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DETERMINATIVE MATHEMATICAL MODEL OF SCREW CONVEYOR OPERATION

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Abstract. *Screw conveyors are used in the construction of machines in various industries, including the agricultural sector. They are designed for horizontal, inclined and vertical movement of root crops and can simultaneously perform related functions – their crushing and transportation. The stability or technological integrity of the process of transporting crushed root crops by a screw conveyor largely depends on the stochastic change in the input and output flows, or their disorganization. The article presents a mathematical model that describes the process of transporting crushed root crops taking into account the disorganization of the output flow of the hopper and the output flow of the collecting channel. Based on the model, an analytical dependence is developed to determine the coefficient of disorganization of flows and the limits of its change are established. It is substantiated that the rational operation of the screw conveyor occurs when the value of the disorganization of the output flow of the hopper and the collecting channel is equal to zero, at which the disorganization coefficient is also equal to zero.*

Key words: *root crops, aggregate bunker, aggregate channel, input flow, output flow, model, flow disorganization coefficient.*

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1. INTRODUCTION

The development of highly efficient technological processes for transporting both single lumpy and bulk materials requires an integrated scientific approach to solving the problems of further improving the screw mechanisms of transport systems of machines in order to increase their technological performance [1].

The tasks are solved on the basis of further improving the methodology and techniques for optimizing the technological performance of the process of transporting materials and the structural and kinematic parameters and operating modes of transport systems [2].

Screw conveyors as transport mechanisms are used in the agricultural sector of production, processing and food industries, the specificity of which is due to the presence of a wide range of technological processes for collecting and processing crop products [3, 4].

At the same time, screw conveyors, due to their design features, can simultaneously perform several related functions and operations – mixing products, grinding or crushing materials, dosing, etc. [5, 6].

Improving existing designs of screw transport mechanisms and substantiating their rational parameters and operating modes allows to significantly increase work productivity and reliability of technological operations.

The analysis of the current state of functioning of screw transport mechanisms [7–10] showed that there are significant prerequisites for further scientific work aimed at developing, researching and introducing into production energy-saving, high-tech screw conveyors with combined working bodies, which ensure the effective implementation of related functional operations of both transportation and simultaneous grinding of raw materials from agricultural products in the process of its processing.

All this will allow us to develop methods and methodologies at the scientific level for substantiating, calculating and optimizing the parameters and operating modes of transport systems, draw well-founded conclusions and, based on the results of effective modeling, provide rational recommendations for the use of transport mechanisms [11].

2. MATERIALS AND METHODS

According to the concept of Ukraine's transition to sustainable development, one of the strategic measures in the industrial sector is to increase the productivity and reduce the energy consumption of the screw conveyors used in the technological lines of raw material processing in the agro-industrial sector for the production of diverse national economic products [12].

Considering the significant technological and design shortcomings, based on the analysis of the current state of functioning of screw transport mechanisms, we have put forward a scientific hypothesis that provides the prerequisites for further research aimed at expanding the functional capabilities of screw transport devices through the development and application of energy-saving and multifunctional combined working bodies of screw conveyors. The implementation of such a technical solution in production conditions will ensure an effective combination of related functional operations of both transportation and simultaneous crushing of root crops by one working body of a screw conveyor, which is mounted in a technological line intended for their processing [13, 14].

The technological and constructive capacity of the implementation of the scientific hypothesis is presented in the form of a structural and functional diagram of the technological process of preparation and processing of root crops, which is shown in Fig. 1.

