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MATHEMATICAL MODEL OF THE PROCESS OF CONTACT INTERACTION OF THE COPIER WITH THE HEAD OF THE CHICORY ROOT CROP

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Summary. *One of the reserves for improving the quality indicators of haulm harvesters is to improve the technological process of haulm cutting by improving the design of cutters for haulm residues from the heads of root crops. In this regard, the development of new and improved working bodies for trimming the remains of tops from the heads of chicory root crops and studying the influence of the constructive and kinematic parameters of the cutter in order to improve the performance of haulm harvesters is an urgent scientific task. The developed mathematical models of the process of contact interaction of the copier with the head of the chicory root crop are the initial prerequisites for further technological analysis of cutting the remains of tops from the heads of root crops. The final solutions of integral equations will make it possible to justify the main parameters of the pruner based on the conditions of permissible horizontal force and permissible normal stresses, or from the condition of not knocking out root crops from the soil and not damaging root crops.*
Key words: *tops of root crops, tops trimmer, copier, speed of movement, strength.*

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Statement of the problem. Chicory roots are an important industrial crop, which is a source of raw materials from which the strategic food product inulin is produced, as well as other important by-products of its processing.

However, the output of processed products from one hectare lags far behind developed countries (Italy, France, the USA, etc.), which is caused by significant mass losses of raw materials due to imperfect technologies for trimming the remains of tops from the haulm of root crops [1, 2].

The mass loss of syria when harvesting chicory is due both to the loss of roots in the process of digging (more than 5...10%), and to imperfect constructive and technical solutions of root cutters from the remains of tops [3, 4].

At the same time: contamination of root crops with haulm residues is 3...5%; waste in the tops of the mass of cut heads to the mass of root crops – 7...9%; damage to root crops due to chips – up to 15%, of which severely damaged – more than 6...8% [5, 6].

The presence of tops creates significant difficulties in the storage and processing of raw materials at the plant, which is one of the reasons for the loss of the output of the processed product [7]. An increase in the contamination of root crops with green mass by 1% reduces the yield of inulin by 0.1%, and one-day storage of root crops in haulm with a tops content of about 4% reduces the yield of processed product by an average of 0.012% [8, 9].

One of the reserves for improving the quality indicators of haulm harvesters is to improve the technological process of haulm cutting by improving the design of cutters for haulm residues from the heads of root crops.

In this regard, the development of new and improved working bodies for trimming the remains of tops from the heads of chicory root crops and studying the influence of the constructive and kinematic parameters of the cutter in order to improve the performance of haulm harvesters is an urgent scientific task.

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Materials and methods. In the world of practice a wide variety of mechanical devices have been widely used to copy beet root roots at the root and install cutting or cleaning working bodies at the required working height. These include passive copiers, active (drive, drum), and combined. However, the requirements of the required level of quality of work in different conditions of collection, simplicity of construction, metal intensity and energy intensity are not always fulfilled.

The object of the study is the improved design of the cutter for the remains of haulm from the heads of chicory root crops, Fig. 1.

The basic structural elements of the cutter are: main frame 1; thrust of the parallelogram mechanism 2; improved rack design 3; passive copier 4; damper plate 5; flat rotary cutting knife 6; spring 7 of the knife; bracket 8 of the rotary knife.

The improved design of rack 3 and the principle of operation of the cutter of the remains of the leaves from the heads of root crops are described in a scientific article [10, 11].

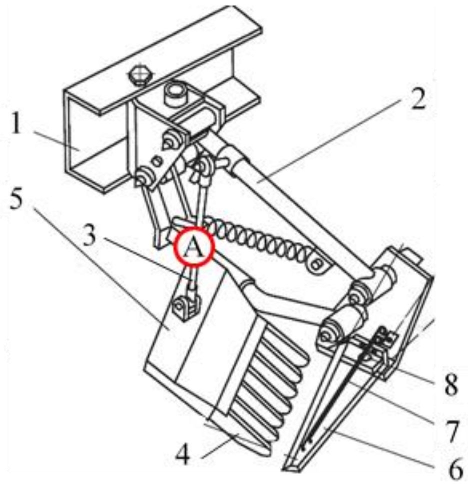

Figure 1. An improved design of the cutter for the remains of the leaves from the heads of root crops

The main characteristics that determine the required quality of the cutter are the indicators of falling out of the roots from the soil and damage to the roots that occur in the process of copying the heads with a passive copier 4 (Fig. 1). At the initial moment of contact of the copying surface of the copier, the copier hits the head of the root crop. The resulting force of impact or impact interaction of two bodies leads to a violation of the bonds of the root crop with the soil, and then to its falling out or damage [12].

