ISSN: 2350-0328

International Journal of Advanced Research in Science, Engineering and Technology

Vol. 6, Issue 12 , December 2019

Theoretical Substantiation of Parameters of Elastic Intensifiers of Separating Working Bodies of Potato Harvesting Machines

N.G.Bayboboev, G.K.Rembalovich, A.A Tursunov, U.G. Goipov,Sh.B.Akbarov

Professor, department "Transport logistics and services" Namangan Engineering-construction Institute, 160103, Uzbekistan, Namangan,I.Karimov-12 str.

Professor, department "Ground transportation technology" "Ryazan State Agrotechnological University Named After P.A.Kostychev, 390044,Russia, Ryazan.

Assistant teacher, department "Mechanical engineering" Namangan Construction Engineering Institute, 160103, Uzbekistan, Namangan, I.Karimova-12 str.

Senior teacher, department "Information Technology" Namangan Construction Engineering Institute, 160103, Uzbekistan, Namangan, I.Karimova-12 str.

Senior teacher, department "General technical sciences" Namangan Construction Engineering Institute, 160103, Uzbekistan, Namangan, I.Karimova-12 str.

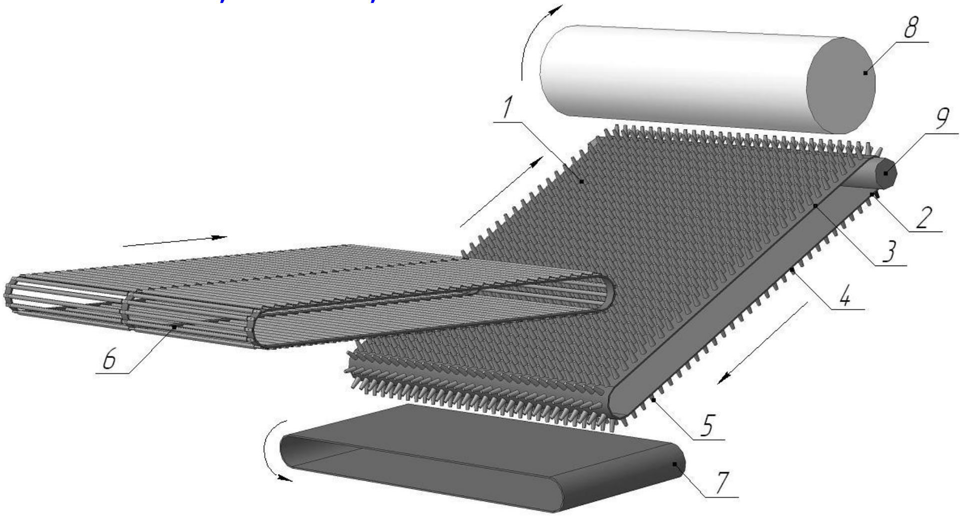
ABSTRACT: The article discusses methods for calculating the separating working bodies of potato harvesters equipped with elastic intensifiers.As a result of theoretical calculation, the permissible interaction rate of potato tubers with working elements m / s and the intensifier r/m rotation speed were determined.Recommendations are given on the choice of the angular and linear velocities of the separating working bodies, the justification of their shape and location.

KEYWORDS: potato harvester, elevator, intensifier, tuber reflector, rotational speed, separation, soil, rotation angle, speed, angle of inclination.