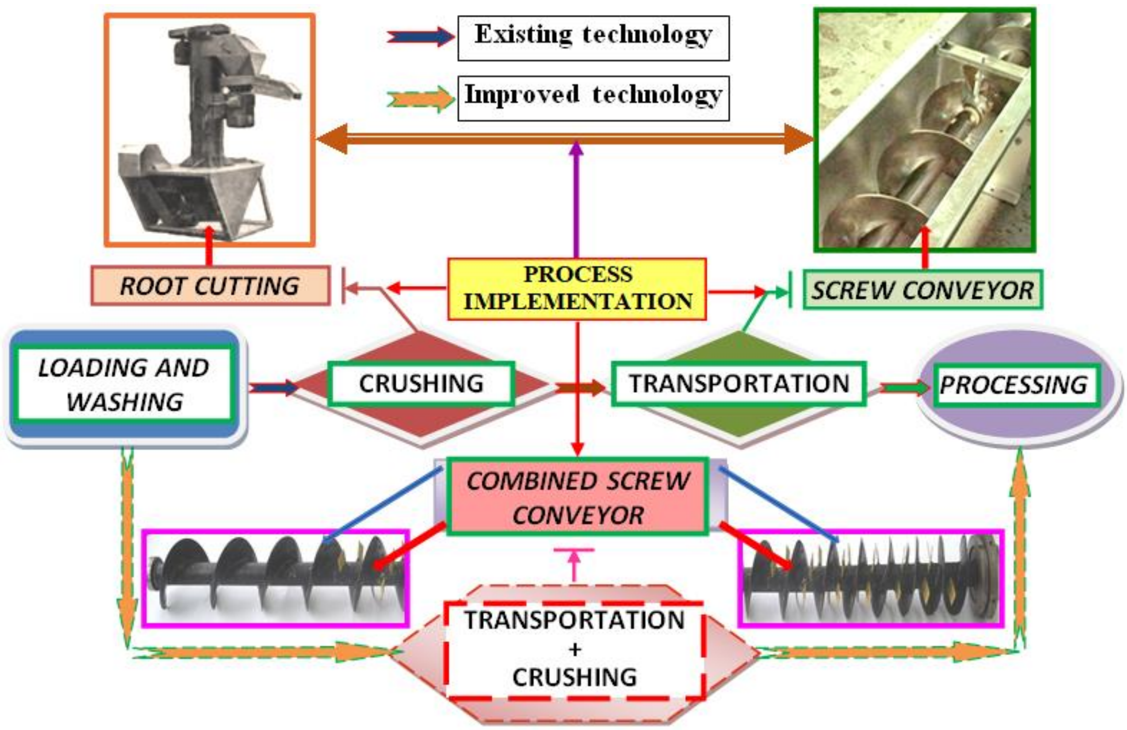

Figure 1. Structural and functional diagram of the technological process of preparation and processing of root vegetables

The diagram shows comparative ways of implementing the existing and proposed improved technology of processing root crops into raw materials of diverse purposes and applications using screw conveyors with a combined working body.

The improved technology for processing root vegetables, unlike the existing technology, in which the operation of «crushing» and «transporting» root vegetables is performed by two separate technical means (root cutter and screw conveyor), involves combining two related operations of «transportation + crushing» root vegetables by one transport mechanism – an improved screw conveyor with a combined working body.

The implementation of the improved technology for processing root vegetables will significantly reduce the energy intensity of the process compared to the existing technology by eliminating an additional intermediate operational and technological means (root cutter) as a separate technical executive element, which has its own certain material consumption and certain energy costs for the independent drive of the working bodies.

The basic elements that regulate the determination of technological and structural-kinematic parameters of screw conveyors with a combined working body should be:

- study of the process of simultaneous transportation of discrete units of crushed material (crushed root crops) by screw conveyors with a combined working body;
- establishment of rational parameters of screw conveyors with a combined working body based on the study of the required productivity of its work and taking into account the refined filling coefficient of the working casing;
- experimental study of technological indicators of the work process depending on the change in the main structural-kinematic parameters of the combined screw conveyor.

3. RESULTS AND DISCUSSION

The purpose and essence of any model is that it should adequately describe and characterize the main properties of the object of scientific research. In addition, it should be more convenient from the point of view of conducting research than a real existing object, and reflect its essential (essential) and non-essential properties, which depend on the set goals and objectives of the research. In this aspect, the theoretical model of the transport system should more adequately describe the laws, principles and, to a lesser extent, the form of their implementation in a specific working case [15].

Based on the analysis of the technological processes of the operation of transport systems, the determining processes were established, which the theoretical model should reflect:

- by the presence of interaction of subsystems or systems in general;
- interaction of individual structural elements in the transport system;
- the essence of the nature of the technological process of transmission and transformation of transport flows;
- the tasks and essence of managing (regulation, control, etc.) transport flows in subsystems and transport systems in general.

All this will allow, at the scientific level, to develop methods and methodologies for substantiation, calculation and optimization of parameters and operating modes of transport systems, to draw substantiated conclusions and, based on the results of effective modeling, to give rational recommendations for the use of transport mechanisms.

In our case, taking into account the design features of an improved screw conveyor or transport system (Fig. 2), the constituent structural elements «passage channel» and «loading hopper» were chosen as the basic elements of the theoretical model.

At the same time, in this aspect, these structural elements in the general context are quite abstract.

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«Passage channel» is a generalized device designed to pass volumetric, mass, piece, etc. units of material (hereinafter – discrete units of material) of the transport flow, «loading hopper» is a generalized device that has the property of accumulating discrete units of material of the transport flow and transforming its properties [16].

