed this dynamic mechanical characteristic [3]:

$$\dot{M}_g = \Psi(\omega_c - p\dot{\varphi}_в) - \frac{1}{T_Э} M_ю;$$
$$T_Э \dot{\Psi} = 2M_k - \Psi - \Psi_Э \omega_c + p\dot{\varphi}_в - M_ю; \qquad (1)$$
$$T_Э = \frac{1}{\omega_c S_k}; \ \Psi = \frac{S_k}{S}(M_ю + T_Э \dot{M}_ю)$$

here, $\dot{\varphi}_в$ – referred mass – screw shaft angular velocity; $M_ю$, M_k – torque on the drive shaft and its critical value; p – number of pairs of poles; ω_c – frequency of rotations of the power supply; $T_Э$ – electromagnetic constant time of the conductor; Ψ – additional variable.

Using Lagrange's II equation [4], we determine the kinetic energy of the system:

$$T = \frac{1}{2} J_{кв} \dot{\varphi}_в^2; \tag{2}$$

here, $J_{кв}$ – moment of inertia used to the screw shaft.

Because the strap elements are not taken into account in the system, potential energy in the Lagrange equation and Rayleigh's dissipative functions are also not taken into account. External effective forces:

$$M_T = M_ю - M_{вс} - M_и \tag{3}$$

here, $M_{вс}$ – resistance moment coming from the linter carried in the screw shaft.

Based on the obtained kinetic energy and taking into account (3), the system of differential equations representing the motion of the machine unit for the screw conveyor is as follows:

$$\begin{gathered} \dot{M}_g = \Psi(\omega_c - p\dot{\varphi}_в) - \frac{1}{T_Э} M_ю; \\ T_Э \dot{\Psi} = 2M_k - \Psi - \Psi_Э \omega_c + p\dot{\varphi}_в - M_ю; \\ T_Э = \frac{1}{\omega_c S_k};\ \Psi = \frac{S_k}{S}(M_ю + T_Э \dot{M}_ю) \\ J_{кв}\dot{\varphi}_в = M_ю - M_{в_1} + M_{в_0} \sin \omega t \pm \delta M_{в_1} - M_и \end{gathered} \tag{4}$$

here, $M_{в_1}, M_{в_0}, \delta M_{в_1}$ – the constituents of the technological resistance coming from linter, respectively the average value, amplitude and random constituent, $M_и$ – moment of resistance of frictional forces on screw shaft supports.

Solution for the problem and analysis of results.

It should be noted that if the electric motor is Y132S-8, P=2.2 kW, n=710 rev/min, the rotation frequency of the propeller shaft is $n_{ум}$ =25,4 да $n_в$ =27,9 rev/min.

The problem is solved numerically $J_{кв} = 7{,}14\ кг \cdot м^2$; $M_{в_1} = (45 \div 65) Нм$; $M_{в_0} = (5{,}0 \div 10) Нм$; $\delta M_{в_1} = (0{,}05 \div 0{,}07) Нм$; and $M_и = (35 \div 45) Нм$.

Initial conditions for solving (4): $t = 0;\ \dot{\varphi}_в = 0;\ M_ю = 0;\ M_{вс} = 0.$

Based on the solution of the problem, the law of movement of the screw of the screw cleaner was obtained. The pitch of the screw, the height and pitch of the wave on the surface of the screw, and the angle of elevation were taken into account. The obtained motion laws are shown in Figure 2.

The analysis of the discovered laws revealed that, provided the resistance and friction from the linter do not change, the height of the wave-like surface on the screw surface largely determines the magnitude of the angular velocity fluctuation in the movement of the screw shaft. Additionally, the value of the wave step on this surface determines how frequently the angular velocity oscillates (Fig. 2).

