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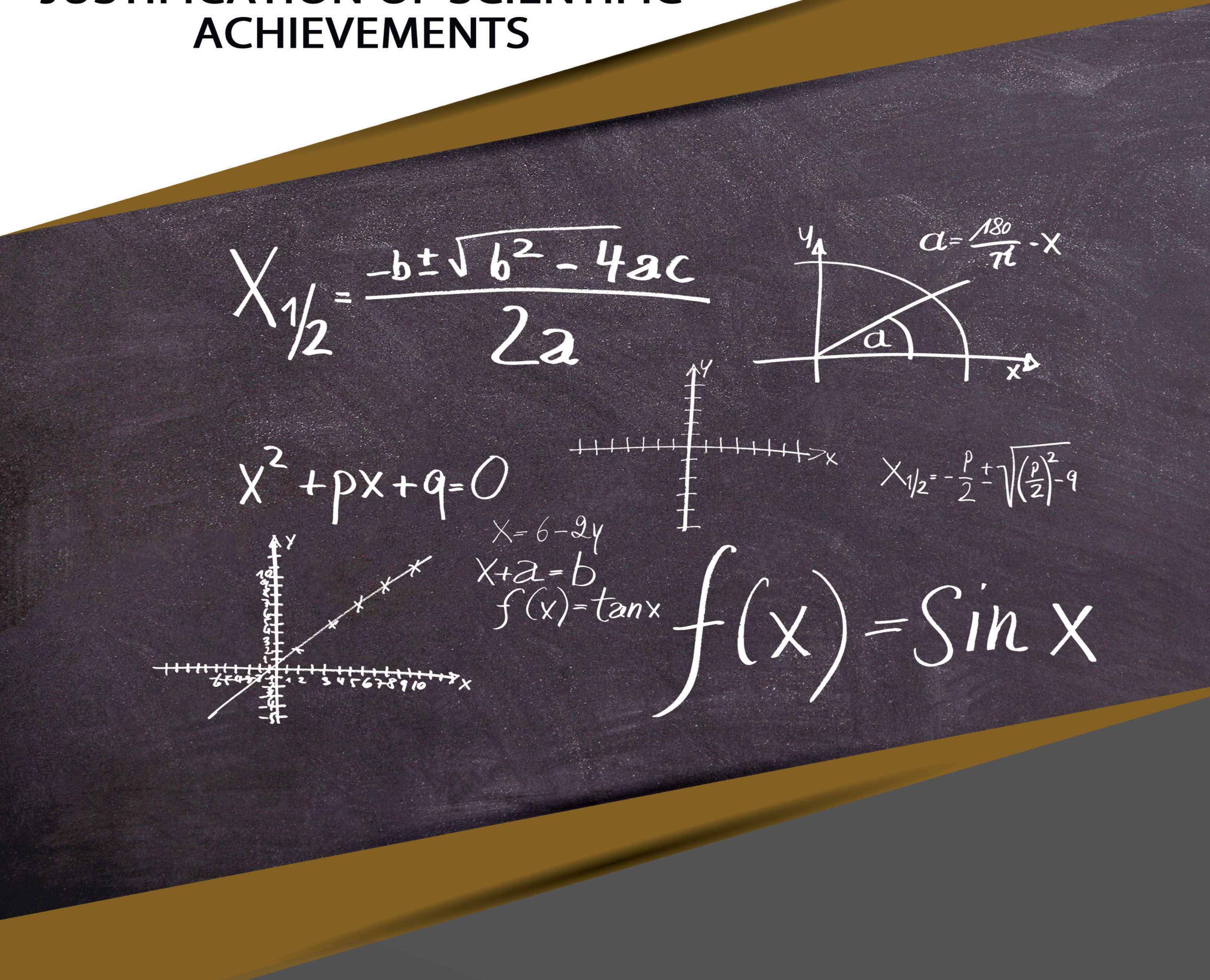

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SECTION 4. MECHANICS

4.1 Screw Conveyors with Elastic Surfaces

One of the problems arising at transporting bulk agricultural products is high degree of their damage because of stuck of grain particles between internal static surface of guiding jacket and rotational peripheral surface of screw operating element. Because of this, it is also possible stuck of operating element causing its breakdowns and energy costs increase.

Solution of the given tasks, in particular development of original constructions of screw operating elements and selection of their rational parameters and operating modes were discussed in the following works [112 - 116].

The research objective is to develop new constructions of auger conveyor with changeable elastic screw blade, make its design and provide theoretical grounds concerning the impact of constructive and technological parameters of elastic screw blade upon force value influencing stuck grain and also to design bench and make test investigations.

New construction of auger conveyor with elastic screw blades and design options of auger elastic rib in the form of petals (sections) [117] depicted in Figure 1 were developed for the implementation of set tasks.

Auger conveyor with elastic screw blade consists of shaft 1, in which band screw spiral 2, to which elastic spiral 3, which can be made as entire one or of separate petals (sections) was fixed with the help of sectional blades 4 and bolt connections with half-round heads 5 and nipples 6.

Width and stiffness of petals are chosen depending on physical and mechanical qualities of transported material. Granular materials interact with operating elastic screw blades while their transporting in guiding jacket 7. In case, when grain falls and it is stuck between unmovable blade of guiding jacket and rotational elastic screw blade, cut petals bend to protect grain from its decay.

