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METHODOLOGY FOR REFINING THE PERFORMANCE OF SCREW CONVEYOR

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Summary. *Improving the existing designs of screw conveyors can significantly increase productivity and expand the functionality of transport mechanisms, which leads to further development of production. One of the reserves to increase the functionality of screw transport mechanisms is to improve the transportation process by developing combined screw working bodies that will ensure the simultaneous movement and grinding of materials. The objective of the work is to refine the mathematical model of productivity of the improved screw conveyor basing on coordination of supply of root crops from the loading channel to the auger and complex geometrical factor of filling the working space of a trench. The developed refined mathematical model allows to determine at the highest level the real productivity of simultaneous transportation and grinding of root crops on a separate technological unit, which is installed, for example, in the line of preparation and processing of root crops for biofuels. This allows to optimize the parameters and modes of operation of the entire processing complex at a practical level and ensure its estimated productivity of the manufacturing process.*

Key words*: loading channel, root crops, auger, knife, grinding, screw interturn volume, design and kinematic parameters, filling factor, complex geometric factor.*

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Statement of the problem. Developing of highly efficient technological processes for transportation of both single lump and bulk materials requires an integrated scientific approach to solving the problems of further improvement of screw mechanisms of transport systems in order to perfect their technological performance [1]. The problems are solved basing on further improvement of methodology and techniques of optimization of rational technological indicators of materials transportation process and structural and kinematic parameters and modes of operation of screw transport systems [2, 3].

The technological process of moving root crops by screw conveyor (SC), which simultaneously transports and grinds them for further processing of shredded root crops into biofuels, is one of the important and complex technical operations in the general context of the technological process of closed cycle energy production [4].

Increasing the productivity of technological equipment and the degree of yield of the final energy product are priorities in the general aspect of improving the technological and economic indicators of the national economy and ensuring the energy efficiency of Ukraine.

The proposed improved SC [5–10] with a combined working body is primarily characterized by operational and technological indicators, including technological capacity or manufacturability, regulates the productivity of transport mechanisms and, ultimately – the productivity of the entire processing complex.

Analysis of available investigations. In general, in most scientific papers, the productivity Q_m (kg/s) of SC work is determined for machines of continuous action by the formula

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$$Q_m = A\vartheta_n \rho \psi \, , \tag{1}$$

Depending on the purpose, angle of installation, material of transportation, etc., the most well-known transformed dependences to determine the productivity Q_m (t/h) of the SC are given in [11–14], which are recorded in the form of analytical dependencies:

$$Q_m = 47D^3 \rho \vartheta_n k_m c \psi \, ; \; Q_m = 3600 F_c \vartheta_n \rho ; \; Q_m = 47.1 \rho \psi T n c \left[(D + 2\lambda)^2 - d^2 \right] ; \tag{2}$$

$$Q_m = 15\pi D^2 T n \rho c \psi \, ; \; Q_m = 15\pi D^2 T n \rho \psi \, ; \; Q_m = 0.047 D^2 E \rho \psi n \lambda \, , \tag{3}$$

where D, d, T, n are respectively outer diameter (m), drum diameter (m), pitch (m), screw speed (rpm); c is the coefficient of the angle of inclination to the horizon; k_m is the coefficient of axial velocity of the material; F_c is the average cross-sectional area of the flow, m^2; λ is radial gap, m.

One of the main parameters that has a significant impact on the functional dependence of changes in productivity and power consumption of screw mechanisms depending on process parameters, both theoretical and experimental, is the filling factor ψ of the working space or working chute of SC [15].

At the first stage of determining the coefficient ψ, the initial generalizing record $\psi = \psi_o k_1 k_2 .. k_i$ ($i = 1, 2 \ldots, n$) is used where $\psi_o = V_m / V_k$ is the total value of the coefficient of filling the working space, which is defined as the ratio of the volume of material V_m in the gutter to the volume of the V_k gutter; $k_1 k_2 .. k_i$ are coefficients that depend on the design and geometry of the screw, the length of the loading and unloading neck, coefficients of friction, moisture content of the material, etc. [16].