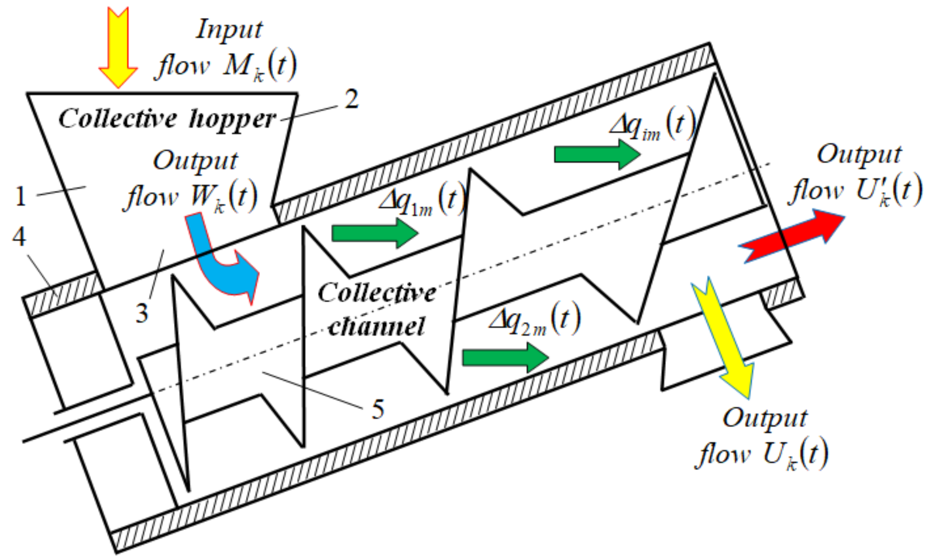

Figure 2. Functional model of an improved screw conveyor:
1 – loading hopper; 2, 3 – inlet and outlet neck; 4 – casing; 5 – screw

In the theoretical model, the entire system is a combined channel and hopper (Fig. 2) In this context, a screw conveyor with a combined working body as a separate transport system performs a dual function – the function of a channel for passing transport flows and the function of an accumulation hopper, in which the corresponding processes, or the corresponding process disturbances, are formed, amplified and absorbed.

That is, the interaction of these structural elements characterizes and regulates technological processes in individual transport mechanisms and transport systems in general.

To develop an ideal mathematical model of a transport system (an improved screw conveyor), it is necessary to accept and record the initial concepts and initial conditions, that is, to the extent possible, to formalize (accept certain assumptions and simplify the work process) the object of study.

In this case, the transport flow is taken to be a set of discrete units of material that moves through the system – a combined loading hopper and a channel:

- a loading hopper (combined hopper) is a structural element of a transport system that is described and characterized by the following technological parameters, in which case: the input flow of discrete units of material into the input mouth of the combined hopper is denoted by $M_k(t)$; the output flow of discrete units of material through the output mouth of the combined hopper is denoted by $W_k(t)$; the current capacity of the loading hopper or the technological state of the loading hopper is denoted by $M_o(t)$; the limiting or stationary capacity of the loading hopper is denoted by Q_o;
- aggregate channel is a structural element of the transport system with the following parameters: the input flow of discrete units of material into the aggregate channel (into the screw conveyor auger) is denoted by $W_k(t)$, which is adequate to the output flow of discrete units of material through the output mouth of the screw conveyor loading hopper; the output

flow of discrete units of material from the aggregate channel, depending on the technological need of the material unloading location, is denoted, respectively, by $U_k(t)$ and $U'_k(t)$; the time of movement of discrete units of material in the aggregate channel of the conveyor auger is denoted by $\tau_k(t)$;

- the throughput of the transport system is denoted by $Q_m = const$; the amount of increase in the throughput of the transport system due to an increase in the pitch of the next spiral turn of the auger is denoted, respectively, by $\Delta q_{1m}(t)$, $\Delta q_{2m}(t),\ldots,\Delta q_{im}(t)$, $i=1,2,...,n$; the input $W_k(t)$ and output $U_k(t)$ or $U'_k(t)$ flows do not exceed the throughput of the aggregate channel, which is denoted by Q_k, are non-constant and change in time; the output flow of the channel $U_k(t)$ or $U'_k(t)$ is equal to the input flow $W_k(t)$, provided that there is some difference in the time of movement of a discrete unit of material; the time of movement of discrete units of material, unlike the throughput of the channel, is a non-constant value, i.e. $\tau_k(t) \neq const$.

From the point of view of the system approach to the analysis of technological objects, it is known that the analytical description of complex transport systems and working bodies that transport the input flow of technological mass must be modeled on the basis of material balance equations and the concept of "input-output" of the system [17]. In this context, theoretical studies of the technological process of moving discrete unit materials were carried out by modeling the process of their transportation along the working bodies of an improved screw conveyor using material balance equations and the concept of «input-output» of a complex material dynamic system [18].