Goal of the work. To determine optimum design and kinematic parameters of copier cutter of heads of root crops on root on the basis of building mathematical model of interaction of flat passive copier with heads of root crops.

Research methods. Methods of construction of mathematical models of operation of farm machines and their end-effectors with the use of original positions of mathematics, theoretical mechanics, development of programs and numerical calculations on the PC.

To study the condition of root crops not falling out of the soil and their non-damage by the copier of the passive trimmer, we will consider the technological process of its operation.

During the movement of the cutter, the working surface of the passive comb copier 2 (Fig. 2), which is mounted rigidly on the hinged parallelogram suspension 8, hits the head of the root crop 1 and moves up the head of the root crop.

This movement through the thrust of the parallelogram suspension and riser 6 is transmitted to the passive knife 4, which has a rigid connection with the copier. The passive copier due to the spring-loaded adjustable thrust 9 and the spring 7, which is installed on the riser 6, is spring-loaded.

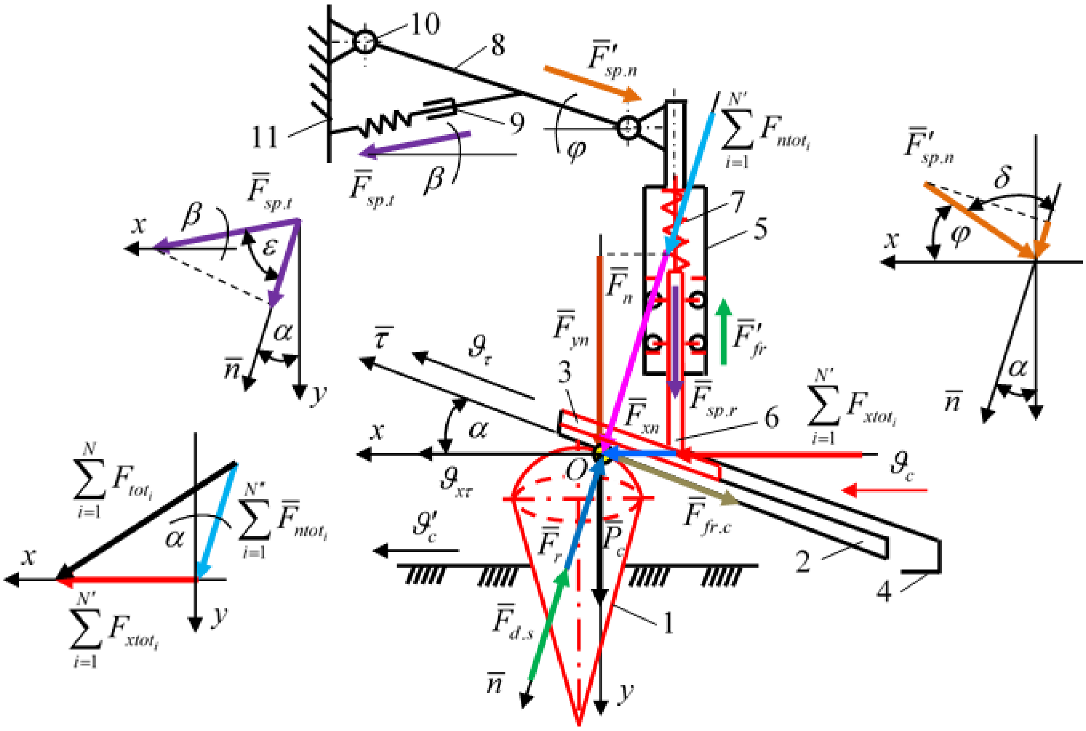

Figure 2. Scheme of dynamic interaction of the copier with the root head:
1 – root crop; 2 – passive copier; 3 – damper; 4 – passive knife; 5 – glass; 6 –- rack; 7 – spring;
8 – parallelogram mechanism; 9 – adjusting spring rod; 10 – frame

Due to the translational movement of the passive knife in the horizontal plane, the remains of the haulm are cut off from the head of the root crop. The cutting height of the root crop head is changed depending on the size of the gap between the knife and the copier and is adjusted with the help of the corresponding cutter mechanisms.