I. INTRODUCTION

In the process of improving the technological operation of secondary separation, intensifiers have been developed to improve the operational and technological performance of potato harvesters in various operating conditions. These are working bodies — longitudinal straight-through separating slides containing levelling intensifiers, equipped with various types of elastic working elements, each of which most effectively implements its functional properties under certain conditions [1, 2, 3, 4,5].The developed devices have common design features: they contain a separation slide 1 (Fig. 1), the endless conveyor belt 2 of which has a working and reverse branch 3 and 4 with elastic fingers 5, a conveyor 6 for loading a potato heap and a conveyor 7 for unloading tubers. In the upper part of the inclined conveyor above the head drum 8 there is a leveling intensifier 9.Improved working bodies of the secondary separation work as follows (Fig. 1). Potato heap, including tubers, soil lumps, tops and plant debris, is delivered by conveyor 6 to the separation hill 1. When tubers and soil lumps fall on the inclined surface of the hill due to different values of the elastic and frictional properties of the components, rolling friction coefficient, sizes and specific gravity , on the working branch 3 of the palm leaf, there is a process of separation of potato heaps, that is, the process of separating tubers from

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 12 , December 2019



soil and plant impurities.
1-dividing hill; 2 - conveyor belt; 3,4-working and reverse branch; 5-elastic finger; 6-conveyor loading potato heaps; 7-conveyor unloading tubers; 8-head drum; 9-intensifier

Figure 1 - Generalized structural and technological scheme of the improved working bodies of the secondary separation.In this case, the bulk of the tubers rolls along the surface of the fingers 5 to the unloading conveyor 7 of the device, and the impurities (soil lumps, stones and plant debris) are held by the fingers of the canvas and rise up to the intensifier 9. Some of the tubers with the heap components holding them and the fingerprint of the slide are fed to the intensifier 9, rotating to meet the movement of the heap. The design features and the principle of operation of these working bodies are discussed in detail in [1,2,3,4,6,7], therefore, in this work we will consider the operating mode and theoretical justify their main parameters.

1) In a theoretical study of the process of secondary separation, we pay attention to two components:
2) the rate of rotation of the intensifier which directly affects the intensity of separation and damage to tubers;
3) the rate of interaction determining the damage to tubers and the possibility of hitting tubers in loss.

II. LITERATURE SURVEY

Based on the foregoing, when choosing the maximum permissible interaction speed as a damage criterion, it is necessary to limit the maximum intensifier rotation frequency at which the total contact speed of the tubers with the working elements will be less than the permissible [1,6,7,8].

The condition for the tuber to be intact is in this case:

The condition for the tuber to be intact is in this case:

$$\vec{V}_C \le \vec{V}_{ДОП} , \qquad (1)$$

Where: $\vec{V}_C$ - the total speed of potato tubers and the surface of the working element of the reflector tubers, м/с; $\vec{V}_{ДОП}$ - permissible contact speed, m / s.

To describe the movement of the working element, we use two coordinate systems: moving OXYZ and fixed OX1YZ1 - with a common origin at the intersection of the axis of attachment of the working element and the axis of rotation of the tuber-reflector O. Both coordinate systems have a common Y axis that coincides with the rotation axis of the tuber-reflector (Fig. 2). We choose the fixed system so that the OX axis is parallel to the surface of the working branch of the elevator in the direction of movement of the potato heap, and the OZ axis is directed perpendicular upward relative to this surface.In the process of operation of the secondary separation device, the intensifier rotates, while the angle of inclination of the working element to the Z axis in the OYZ plane (Fig. 2.) will change in time t according to the harmonic law [3]:

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 12 , December 2019

$$\beta = \beta_1 \cdot \cos(\omega_1 t + \psi_{01}), \qquad (2)$$

where: β_1 the amplitude of the angle of inclination of the working element to the coordinate axis OZ in the OYZ plane as a result of rotation of the intensifier OY, rad;

ω_1 - angular frequency of rotation of the intensifier, rad / s;

ψ_{01} phase (initial) angle of rotation of the intensifier around its axis, rad

The value ψ_{01} shows the angle of rotation of the moving coordinate system OX1YZ1 relative to the fixed OXYZ (around the axis OY) at the initial time t = 0.