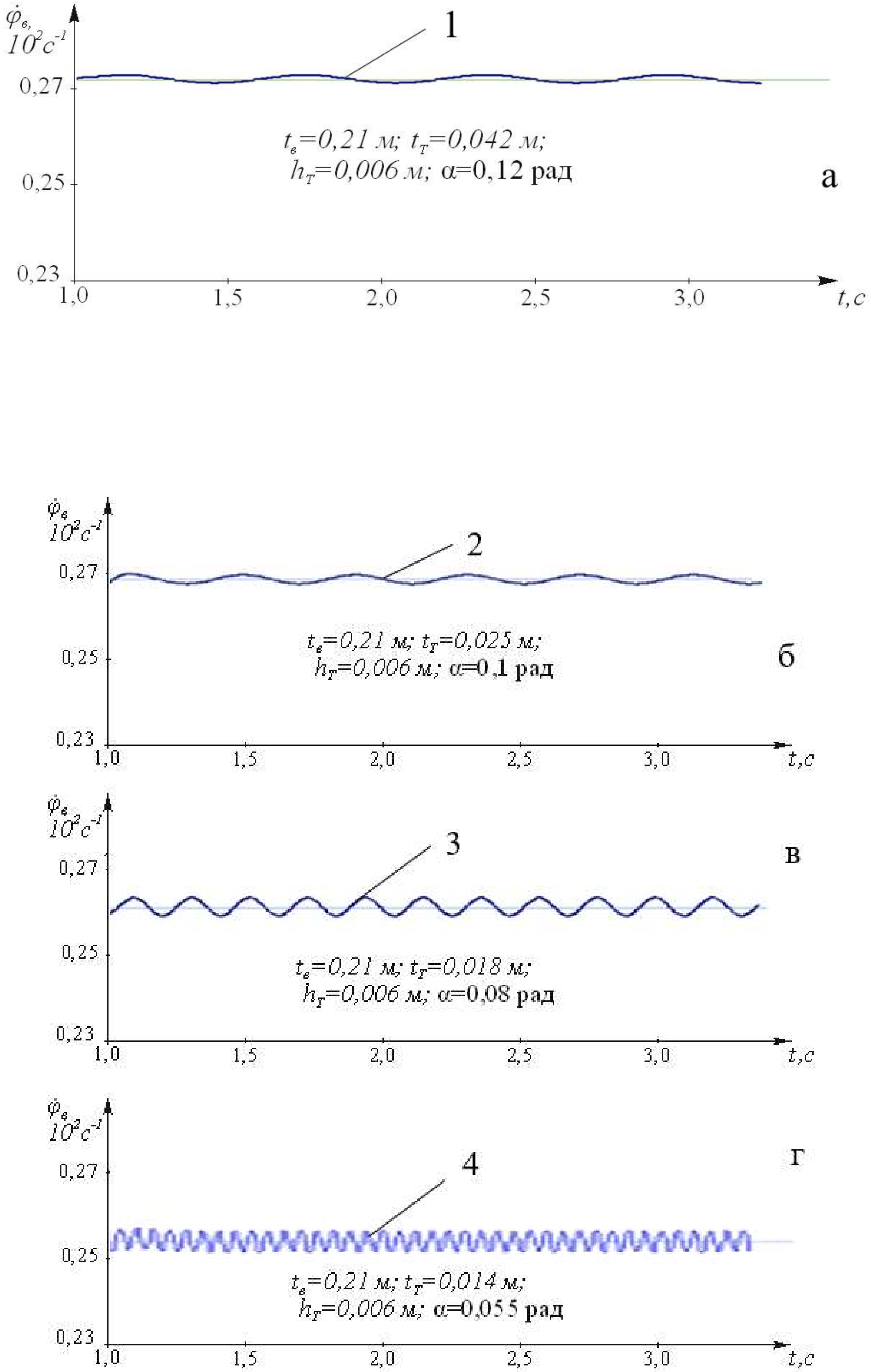


Figure 2. The laws of changing the angular speed of the propeller shaft

The construction of connection graphs was based on analyzing the screw motion rules. The graphs illustrating the relationship between the screw's changing angular speed and the height of the waves on its surface are shown in Fig. 3.

Based on the graph analysis, when the wave height increases from $0{,}6 \cdot 10^{-2}$ m to $11{,}5 \cdot 10^{-2}$ m and is equal to $M_{вс} / M_{вс}^{x} = 0{,}7$, it was found that the range of angular velocity changes increases from $1{,}62\ c^{-1}$ *to* $2{,}52\ c^{-1}$ in a non-linear pattern.

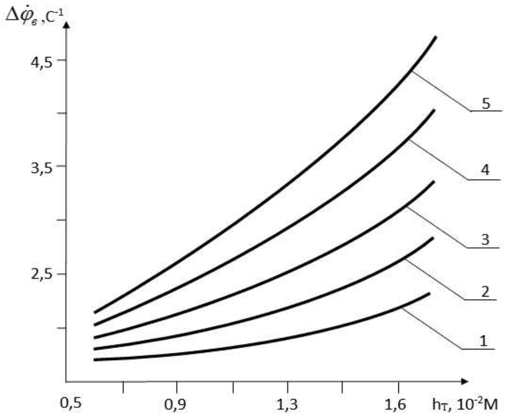
It was found that when the loading was increased to $M_{вс} / M_{вс}^{x} = 1{,}9$, the values of $\Delta\dot{\varphi}_{в}$ increased from $2{,}21\ c^{-1}$ *to* $4{,}47\ c^{-1}$.