The condition of root crops not falling out of the soil is characterized by the permissible total horizontal force $[\sum_{i=1}^{N'} F_{xtot.i.\max}]$, and the condition of no damage is characterized by the permissible stresses $[\sigma_{n.\max}]$ that occur in the body of the root crops during the contact of the working surface of the copier with the head of the root crop [13, 14].

To analyze the process of interaction between two bodies – a passive comb copier and the head of a root crop, which is fixed in the soil, an equivalent diagram was drawn up, Fig. 2. At the same time: the starting point of the selected coordinate system xOy is placed at point O; the Ox axis is directed horizontally along the direction of movement of the copier, and the Oy axis is directed down, perpendicular to the Ox axis.

During the construction of the equivalent scheme and formalization of the process of interaction of the working surface of the copier with the head of the root crop, the following simplifications and assumptions were adopted:

- the head of the root crop has the shape of a hemisphere [15]; the working surface of the copier, which has the form of a rectilinear flat surface, deviated from the horizon by an angle α, or the angle of inclination of the copier to the horizon; the impact of the working surface of the copier on the head of the root crop is elastic, while the recovery coefficient is within $0.3 \leq k \leq 0.7$ [16]; during the contact of the working surface of the copier with the head of the root crop, its speed of movement ϑ_c is rectilinear and equal to the speed of movement of the machine ϑ_m; after the end of the impact, the copier moves with speed $\vartheta_{x\tau}$.

Taking into account the received scheme of forces, on the basis of the fundamental law of the dynamics of the material point, we write the differential equation of motion of the flat copy on the head of the root of the beet in a vector form:

$$\sum_{i=1}^{N}\bar{F}_{tot_i}=\bar{F}_n+\bar{P}_c+\bar{F}_{sp.r}+\sum_{i=1}^{n}\bar{F}_{fr_i}+\bar{F}_N+\bar{F}_{ds}+\bar{F}_{sp.t}+\sum_{i=1}^{j}\bar{F}_{sp.n_i}\ , \tag{1}$$

where: $\sum_{i=1}^{N}\bar{F}_{tot_i}$ – total force, N; F_n – normal contact force, H; P_c – the force of gravity of the cutter, N; $F_{sp.r}$ – compressive force of the rack spring, N; $\sum_{i=1}^{n}F_{fr_i}$ – the total frictional force of rolling bearings of the rack, H; $\bar{F}_N$ – normalizing reaction force, N; F_{ds} – damper spring force, N; $F_{sp.t}$ – force of compression of the spring of the adjusting rod; $\sum_{i=1}^{j}F_{sp.n_i}$ – the total frictional force of the rolling joints of the parallelogram mechanism, N ($i=1,2,...,j$).

The condition of root crops not falling out of the soil with a copier of the cutter of the remains of the gorse and the condition of root crops not being damaged is written in the: form:

$$\sum_{i=1}^{N'}F_{xtot_i}\le[\sum_{i=1}^{N'}F_{xtot_i\max}],\ \text{or}\ \sum_{i=1}^{N'}F_{tot_i}\sin\alpha\le[\sum_{i=1}^{N'}F_{xtot_i\max}],\ \text{where}\ i=1,2,...,N'; \tag{2}$$

$$\sigma_{ntot}\le\left[\sigma_{n.\max}\right],\ \text{or}\ \sum_{i=1}^{N''}F_{ntot_i}/S_k\le\left[\sigma_{n.\max}\right],\ \text{where e}\ i=1,2,...,N'', \tag{3}$$