In this case, summarizing the results of research, we can conclude that the most universal of them are the dependencies, which are given in [17, 18]:

$$\psi = 1 - (Kn / 1000); \; \psi = \left(1 - 0.4 \sin \beta\right) Km / \sqrt{n} \, , \tag{4}$$

where K is the coefficient that depends on the diameter of the screw; $\beta \le 30$ degrees is the angle of inclination of the SC to the horizon; m is the coefficient that depends on the length of the loading space.

To calculate the volumetric productivity of horizontal SCs [19], in which the auger is located in a closed casing, the most commonly used ‘classical’ formula, or its interpretation

$$Q_m = 0.25\pi \psi \vartheta_n^2 \left(D^2 - d^2\right) \text{, or } Q_m = 0.25\pi \left(D^2 - d^2\right)\left(T - \frac{b}{\cos \alpha}\right) n K_o \, , \tag{5}$$

where b is the thickness of the coil of rectangular cross section, m; K_o is the total complex coefficient, which reduces the load of the auger.

Kerzhentsev V.A. [20], taking into account the conclusions [21–24] (productivity gap is from 10 to 30%), to adjust the accuracy during the calculations proposed to introduce the operation of redistribution of arguments in the function of determining the productivity of Q_m of SC.

That is, first determine the diameter D of the SC auger depending on the introduced independent argument 'performance' Q_m, i.e.

$$D = \left(4Q_m / AC_1C_2\right)^{0,33}, \tag{6}$$

where C_1, C_2 are dimensionless coefficients obtained on the basis of transformation of the total complex coefficient K_o.

In this case, this technique allows to calculate the parameters of the auger, which provide a discrepancy of not more than 3.5% of the design.

Statement of the problem. Clarification of the mathematical model of the improved SC productivity based on the coordination of feeding the root crops from the loading channel to the auger and the complex geometric coefficient of filling the working space of the chute.

Materials and methods. Substantiation of rational parameters of the combined working body will be carried out on the basis of analytical study of its capacity or productivity Q_m of the improved SC (Fig. 1a) [5–10].

The main structural and kinematic parameters of the SC and their relationship is regulated by the criteria of the main indicators of technological and operational stability of the auger [25].

According to Fig. 1a, productivity Q_m of the improved SC in general and in the main aspect is regulated by the productivity of the auger 3, which is noted by Q_k. The criterion for the manufacturability of the process of simultaneous transportation and grinding of root crops with knives mounted on the auger drum will be the condition under which the capacity or productivity Q_k of the auger must be at least (greater than or equal) for feeding root crops W_k for a certain period of time t.

In order to formalize the process of loading root crops and their subsequent transportation by improved SC and to justify the rational parameters of the working bodies, consider the functional diagram of the technological process of the loading channel, which is shown in Fig. 1 b.

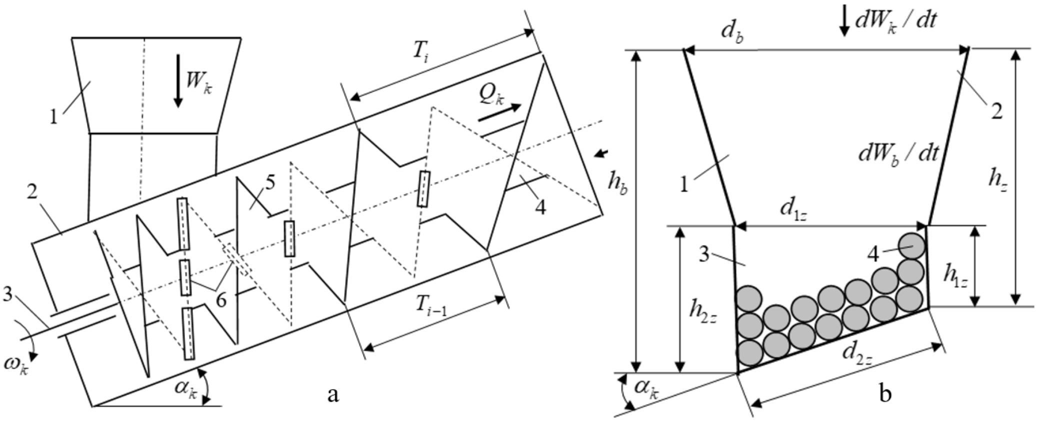

Figure 1. Scheme: a – improved screw conveyor: 1 – hopper; 2 – casing; 3 – auger; 4 – drum; 5 – turn; 6 – knife; b – to calculate the parameters of the loading channel: 1 – hopper; 2 – loading neck; 3 – output neck; 4 – root crop

The transport nodes of the loading channel are the hopper 1 (Fig. 1 b), which has a loading neck 2, that passes into the output neck 3.