To analyze the technological process of transporting discrete units of crushed root vegetables by an improved screw conveyor, we will consider its structural and functional diagram, which is shown in Fig. 2. In this aspect, the functioning (functional description) of the technological process of transporting discrete units of crushed root vegetables by an improved screw conveyor can be represented as the movement of a continuous discrete flow along its working structural elements or bodies [19].

Based on the assumptions made and in accordance with Fig. 2 and coordination of the functioning of the input and output transport flows, the following analytical relations or functional conditions can be written down, characteristic and abstracted for each structural element of a complex transport system (improved screw conveyor) [20]:

- for a cumulative bunker, the following basic technological conditions are observed for all values of time t:

$$M_o(t) \le Q_o; \quad M_o(t+\Delta t) = M_o(t) + M_k(t) - W_k(t) \le Q_o; \tag{1}$$

- for a cumulative channel:

$$W_k(t) \le Q_m \le Q_k; \; U_k(t) \le Q_m \le Q_k; \; U_k(t) = W_k\left[t - \tau_k(t)\right] \le Q_m \le Q_k; \tag{2}$$

$$W_k(t+\Delta t) \le U_k(t) \le W_k(t) + \Delta q_{1m}\left[\tau_{1k}(t)\right] + \Delta q_{2m}\left[\tau_{2k}(t)\right] + \ldots + \Delta q_{im}\left[\tau_{ik}(t)\right] \le U_k(t); \tag{3}$$

$$W_k(t+\Delta t) \le U_k(t) \le W_k(t) + \sum_{i=1}^{n} q_{im}\left[\tau_{ik}(t)\right] \le U_k(t),\; i = 1, 2, \ldots, n, \tag{4}$$

where $\Delta t = 1$ is the unit time of passage of a discrete unit of material.

Then, according to equations (1)-(4), the condition can be written down

$$M_o(t+1) \le W_k(t+1) \le U_k(t) \le W_k(t) + \sum_{i=1}^{n} q_{im}\left[\tau_{ik}(t)\right] \le U_k(t) \le Q_o \le Q_m \le Q_k \le U_k(t), \tag{5}$$

while

$$M_o(t+1) = M_o(t) + M_k(t) - W_k(t) \le W_k(t) + \sum_{i=1}^{n} q_{im}\left[\tau_{ik}(t)\right] \le U_k(t) \le Q_o \le Q_m \le Q_k \le U_k(t). \tag{6}$$

Due to the existing changes in the time of movement of discrete units of crushed root crops in the aggregate channel, or the time of travel of discrete units of material when passing through the channel, the stability of the discrete flow of material is significantly reduced.

At the same time, the discrete flow of material units becomes more disorganized, unstable and variable in some time. In this context, for effective transportation of the flow (passing the flow without disrupting the technological process of moving discrete units of crushed root crops or stabilizing the flow movement), it is necessary to provide a reserve of throughput capacity

$$\tilde{q}_k = U_{k.c}\left(1+\Psi_k\right) \le Q_m \le Q_k \text{, or } U_{k.c}\left(1+\Psi_k\right) \le Q_m \le Q_k, \tag{7}$$

where $\tilde{q}_k$ is analytically calculated flow of discrete units of crushed root crops;
Ψ_k the indicator of disorganization of the flow of discrete units of material;
$U_{k.c}$ the average value of the output flow of the aggregate channel.

The flow disorganization indicator Ψ_k can be considered in this case as an analogue of the non-uniformity coefficient μ_n, with

$$\Psi_k(\Delta t) = \mu_n(\Delta t) = \left[W_k(t) \pm W_k(\Delta t)\right] / W_k(t), \tag{8}$$

where $W_k(\Delta t)$ is the value of flow disorganization per unit time of passage of a discrete unit of chopped root vegetables.

Then, taking into account inequality (7), we have

$$\tilde{q}_k = U_{k.c}\left(1+\frac{W_k(t) \pm W_k(\Delta t)}{W_k(t)}\right) \le Q_m \le Q_k \tag{9}$$

or

$$U_{k.c}\left(1+\frac{W_k(t) \pm W_k(\Delta t)}{W_k(t)}\right) \le Q_m \le Q_k. \tag{10}$$

At the exit from the aggregate channel, the disorganization of the flow of discrete units of crushed root crops increases, and the aggregate bunker, unlike the channel, is able to reduce the unevenness, that is, restore the organization of the flow:

$$\mu_n^{(U_k)}(\Delta t) = \mu_n^{(W_k)}(\Delta t) \pm \Delta\mu_n(\Delta t); \tag{11}$$

$$\frac{U_k(t) \pm U_k(\Delta t)}{U_k(t)} = \frac{W_k(t) \pm W_k(\Delta t)}{W_k(t)} \pm \Delta\mu_n(\Delta t), \qquad (12)$$

where the expression ($+\Delta\mu_n(\Delta t)$) is characteristic of the aggregate channel, and the expression ($-\Delta\mu_n(\Delta t)$) is for the aggregate bunker.