where $\sum_{i=1}^{N'}F_{xtot_i}$ is the total horizontal force acting on the head of the root crop, H; $[\sum_{i=1}^{N'}F_{xtot_i\max}]$ is the maximum permissible horizontal force, N; α is the angle between the directions of the *Ox* axis and the total horizontal force $\sum_{i=1}^{N'}F_{xtot_i}$ acting on the head of the root crop, or the angle of installation of the copier slide relative to the horizontal plane, degrees; σ_{ntot} – normal stresses that occur during the impact of a copier with a fixed root head, Pa; $\left[\sigma_{n.\max}\right]$ – maximum permissible normal stress, Pa; $\sum_{i=1}^{N''}F_{ntot_i}$ is the total force applied along the *On* normal to the contact surface of the copier with the head of the root crop, H; S_k is the contact area of the working surface of the copier with the head of the root crop during impact, m^2.

The total horizontal force $\sum_{i=1}^{N'}F_{xtot_i}$ and the total force $\sum_{i=1}^{N''}F_{ntot_i}$ consist of the algebraic sum of the projections of all forces, respectively, on the Ox axis and the On axis, which are applied at the contact point *O*, while:

$$\sum_{i=1}^{N'}F_{xtot_i}=F_n\sin\alpha+F_{sp.t}\cos\beta-F_r\sin\alpha-F_{ds}\sin\alpha-\sum_{i=1}^{j}F_{sp.n_i}\cos\varphi\ ; \tag{4}$$

$$\sum_{i=1}^{N''} F_{ntot_i} = F_n + P_c \cos\alpha + F_{sp.r} \cos\alpha + F_{sp.t} \cos\varepsilon - \\ -\sum_{i=1}^{n} F_{fr_i} \cos\alpha - F_r \cos\alpha - F_{ds} \cos\alpha - \sum_{i=1}^{j} F_{sp.n_i} \sin\delta, \quad (5)$$

where β, φ is the angle between the directions of the force vectors $\bar{F}_{sp.t}$ and $\bar{F}'_{sp.n}$ and the Ox axis, degrees; $\varepsilon = 90 - (\beta + \alpha)$ is the angle between the directions of the force vector and its projection on the axis, degrees; $\delta = 90 + (\varphi - \alpha)$ is the angle between the directions of the unit force vector and its projection on the axis, degrees.

With:

- the vector value of the impact force $\bar{F}_n$ of the cutter, which occurs during the interaction of the working surface of the passive copier with the head of the root crop, depends on the initial impact speed V_c and the total weight force $\sum_{i=1}^{n_c} m_{ic}$ of the center of mass of the moving components of the cutter and according to [17] is determined by the formula

$$\bar{F}_n = \sqrt{\left(\vec{P}_{xn}\right)^2 + \left(\vec{P}_c\right)^2} = \sqrt{\left(\sum_{i=1}^{n_k} m_{ci}\right)^2 \left(\frac{d^2\vec{L}_\tau}{dt^2}\right)^2 + \left(\sum_{i=1}^{n_c} m_{ci}\right)^2 \vec{g}^2} = \sum_{i=1}^{n_c} m_{ci} \sqrt{\left(\frac{d\vec{\vartheta}_\tau}{dt}\right)^2 + \vec{g}^2}, \quad (6)$$

where P_{ϑ_c} is the horizontal impact force that occurs when the working surface of the copier hits the head of the root crop, H; $\sum_{i=1}^{n_c} m_{ci}$ is the total mass of the moving parts of the trimmer, kg, ($i = 1, 2, \ldots, n_c$); L_τ – movement of the working surface of the copier, m; g – acceleration of free fall, m/s^2; ϑ_c – initial impact speed, m/s;

- compression force $F_{sp.r}$ and $F_{sp.t}$ of a cylindrical helical spring according to [18] is determined by Hooke's law

$$F_{sp.r} = -c\Delta x = -\frac{Gd_n^4}{8D_n^3 z}\Delta x = F_{sp.t}, \quad (7)$$

where c is the elasticity coefficient of the spring material, kg/s^2; Δx – absolute compression of the spring, mm; G is the shear modulus of the material from which the spring is made, N/mm^2; d_n is the diameter of the material from which the spring is made, mm; D_n is the average diameter of the spring, mm; z – the number of turns of the spring, pcs.;