The root crops 4 with the loading device through the loading neck 2 enters the hopper 1, and then through the upper and lower holes of the outlet neck 3 freely fall into the interturn space of the auger 3 (Fig. 1a). Here the root crops are simultaneously transported and shredded with knives 6, and then shredded root crops are unloaded through the unloading channel 3 (Fig. 1 b) SC.

To formalize the process of operation of the loading channel, we take the following assumptions (Fig. 1 b):

- the flow rate of root crops through the outlet 3 of the hopper 1 to the turns of the auger in the final aspect is not less than the capacity dQ_k / dt of the auger for time t;
- patterns of movement of roots crops in the the hopper 1 are described (subordinated) by the main processes of free flow of material from the container [26];
- the flow rate of root crops through the outlet 3 occurs in the process of draining the root crops into the funnel at an angle of natural slope to the period of destruction of the height of the dynamic unloading vault [26];
- the cross-section of the loading neck 2 and the upper hole of the output neck of the hopper 1 are circular, and the cross-section of the lower hole of the output neck 3 is elloipse-shaped.

The diameter of the loading neck is noted by d_b, the diameter of the upper hole of the output neck is noted by d_{1z}, the small and large axes of the ellipse are noted by $a_1 = d_{1z}$, $b_1 = d_{2z}$, respectively.

Results and discussion. The capacity of the hopper dW_b / dt in the general context is regulated by the root crops flow through the lower opening of the output neck of the hopper.

According to the previous assumptions, as well as the fact that the cross-sectional area of the upper outlet or the area S_1 of a circle with a diameter d_{1z} is always less than the cross-sectional area of the lower outlet, or the area of an ellipse S_2 whose small axis is equal to the diameter of the circle d_{1z}.

That is $S_1 < S_2$, the flow of material through the output neck of the hopper (or in our case – the capacity of the hopper dW_b / dt) will be regulated primarily by the flow of material through the upper hole of the outlet of the hopper.

Based on this, we can write the inequality that characterizes the manufacturability of simultaneous transportation and grinding of roots by the auger of the improved SC, or its condition of rational functioning

$$dM_k / dt \geq dW_k / dt \text{, або } Q_k \geq W_k , \tag{7}$$

where dM_k / dt is the mass of unloaded crushed root crops through the unloading channel of the improved SC for time t, kg; dW_k / dt is total weight (supply) of loaded root cops through the loading channel (hopper) for time t, kg; Q_k is productivity of the auger, kg/s; W_k is supply of root crops, which are loaded through the hopper of the improved SC per second, kg/s.

Functional relationship between the dimensional parameters of the loading channel 1 (Fig. 1 b) and structural and kinematic parameters of the auger 3 (Fig. 1 a) of the improved SC will be determined based on theoretical analysis of the total mass (feed) of loaded root crops dW_k / dt through the hopper, hopper capacity dW_b / dt (kg), the required design capacity dQ_k / dt of the auger for time t.

In this regard, condition (7) is written in the form

$$dQ_k / dt \geq dW_b / dt \geq dW_k / dt\,, \tag{8}$$

and according to [17] the capacity of the hopper W_b (kg/s) is

$$W_b = V_v \rho S_o = \lambda_u \rho S_o \sqrt{3.2 g R_k} \,/\, \sqrt{f_m}\,, \tag{9}$$

where $V_v = \lambda_u \sqrt{3.2 g R_k}$ is the flow rate of the root crops from the hopper hole, m/s; λ_u is the coefficient of load resistance; R_k is reduced critical radius of the hole, m; ρ is volume weight of load, kg/m^3; S_0 is the area of the the load outlet channel of the hopper, m^2; g is free fall acceleration, m/s^2; f_m is the coefficient of internal friction.