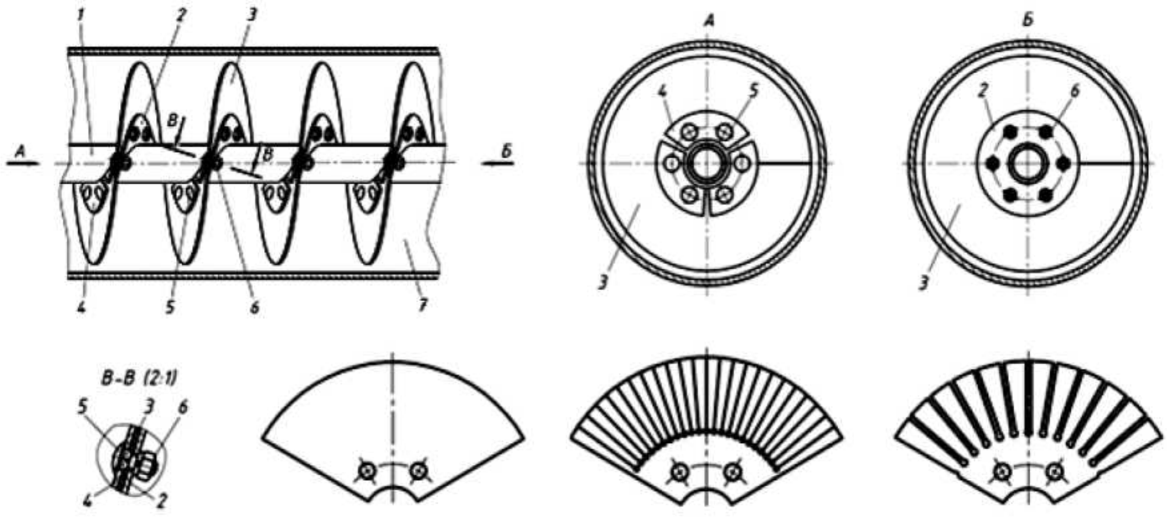

Fig. 1. Auger conveyor with elastic screw blades and blades design options

An offered construction of auger conveyor with elastic screw blade gives the opportunity to change quickly an operating elastic spiral in case of its runout or when it is necessary to transport materials of another rheological quality.

Defining efforts arising during close interaction of elastic rib screw blade, corn grain is going to be investigated, the form of which can be described as half-sphere transiting to cone.

Performing theoretical calculations (on the first stage), we take the following hypotheses: the grain form is ideal and it is described by basic mathematical formulas; peripheral surface of operating element is ideal and it is described by the form of right angle; friction coefficient in the process of elastic rib screw blade interworking with grain products is stable; elastic surface of operating element is up to parameters of absolutely elastic blade (for small deformations); we ignore movements of radial and angular grain; centrifugal forces are not taken into consideration; fluctuation between elements interaction are not taken into account; deformation of elastic sections fixed on the surface of auger conveyor rib is defined according to common formulas of products resistance; in the process of deformation the bend line of elastic rib screw blade is formalized by ideal span.

The process of interworking screw auger blades (Fig. 2) with half-spherical corn grain surface 1 stuck between internal surface of guiding jacket 2 and peripheral surface of auger elastic rib 3 is going to be investigated.

Corn grain position, which can be much more likely stuck, is shown in Figure 2. In this case, corn grain touches surface of internal jacket surface with its cone surface and spherical surface interworks with auger elastic rib.

There is stuck corn grain only when maximal starting angle α_n between normal force of interaction of auger elastic rib with the surface of grain N_b and plane, which is perpendicular to axis of rotation of auger conveyor, is less than angle of grain friction on internal surface of jacket.

In the process of grain stuck, auger conveyor rotates and its elastic blade slips in circular and axial directions with corresponding deformation regarding to grain. During this process force direction N_b approaches to axis OY and its size increases.

The aim of theoretical calculation is defining such parameters of interaction of auger elastic rib with grain material, which protect its possible decay. That is to say, auger conveyor rib will rotate with definite deformation relatively to grain not damaging it. Interaction parameters include constructive and geometrical system parameters, and rheological qualities of transporting object and materials used for manufacturing auger elastic rib.

Stuck corn grain is deformed in the process of rotation of auger elastic rib. The process of rotating of elastic rib from the start of its contact with grain p. A, which is defined by angle α_T to definite the current value position p. B is going to be investigated.

As far as auger elastic rib is not absolutely elastic and its deflection size is insignificant, then in first approximation we take that length of span OB is equal to overhang length of elastic rib l.

Preliminary let us define the height of elastic rib in deformed state Y_T transporting its running end from p. A to p. B that is from starting angle of contact α_n to the current value α_T. Then

$$Y_T = l - \Delta_T. \tag{1}$$

Value Δ_T is defined in statement

$$\Delta_T = \Delta_n - \Delta_з, \tag{2}$$

where Δ_T - value of the current value overlap of elastic rib with a grain, m; Δ_n - value of starting overlap of elastic rib with a grain, m; $\Delta_з$ - value of residual overlap of elastic rib with a grain, m.