Based on this, it can be stated that the output flow $U_k(t)$, or the identical flow $U'_k(t)$ from the aggregate channel, is a controlled quantity and can be controlled in the process of optimizing the technological parameters of the improved screw conveyor.

In this case, the value of the flow disorganization $\pm\Delta\mu_n(\Delta t)$ will depend on the limiting or stationary capacity of the loading hopper Q_o and the coefficient of filling the working space with material.

To reconcile the input and output flow of discrete units of material of the aggregate bunker, it can be written that

$$\frac{M_k(t)}{1+\mu_n^{(M_k)}} = \frac{W_k(t)}{1+\mu_n^{(M_k)} - \Delta\mu(\Delta t)}; \qquad (13)$$

$$\frac{M_k(t)}{1+\frac{M_k(t) \pm M_k(\Delta t)}{M_k(t)}} = \frac{W_k(t)}{1+\frac{M_k(t) \pm M_k(\Delta t)}{M_k(t)} - \Delta\mu(\Delta t)}. \qquad (14)$$

If we assume that $W_k(\Delta t) = \sum_{i=1}^{n} q_{im}\left[\tau_{ik}(t)\right]$, then equation (12) can be written as

$$U_k(\Delta t)/U_k(t) = \left(\sum_{i=1}^{n} q_{im}\left[\tau_{ik}(t)\right]/W_k(t)\right) + \Delta\mu_n(\Delta t). \qquad (15)$$

At the same time, it can be stated that the more uneven the input flow and the greater the damping capacity of the bunker, or the magnitude of the flow disorganization $\pm\Delta\mu_n(\Delta t)$, the greater the difference in throughput of the aggregate bunker and the aggregate channel can be.

The obtained equations (14), (15) are a deterministic mathematical model that describes the nature of the technological process of transporting discrete units of material by the working bodies of an improved screw conveyor, or that characterize the relationship between the movement of components of discrete units of root crops along the working surfaces of the aggregate bunker and the aggregate channel.

The joint solution of the models using, for example, the direct and inverse Laplace transform, will allow optimizing the structural and kinematic parameters and operating modes of the working bodies of transport and technological systems and transport machines in general.

Substituting the value of the input flow $W_k(t)$ from (12) into equation (15), we obtain the dependence for determining the value of the output flow $U_k(t)$ or $U'_k(t)$ of the aggregate channel, while

$$\frac{U_k(\Delta t)}{U_k(t)} = \left(\frac{\sum_{i=1}^{n} q_{im}\left[\tau_{ik}(t)\right]}{\left(\frac{M_k(t)\left(1+\mu_n^{(M_k)} - \Delta\mu(\Delta t)\right)}{1+\mu_n^{(M_k)}} \right)} \right) + \Delta\mu_n(\Delta t); \tag{16}$$

$$U_k(t) = \frac{U_k(\Delta t)\left(\frac{M_k(t)\left(1+\mu_n^{(M_k)} - \Delta\mu(\Delta t)\right)}{1+\mu_n^{(M_k)}} \right)}{\sum_{i=1}^{n} q_{im}\left[\tau_{ik}(t)\right] + \left(\frac{M_k(t)\left(1+\mu_n^{(M_k)} - \Delta\mu(\Delta t)\right)}{1+\mu_n^{(M_k)}} \right)\Delta\mu_n(\Delta t)}, \tag{17}$$

or

$$U_k(t) = \frac{U_k(\Delta t)}{\left[\frac{\sum_{i=1}^{n} q_{im}\left[\tau_{ik}(t)\right]\left(1+\mu_n^{(M_k)}\right)}{M_k(t)\left(1+\mu_n^{(M_k)} - \Delta\mu(\Delta t)\right)} \right] + \Delta\mu_n(\Delta t)} \le Q_m \le Q_k. \tag{18}$$

If we write the equation of the disorganization of the flow of discrete units of root crops (12) in the form of $1 \pm \left[\frac{U_k(\Delta t)}{U_k(t)}\right] = \left[\frac{1 \pm W_k(\Delta t)}{W_k(t)}\right] \pm \Delta\mu_n(\Delta t)$, then we obtain

$$\pm\Delta\mu_n(\Delta t) = \pm\left[\frac{U_k(\Delta t)}{U_k(t)}\right] \pm \left[\frac{W_k(\Delta t)}{W_k(t)}\right]. \tag{19}$$

A graphical interpretation of the matching of the output flow of the aggregate channel relative to the input flow of the aggregate hopper can be represented in the form of Fig. 3.

