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Justification Of The Cinematic Parameters Of The Oscillating Lattice Of Potato Harvesters

Nabijon Gulamovich Bayboboev
Doctor Of Technical Sciences, Professor, Department "Transport Logistics", Namangan Engineering-Construction Institute, Uzbekistan

Umidjon Gulomjonovich Goyipov
Senior Teacher, Department "Information And Information Technology", Namangan Engineering-Construction Institute, Uzbekistan

Ahror Aminjon o'g'li Tursunov
Assistant Teacher, Department Of "Technological Machines And Equipments", Namangan Institute Of Engineering Technology, Uzbekistan

Xayrullo Xolmirzayevich Nishonov
Teacher, Department "Transport Logistics", Namangan Engineering-Construction Institute, Uzbekistan

ABSTRACT

The paper theoretically explores the work of a fluctuating potato harvester grate to separate the soil from the potato tubers using vertical oscillations in the separation of potato tubers. A link has been established between the flying phase and the tuber rip phase of the potatoes for the planes, which are horizontal with vertical oscillations and inclined with fluctuations at a certain angle. The altitude of the particles and the rate of the impact thereof with the oscillating plane are considered, which made it possible to determine the optimal parameters and kinematic modes of the separating working organs of the potato combine combine.

KEYWORDS

Potato harvester, silo, sieve, flapping, soil, tuber, plane, phase, impact velocity, oscillation amplitude.

INTRODUCTION

The fluctuating sieves are the main separating bodies of modern potato harvesters. A sieve is a fluctuating sieve that separates the soil from the potato tubers and transports the potato mass up the lattice, thereby shaking the potato tubers from the soil. These working bodies shall be subject to the following requirements [1, 2, 3]:

- Effective soil separation from potato tubers.
- Minimum tuber damage and loss.
- Minimum dynamic loads and vibrations of the machine.

These requirements are contradictory to each other if one of them is met, the other cannot be met. For example, intensification of soil separation usually requires increased shaking of the sieve, which causes wilting of damage to the tubers as well as avoiding dynamic loads.

Increased speed has a positive impact on productivity but negatively affects soil separation. All this requires finding the optimal parameters of the separating working bodies to ensure a rational balance of these requirements.

This is determined by the correct choice of the kinematic oscillations of the decks. [3,4,5]. This article introduces a theoretical study to justify the optimal variation of potato machine grids

Data available in the literature [6,7,8,9,10] on this subject, for example for grain-cleaning machines [9] cannot be used in the calculation of the separator working organs of potato harvesters. Shrubs of grain-cleaning machines, in the process of separation, transport the mass downwards, while in potato-harvesting machines transport the mass upwards and deal with such a delicate product as potato.

PURPOSE AND OBJECT OF RESEARCH

For the correct selection of the sieves of potato harvesters first consider the motion of the particle freely lying on a horizontal plane with vertical oscillations, Ha Rice. 1 shows the motion of the oscillating plane with the particle lying freely on it. The equation for the motion of this particle at vertical oscillations of the plane is as follows [11]:

$$\ddot{y} = -g \qquad (1)$$

$$\dot{y} = -gt + \vartheta_0 \qquad (2)$$

$$y = -\frac{gt^2}{2} + \vartheta_0 t \qquad (3)$$

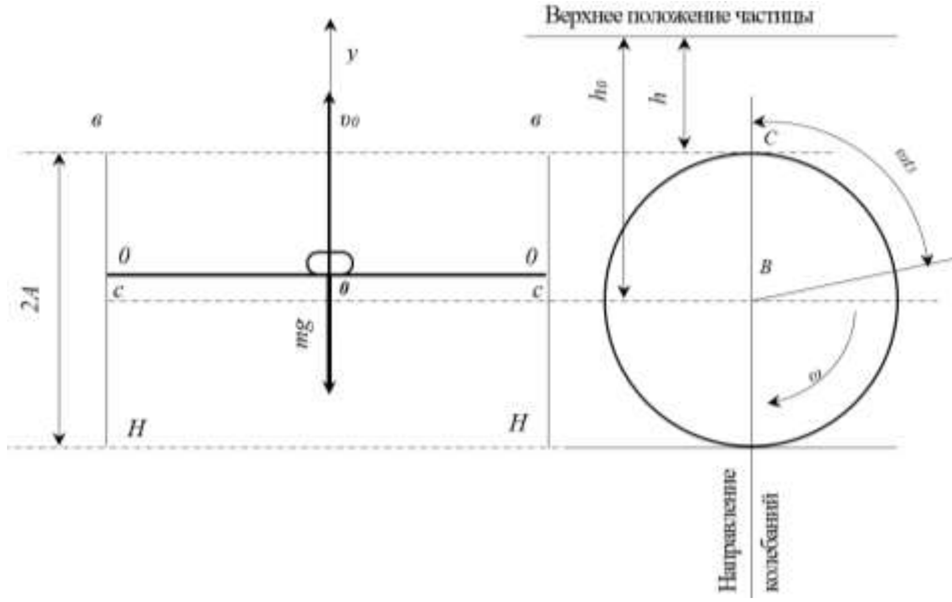

Figure. I. Horizontal plane diagram with vertical variations (oscillating plane positions: *вв* -upper; *HH* -Lower; cc-middle; 00-at the moment of particle removal from the sieve)

Plane movement equations, i.e. of the grid (origin coincides with the point of separation of the particle from the plane) [1]:

$$\ddot{y} = -\omega^2 A\cos(\omega t - \omega t_3); \quad (4)$$

$$\acute{y} = -\omega A\sin(\omega t - \omega t_3); \quad (5)$$

$$y = A[\cos(\omega t - \omega t_3) - \cos\omega t_3]; \quad (6)$$

Where

g -is the acceleration of gravity;

t - time;

vo - is the velocity of the particle at the moment of separation;

A is the oscillation amplitude of the plane;

ω -is the circular frequency of plane oscillations;

ωt3 – is the phase of the plane oscillation corresponding to the moment when the particle is detached from the plane.

The magnitude of the flight phase is determined by the phase of the plane oscillation corresponding to the free flight of the particle from the moment it is removed from the plane to the moment when it falls to the plane. $\frac{\omega^2 A}{2} = k$

Equate equations (3) and (6) result in:

$$A[cos(\omega t - \omega t_3) - cos\omega t_3] = v_0 t - \frac{gt^2}{2} \quad (7)$$

where, of (7), determine the velocity of the particle at the point of departure from the plane $cos\omega t_3 = \frac{g}{\omega^2 A}$

$$v_0 = \omega A \, sin\omega t_3 = \frac{\sqrt{(\omega^2 A)^2 - g^2}}{\omega}$$

By substituting the values of v0 and cosωt3 in (7) and performing the transformation, we get:

$$k = \sqrt{\left[\frac{\frac{(\omega t)^2}{2} + cos\omega t - 1}{\omega t - sin\omega t}\right] + 1} \quad (8)$$

As mentioned above, the particle phase is defined by the expression:

$$cos\omega t_3 = \frac{g}{\omega^2 A} \quad (9)$$

Thus, the relationship between the coefficient of mode k and the phase of separation ωt3 is:

$$k \, cos\omega t_3 = 1 \quad (10)$$

The relationship between the separation phase of ωt3 and the flight phase of ωt is as follows:

$$tg\omega t_3 = \frac{\frac{(\omega t)^2}{2} + cos\omega t - 1}{\omega t - sin\omega t} \quad (11)$$

The table shows k, $cos\omega t_3$, ωt_3 и $(\omega t - \omega t_3)$ depending on the flight phase, and figures 2, 3, 4 and 5 show the variation of these values corresponding to equations (8), (9), (11) calculated from the Mathcad program on the mainframe.

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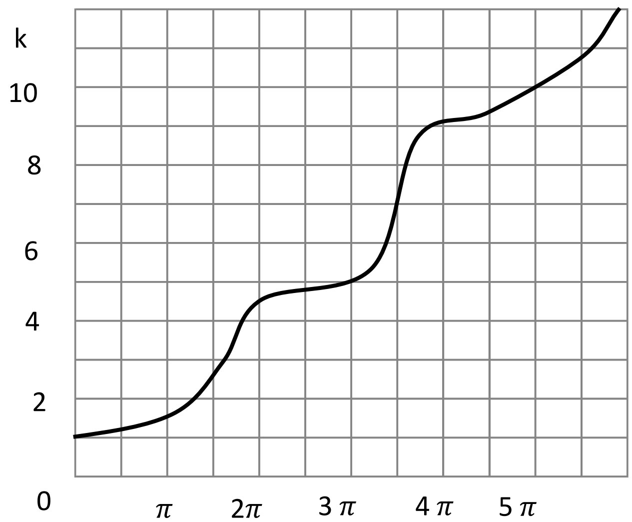