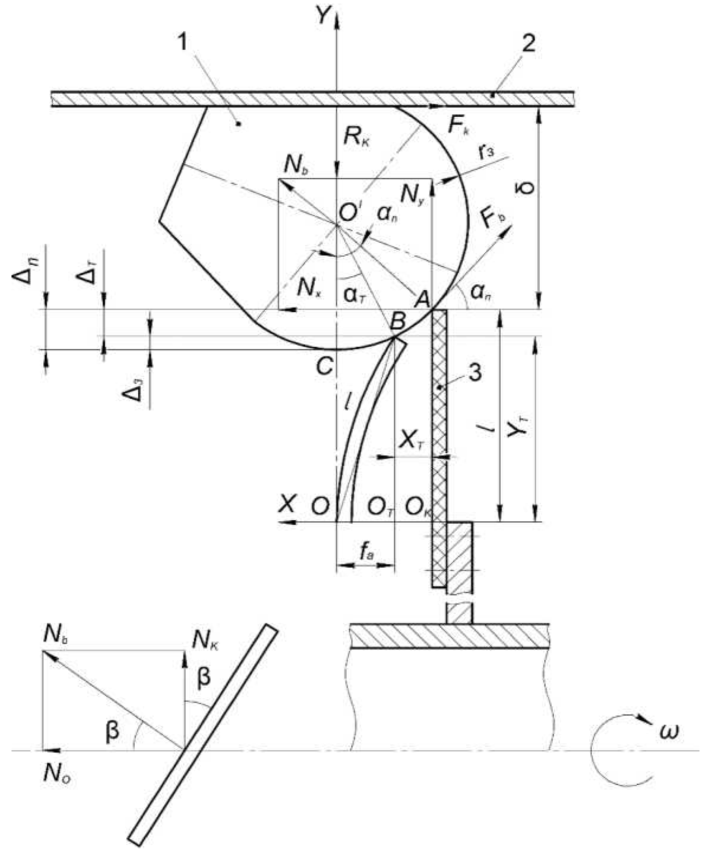

Fig. 2. Design model for the evaluation of transpositions, deformations and forces, which occur between elastic rib screw blade and stuck grain

Values Δ_n and $\Delta_з$ are correspondingly defined

$$\Delta_n = r_з - r_з \cos\alpha_n = r_з(1 - \cos\alpha_n), \quad (3)$$

$$\Delta_з = r_з - r_з \cos\alpha_T = r_з(1 - \cos\alpha_T)., \quad (4)$$

where $r_з$ - radius of dome-shaped corn grain surface, m.

Substituting dependences (3) and (4) into (2), we get

$$\Delta_T = r_з(1 - \cos\alpha_n) - r_з(1 - \cos\alpha_T) = r_з(\cos\alpha_T - \cos\alpha_n). \quad (5)$$

Substituting (5) into (1), we get

$$y_T = l - r_з(\cos\alpha_T - \cos\alpha_n). \quad (6)$$

Then in triangle BOO_T we define the current value meaning of sag of elastic rib

$$f_a^2 = l^2 - y_T^2, \quad (7)$$

where $f_a = \sqrt{l^2 - (l - r_з[\cos\alpha_T - \cos\alpha_n])^2}$.; f_a - magnitude of movement of auger elastic rib end, m.

After transformations we get

$$f_a = \sqrt{r_з(\cos\alpha_T - \cos\alpha_n)(2l - r_з[\cos\alpha_T - \cos\alpha_n])}. \quad (8)$$

According to known dependences of resistance of materials transporting of loaded cantilever fitted beam end is defined as

$$f_a = \frac{Nl^3}{3EI}k., \quad (9)$$

where N - force acting on running end of auger elastic rib, N; E - module of elasticity of auger elastic rib, Pa; I - moment of rib inertia, m^4; k - coefficient taking into account auger elastic rib profile.

In case of using elastic rib in the form of trapezium, its moment of inertia is defined by dependence $I = \frac{l(b^4 - a^4)}{48(b-a)}$.

Substituting meaning f_a from equation (8) into equation (9), and also taking into account the moment of inertia of rib of force N_b, which appear between periphery of elastic rib and grain is defined by dependence

$$N_b = \frac{E(b^4 - a^4)\sqrt{r_з(\cos\alpha_T - \cos\alpha_n)(2l - r_з[\cos\alpha_T - \cos\alpha_n])}}{16l^2(b-a)k}, \quad (10)$$

where *в* - width of bigger base of trapezoidal rib, m; a - width of smaller base of trapezoidal rib, m.

To the case when width of element of elastic rib changes in length l from a to b, coefficient k in the first approximation will be equal $k = 1 - \frac{b-a}{4l}$.

Analyzing dependence (10) we preliminary define the intensity impact one or other parameters of interaction on value of N_b.

For this, possible limits of change of value of parameters should be defined. Elastic rib section of auger conveyor is in the form of trapezium and can be made of rubber, polyethylene of law and high pressure, and polypropylene can be accepted as the fact. According to data [118] module of elasticity for these materials is: rubber (at law deformation) – $E = (0.01…0.1)\cdot 10^9$ Pa; polyethylene of law pressure –

$E = 0.2\cdot10^9$ Pa; polyethylene of high pressure – $E= 0.8\cdot10^9$ Pa.

Let us accept that analysis of the dependence (10) will be done in the range of meanings $E = (0.05\ldots0.25)\cdot10^9$ Pa, at medium meaning $E = 0.15\ 10^9$ Pa.

Overhang size of auger elastic rib will be changed in the range of $l = 0.024\ldots0.032$ m, at average meaning $l = 0.028$ m.

Width of bigger *в* and less *a* base of auger rib section in the form of trapezium is accepted in the range of *в* = 0.020…0.024 m (average meaning *в* = 0.022 m); $a = 0.014\ldots0.018$ m (average meaning $a = 0.016$ m).

According to known investigations [119] corn grain is from 5.2 to 14 mm long; from 5 to 11 mm wide; from 3 to 8 mm thick. That is why radius of its dome-shaped surface is considered in the range of $r_з = 0.0015\ldots0.0045$ m (average meaning $r_з = 0.003$ m).

According to [119] let us take the range of change of friction angle of corn grains along different types of materials and roughness of guiding jacket internal surface in the range of $\alpha_n = 6°\ldots14°$ (average meaning $\alpha_n = 10°$). The current value angle α_T varies from α_n to zero.

Tilt angle β of elastic screw blade is considered ranging from 10°...30° (average meaning β = 20°).