Then, according to dependence (9), the capacity of the hopper dW_b / dt (kg) for the period of time t is determined by the formula [12]

$$dW_b = \left(\lambda_u \rho_k S_1 \sqrt{1.6 g d_{1z}} \,/\, \sqrt{f_m} \right) dt\,, \tag{10}$$

where $\lambda_u = 0.65$ is the coefficient of resistance for dry lump loads [3]; $\rho_k = 550$ kg/m^3 is the volume weight of root crops; $S_1 = 0.25\pi \left(d_{1z} - a' \right)^2$ is the area of the upper hole of the output neck of the hopper, taking into account the lumpiness of the load, m^2; d_{1z} is the reduced diameter of the upper hole of the output neck of the hopper, m; a' is an average transverse size of root crops, m; $f_m = 0.25 d_{1z} / \left(h_{1z} + h_{2z} \right)$ is coefficient of internal friction; h_{1z}, $h_{2z} = h_{1z} + d_{2z} \sin \alpha_k$ is height of the vault, m.

After substituting the component values in (10), we obtain

$$dW_b = \left(\lambda_u \rho_k \pi \left(d_{1z} - a' \right)^2 \sqrt{1.6 g d_{1z} \left(2h_{1z} + d_{2z}\, sin\, \alpha_k \right)} \,/\, 2\sqrt{d_{1z}} \right) dt\,, \tag{11}$$

the productivity of the auger Q_k (kg/s) is determined by the general formula for the productivity of machines of continuous action, i.e.

$$Q_k = F_v \rho_k \mu_n \psi_\alpha V_w\,, \tag{12}$$

where F_v is cross-sectional area of the load flow, m^2; ψ_α is the coefficient of the angle of the auger to the horizon; V_w is the average speed of movement (transportation) of load in the direction of the output part of the auger, m/s.

The auger feed rate (productivity ratio) is determined according to [26]:

$$\mu_n = k_z - \lambda_c\,;\ V_n = V_{o.m} k_v\,;\ k_v = k_\alpha k_y\,, \tag{13}$$

where k_v, k_α, k_y are, respectively: sliding coefficient; a coefficient that shows the degree of influence of the angle of rise α of the helix along the average radius of the last turn of the auger; the coefficient of compaction of crushed roots by turns of the auger.

In this regard, given the above, it can be stated that for our case:

- in the absence of "leakage" of crushed roots through the gap ($\lambda_c = 0$), the value of the screw feed factor μ_n will be equal to the fill factor k_z, or $\mu_n = k_z$;
- the average speed V_w of axial movement of crushed roots by turns of the auger and the value of the step of the last turn $T_i = T_1 + n\Delta T$ under the accepted condition that $T_2 = T_1 + \Delta T$;…;$T_i = T_{i-1} + \Delta T$; is determined

$$V_w = \frac{T_i \omega_k}{2\pi} k_v = \frac{\left(T_1 + n\Delta T\right) k_v}{2\pi} \frac{d\varphi_k}{dt}, \tag{14}$$

where ω_k is the angular speed of the auger, deg./s; φ_k is the angle of rotation of the auger, degrees;

- the cross-sectional area of the load flow F_v will be equal to the inner cross-sectional area of the casing F_k

$$F_k = 0.25\pi d_k^2 = 0.25\pi \left(D_k + c_v\right)^2, \tag{15}$$

where c_v is the gap between the turning and the casing, m.

After a series of transformations we obtain the dependence to determine the required design capacity dQ_k / dt of the auger over time t, while the outer diameter D_k of the auger during the design of auger screw mechanisms that transport lump materials is taken by the ratio $D_k = k_d d_m$, where k_d = 6…8 is the ratio where the diameter of the auger drum pipe will be defined as a relation $d_m = D_k / k_d$

$$dQ_k = 0.125 D_k^2 \rho_k \psi_\alpha \left(T_1 + n\Delta T\right) k_a k_y \left(\frac{d\phi_k}{dt}\right) \varPhi, \tag{16}$$