- the value of the total friction force $\bar{F}'_{sp.n}$ of one turning pair «finger-sleeve» of the hinge 10 (Fig. 2) of the parallelogram suspension 8 of the cutter according to [19] is determined by the formula

$$F'_{sp.n} = \sqrt{\left(F'_m\right)^2 + \left(F'_n\right)^2}, \quad (8)$$

where $F'_m = f'F'_n = 2 f p_0 l R_n$ is the frictional force of one rotary pair «finger-sleeve», N; f' is the combined coefficient of friction of the finger on the sleeve; $F'_n = 0,5\pi p_o l R_o$ is the force of normal pressure, N; f – coefficient of friction of the finger on the sleeve; p_0 – specific pressure distribution on the contact area, N/m^2; l – sleeve length, m; r_n is the radius of the sleeve, m;

- hen the total component $\sum_{i=1}^{j} F_{sp.n_i}$, which takes into account the force of friction in the hinges of the parallelogram suspension, which prevents the free translational movement of the copier upwards to [20] is determined by the formula

$$\sum_{i=1}^{j} F_{sp.n_i} = \sum_{i=1}^{j} p_{o_i} l r_n \sqrt{4f^2 + 0,25\pi^2} = p_{o_i} l r_n j \sqrt{4f^2 + 0,25\pi^2}\,; \tag{9}$$

- the value of the force $\bar{F}'_{fr}$ of rolling friction of one roller according, the friction force $\bar{F}_{fr.c}$ of the copier on the head of the root crop according, the elastic force $F_{d.s}$ of the damper according and the normal reaction force F_r according to [21, 22, 23] is determined by the formula:

$$F'_{fr} = f_r F'_{pr} / r_r\,;\;\; F_{fr.c} = \mu_c N_c\,;\;\; F_{d.s} = k_e \Delta n\,;\;\; F_r = P_c = \sum_{i=1}^{n_c} m_{ci} g\,, \tag{10}$$

where f_r is the coefficient of rolling friction, units of measurement are meters; F'_{pr} is the compressive force of the body against the surface, N; r_r is the radius of the rolling element, m; μ_c is the sliding friction coefficient; N_c is the normal reaction force, N; k_e is the damper material stiffness factor, N/m; is the Δn damper material compression, m.

The compression force F'_{pr} of the body to the surface occurs only in the case of bending deformation of the rod 6. Since the bending deformation of the rod is insignificant and close to zero $F'_{pr} \cong 0$, then we ignore the friction force F'_{fr}.

To find the total generalized horizontal $\sum_{i=1}^{N'} F_{xtot_i}$ and normal $\sum_{i=1}^{N''} F_{ntot_i}$ forces, we will compose a vector differential equation of motion of the copy machine, based on the application of Newton's second law:

$$\sum_{i-1}^{n_c} m_{ci} \left(\frac{d\vec{V}_{xc}}{dt} - \frac{d\vec{V}_c}{dt} \right) = \sum_{i=1}^{N'} \vec{F}_{xtot_i}\,;\;\; \sum_{i-1}^{n_c} m_{ic} \frac{d\vec{V}_n}{dt} = \sum_{i=1}^{N''} \vec{F}_{ntot_i}\,, \tag{11}$$

or

$$\int_{\vartheta_c}^{\vartheta_{x\tau}} \sum_{i=1}^{N'} m_{ci} d\vartheta_{xc} = \int_0^{t_{sm}} \sum_{i=1}^{N'} F_{xtot_i} dt_{cm}\,;\;\; \int_{\vartheta_c}^{\vartheta_{y\tau}} \sum_{i=1}^{N'} m_{ci} d\vartheta_{nc} = \int_0^{t_{sm}} \sum_{i=1}^{N''} F_{ntot_i} dt_{cm}\,, \tag{12}$$

where t_{sm} is the time of impact, s.