Then in the evaluation of intensity impact of stated above parameters on value of N_b let us take the last meaning $\alpha_T = 0°$. Correspondingly in formula (10) value of cos $\alpha_T = 1$. Then dependence (10) takes the form

$$N_b = \frac{E\left(b^4 - a^4\right)\sqrt{r_з\left(1-\cos\alpha_n\right)\left(2l - r_з\left[1-\cos\alpha_n\right]\right)}}{16l^2\left(b-a\right)k}. \qquad (11)$$

Force N_b, which acts perpendicular to rib plane, expands on axial N_o acting in the direction of auger axis and circular N_k acting in its cross-section. Then axial and circular forces are defined correspondingly

$$N_o = \frac{E\left(b^4 - a^4\right)\sqrt{r_з\left(1-\cos\alpha_n\right)\left(2l - r_з\left[1-\cos\alpha_n\right]\right)}}{16l^2\left(b-a\right)k}\sin\beta; \qquad (12)$$

$$N_k = \frac{E\left(b^4 - a^4\right)\sqrt{r_з\left(1-\cos\alpha_n\right)\left(2l - r_з\left[1-\cos\alpha_n\right]\right)}}{16l^2\left(b-a\right)k}\cos\beta, \qquad (13)$$

where β - tilt angle of screw blade of auger elastic rib, deg.

To reduce the degree of grain material damage whilst its transportation by screw conveyors we suggest to fasten some elastic sections to the rigid screw base which would bend when some corns are in a clearance between fixed internal surface of a guiding jacket and rotational peripheral surface of the screw.

For this purpose, an elastic screw conveyor with adjacent elastic sections overlapping has been developed whose general view is presented on Fig. 3. It consists of a central shaft 1 with rigid base 2 on which elastic sections 3 are fixed by screw plates 4 and screw bolts with cup heads 5 and screw nuts 6. Whilst agricultural loose materials transportation in the guiding jacket 7 the elastic sections are bending when some grains are pinched between the jacket fixed surface and rotational surface of the elastic sections. This results in less damage of grain material.

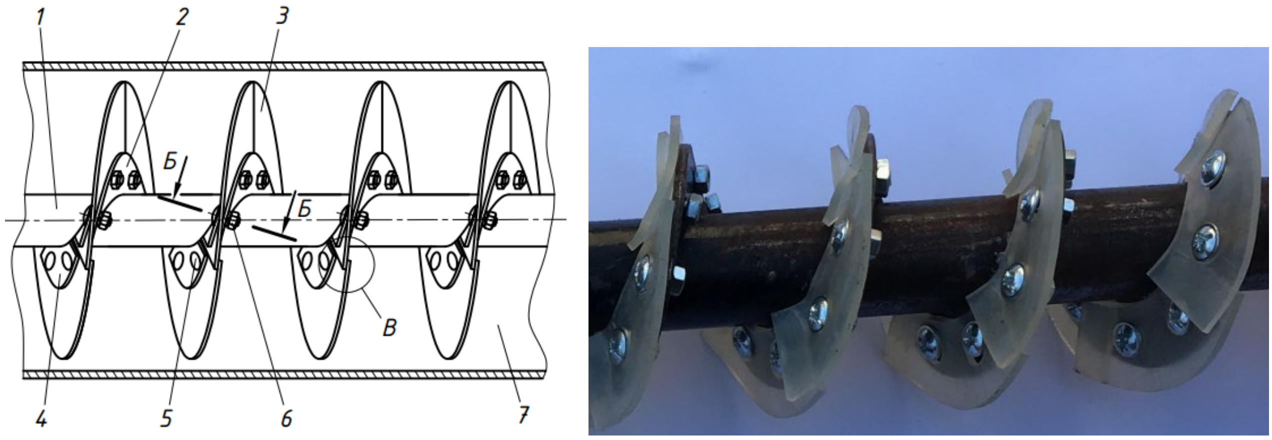

Fig. 3 – General view of the screws with elastic sections overlapping

The transported material while in operation will be rolling off the top edge of the upper section on the lower end of the next section which will have some positive effect on energy consumption of the transportation process and reduce the damage degree of the loose material.

To determine the parameters of loose material flow motion between adjacent elastic sections we consider the general view of position of adjacent elastic sections edges which are fixed to the screw rigid base (Fig. 4).

Figure 4 specifies: ξ – helix angle of screw surface of auger base; ξ_1 – inclination angle of external section edge.

The size of overlapping between the edges of adjacent elastic sections and the numeric values of above-mentioned angles are defined constructively and can be chosen depending on transportation conditions.

The aim of conducting theoretical investigation is to define the motion path of loose material flow after its leaving the elastic section overhang depending on the design and kinematic parameters of the operating device, and also determining the conditions for the further motion path of loose material flow in case of its landing on the next elastic section.

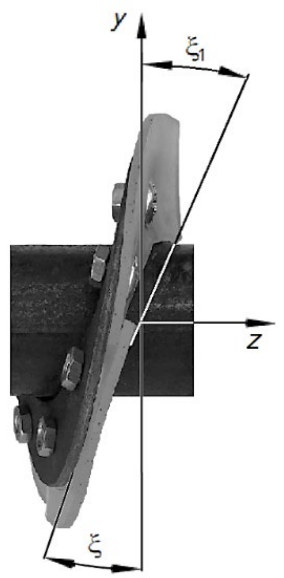

Fig. 4 – General view of position of adjacent elastic sections edges

The research results are necessary to prevent the impact interaction of loose material flow leaving the section edge with the rough base of the further screw turn where some metal joints are located which can cause the increased damage of material.