where $\varPhi = \left(1 - \frac{1}{2\pi k_d^2}\left[\frac{1}{\pi} + \frac{4\varOmega\delta_c z\left(k_d - 1\right)k_d}{n\left[2T_1 + \varDelta T\left(n-1\right)\right]D_k} + \theta_1\left(n_z n - 1\right)\delta_n \times \times\left(\frac{2D_k k_d\left(a+b\right)\left(\left(k_d-1\right)\right)\cos\gamma_n - \delta_n\left[2btg\alpha_n\cos\gamma_n + \frac{D_k}{k_d}\left(k_d-1\right)\right]}{D_k^2 n_z n\left[2T_1 + \varDelta T\left(n-1\right)\right]\cos\gamma_n} - \frac{\varTheta}{\delta_n}\right)\right]\right)dt$; δ_c is the thickness of the spiral coil blade, m; Z is the number of auger measures, pcs.; a, b are the bases of a trapezoid of a knife, m; δ_n is prism height (knife thickness), m; γ_n -is the angle between the height of the knife and the edge of the trapezoid, deg.; n_z is the number of turns of one step, pcs.; ΔT is the increment of step pitch, m; n is the number of T_i -steps, pcs.; θ_1 is the number of knives of one step, pcs.;

$$\mathit{\Omega} = \sqrt{T_1^2 + 0.25\left(D_k + d_m\right)^2} + \sqrt{\left(T_1 + \mathit{\Delta} T\right)^2 + 0.25\left(D_k + d_m\right)^2} + \\ + ... + \sqrt{\left[T_i + \mathit{\Delta} T\left(n-1\right)\right]^2 + 0.25\left(D_k + d_m\right)^2} ;$$

$$\Theta = \left(\frac{\pi \arcsin \frac{a}{d_m}}{180} \right) + \frac{a}{d_m} \cos \arcsin \frac{a}{d_m} .$$

The developed dependence (16) is a mathematical model that characterizes the change in the capacity dQ_k / dt of the improved SC over a period of time t depending on the design and kinematic parameters of the auger.

For the practical use of model (16) we will perform the following transformations:

- express the component of the angular velocity of the auger $d\varphi_k / dt$ through the frequency of rotation of the auger, where $d\varphi_k / dt = \omega_k = \pi n_k / 30$, when n_k is the frequency of rotation of the auger, rpm;
- express the parameters of the shredder knife a and b through the parameters of the auger, while for simplicity we assume that the large base of the shredder knife is approximately equal to a quarter of the length of the drum drum circle, i.e. $a \cong l_{d_m} / 4 \cong 0{,}25\pi d_m \cong 0{,}25\pi D_k / k_d$, where l_{d_m} is the length of the screw drum circle, m.

In this case, we obtain:

$$b = a - 2h_n tg\gamma_n = 0{,}25\pi D_k / k_d - 2 \cdot 0.5\left(D_k - d_m\right) tg\gamma_n = \frac{D_k}{k_d}\left[0.25\pi - tg\gamma_n\left(k_d - 1\right)\right]. \quad (17)$$

$$a + b = 0.25\pi D_k / k_d + D_k\left[0.25\pi / k_d - tg\gamma_n\left(1 - k_d^{-1}\right)\right] = \frac{D_k}{k_d}\left[0.5\pi - tg\gamma_n\left(k_d - 1\right)\right] \quad (18)$$

.

Then the dependence to determine the performance Q_k of the improved SC after simplification will have the final form

$$Q_k = \frac{\pi n_k D_k^2 \rho_k \psi_\alpha \left(T_1 + n\mathit{\Delta} T\right) k_a k_y}{240} K ; \quad (19)$$

or in simplified form

$$Q_k = \frac{\pi n_k D_k^2 \rho_k \psi_\alpha \left(T_1 + n\Delta T\right) k_a k_y}{240} \left(1 - k_n\right). \quad (20)$$

where $$K=\left(1-\frac{1}{2\pi k_d^2}\left[\frac{1}{\pi}+\frac{4\Omega\delta_c z\left(k_d-1\right)k_d}{n\left[2T_1+\Delta T\left(n-1\right)\right]D_k}+\frac{D_k}{k_d}\theta_1\delta_n\left(n_z n-1\right)\times\left(\frac{\begin{array}{l}D_k k_d\left[\pi-tg\gamma_n\left(k_d-1\right)\right]\left(\left(k_d-1\right)\right)cos\,\gamma_n-\\-\delta_n\left[\left[0{,}5\pi-tg\gamma_n\left(k_d-1\right)\right]tg\alpha_n\,cos\,\gamma_n-2\left(k_d-1\right)\right]\end{array}}{D_k^2 n_z n\left[2T_1+\Delta T\left(n-1\right)\right]cos\,\gamma_n}-\frac{k_d\Theta}{D_k\delta_n}\right)\right]\right);$$