According to (4)-(10), we have:

$$\begin{aligned} \sum_{i=1}^{N'} F_{xtot_i} = \sum_{i=1}^{n_c} m_{ci} \sin\alpha \left(\sqrt{\left(\frac{d\bar{\vartheta}_\tau}{dt} \right)^2 + \vec{g}^2} - g \right) - \frac{G d_n^4}{8 D_n^3 z} \Delta x \cos\beta - ; \\ -k_e \Delta n \sin\alpha - p_{o_i} l r_n j \sqrt{4f^2 + 0,25\pi^2} \cos\varphi \end{aligned} \tag{13}$$

$$\sum_{i=1}^{N''} F_{ntot_i} = \sum_{i=1}^{n_c} m_{ci} \sqrt{\left(\frac{d\bar{\vartheta}_\tau}{dt}\right)^2 + g^2} + \frac{Gd_n^4}{8D_n^3 z}\Delta x \sin(\alpha+\beta) + \\ + p_{o_i} l r_n j \sqrt{4f^2 + 0,25\pi^2}\cos(\varphi-\alpha) + \left(\frac{Gd_n^4}{8D_n^3 z}\Delta y - k_e \Delta n\right)\cos\alpha \quad . \tag{14}$$

According to (12)–(14), we get

$$\int_{\vartheta_c}^{\vartheta_{xc}} \sum_{i=1}^{N'} m_{ci} d\vartheta_c = \int_0^{t_{cm}} \sum_{i=1}^{n_c} m_{ci} \sin\alpha \left(\sqrt{\left(\frac{d\bar{\vartheta}_\tau}{dt}\right)^2 + \vec{g}^2} - g\right) dt_{cm} - \int_0^{t_{cm}} \frac{Gd_n^4}{8D_n^3 z}\Delta x \cos\beta dt_{cm} - \\ - \int_0^{t_{cm}} k_e \Delta n \sin\alpha dt_{cm} - \int_0^{t_{cm}} p_{o_i} l r_n j \sqrt{4f^2+0,25\pi^2}\cos\varphi dt_{cm} \quad ; \tag{15}$$

$$\int_{\vartheta_c}^{\vartheta_{y\tau}} \sum_{i=1}^{N'} m_{ci} d\vartheta_n = \int_0^{t_{cm}} \sum_{i=1}^{n_c} m_{ci} \sqrt{\left(\frac{d\bar{\vartheta}_\tau}{dt}\right)^2 + g^2} dt_{cm} + \int_0^{t_{cm}} \frac{Gd_n^4}{8D_n^3 z}\Delta x \sin(\alpha+\beta) dt_{cm} + \\ + \int_0^{t_{cm}} p_{o_i} l r_n j \sqrt{4f^2+0,25\pi^2}\cos(\varphi-\alpha) dt_{cm} + \int_0^{t_{cm}} \left(\frac{Gd_n^4}{8D_n^3 z}\Delta y - k_e\Delta n\right)\cos\alpha dt_{cm} \quad . \tag{16}$$

The resulting integral equations (15) and (16) are mathematical models that describe the process of interaction of the copier with the head of the root crop. Subsequent solutions to the models make it possible to substantiate the main parameters of the working parts of the trimmer of tops leftovers on root crops.

After substituting the limits of integration and transformation (15) and (16), we obtain the dependences of the change in the speed of movement of the copier:

- to ensure that the root crop does not fall out of the soil

$$\Delta\vartheta_{xc} = \frac{\left(\begin{array}{l} \sum_{i=1}^{n_c} m_{ci} \sin\alpha \left(\sqrt{\left(\frac{d\vartheta_{cx}}{dt}\right)^2 + g^2} - g\right) - \frac{Gd_n^4}{8D_n^3 z}\Delta x\cos\beta - \\ -k_e\Delta n \sin\alpha - p_{o_i} l r_n j\sqrt{4f^2+0,25\pi^2}\cos\varphi \end{array}\right) t_{cm}}{\sum_{i=1}^{n_c} m_{ci}} ; \tag{17}$$