Let's analyze some loose material flow motion in case when there are some overhangs on the screw surface caused by edges overlapping of adjacent elastic sections (Fig. 5).

Figure 5 contains the following symbols: h – height of position of external blade edge above the lower blade; R_κ – jacket radius; N_1 – screw response on the load; F_1 – friction force caused by reaction N_1; N_2 – jacket response on the load; F_2 – friction force caused by reaction N_2; μ_1 – load friction coefficient on screw surface; μ_2 – load friction coefficient on jacket surface; χ – direction angle of load particle motion against jacket; ψ – angular position of load particle in its rotational motion; z – longitudinal coordinate of the particle along the jacket axis.

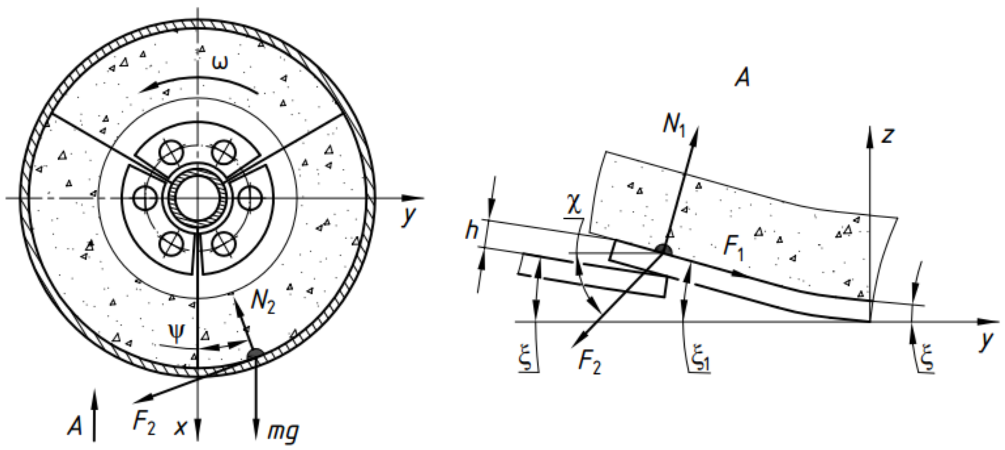

Fig. 5 – Forces acting on an elementary particle of loose cargo flow

We extract an elementary part of loose material which is simultaneously touching the jacket and the screw. Then we define the forces acting on this part and on their basis we set up the equation of its motion. On the jacket side a reaction is taking place on the elementary particle of the flow which is perpendicular to its surface N_2, and friction force F_2, directed at the side opposite to the direction of particles motion against the jacket. Jacket's reaction is determined by the vector sum of forces obtained from the force of weight of material flow particle and centrifugal force caused by rotation. The particle is also influenced by the screw blade surface N_1 which is perpendicular to the screw surface in the contact point and correspondent force of friction F_1 acting in the direction opposite to the flow motion against the screw conveyor, i.e. tangentially to the screw edge.

The equation of motion of a certain particle of load with mass m transported by horizontal screw conveyor can be written as a system of equations

$$m\frac{d^2z}{dt^2} = N_1\cos\xi - F_1\sin\xi - F_2\sin\chi\,; \qquad (14)$$

$$mR_к \frac{d^2\theta}{dt^2} = N_1 \sin\xi + F_1 \cos\xi - F_2 \cos\chi \; ; \tag{15}$$

$$N_2 = mg\cos\psi + mR_к \left(\frac{d\psi}{dt}\right)^2 ; \tag{16}$$

$$F_1 = \mu_1 N_1 ; \tag{17}$$

$$F_2 = \mu_2 N_2 . \tag{18}$$

The following geometrical dependences can be written between the directions of particle motion and screw conveyor geometry at its rotation with angular velocity ω

$$\mathrm{tg}\chi = \frac{\dot{z}}{R_к \dot{\psi}} ; \tag{19}$$

$$\mathrm{tg}\xi = \frac{\dot{z}}{R_к (\omega - \dot{\psi})} . \tag{20}$$

To solve the system of equations (14) - (20) we use transformations and substitutions to get rid of the unknown force and express all parameters in the terms of value of angle ψ. At first the system looks like

$$m\ddot{z} = N_1 (\cos\xi - \mu_1 \sin\xi) - \mu_2 \left(mg\cos\psi + mR_к \dot{\psi}^2\right)\sin\chi ; \tag{21}$$

$$mR_к \ddot{\theta} = N_1 (\sin\xi + \mu_1 \cos\xi) - \mu_2 \left(mg\cos\psi + mR_к \dot{\psi}^2\right)\cos\chi . \tag{22}$$

The differential equation of material particle motion for variable ψ will eventually have the form

$$\ddot{\psi} + \dot{\psi}^2 A + B\cos\psi = 0 . \tag{23}$$

In this equation the coefficients *A* and *B* are found by the following dependencies

$$A = \mu_2 \left[\cos(\chi + \xi) - \mu_1 \sin(\chi + \xi)\right] ; \tag{24}$$

$$B = \frac{\mu_2 g}{R_к} \left[\cos(\chi + \xi) - \mu_1 \sin(\chi + \xi)\right] \cos\xi . \tag{25}$$

While some loose material flow is moving it's necessary that centrifugal force is bigger than weight force. Otherwise, the flow particles won't move constantly, and their overflow and mixing will take place which will spoil badly the whole picture of flow transportation. Thus, this will be obtained under conditions

$$\dot{\psi} > \sqrt{\frac{g}{R_{\kappa}}} \,. \tag{26}$$

The equation (23) is a second-order nonlinear differential equation whose analytical solution is impossible and we must use a numerical method of such equations integration, namely Runge-Kutta method.