k_n the geometric constructive coefficient, which is determined by the analytical expression written in parentheses after the writing ‘1 –‘ in formula (19), that is

$$k_n=-\frac{1}{2\pi k_d^2}\left[\frac{1}{\pi}+\frac{4\Omega\delta_c z\left(k_d-1\right)k_d}{n\left[2T_1+\Delta T\left(n-1\right)\right]D_k}+\frac{D_k}{k_d}\theta_1\delta_n\left(n_z n-1\right)\times\left(\frac{\begin{array}{l}D_k k_d\left[\pi-tg\gamma_n\left(k_d-1\right)\right]\left(\left(k_d-1\right)\right)cos\,\gamma_n-\\-\delta_n\left[\left[0{,}5\pi-tg\gamma_n\left(k_d-1\right)\right]tg\alpha_n\,cos\,\gamma_n-2\left(k_d-1\right)\right]\end{array}}{D_k^2 n_z n\left[2T_1+\Delta T\left(n-1\right)\right]cos\,\gamma_n}-\frac{k_d\Theta}{D_k\delta_n}\right)\right]. \qquad (21)$$

According to the formula (20) under the initial conditions ρ_k = 550 кг/м^3; ψ_a = 0.7; k_a = 0.65; k_y = 0.7; k_n = 0.7 the dependence of the change in productivity Q_k on the main structural-kinematic and technological parameters of the auger in the form of a functional is drawn: Fig. 2a – $Q_k=f\left(D_k;T_1\right)$ when $\Delta T=$ 0.04 m; Fig. 2b – $Q_k=f\left(D_k;n_k\right)$ when $\Delta T=$ 0.04 m; Fig. 3 – $Q_k=f\left(D_k;\Delta T\right)$ when $T_1=$ 0.11 m; Fig. 4a – $Q_k=f_Q\left(D_k\right)$; Fig. 4 b – $Q_k=f_Q\left(n_k\right)$; Fig. 4c – $Q_k=f_Q\left(\Delta T\right)$.

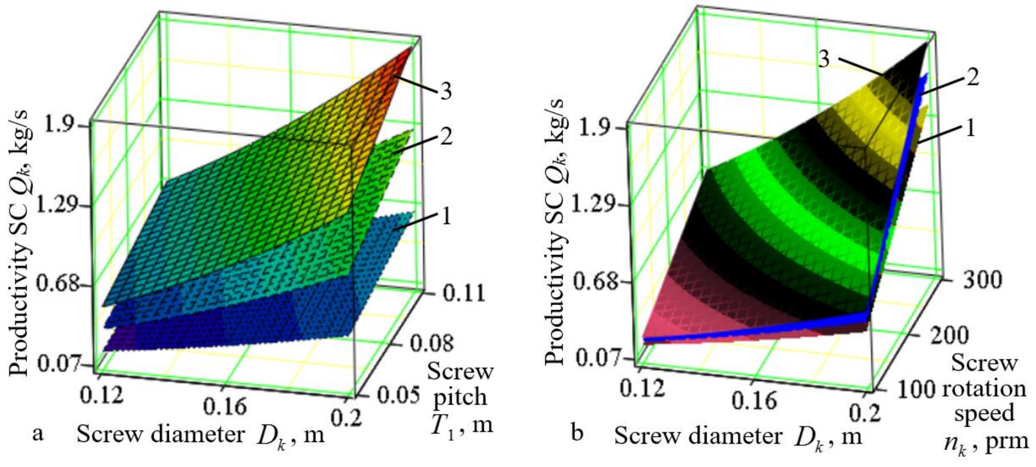

Figure 2. Dependence of changes in productivity Q_k of the improved SC as a functional: a – $Q_k=f_Q(D_k;T_1)$, 1, 2, 3 – $n_k=100, 200, 300$ rpm; б – $Q_k=f_Q(D_k;n_k)$, 1, 2, 3 – $T_1=0.05;\ 0.08;\ 0.11$ m;