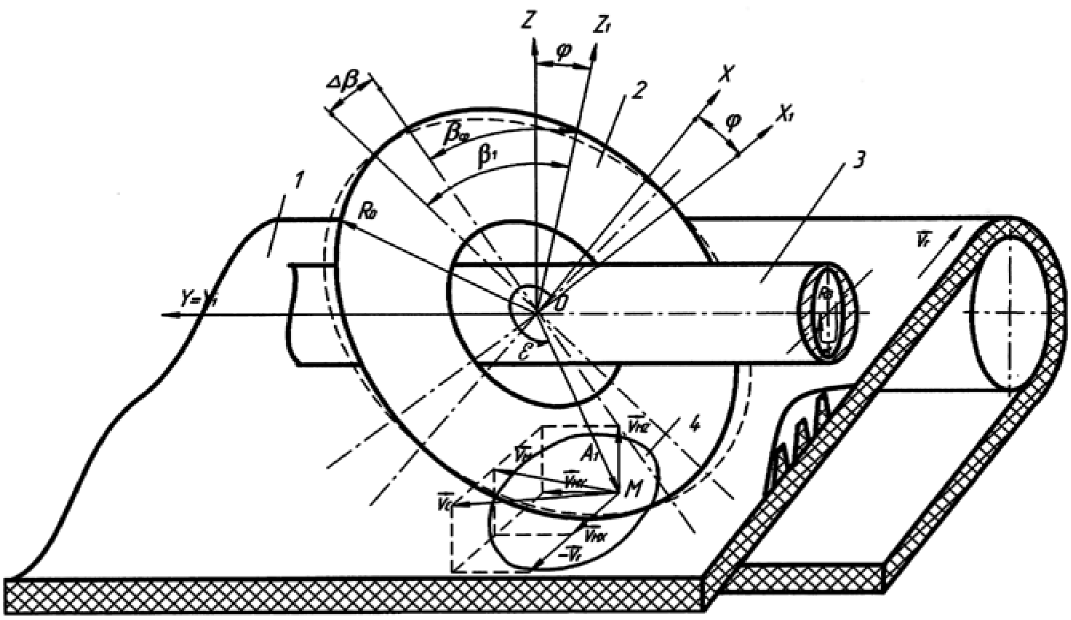
Now we consider an arbitrary point M on the surface of the working element, since any point on the surface of the working element can be in contact with the components of the heap. To do this, we use a flat polar coordinate system located on the plane of the working element and rigidly connected with it. At the origin, we will choose point O. To determine the position of point M in the polar coordinate system, we set the distance A1 from the center O to the point M under consideration, and for disk work items, we introduce a restriction based on their overall dimensions:

$$\frac{R_B}{\cos(\beta_{CP} + \Delta\beta)} < A_1 \leq R_D, \qquad (3)$$

Where: R_D – height (outer radius of the disk) of the working element, m;

R_B - the external radius of the intensifier, m

We set the rotation angle ε of the radius vector OM from the initial position corresponding to the axis OX1, counter clockwise.



1 - working branch of the elevator blade; 2 - work item; 3 - tuber reflector; 4 - potato tuber

Figure 2 - Calculation scheme of the movement of the elastic working element of the levelling intensifier and coordinate system.

In the moving coordinate system OX1YZ1, the position of the point M, taking into account the condition:

$$0 \leq \varepsilon \leq 2\pi, \qquad (4)$$

will be determined by the expressions:

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 12 , December 2019

$$\begin{cases} X_{1M} = A_1 \cdot \cos\varepsilon \ , \\ Y_{1M} = A_1 \cdot \sin\varepsilon \cdot \sin(\beta_{CP} + \Delta\beta \cdot \cos(\omega_1 \cdot (n+1) \cdot t + \psi_{02})) \ , \\ Z_{1M} = A_1 \cdot \sin\varepsilon \cdot \cos(\beta_{CP} + \Delta\beta \cdot \cos(\omega_1 \cdot (n+1) \cdot t + \psi_{02})) \ . \end{cases} \tag{5}$$