The important moment of motion is separation of a particle of the material flow from the external blade overhang and free motion of the flow on the jacket surface till the moment of contact with the next screw blade.

Separation of a flow particle from the blade surface is taking place at angle $\xi_1 > \xi$, which is defined by the geometry of adjacent blades relative position (Figure 4). Here the velocity of material flow against the screw surface due to the negligible change of angle ξ_1 remains steady. The value of linear velocity of relative motion V of material flow is found from the kinematic dependence

$$V \sin\xi = \dot{z} \,. \tag{27}$$

Therefore, at angle change of flow descending off the overhang

$$V \sin\xi_1 = \dot{z}_1 \,. \tag{28}$$

Thus, the velocity values of loose material flow motion while descending off the overhang and taking into account the equations (19, 20) and (27, 28), are calculated by the formulae

$$\dot{z}_1 = \dot{z}\frac{\sin\xi_1}{\sin\xi} \,; \tag{29}$$

$$\dot{\psi}_1 = \dot{\psi}\frac{\cos\xi_1}{\cos\xi} + \omega\left(1 - \frac{\cos\xi_1}{\cos\xi}\right). \tag{30}$$

Free motion of particles on the jacket surface in case of separation from the blade is written in the form of two second-order differential equations

$$m\frac{d^2 z}{dt^2} = -F_2 \sin\chi \,; \tag{31}$$

$$mR_{\kappa}\frac{d^2\psi}{dt^2} = -F_2\cos\chi - mg\sin\psi\,, \qquad (32)$$

with initial conditions at the beginning of loose material leaving the section edge

$$\dot{z}(0) = \dot{z}_1\,, \qquad z(0) = z_1 + h\,,$$

where h – the value of overhang of external section edge above the internal surface

$$\dot{\psi}(0) = \dot{\psi}_1\,; \qquad \psi(0) = \psi_1\,; \qquad (33)$$

$$\mathrm{tg}\chi = \frac{\dot{z}_1}{R_{\kappa}\dot{\psi}_1}\,.$$

After transformation we obtained

$$m\ddot{z} = -\mu_2\left(mg\cos\psi + mR\dot{\psi}^2\right)\sin\chi\,; \qquad (34)$$

$$mR_{\kappa}\ddot{\psi} = -\mu_2\left(mg\cos\psi + mR_{\kappa}\dot{\psi}^2\right)\cos\chi - mg\sin\psi\,. \qquad (35)$$

Free motion of material flow will take place until the moment of contact with one of the next screw blades. To calculate the moment and place of contact we assume that further part of screw surface is without any overhangs.

The condition of free motion of a flow particle on the screw jacket is described by the inequality

$$R_{\kappa}\omega t\,\mathrm{tg}\,\xi < z + R_{\kappa}\psi\,\mathrm{tg}\,\xi\,, \qquad (36)$$

where the expression for the screw surface ascending at its rotation is on the right-hand side, integrated motion of the flow particle along the axis z and towards rotational motion. is on the left-hand side.

The material particle doesn’t touch the screw surface being in free motion when the inequality is satisfied. The values z and ψ are in the solution of the system of equations (34, 35) with correspondent initial conditions.

From the inequality (36) at solving the system of equations of motion at each step the satisfaction of the above-mentioned condition, the time when a particle stops free motion $t_2$$t_2$, and also the value of axial movement of a flow particle z_2 are defined.

Therefore, it’s necessary to find the value of angle of screw relative turning and flow particle φ_2 till the moment of their next contact in time point t_2. Its value is found by the formula

$$\varphi_2 = \frac{z_2}{R_к \operatorname{tg} \xi}. \qquad (37)$$

While defining the impact of any interaction parameter on values N_o and N_k its value was changed within a certain range. The other parameters remained unchangeable, and their average values were substituted in formulae (12) and (13). It was found that the elasticity modulus of elastic section screw surface had the maximal impact on values N_o and N_k, i.e. the properties of material of which the section screw surface was made.

The second in importance after the above-mentioned elasticity modulus regarding impact depth on the value N_o are the initial angle of interaction of elastic section with the grain surface α_n, length of cantilever overhang of screw elastic edge l and inclination angle β of elastic section screw surface.

The increase of a grain radius r_c results in increase both N_o and N_k.

Design parameters of trapezoid elastic section, namely the parameters a and b have minimum impact on values N_o and N_k.

As for the centrifugal force N_k, the inclination angle β of elastic edge screw surface is second in importance after modulus of elasticity with regard to the impact power on its value.

Thus, within the boundaries of parameters values range change for the axial force N_o its increase is as follows: for E – 5 times increase; for α_n, – 2.34 times increase; for r_c – 1.79 times increase; for b– 1.42 times increase; for a –1.27 times increase. The decrease of value N_o is as follows: for l – 1.49 times decrease; for β – 1.15 times decrease.

For the centrifugal force N_k its increase is as follows: for E – 5.12 times increase; for β – 2.88 times increase; for α_n – 2.32 times increase; for r_c – 1.79 times increase; for b – 1.4 times increase; for a – 1.32 times increase. The decrease of value N_o is only for l – 1.33 times decrease.

For the given boundaries of interaction parameters values for the central point where plots are met the axial force value N_o is 2.76 times larger than the centrifugal force value N_k.

To analyze the obtained dynamic model (formulae 14 – 37) the program based on the language Delphi has been developed. The program helped to determine the numerical characteristics and to plot parameters of the flow free motion versus the change of main coefficients of the mathematical model.

The aim of the analysis was to find the positive effect of mathematical model parameters on free motion of loose material flow. The results of modelling are shown on Figures 6 - 11. Each plot shows the effect of a certain parameter on the x-axis. Here, on y-axis of the plot time t_p and path l_p are shown of material particle free motion till its contact with the next section.