Figure 2. Mode k coefficient dependent on the flight phase

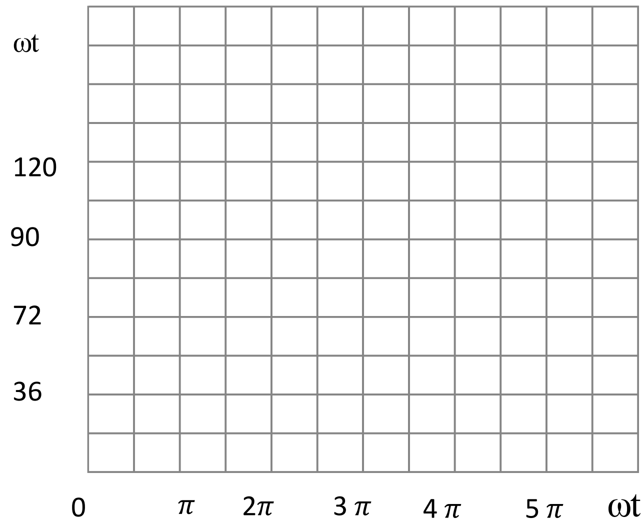

Figure 3. Phase dependent on phase ωt_3 for flight phase ωt

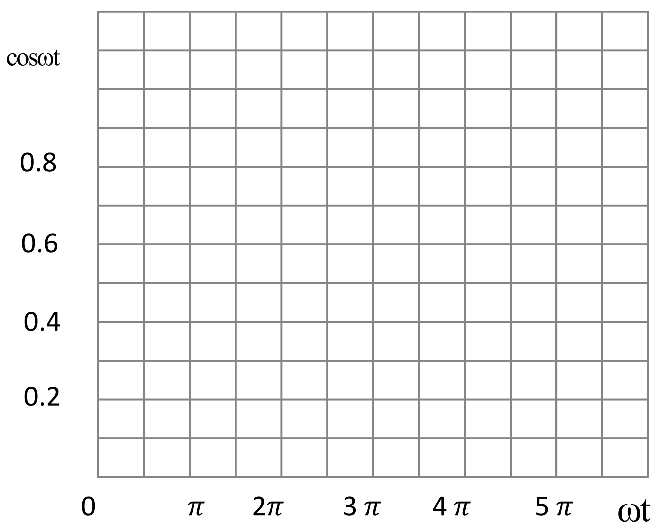

Figure 4. Phase dependent on opening $\cos\omega t_3$ for flight phase ωt

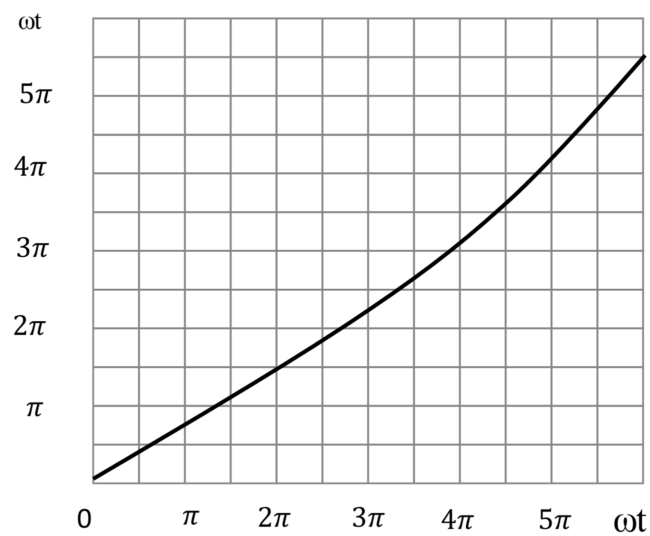

Figure 5. Separation phase difference versus flight phase ωt

RESULTS OF THE STUDIES AND THEIR DISCUSSIONS

The resulting data provide values such as the acceleration of oscillations, the frequency of oscillations corresponding to the mode ,, the height of the drop of particles above the plane, and the rate of collision of particles with the plane. These values are of interest to the designer: for example, impact velocity determines damage to the tubers on the cracks; The acceleration of oscillations determines the dynamic forces.

