ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 10 , October 2019

# The movement of potato tubers on the sorting surface of the machine with a new design

**Bahadirov G.A., Umarov B.T**

Chief Researcher, Institute of Mechanics and Seismic Stability of Structures named after M.T. Urazbaev Academy of Sciences of the Republic of Uzbekistan, Uzbekistan, Tashkent city, Do’rmonyo’list.
Doctoral student of Fergana Polytechnic Institute, Uzbekistan, Ferganacity, Ferganast.

**ABSTRACT**: This article highlights the results of a study of the movement of potato tubers on the working surface of a new sorting machine for small farms. Differential equations and their analysis are presented that describe the movement of potato tubers along the sorting surface.

**KEY WORDS**: Potato tuber, Differential equation, Gravity, Normal support reactions, Friction forces, Speed, Angular velocity.

## I.INTRODUCTION

At present, the sorting of potatoes on farms involves considerable labor costs due to low mechanization and electrification of the technological process. Serial production of machines for sorting potatoes has practically ceased due to their high cost and low reliability of work, due to the large number of rotating and failing parts, therefore, the share of manual labour in sorting potatoes has sharply increased in farms. The use of obsolete, worn and energy-intensive equipment is not effective. The disparity of prices between agricultural products and prices for equipment and energy requires the improvement of technology and technical means in the production of agricultural products [1, 2].

In this regard, the creation of machines for sorting potatoes with high technical and economic indicators is an urgent task [1, 2].

We propose a new design of the sorting machine, with the purpose of qualitative sorting of potatoes according to external dimensions, taking into account the size-mass properties of tubers of cultivating potato varieties [3].

This article explores the movement of a potato tuber based on two new-design sorting machine belts moving at different speeds.

## II. SCOPE OF RESEARCH AND PROPOSED METHODOLOGY

The main purpose of studying motion is to prevent the rallying of potato tubers on the sorting surface.

Rallying of tubers is mainly manifested in the initial part of the sorting surface and will cause a sharp decrease in the quality of sorting, changing the parameters of the sorting surface.

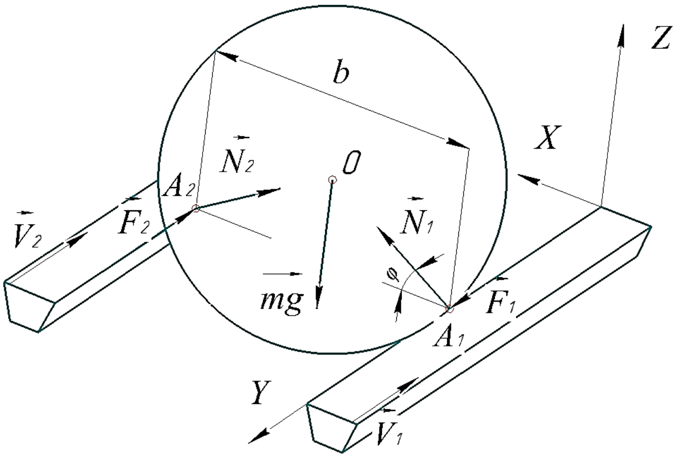


**Fig. 1. Scheme of forces acting on a potato tuber moving along a sorting surface**

We study the movement of potato tubers relative to the belt at a low speed. We will consider the tuber a continuous homogeneous ball of radius R[4].

In the case under study, we assumed that the belts were parallel to each other, since the distance between the belts was less than the size of the potato tuber, and the angle between the belts was very small.

We will connect the $XYZ$ coordinate system rigidly with the low-speed belts (Figure 1). The $Y$ and $X$ axes are located in the sorting plane, which is horizontal. The $X$ axis is directed along the line perpendicular to the direction of belt speed, the $Y$ axis in the direction of movement of the belts (Fig. 1)[4].

Since the belt moves uniformly and rectilinearly at low speed, the $XYZ$ reference system associated with it will be inertial.

The speed of the second belt $V_2$ in the $XYZ$ coordinate system is equal to the difference in the absolute speeds of the first and second belts of the sorting surface.

The following forces act on the tuber: gravity, normal support reactions and friction forces.

We write the differential equations of tuber motion in the $XYZ$ coordinate system under the action of these forces.

Denote by $x$, $y$, $z$ the coordinates of the tuber's center of gravity, and by $p$, $q$, $r$ the projections of the instantaneous angular velocity of the tuber on the axis parallel to $XYZ$ and passing through the center of the tuber. Differential equations of motion have the form[4,5]:

$$mx'' = (N_1 - N_2)\cos\varphi; \tag{1.1}$$

$$my'' = F_1 - F_2; \tag{1.2}$$

$$mz'' = (N_1 + N_2)\sin\varphi - mg; \tag{1.3}$$

$$Ip' = (-F_1 + F_2)R\sin\varphi; \tag{1.4}$$

$$Iq' = 0; \tag{1.5}$$

$$Ir' = (F_1 + F_2)R\cos\varphi. \tag{1.6}$$

where$m$ is the mass of the tuber; $I$ is the moment of inertia of the tuber about the axis passing through its center; $\varphi$-angle between the horizon and the direction of the reaction from the side of the belt $N$.