The plot on Figure 6 shows that the increase of helix angle of screw base screw surface ξ results in decrease of distance covered l_p and, correspondingly, time t_p of free motion of particles till the contact with the next section due to the decrease of velocity of loose material flow against the screw surface as exemplified by the analysis of dependency (20). So, the increase of value ξ from 10° to 30° causes the 4.2 times shorter path l_p and 3.1 times less time t_p.

Figure 7 presents plots t_p and l_p versus friction coefficient of loose material on the screw elastic sections μ_1.

Similar to the previous case, increase of value μ_1 results in decreased values t_p and l_p. Thus, the increase of friction coefficient value μ_1 from 0.2 to 0.8 results in 1.6 times shorter path l_p and 1.09 times increase of time t_p.

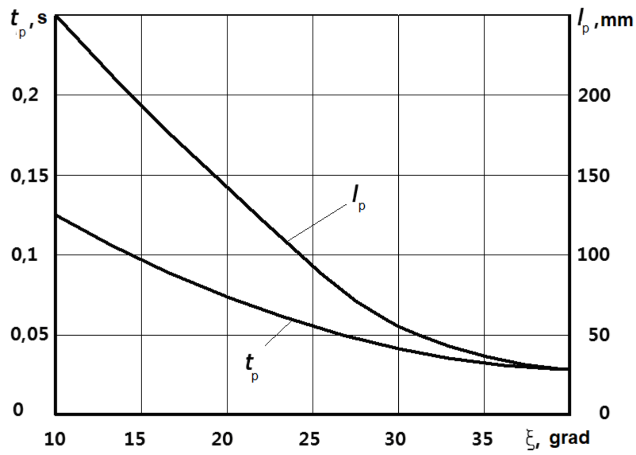

Fig. 6 – Dependencies t_p and l_p versus helix angle ξ of screw base screw surface

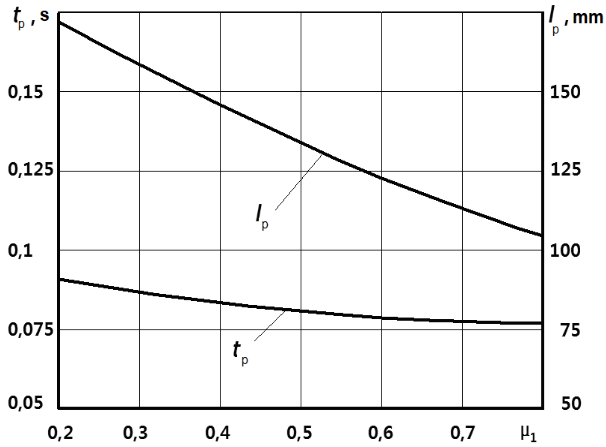

Fig. 7 – Dependencies t_p and l_p versus material friction coefficient μ_1 on screw elastic sections

Figure 8 presents plots t_p and l_p versus friction coefficient of loose material on the jacket internal surface μ_2.

Analysis of plots data shows that decreasing tendency of values t_p and l_p at increasing friction coefficient μ_2 is the same as in the previous case but the impact force is much bigger. Increase of friction coefficient μ_2 from 0.2 to 0.8 results in 2.1 times decrease of path l_p, and 1.5 times decrease of time t_p.

The following parameters have the opposite effect on the values t_p and l_p behavior.

Figure 9 presents plots t_p and l_p versus rotation frequency n of screw operating device. Rotation frequency n increase results in significant increase of value l_p due to the increase of velocity of particle's rolling off the external blade edge.

Thus, increase of value n from 200 to 800 rev/min results in approximately 5 times increase of value l_p.

In this case, time t_p is not changing greatly. It can be explained by the increase of angular velocity of screw rotation in such a way that the next section has approximately the same period of time to approach the flow particles.

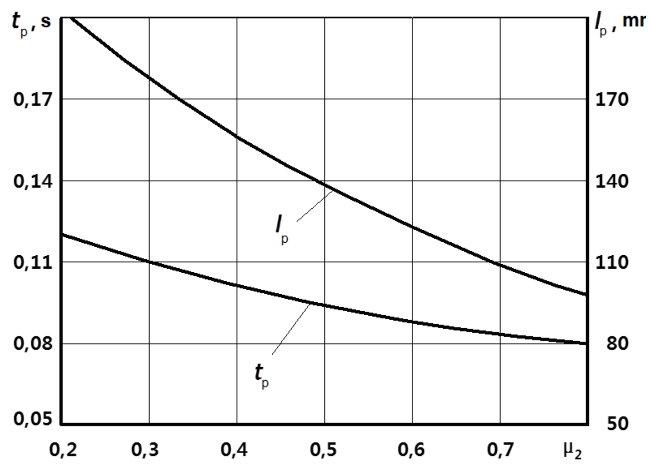

Fig. 8 – Dependencies t_p and l_p versus friction coefficient μ_2 of material on the jacket surface

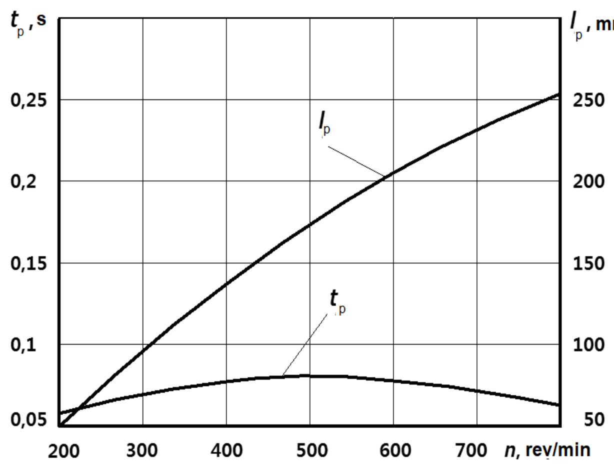

Fig. 9 – Dependencies t_p and l_p versus rotation frequency n of screw operating device

Figure 10 presents plots t_p and l_p against height h external blade edge position above the lower blade.