We use well-known expressions for the transition from the moving coordinate system OX1YZ1 to the fixed system OXYZ, which have the form::

$$\begin{cases} X = X_1 \cdot \cos\varphi + Z \ \cdot \sin\varphi \ , \\ Y = Y_1 \ , \\ Z = -X_1 \cdot \sin\varphi + Z_1 \cdot \cos\varphi \ . \end{cases} \tag{6}$$

We turn to the fixed coordinate system OXYZ using expression (6), as a result of (5) we obtain:

$$\begin{cases} X_M = A_1 \cdot \cos\varepsilon \cdot \cos(\omega_1 \cdot t + \psi_{01}) + A_1 \cdot \sin\varepsilon \cdot \sin(\omega_1 \cdot t + \psi_{01}) \times \\ \qquad \times \cos(\beta_{CP} + \Delta\beta \cdot \cos(\omega_1 \cdot (n+1) \cdot t + \psi_{02})) \ , \\ Y_M = A_1 \cdot \sin\varepsilon \cdot \sin(\beta_{CP} + \Delta\beta \cdot \cos(\omega_1 \cdot (n+1) \cdot t + \psi_{02})) \ , \\ Z_M = -A_1 \cdot \cos\varepsilon \cdot \sin(\omega_1 \cdot t + \psi_{01}) + A_1 \cdot \sin\varepsilon \cdot \cos(\omega_1 \cdot t + \psi_{01}) \times \\ \qquad \times \cos(\beta_{CP} + \Delta\beta \cdot \cos(\omega_1 \cdot (n+1) \cdot t + \psi_{02})) \ . \end{cases} \tag{7}$$

To determine the components of the speed of movement of the point M along the axes of the fixed coordinate system OXYZ, we differentiate each of the expressions (7) with respect to time t, as a result, we obtain the values of the components of the speed t. M along the axes OX, OY, OZ:

$$\begin{cases} V_{MX} = \dfrac{\partial X_M}{\partial t} = A_1 \cdot \omega_1 \cdot ((\Delta\beta \cdot (n+1) \cdot \sin\varepsilon \cdot \sin(\omega_1 \cdot (n+1) \cdot t + \psi_{02}) \cdot \sin(\beta_{CP} + \\ + \Delta\beta \cdot \cos(\omega_1 \cdot (n+1) \cdot t + \psi_{02})) - \cos\varepsilon) \cdot \sin(\omega_1 \cdot t + \psi_{01}) + \\ + \sin\varepsilon \cdot \cos(\beta_{CP} + \Delta\beta \cdot \cos(\omega_1 \cdot (n+1) \cdot t + \psi_{02})) \cos(\omega_1 \cdot t + \psi_{01})) \ , \\ V_{MY} = \dfrac{\partial Y_M}{\partial t} = -A_1 \cdot \omega_1 \cdot \Delta\beta \cdot (n+1) \cdot \sin\varepsilon \cdot \sin(\omega_1 \cdot (n+1) \cdot t + \psi_{02}) \cdot \cos(\beta_{CP} + \\ + \Delta\beta \cdot \cos(\omega_1 \cdot (n+1) \cdot t + \psi_{02})) \ , \\ V_{MZ} = \dfrac{\partial Z_M}{\partial t} = A_1 \cdot \omega_1 \cdot ((\Delta\beta \cdot (n+1) \cdot \sin\varepsilon \cdot \sin(\omega_1 \cdot (n+1) \cdot t + \psi_{02}) \cdot \sin(\beta_{CP} + \\ + \Delta\beta \cdot \cos(\omega_1 \cdot (n+1) \cdot t + \psi_{02})) - \cos\varepsilon) \cdot \cos(\omega_1 \cdot t + \psi_{01}) - \\ - \sin\varepsilon \cdot \cos(\beta_{CP} + \Delta\beta \cdot \cos(\omega_1 \cdot (n+1) \cdot t + \psi_{02})) \cdot \sin(\omega_1 \cdot t + \psi_{02})) \ . \end{cases} \tag{8}$$

Expressions (7 ... 8) describing the complex movement of the intensifier working element are the basic regularity of the secondary separation process in potato harvesters, and can be used to study the effect of working

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 12 , December 2019
bodies on the components of a potato heap and to determine its main structural parameters.