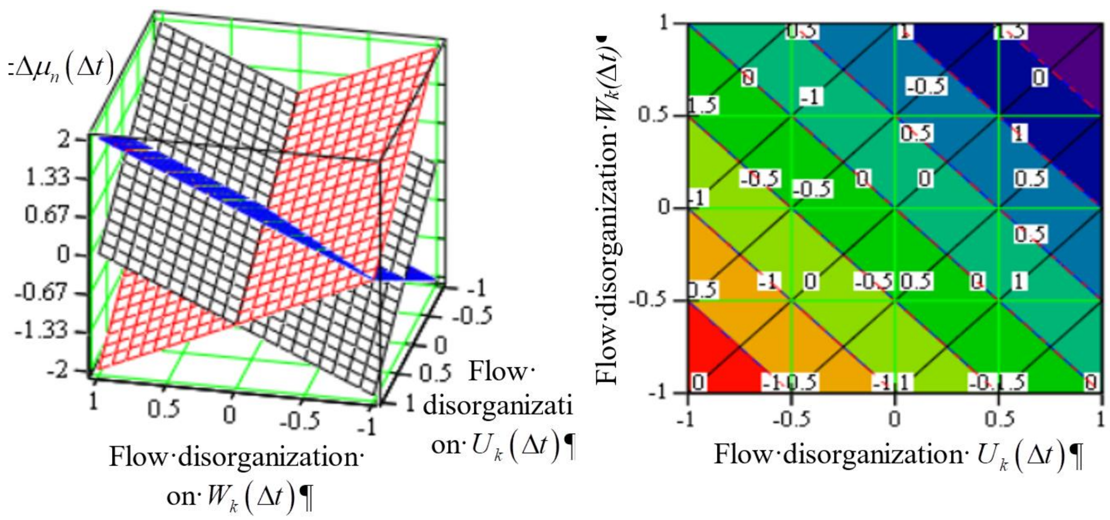

Figure 3. Graphical interpretation of the disorganization of the flow of discrete units of root vegetables (coordination of input and output flows)

The throughput of the hopper $W_b(t)$ and the productivity of the screw conveyor $Q_k(t)$ according to [10] are recognized, respectively, by the formula:

$$W_b(t) = \frac{\lambda_u \rho_k \pi (d_{1z} - a')^2 \sqrt{1,6 g d_{1z} (2h_{1z} + d_{2z} \sin\alpha_k)}}{2t\sqrt{d_{1z}}}, \tag{20}$$

$$Q_k(t) = \frac{\pi n_k D_k^2 \rho_k \psi_\alpha (T_1 + n\Delta T) k_a k_y}{240t}(1 - k_n), \tag{21}$$

where $\lambda_u = 0,65$ is the resistance coefficient for dry lumpy cargo [21];
$\rho_k = 550$ kg/m^3 is the volumetric mass of root crops [22];
$S_1 = 0,25\pi (d_{1z} - a')^2$ is the area of the upper outlet opening of the hopper outlet, taking into account the lumpiness of the cargo, m^2 [20];
d_{1z} is the combined diameter of the upper outlet opening of the hopper, m;
a' is the average transverse size of the root crops, m;
$g = 9,8$ m/s^2 is the acceleration of free fall;
$f_m = 0,25 d_{1z} / (h_{1z} + h_{2z})$ is the coefficient of internal friction, h_{1z}, $h_{2z} = h_{1z} + d_{2z}\sin\alpha_k$ is the height of the vault, m [23];
ψ_α is the coefficient of the angle of inclination of the screw to the horizon;
D_k – outer diameter of the spiral turns of the screw, m;
k_n – constructive geometric coefficient;
n – number of T-steps, pcs.;
k_a – coefficient showing the degree of influence of the angle of elevation of the helix on the average radius of the last turn of the screw;
k_y – coefficient of compaction of crushed root crops by the turns of the screw;
$T_i = T_1 + n\Delta T$ – pitch of the last turn of the screw, m;
n_k – screw rotation frequency, rpm.

If we assume that the throughput $W_b(t)$ of the hopper 1 (Fig. 2) is equivalent to the output flow $W_k(t)$, which passes through the output mouth 3, and the productivity of the screw conveyor $Q_k(t)$ is equivalent to the output flow $U_k(t)$ of the aggregate channel of the screw 5, then based on equation (19) and equations (20) and (21) we can write

$$\pm\Delta\mu_n(\Delta t) = \pm\left[\frac{240 t U_k(\Delta t)}{\pi n_k D_k^2 \rho_k \psi_\alpha (T_1 + n\Delta T) k_a k_y (1 - k_n)}\right] \pm \left[\frac{2t\sqrt{d_{1z}} W_k(\Delta t)}{\lambda_u \rho_k \pi (d_{1z} - a')^2 \sqrt{1,6 g d_{1z} (2h_{1z} + d_{2z}\sin\alpha_k)}}\right]. \tag{22}$$

According to (22), a graphical representation of the dependence of the functional change in the disorganization of the flow of root crops in the screw conveyor is constructed: Fig. 4 as a function $\pm\Delta\mu_n(\Delta t) = f(W(\Delta t); U(\Delta t))$; Fig. 5 – as a function $\pm\Delta\mu_n(\Delta t) = f(W(\Delta t))$.