Thus, for the accepted value of the flight phase, the maximum acceleration of oscillations is determined from the expression:

$$\omega^2 A = kg \qquad (12)$$

The value k, depending on the phase of flight, should be taken from the table. The drop height of the particle above the plane shall be calculated from the upper extreme position of the oscillating plane. The drop height of the particle relative to the position of the oscillating plane corresponding to the moment of separation (see fig. 1) is determined from the expression

$$h_0 = \frac{v_0^2}{2g} = \frac{\omega^2 A^2}{2g} - \frac{g}{2\omega^2}, \qquad (13)$$

The ejection height of hparticles above the upper extreme position of the plane (see fig. 1) is equal to

$$h = h_0 - CD = \frac{\omega^2 A^2}{2g} + \frac{g}{2\omega^2} - A \qquad (14)$$

where $CD = A(1 - cos\omega t_3) = A - \frac{g}{\omega^2}$

The height h generated by the coefficient of mode k is equal to

$$\mathrm{h} = A \cdot \frac{(k-1)^2}{2k} = k_2 A, \qquad (15)$$

where is the coefficient of the height of the flip.

$$k_2 = \frac{(k-1)^2}{2k}$$

The velocity vc of the collision of a particle with an oscillating plane when the particle falls into the plane is folded at the velocity of vrparticle and the velocity of vp of the lattice (plane) determined by equation (5):

$$\boldsymbol{v_c = v_p + v_r}$$

The velocity of the particle is defined as follows. Suppose we know the entire height hp of the particle falling from its upper position to the moment it falls to the plane, then the velocity of the particle when it falls to the plane will be

$$v_r = \sqrt{2gh_n} = \sqrt{2g(h + h_g)}$$

Where hg – is the additional height, i.e. the height from the top of the plane to its position when the particle falls. This height depends on the position of the plane when the particle hits it and is determined from the expression.

$$h_g = A[1 - \cos(\omega t - \omega t_3)]$$

Thus, the rate of collision of particles with lattice strength can be expressed by the following equation:

$$v_c = \sqrt{gA}\left[\sqrt{2\left[\frac{(1-cos\omega t_3)^2}{2cos\omega t_3} + 1 - \cos(\omega t - \omega t_3)\right]} - \sqrt{\frac{1}{cos\omega t_3}}\sin(\omega t - \omega t_3)\right] \qquad (16)$$

Let's denote where k3 is the coefficient of impact velocity. Figure 5 shows the evolution of the coefficient k3 according to the phase of flight.

$$v_c = k_3\sqrt{gA}$$

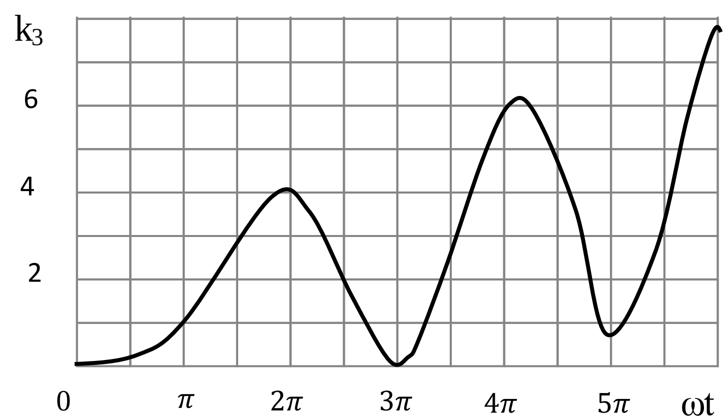

Figure 6. Impact velocity coefficient k_3 dependent on flight phase ωt

In the table, according to the obtained expressions (8), (14) and (16), the values of the oscillation frequency, the drop height and the impact velocities of the particle on the oscillating plane are calculated for the oscillation amplitude 6,7 mm, which corresponds to the normal component of the oscillation amplitude of the potato combine. Furthermore, the purity of the oscillation of the silo depends on its speed, so the table gives the values of the silo speed, which is determined by the following equation [3].

$$v_{эл} = \frac{\sqrt{kg(a+b)^2 cos\propto_{эл}}}{8(\propto - \beta)}$$

where, k - mode coefficient;

a – is the largest; b is the smallest size;

∝_эл is the angle of the elevator.

From table and figure. 5 It follows that the normal component of the impact velocity of the particle with the oscillating plane increases from

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a minimum to a certain maximum value and then falls to small values, after which it rises again, etc.

Now, on the basis of the above, consider the motion of the particle lying on an inclined plane with an angle of rise α and an angle of oscillation β (tumbling rumble, pic. .6)