Considering that the wave screw shaft is known to be in the range of $\Delta\dot{\varphi}_{в} \le (2{,}5 \div 3{,}5)c^{-1}$ according to the results of experimental studies, if it is desirable to choose a load in the range of $M_{вс} / M_{вс}^{x} = (1{,}2 \div 1{,}4)$, it is recommended that the height of the waves on the screw is within $(0{,}8 \cdot 1.25) \cdot 10^{-2}$ m.

Fig. 4 shows graphs of dependence of the angular velocity of the screw shaft of the lint remover on the increase of the loading from the linter.

Based on the analysis of the obtained graphs, if the relative values of loading are increased from 0.4 to 2.2, the unevenness coefficient of the angular speed is h_T=0.006 m; it can increase from 0.01 to 0.07 in case of α=0.12 rad. If h_T=0.015 m; α=0.055 rad, it was found that the values of d increase from 0.024 to 0.131. In order to ensure the desired cleaning effect, according to the results of experimental studies, the values of δ are recommended to be within the range of (0.04÷0.05).

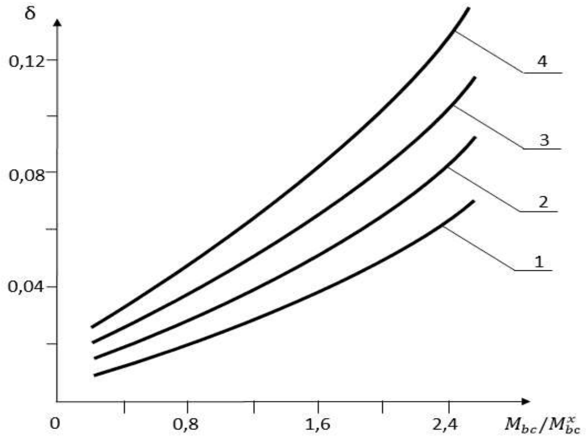
In order to ensure the desired cleaning effect, according to the results of experimental studies, the values of δ should be within the limit of (0.04÷0.05) $M_{вс} / M_{вс}^{x} \le (0{,}8 \div 1{,}25)$ values are recommended.



$1 - M_{вс} / M_{вс}^{x} = 0{,}7;$ $2 - M_{вс} / M_{вс}^{x} = 1{,}0;$ $3 - M_{вс} / M_{вс}^{x} = 1{,}3;$

$4 - M_{вс} / M_{вс}^{x} = 1{,}6;$ $5 - M_{вс} / M_{вс}^{x} = 1{,}9.$

Fig 3. Graphs of the dependence of the change in the coverage of the screw angular speed on the increase of the height of the waves on the surface of the screw



here, $1 - h_T = 0{,}006\,m;\ \alpha = 0{,}12\,rad;$
$2 - h_T = 0{,}009\,m;\ \alpha = 0{,}1\,rad;\ \ 3 - h_T = 0{,}0012\,m;\ \alpha = 0{,}08\,rad;$
$4 - h_T = 0{,}015\,m;\ \alpha = 0{,}055\,rad;$

Fig 4. Graphs of the load dependence of the change of the roughness coefficient of the angular speed of the wiper screw shaft

Conclusion. The mechanical dynamic properties of the electric motor, inertial parameters, technical and frictional resistances were taken into account when developing dynamic and mathematical models that reflect the dynamics of a single-mass machine assembly of a screw conveyor. Based on the numerical solution of the problem, the laws of change of the angular speed of the screw shaft of the external conveyor of fluff cleaning were obtained. Graphs of the dependence of the screw angular velocity coverage on the height of the waves on the screw surface were constructed.

Considering that it is in the range of $\Delta\dot{\varphi}_в \le (2{,}5 \div 3{,}5)c^{-1}$ according to the results of experimental studies, it is advisable to choose the load in the range of $M_{вс}/M_{вс}^x = (1{,}2 \div 1{,}4)$, it was recommended that the height of the waves in the screw should be within the limit of $(0{,}8 \cdot 1.25) \cdot 10^{-2}$m.

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