It was found that the given parameter has a little influence on the flow free motion, but the increased value h causes the increase of values t_p and l_p. In fact, time difference is proportional to the time of screw rotation by value h. Thus, increase of value h from 0.5 to 0.35 mm causes the 1.24 times increase of l_p and 1.14 times increase of t_p.

Figure 11 presents plots t_p and l_p versus material convergence angle which is determined by the inclination angle of external section edge ξ_1.

Unlike the previous case the change of inclination angle ξ_1 of external section edge greatly affects the value t_p and l_p. So, the increase of angle value ξ_1 from 25° to 45° results in 3.53 times longer path l_p and 3.16 times increase of time t_p.

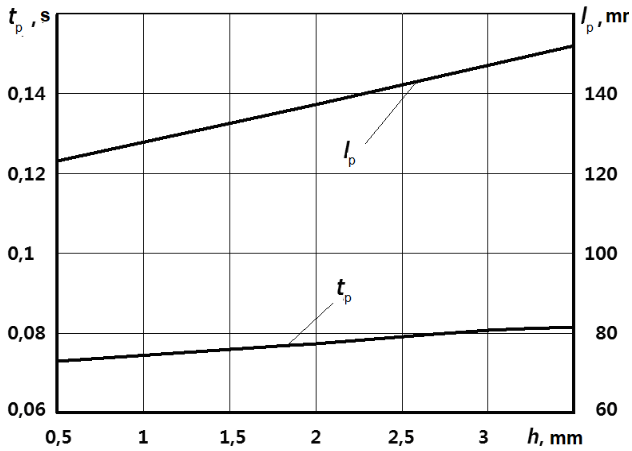

Fig. 10 – Dependencies t_p and l_p versus height h of external blade edge position above the lower blade

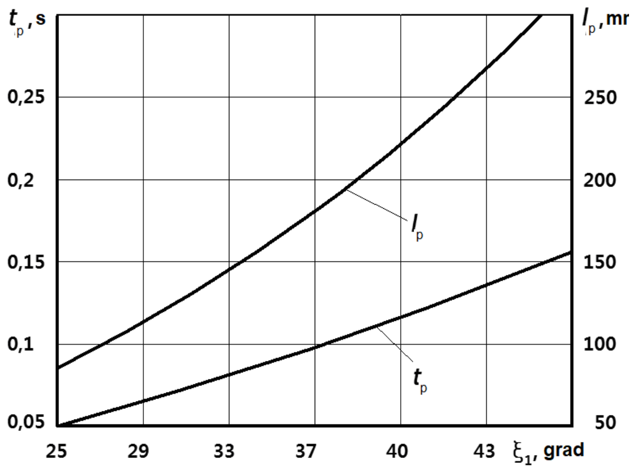

Fig. 11 – Time dependencies t_p and l_p versus inclination angle ξ_1 of external section edge

Analysis of diagrams on Figures 6 – 11 allows to evaluate the impact of each parameter of the system on the loose material flow behavior at its passing through the obstacle like a step between the screw plates.

CONCLUSIONS

The most efficient parameters of elastic sections interactions with the grain material of hemisphere-cone shape have been substantiated on the basis of obtained analytical dependencies.

The impact depth of interaction parameters of screw elastic section and a corn grain on the values of axial N_o and centrifugal force N_k has been determined. It was found that elasticity modulus of screw elastic section has the maximal impact on the values N_o and N_k. The second in importance on the value N_o are the initial angle of interaction of screw elastic edge with grain surface, length of cantilever overhang of screw elastic section and its inclination angle.

As for the centrifugal force N_k, the second in importance after the elasticity modulus regarding impact depth on its value is the inclination angle of elastic section screw surface.

The impact of elastic screw design and kinematic parameters on the loose material flow behavior in the area between the adjacent sections which are overlapped has been determined.

On the basis of obtained analytical dependencies and their analysis we came to the conclusion that the increase of friction forces both on the screw surface μ_1 and jacket surface μ_2 results in decrease of time t_p and path l_p of particles free motion of loose material flow. The increase of friction coeficient value μ_1 from 0.2 to 0.8 causes the 1.6 times shorter path l_p and 1.09 less time t_p. The increase of friction coeficient value μ_2 from 0.2 to 0.8 causes the 2.1 times shorter path l_p and 1.5 less time t_p.

The increase of screw helix angle ξ results in shorter path l_p and time t_p due to the decrease of loose material flow velocity against the screw surface. The increase of screw helix angle ξ from 10° to 30° results in 4,2 times shorter path l_p and 3,1 times more time t_p.

The change of rotation frequency of operating device n from 200 to 800 rev/min causes the 5 times increase of path l_p of particle free motion. In this case, the time of the particle free flight t_p does not change greatly, and it can be explained by the increase of angular velocity of screw rotation, so that the next section is able to approach the flow particles in approximately the same period of time.

It was found that height h of external section free end position over the lower section has a negligible effect on material flow though the increase of value h causes the increase of values of time t_p and path l_p.

Increase of value of inclination angle of external section edge ξ_1 from 25° to 45° results in 3.53 times longer path l_p and 3.16 times more time t_p.

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