Based on the foregoing, we consider the interaction of the tuber with the lateral surface of the elastic working element of the levelling intensifier. The maximum allowable speed of the intensifier is determined from the expression::

$$n_{MAX} = \frac{30 \cdot \omega_{1MAX}}{\pi}$$, rpm (9)

where: ω_{1MAX} - maximum allowable angular velocity of the intensifier, rad / s.

Thus, the task is to determine the maximum allowable value of the angular velocity of the intensifier, which upon contact does not damage potato tubers.

Before the interaction, the components of the potato heap move uniformly and rectilinearly together with the elevator blade with a speed of VГ. The working elements of the intensifier, rotating towards the elevator blade, affect the potato heap. The point M of the surface of the working element at which the interaction with the tuber occurs, at this moment in time t has a speed VM (t). The tuber at an angle to the direction of its feed is discarded from the surface of the working element and rolls down, then when the tuber reaches the speed V = 0 on the canvas, provided it does not go from the canvas to the next working body, it returns to the intensifier with the canvas. This can happen several times until the tuber comes off the canvas.

III. MATERIAL AND METHODS

We study the process of interaction of potatoes with the surface of the working element [7]. A tuber with a total speed VC (represents the vector sum of the speed of the web $\vec{V}_{\Gamma}$ and the speed of point M of the work item $\vec{V}_{M}$) interacts with the surface of the work item of the intensifier. As a result of the interaction, the potato tuber changes direction and magnitude of speed.

It must be taken into account that the total rate of exposure to the potato tuber should not exceed the value of the contact speed, beyond which the potato tubers receive damage.The projections of the contact velocity VC on the axis OX, OY, OZ of the fixed coordinate system OXYZ will be expressed by the following relationships:

$$\begin{cases} V_{CX} = V_{MX} + V_{\Gamma}, \\ V_{CY} = V_{MY}, \\ V_{CZ} = V_{MZ}, \end{cases} \qquad (10)$$

where: V_{CX}, V_{CY}, V_{CZ} - components of the contact velocity along the coordinate axes OX, OY, OZ, respectively.

The contact speed is determined by the expression:

$$V_C = \sqrt{V_{CX}^2 + V_{CY}^2 + V_{CZ}^2}, \qquad (11)$$

In accordance with (3.93), expression (3.94) will be rewritten:

$$V_C = \sqrt{(V_{MX} + V_{\Gamma})^2 + V_{MY}^2 + V_{MZ}^2}, \qquad (12)$$

Based on the expression (2.99), the value of the permissible interaction rate can be expressed as:

$$V_{ДОП} \geq \sqrt{(V_{MX} + V_{\Gamma})^2 + V_{MY}^2 + V_{MZ}^2} \qquad (13)$$

The permissible speed of potato tubers when interacting with a metal surface is 1.0 m / s, and with a surface of elastic material - 3.0 m / s [1,2,3]. Since the working elements of the intensifier are made elastic, we take the value $V_{ДОП}$ = 3 m / s. Research A.A. Sorokin found that the speed of the canvas, at which the most effective separation of the

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 12 , December 2019

components of the potato heap, is in the range of 1.0 - 1.5 m / s. Values of quantities $V_{M\ X}, V_{M\ Y}, V_{M\ Z}$ are determined by expressions (8).

IV. SIMULATION &RESULTS

The combination of expressions (8) and (13) is the basis for obtaining the value of the maximum allowable angular velocity of the intensifier. When determining the maximum allowable angular velocityintensifier analytic method there are significant difficulties. Therefore, we will use numerical methods, and we will solve this problem on a computer using the MathCAD software package [5].