In the case of rolling without sliding along the $XY$ plane, the speed of the contact point $A_1$ of the tuber and belt-1 will be zero:

$$\vec{V}_{A_1} = \vec{V}_0 + \vec{\omega} \cdot \vec{OA}_1 = 0. \tag{1.7}$$

The speed of the point of contact of the tuber and the second belt with a high speed $A_2$ is determined by the expression:

$$\vec{V}_{A_2} = \vec{V}_0 + \vec{\omega} \cdot \vec{OA}_2, \tag{1.8}$$

where $\vec{V}_0$ is the center velocity of the potato tuber; $\vec{\omega}\cdot$ - instant angular velocity of the tuber.

From equation (1.5) it follows that the angular velocity of rotation of the tuber with respect to the axis parallel to Y is constant and equal to zero. Due to the fact that the x and z coordinates of the tuber center remain unchanged ($x=const=R\cos\varphi$, $z=const=R\sin\varphi$), equations (1.1) and (1.3) are equilibrium equations, since, in connection with $x''=0; z''=0$

$$0=(N_1-N_2)\cos\varphi;\ N_1=N_2;$$

$$0=(N_1+N_2)\sin\varphi-mg;\ mg=(N_1+N_2)\sin\varphi=2N_1\sin\varphi;$$

from this $N_1=N_2=\dfrac{mg}{2\sin\varphi}$.

Therefore, according to the Kulon-Amonton law, the sliding friction force acting on the tuber from the side of the belts has the form:

$$F_1=F_2=f\frac{mg}{2\sin\varphi},\qquad (1.9)$$

where$f$-is the coefficient of friction of the tuber against the rubber of the belts.

At points $A_1$ and $A_2$ of the contact of the tuber with the belts, there is no sliding, and the laws of sliding friction are not applicable in this case. The friction forces $F_1$, $F_2$ completely go to prevent slipping.

Thus, the right side of equations (1.2) and (1.4) are balanced by 0, that is, the potato tuber moves along the sorting surface uniformly rectilinear and rotates relative to the axis passing through the center of the tuber and parallel to *Z*.

Taking into account (1.9) from (1.6) we find the projections of the angular acceleration of the tuber on the *Z* axis:

$$r'=f\frac{mg}{I\sin\varphi}R\cos\varphi.\qquad (1.10)$$

Given that the moment of inertia of the ball relative to any axis passing through its center:

$$I=\frac{2}{5}mR^2.\qquad (1.11)$$

We obtain from (1.10):

$$r'=f\frac{5g}{2R}ctg\varphi.$$

We integrate this expression under zero initial conditions and obtain the law of change in the projection of the angular velocity of the tuber when the tuber rotates relative to the axis parallel to:

$$r(t)=tf\frac{5g}{2R}ctg\varphi.\qquad (1.12)$$

From the projection of (1.7) and (1.8) onto the *Y* axis, we can obtain the following additional expressions:

$$y'+rR=0,\qquad (1.13)$$

$$V_{A_2}=y'+rR\cos\varphi.\qquad (1.14)$$

We differentiate (1.13) with respect to time and obtain the projection of the angular acceleration on the *Z* axis:

$$r'=\frac{y''}{R}.\qquad (1.15)$$

From (1.6), (1.9) and (1.15) we obtain the following relation:

$$I\frac{y''}{R}=-f\frac{mg}{\sin\varphi}R\cos\varphi.\qquad (1.16)$$

Taking into account (1.11) we determine the acceleration of the tuber's center of gravity:

$$y''=-f\frac{5g}{2\sin\varphi}\cos\varphi.\qquad (1.17)$$

We integrate (1.17) under zero initial conditions and obtain the law of variation of the tuber center velocity along the *Y* axis:

$$V_y(t) = -f\frac{5g}{2\sin\varphi}\cos\varphi t. \tag{1.18}$$

Further integration will allow you to get the law of movement of the center of the tuber along the belt 1 low speed:

$$y(t) = -f\frac{5g}{2\sin\varphi}\cos\varphi\frac{t^2}{2}. \tag{1.19}$$

Equations (1.12, 1.18, and 1.19) allow us to analyze the movement of a tuber depending on its size, in this case, on the radius *R*. The size of the tuber will affect the position of the point of contact with the belts: the larger the radius of the tuber, therefore, increases the angle $\varphi$ (Fig. 1).