- to ensure that the root crop is not damaged

$$\Delta\vartheta_{nc} = \frac{\left(\begin{array}{l} \sum_{i=1}^{n_c} m_{ci} \sqrt{\left(\frac{d\vartheta_{nx}}{dt}\right)^2 + g^2} + \frac{Gd_n^4}{8D_n^3 z}\Delta x \sin(\alpha+\beta) + \\ + p_{o_i} l r_n j\sqrt{4f^2+0,25\pi^2}\cos(\varphi-\alpha) + \left(\frac{Gd_n^4}{8D_n^3 z}\Delta y - k_e\Delta n\right)\cos\alpha \end{array}\right) t_{cm}}{\sum_{i=1}^{n_c} m_{ci}} , \tag{18}$$

where $t_{sm} = \frac{1}{\vartheta_c}\left(\frac{1}{B_r} - l_r + 0,5d_r\right)$, B_r is number of root crops per linear meter of row, pcs./l.m; l_r is distance between adjacent root crops, m; d_r is diameter of the cutting plane of the head of the root crop, m.

Under initial conditions B_r = 5 pcs./l.m, $\alpha = \pi/6$ degrees, $\frac{Gd_n^4}{8D_n^3 z} = c =$ 60 kg/m, $\Delta x =$ 0,1 m, $\beta = \pi/8$ degrees, $\varphi = \pi/8$, according to formulas (17) and (18), graphical dependences of the difference $\Delta\vartheta_{xc}$ and $\Delta\vartheta_{nc}$ of the initial speed of movement ϑ_{xc} of the copier before the impact and the speed of movement ϑ_{nc} of the copier after the impact are plotted as a function of $\Delta\vartheta_{xc} = f(\sum_{i=1}^{n_c} m_{ci}, \vartheta_c)$ and $\Delta\vartheta_{nc} = f(\sum_{i=1}^{n_c} m_{ci}, \vartheta_c)$, Fig. 3, Fig. 4.

Analysis of the induced dependencies shows that the difference between $\Delta\vartheta_{xc}$ and $\Delta\vartheta_{nc}$ changes in pre-shock and post-shock speeds is within the range:

- horizontal component of speed $\Delta\vartheta_{xc}$ from 6 to 8 m/s, Fig. 2;
- normal component of speed $\Delta\vartheta_{nc}$ from 4 to 6 m/s, Fig. 4.

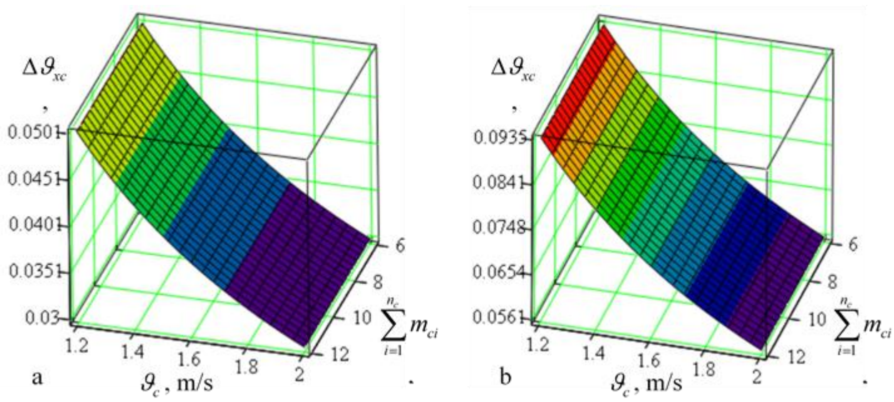

Figure 3. Dependence of the change in the horizontal component of the speed $\Delta\vartheta_{xc}$ on the total mass $\sum_{i=1}^{n_c} m_{ci}$ of the supporting parts of the edger and the translational speed ϑ_c of the copier: a, b – a_{cx} = 5, 7 m/s^2