Graphically, the process of determining the value is presented in Fig. 3. The problem consists in the closest approximation of the maxima of the surface of the species $V_C = f(t,\varepsilon)$, which is the dependence of the contact speed on time and the position of the interaction point on the surface of the working element, to the horizontal plane of the species $V_{ДОП} = 3м/с$, under which lies the region of permissible contact velocities, by changing the value of the angular velocity of the intensifier ω_1.

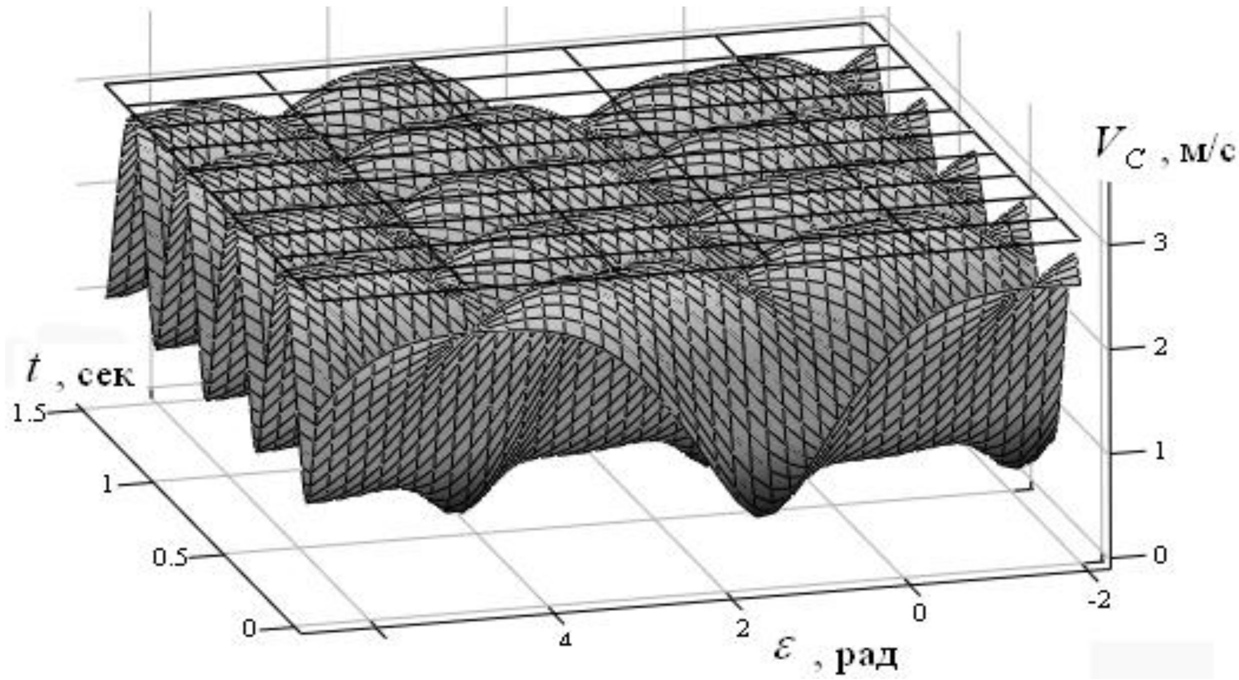


Figure 3 - The dependence of the contact speed on time at the moment of interaction and the position of the contact point on the surface of the working element of the intensifier type of $V_C = f(t,\varepsilon)$.