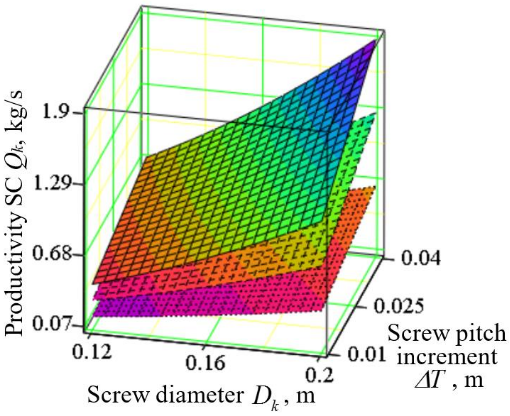

Figure 3. Dependence of changes in productivity Q_k of the improved SC as a functional $Q_k = f_Q(D_k; \Delta T)$, 1, 2, 3 – n_k = 100, 200, 300 rpm

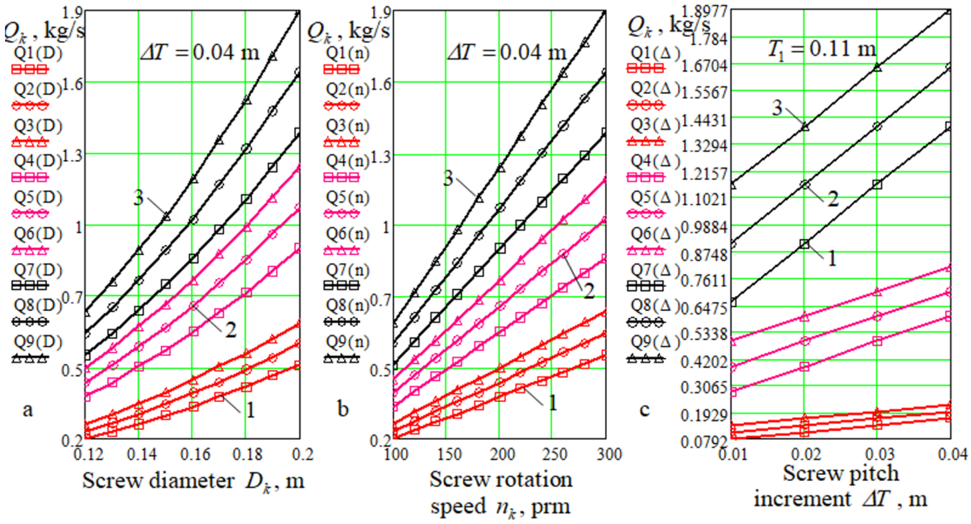

Figure 4. Dependence of changes in productivity Q_k of the combined SC as a functional:
a – $Q_k = f_Q(D_k)$: Q1, Q2, Q3 – $n_k = 100$ rpm, Q4, Q5, Q5 – $n_k = 200$ rpm,
Q7, Q8, Q9 – $n_k = 300$ rpm, 1, 2, 3 – $T_1 = 0.05; 0.08; 0.11$ m; b – $Q_k = f_Q(n_k)$:
Q1, Q2, Q3 – $D_k = 0.12$ m; Q4, Q5, Q5 – $D_k = 0.16$ m; Q7, Q8, Q9 – $D_k = 0.2$ m;
1, 2, 3 – $T_1 = 0.05; 0.08; 0.11$ m; c – $Q_k = f_Q(\Delta T)$: Q1, Q2, Q3 – $n_k = 100$ rpm,
$D_k = 0.12$ м; Q4, Q5, Q5 – $n_k = 200$ rpm, $D_k = 0.16$ m; Q7, Q8, Q9 – $n_k = 300$ rpm,
$D_k = 0.2$ m; 1, 2, 3 – $T_1 = 0.05; 0.08; 0.11$ m

It is found that the estimated productivity Q_k of the improved SC is in the range of $Q_k = 0.07 \ldots 1.9$ kg/s, and depending on the parameters of the auger has a directly proportional functional nature of change – with increasing rotation speed n_k, diameter D_k, pitch T_1 and auger increment increase ΔT productivity Q_k increases. Dominant factors that have a significant impact on productivity increase Q_k are the rotatin speed n_k and diameter D_k of the auger.

A significant increase in the theoretical design productivity Q_k of the improved SC occurs at a diameter $D_k \geq 0.16$ m and a screw speed $n_k \geq$ 200 rpm. The average value of the increase Q_k is (varies) in the range from 0.8 to 1.2 kg/s depending on the value of the step of the first turn T_1 and the increase in the increment of the step ΔT .