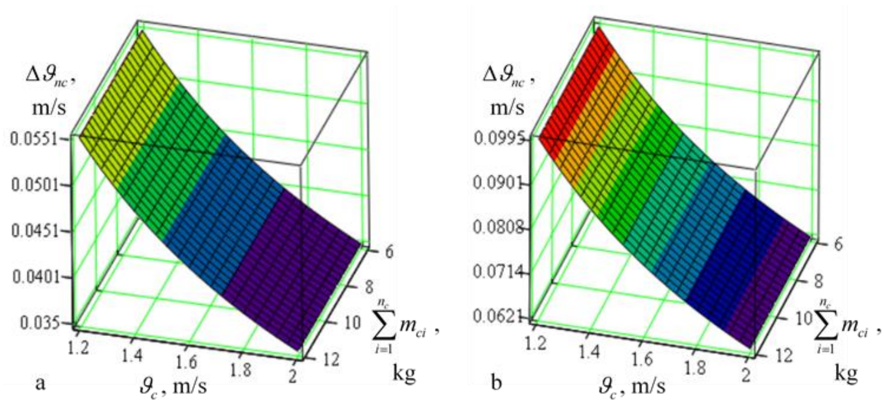

Figure 4. Dependence of the change in the horizontal component of the speed $\Delta\vartheta_{nc}$ on the total mass $\sum_{i=1}^{n_c} m_{ci}$ of the supporting parts of the edger and the translational speed ϑ_c of the copier: a, b – a_{cx} = 6, 8 m/s^2

At the same time, the total mass $\sum_{i=1}^{n_c} m_{ci}$ does not significantly affect changes in the difference in speeds $\Delta\vartheta_{xc}$ and $\Delta\vartheta_{nc}$, and the dominant influence is exerted by the translational speed ϑ_c of the copier.

When the translational speed P of the copier changes by 0.2 m/s, the difference in speeds $\Delta\vartheta_{xc}$ and $\Delta\vartheta_{nc}$ increases on average by:

- horizontal component $\Delta\vartheta_{xc}$ by 0.004…0.006 m/s, Fig. 2;

- normal component $\Delta\vartheta_{nc}$ by 0.008…0.01 m/s, Fig. 3.

Conclusions. The developed mathematical models of the process of contact interaction of the copier with the head of the chicory root crop are the initial prerequisites for further technological analysis of cutting the remains of tops from the heads of root crops.

The final solutions of integral equations (15) and (16) will make it possible to justify the main parameters of the pruner based on the conditions of permissible horizontal force and permissible normal stresses, or from the condition of not knocking out root crops from the soil and not damaging root crops.

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МАТЕМАТИЧНА МОДЕЛЬ ПРОЦЕСУ КОНТАКТНОЇ ВЗАЄМОДІЇ КОПІРА З ГОЛОВКОЮ КОРЕНЕПЛОДУ ЦИКОРІЮ

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Резюме. *Одним із резервів покращення якісних показників гичкозбиральних комбайнів є удосконалення технологічного процесу зрізування залишків гички за рахунок удосконалення конструкції обрізувачів головок коренеплодів цикорію. У зв'язку з цим розроблення нових удосконалених робочих органів для зрізування залишків гички з головок коренеплодів цикорію та дослідження впливу конструктивно-кінематичних параметрів робочих органів обрізників з метою підвищення продуктивності корензбиральних комбайнів є актуальним і науковим завданням. На основі проведеного математичного аналізу розроблено математичні моделі процесу контактної взаємодії копіра з головкою коренеплоду цикорію, які є вихідними передумовами для подальшого технологічного аналізу зрізування залишків гички з головок коренеплодів робочими органами обрізника, який виконано за принципом «пасивний копір-підпружинений ніж». Встановлено, що різниця доударної та післяударної швидкостей пасивного переміщення копіра знаходиться в межах: для горизонтальної швидкості – від 0,004 до 0,006 м/с; для нормальної швидкості – від 0,008 до 0,01 м/с. Домінуючим фактором, який має суттєвий вплив на зміну швидкості переміщення копіра по головці коренеплоду, є поступальна швидкість руху копіра або гичкозбиральної машини. Кінцеві рішення інтегральних рівнянь дозволять обґрунтувати основні параметри обрізувача з умов допустимої горизонтальної сили та допустимих нормальних напружень, або з умови невибивання коренеплодів із ґрунту та непошкодження коренеплодів.*

Ключові слова: *гичка коренеплодів, обрізувач гички, копір, швидкість руху, сила.*

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