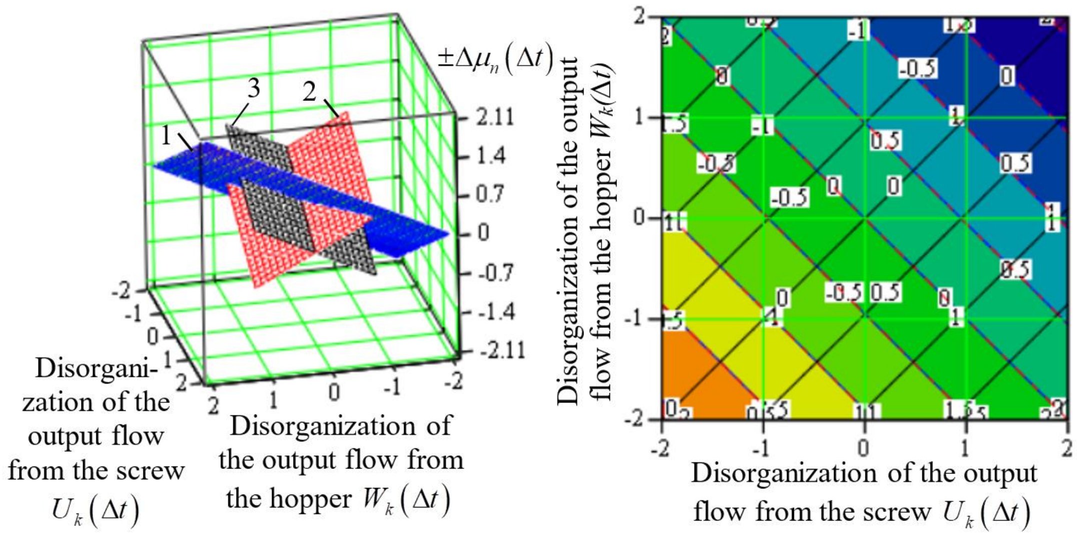

Figure 4. Dependence of the functional change in the disorganization of the flow of root crops in the screw conveyor as a function of $\pm\Delta\mu_n(\Delta t) = f(W(\Delta t);U(\Delta t))$:
1, 2, 3 – respectively, $(U_k(\Delta t)+W_k(\Delta t))$, $(-U_k(\Delta t)-W_k(\Delta t))$, $(U_k(\Delta t)-W_k(\Delta t))$