At the screw rotation speed in the range of $100 \leq n_k \leq 200$ rpm, the increase in productivity Q_k of the SC in the general context is insignificant and averages 0.3 kg/s (Fig. 4 a, b, c).

A significant increase in productivity Q_k of the improved SC depending on the increase in step increment ΔT occurs at a speed $n_k \geq 300$ rpm and a screw conveyor diameter $D_k \geq$ 0.2 m, with an average increase Q_k is 0.7…0.8 kg/s. When a screw diameter is $D_k \leq$ 0.12 m, the increase in SC productivity is insignificant (within 0.04…0.06 kg/s), or practically non-existent, Fig. 3 c.

Thus, based on the theoretical analysis of the structural scheme and the technological process of functioning of SC, it can be stated that the rational structural and technological parameters of the adopted constructive model of the improved SC will be:

- the structural geometric coefficient k_n of the auger is in the range of 0.026…0.07;
- filling factor k_z of the working space of the improwed SC is I the range of 0.7…0.94;
- the estimated productivity Q_k of the improved SC will be $Q_k = 0.07 \ldots 1.9$ kg/s;
- the diameter d_{2z} of the load output hole of the outlet channel of the loading hopper is from 0.07 to 0.22 m.

Conclusions. According to the results of the analysis of the technological process of simultaneous transportation and crushing of root crops, it can be stated that the developed mathematical model of productivity of the improved SC allows optimization of rational parameters of the process of transport screw mechanisms.

It was found that the estimated productivity Q_k of the improved SC is in the range of $Q_k = 0.07 \ldots 1.9$ kg/s, depending on the parameters of the auger has a directly proportional functional nature of change – with the increasing of rotation speed n_k, diameter D_k, pitch T_1 and increment ΔT of the auger productivity Q_k increases. A significant increase in productivity Q_k depending on the increase in step increment ΔT occurs at a speed $n_k \geq$ 300 rpm and a screw diameter $D_k \geq$ 0.2 m, with an average incrase Q_k of 0.7…0.8 kg/s. With a value of diameter $D_k \leq$ 0.12 m, the increase in productivity is insignificant – from 0.04 to 0.06 kg/s or almost does not take place.

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МЕТОДОЛОГІЯ УТОЧНЕННЯ ПРОДУКТИВНОСТІ РОБОТИ ГВИНТОВОГО КОНВЕЄРА

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***Резюме**. Удосконалення існуючих конструкцій гвинтових конвеєрів дозволяє істотно підвищити продуктивність і розширити функціональні можливості роботи транспортних механізмів, що призводить до подальшого розвитку виробництва. Одним із резервів підвищення функціональних можливостей гвинтових транспортних механізмів є удосконалення процесу транспортування шляхом розроблення комбінованих гвинтових робочих органів, які забезпечать одночасне переміщення та подрібнення матеріалів. Для реалізації технологічного процесу одночасного транспортування та подрібнення коренеплодів, наприклад, під час приготування концентрованих кормів, або переробки коренеплодів на біологічне пливо, ми розробили комбінований робочий орган, який складається з направляючого кожуха та встановленого в ньому шнека. На витках шнека закріплено ріжучі ножі. Під час обертання шнека ріжучі ножі подрібнюють коренеплоди одночасно з їх переміщенням уздовж осі обертання шнека. Метою роботи є уточнення математичної моделі продуктивності удосконаленого гвинтового конвеєра на основі узгодження подачі коренеплодів із завантажувального каналу до шнека та комплексного геометричного коефіцієнта заповнення робочого простору жолоба. Розроблена уточнена математична модель дозволяє на вищому рівні прогнозувати й точніше визначати реальну продуктивність одночасного транспортування й подрібнення коренеплодів окремого технологічного вузла, який встановлений, наприклад, у лінії підготовки та переробки коренеплодів під час приготування концентрованих кормів, або на біологічне паливо. Це дозволяє на практичному рівні оптимізувати параметри й режими роботи робочих органів переробного комплексу та забезпечити їх розрахункову продуктивність, або прикінцеву технологічну продуктивність усього процесу виробництва продукції.*

***Ключові слова**: завантажувальний канал, коренеплоди, шнек, ніж, подрібнення, міжвитковий об’єм шнека, конструктивно-кінематичні параметри, коефіцієнт заповнення, комплексний геометричний коефіцієнт.*

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