From figure-1 follows:

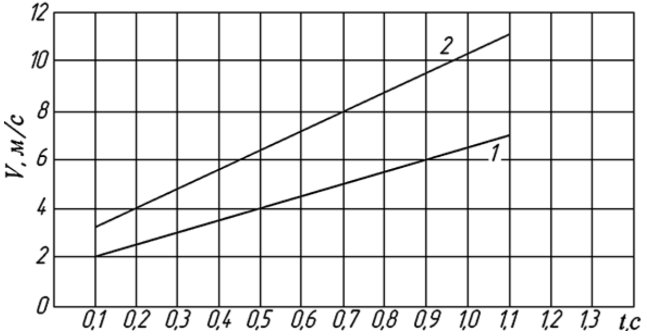
$$\varphi = \arccos\frac{b}{D}, \tag{1.20}$$

Where *D* is the thickness of the potato tuber.

## III. RESEARCH RESULTS AND DISCUSSION

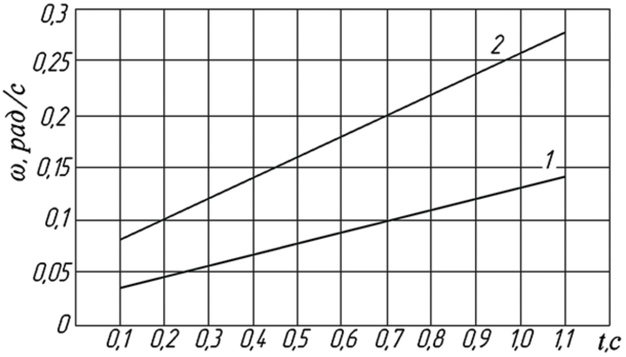
This is known from the requirements for sorting potato crops; the value of *b* varies between 28-55 mm. The sizes of the smallest fractions that are sorted are from 28 mm to 35 mm. We can take the average of these values. Therefore, *b=31* mm. The average size of tubers of the largest fraction is *D=49* mm. The average size of the tubers of the middle fraction is *D=39* mm.

We plot the velocity center of gravity of potato tubers of large and medium fractions depending on time:



*Straight line-1-speed center of gravity of large tubers, straight line-2-speed center of gravity of medium tubers*

**Fig. 2. Graph of speed change center of gravity of large and medium tubers versus time**



*a straight line is the 1-angular velocity of large tubers when rotating around an axis parallel to Z, a straight line is a 2-angular velocity of large tubers when rotating around an axis parallel to Z*

**Fig. 3. Graph of changes in the angular velocity of the tuber as a function of time**

## IV. CONCLUSION

Figures 2.3 and expression (1.19) show that tubers of small size move faster along the sorting surface. However, the forces Ғ$_1$ and Ғ$_2$ affect the tuber through the belts and their directions are unchanged, that is, they are not attached to points $A_1$ and $A_2$. The speed of the point of contact between the tuber and the belts is almost equal to the speed of the belts. Due to the inertia of the tubers, friction between the belts and the tubers prevents the speed increase. Therefore, Figures 2, 3 and expressions (1.12), (1.18), (1.19) do not describe the actual movement of tubers. However, due to the mutual non-attachment of the tuber and the belts at the points of contact, due to the inertia force, partial sliding occurs. In this regard, we can conclude that the tuber velocities with greater inertia will be greater than the tuber velocities with lower inertia.

In this case, smaller tubers do not block the path of larger ones, and a heap does not form on the sorting surface, and the tubers are evenly distributed on the sorting surface.

## REFERENCES

[1] Bahadirov G. A., Umarov B. T.. Basics of calculation of certain parameters of the belt drive of the machine for sorting of potatoes. European Sciences review. Scientific journal № 1–2 2018 (January–February),-48-50p.

[2] GilvanovV.F.. Development of self–oscillating linear asynchronous electric drive of a machine for potato sorting: the dissertation Author's abstract on competition of a scientific degree of the Cand.Tech.Sci. Izhevsk,– 2012.–18 p.

[3] Bahadirov G.A., Sabirjanov T.M., Umarov B.T., Bakhadirov K.G. Sorting machine. Patent.Republic of Uzbekistan.№ FAP 01241.State Patent Office of the Republic of Uzbekistan, Official Gazette No. 10 (198),–2017.

[4] GordeevO.V.Совершенствованиерабочихорганов машиндляуборкиипослеуборочнойдоработкисеменногокартофеля: the dissertation on competition of a scientific degree of the Doc.Tech.Sci. Chelyabinsk,– 2014.–319 p.

[5] Eduard L. Stiefel, Gerhard Scheifele. Linear and regular gelestial mechanics.Perturbed Two-body Motion Numerical Methods Canonical Theory. Springer-Verlag Berlin Heidelberg New York 1971