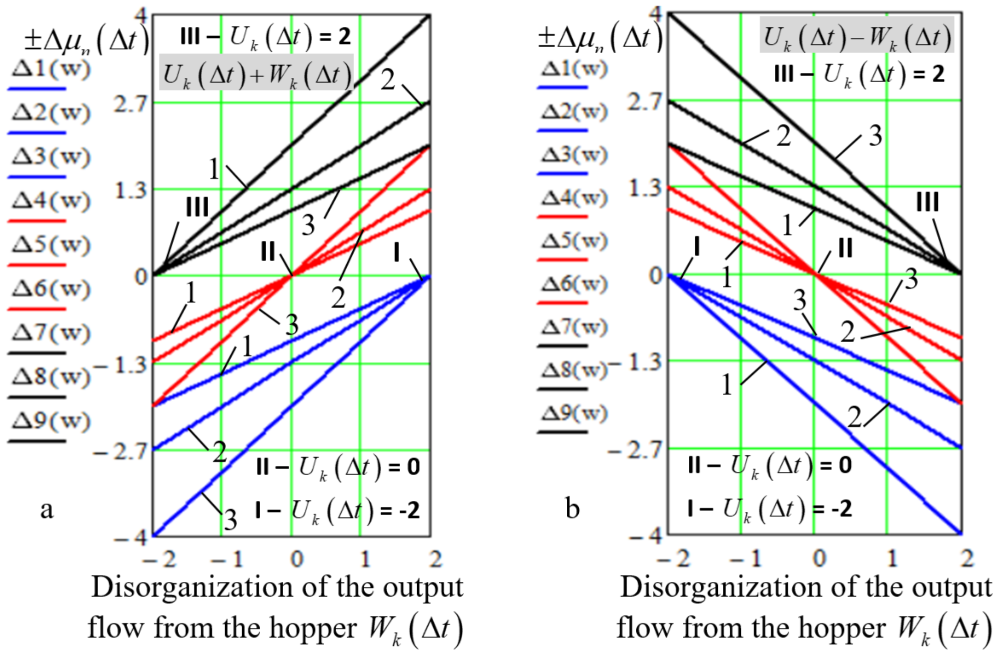

Figure 5. Dependence of the functional change in the disorganization of the flow of root crops in the screw conveyor as a function of $\pm\Delta\mu_n(\Delta t) = f(W(\Delta t))$: 1, 2, 3 – respectively, D_k = 0.15, 0.18, 0.21 m; n_k = 300 rpm

Based on the analysis of the constructed dependencies (Fig. 4, 5), it is necessary to state that the disorganization coefficient of the aggregate bunker ($-\Delta\mu_n(\Delta t)$) and the aggregate channel ($+\Delta\mu_n(\Delta t)$) varies within the range from (-4) to (+4) depending on the disorganization of the output flow $W_k(\Delta t)$ from the bunker and the disorganization of the output flow $U_k(\Delta t)$ from the aggregate channel, which are set within the range of change from (-2) to (+2) «conditional units» (here «conditional units» can be units of measurement of the mass of root crops, the second supply of root crops, etc.).

At the same time, for the value of the disorganization of the flow $W_k(\Delta t)$ from the bunker $W_k(\Delta t)$ = 0, the disorganization coefficient of the aggregate bunker ($-\Delta\mu_n(\Delta t)$) and the aggregate channel $+\Delta\mu_n(\Delta t)$ is zero, or $\pm\Delta\mu_n(\Delta t)$ = 0. In this case, the technological process of moving root crops is stable without any deviations, for which the input flows of the aggregate bunker $W_k(t)$ and the output flows of the aggregate channel $U_k(t)$ are equivalent, or $W_k(t) = U_k(t)$.

4. CONCLUSIONS

1. Disorganization of the screw conveyor process during the transportation of root crops is a consequence of a single stochastic-periodic change in the output flow from the hopper and the output flow from the collecting channel or their simultaneous interaction.

2. The change in the disorganization coefficient of the flow of the collecting hopper and the collecting channel functionally depends on the change in the disorganization of their output flows, the sum of which leads to its increase, and the difference to its decrease.

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ДЕТЕРМІНОВАНА МАТЕМАТИЧНА МОДЕЛЬ ФУНКЦІОНУВАННЯ ГВИНТОВОГО КОНВЕЄРА

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Резюме. *Гвинтові конвеєри застосовують у конструкціях машин різних галузей промисловості, у тому числі аграрного сектору. Вони призначені для горизонтального, похилого й вертикального переміщення коренеплодів та можуть одночасно виконувати суміжні функції – їх подрібнення й транспортування. Стабільність або технологічне непорушення процесу транспортування подрібнених коренеплодів гвинтовим конвеєром значною мірою залежить від стохастичної зміни вхідних і вихідних потоків, або їх дезорганізації. Мета роботи – підвищення технологічної стійкості процесу подрібнення й транспортування коренеплодів гвинтовим конвеєром шляхом узгодження вхідних і вихідних потоків сукупного бункера та сукупного каналу транспортного механізму. Наведено математичну модель, яка описує процес транспортування подрібнених коренеплодів із урахуванням дезорганізації вихідного потоку бункера та вихідного потоку сукупного каналу. На основі моделі розроблено аналітичну залежність для визначення коефіцієнта дезорганізації сукупного бункера та сукупного каналу та встановлено межі його функціональної зміни, який залежно від зміни дезорганізації потоку сукупного бункера та сукупного каналу від (-2) до (+2) умовних одиниць знаходиться в межах від (-4) до (+4). Обґрунтовано, що раціональна або стабільна робота гвинтового конвеєра відбувається за значення коефіцієнта дезорганізації сукупного бункера та сукупного каналу, що дорівнює нулю, що досягається за значення дезорганізації вихідного потоку бункера та вихідного потоку сукупного каналу, що дорівнює нулю. Наведена методологія розроблення математичної моделі та отримана аналітична залежність функціональної зміни коефіцієнта дезорганізації вхідних і вихідних потоків процесу подрібнення й транспортування коренеплодів є технологічними передумовами для оптимізації раціональних параметрів і режимів роботи гвинтових транспортних механізмів.*

Ключові слова: *коренеплоди, сукупний бункер, сукупний канал, вхідний потік, вихідний потік, модель, коефіцієнт дезорганізації потоку.*