V. EXPERIMENTAL RESULTS

A similar method of determining the permissible value is true only for the values of quantities accepted in each particular case. $\Delta\beta; n; \beta_{CP}; \psi_{01}; \psi_{02}$ and R_D. In our case, the parameters were accepted like:

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 12 , December 2019

$\Delta\beta = \frac{\pi}{32}; \quad n = 1; \quad \beta_{CP} = \frac{\pi}{6}; \quad \psi_{01} = \psi_{02} = 0; \quad R_D = 0{,}11м$, and the value of the maximum allowable angular velocity of the intensifier is obtained ω_{1MAX} =18,0 rad / s, which corresponds to a speed of 172 rpm. In this case, the maximum possible permissible rate of interaction of the tuber with the surface of the working element V_C was 2.58 m / s.

VI.CONCLUSION

Thus, when using the parameter of the permissible interaction rate as a criterion for damage to potato tubers, the value of the intensifier rotation speed should not exceed 172 rpm, and the speed $V_C = 2{,}58 м/c$. It should be noted that the use of the above methods describes in detail the kinematics of the intensifier movement. Thus, on the basis of theoretical studies of the laws of the process of interaction between potato tubers and the elastic working elements of the intensifier, the following rational parameters of the working element are established based on the strength of the tuber: outer radius 0.11 m, installation pitch 0.116 m, rotation angle relative to the axis of rotation of the tuber reflector 0.50 rad, the angle of inclination to the longitudinal axis of the tuber-reflector is 0.52 rad, the permissible interaction speed = 2.58 m / s, and the permissible intensifier rotation frequency = 168 ... 172 rpm.

REFERENCES

1. Pat. 2245011, RU, M.C. 7 A 01 D 33/08. A device for separating root crops from impurities / BorychevS.N., RembalovichG.K., UspenskyI.A. - Publ. 01/27/2005, bull. No. 3.
2. Pat. 2464765 IPC A 01 D 33/08. Separating device of a root-harvesting machine. / RembalovichG.K., Volchenkov D.A., ByshovN.V. [et al.] Publ. 10/27/2012. Bull.№30.
3. Pat. 95960, RU, IPC A 01 D 33/08 A device for separating root tubers from impurities / BznosyukR.V., ByshovD.N., RembalovichG.K. [and others] - Publ. 07/20/2010, bull. No. 20
4. Pat. 129345 IPC A 01 D 33/08. Separating device of a root-harvesting machine. / RembalovichG.K., GolikovA.A., ByshovD.N. [et al.] Publ. 06/27/2013. Bull.№18.
5. Rembalovich, G.K. Prospects for improving the organs of secondary separation of potato harvesting machines. / G.K. Rembalovich // In Zh. "Bulletin of the Moscow State Agrarian University V.P. Goryachkina. "AgroengineeringSeries. - 2006, No. 3 p. 64-65.
6. Byshov, N.V. Principlesandmethodsofcalculationanddesignofworkingbodiesofpotatoharvestingmachines / N.V. Byshov, A.A. Sorokin, I.A. Uspensky [etal.] Ryazan, RSTU, 2005. - 284 p.
7. UspenskyI.A. Fundamentalsofimprovingtheprocessandreducingenergycostsofpotatoharvesters / I.A.Uspensky. Dis. ... doc. tech. sciences. - Moscow, 1997.- 396
8. Rembalovich, G.K. Prospectsforimprovingtheorgansofsecondaryseparationofpotatoharvesters. / G.K. Rembalovich // In Zh. "BulletinoftheMoscowStateAgrarianUniversityV.P. Goryachkina. " AgroengineeringSeries. - 2006, No. 3 p. 64-65.
9. Bayboboev, N.G.Byshov, N.V, Rembalovich, G.K, AkbarovSh.B. Scientific and technical basis for the improvement of the separating working bodies of potato harvesters -T: “Fan Tehnologiya” 2019- p.144
10. Bayboboev, N.G.HamzayevA.A. RahmonovU.T.
Calculation of kinetic energy of a bar elevator with centrifugal separation.Vestnik, RSATU, Russia-2015., p-19-21
11. Bayboboev, N.G Justification of parameters of the running wheels of the preseeding soil tillage assembly// European Sciences review №5-6 2018, (May-June)