In this case, the upward movement of the material on an inclined plane may be recorded as follows:

a. Equations of particle motion under the condition that the speeds of the particle and the plane are equal at the moment when the particle is detached from the plane:

$$\ddot{x}=0; \qquad \ddot{y}=-g; \qquad (17a)$$

$$\dot{x}=v_0\cos(\alpha+\beta); \qquad \dot{y}=v_0\sin(\alpha+\beta)-gt; \qquad (18b)$$

$$x=v_0t\cos(\alpha+\beta); \qquad y=v_0t\sin(\alpha+\beta)-\frac{gt^2}{2} \qquad (19v)$$

where, $v_0=\frac{\sqrt{(\omega^2 r\sin\beta)^2-(g\cos\alpha)^2}}{\omega\sin\beta}$

b. Equation of the motion of an inclined plane with an angle of rise α>0 and an angle of oscillation β>0 (swinging sieve):

$$\ddot{y}=-\frac{\omega^2 A\cos(\omega t-\omega t_3)\sin\beta}{\cos\alpha}; \qquad (20a)$$

$$\dot{y}=-\frac{\omega A\sin(\omega t-\omega t_3)\sin\beta}{\cos\alpha}; \qquad (21b)$$

$$y=xtg\propto+\frac{A[\cos(\omega t-\omega t_3)-\cos\omega t_3]\sin\beta}{\cos\alpha}; \qquad (22v)$$

where $\cos\omega t_3=\frac{g\cos\alpha}{\omega^2 A\sin\beta}$

	ωt	0	$0,167\pi$	$0,5\pi$	$0,7\pi$	π	$1,3\pi$	$1,5\pi$	$1,7\pi$	$1,9\pi$	2π	$2,5\pi$	3π	$3,5\pi$	4π	$4,5\pi$	5π
1.	k	I	1.01	1.081	1.205	1.375	1.7	2.035	2.6	3	3.33	4.47	4.61	5.02	7.01	7.61	7.8
	$\sqrt{k}$		1.005	1.039	1.095	1,171	1.302	1.425	1.612	1.73	1.825	2,115	2,146	2.258	2.65	2.76	2.792
2.	$cos\omega t_3$	I	0.99	0.925	0.830	0.727	0.588	0.492	0.385	0.333	0.308	0.224	0.2178	0.199	0.1425	0.1315	0.1287
3.	ωt_3	0	8°0'	22°20'	33°50'	43°20'	54°0'	60°30'	67°20'	70°30'	72°20'	77°05'	77°25'	78°30'	80°55'	82°25'	82°40'
			$0,0445\pi$	$0,122\pi$	$0,188$	$0,24\pi$	$0,30\pi$	$0,336\pi$	$0,375$	$0,391$	$0,40\pi$	$0,428$	$0,431\pi$	$0,436$	$0,450\pi$	$0,458$	$0,046$
4.	$\omega t - \omega t_3$	0	$0,1225\pi$	$0,378\pi$	$0,512$	$0,76\pi$	$1,0\pi$	$1,164\pi$	$1,325$	$1,5\pi$	$1,6\pi$	$2,071$	$2,569\pi$	$3,064$	$3,546\pi$	$4,041$	$4,54\pi$
			0.385	1.19		2.39		3.66	4.17		5.4	6.51				12.7	14.26
5.	$k_2 = \frac{h}{r}$	0	0.00005	0.003	0.0175	0.051	0.144	0.255	0.493	0.667	0.815	1.35	1.42	1.62	2.57	2.88	2.956
6.	$k_3 = \frac{v_c}{\sqrt{gr}}$	0	0.035	0.164	0.329	1,115	2.07	2.9	3.638	3.56	3.84	1.843	0.05	2.68	5.32	3.03	0.996
7.	n, o/min	358	360	372	393	420	467	510	576	620	653	758	769	804	949	988	1000
8.	h, mm	0	0.00034	0.0201	0.1175	0.343	0.965	1.71	3.31	4.48	5.47	9.06	9.55	10.90	17.6	19.3	19.85
9.	v_c, m/sec	0	0.0089	0.042	0.0841	0.0284	0.53	0.743	0.93	0.91	0.98	0.47	0.0127	0.686	1.365	0.776	0.255
10.	v_{3n}, m/sec	0.84	0.86	0.874	0.921	0.985	1.096	1.20	1.355	1.455	1.535	1.775	1.804	1.89	2.222	2.32	2.35
11.	h, mm	0	0.0000715	0.043	0.25	0.73	2.06	3.64	7.02	9.5	11.65	19.3	20.3	23.2	36.7	41.1	42.1
12.	v_c	0	0.0131	0.0615	0.123	0.418	0.775	1.085	1.36	1.331	1.44	0.69	0.0187	1.00	2.00	1,135	0.373

The free flight phase ωtfor the particle in the inclined plane with angles α>0 and β>0 is determined from equations (19) and (22). By substituting the values of x and y from equations (3) into equation (22),

$$v_0 t sin(\alpha+\beta) - \frac{gt^2}{2} = v_0 t cos(\alpha+\beta) tg\alpha + \frac{A[\cos(\omega t-\omega t_3) - cos\omega t_3] sin\beta}{cos\alpha}$$

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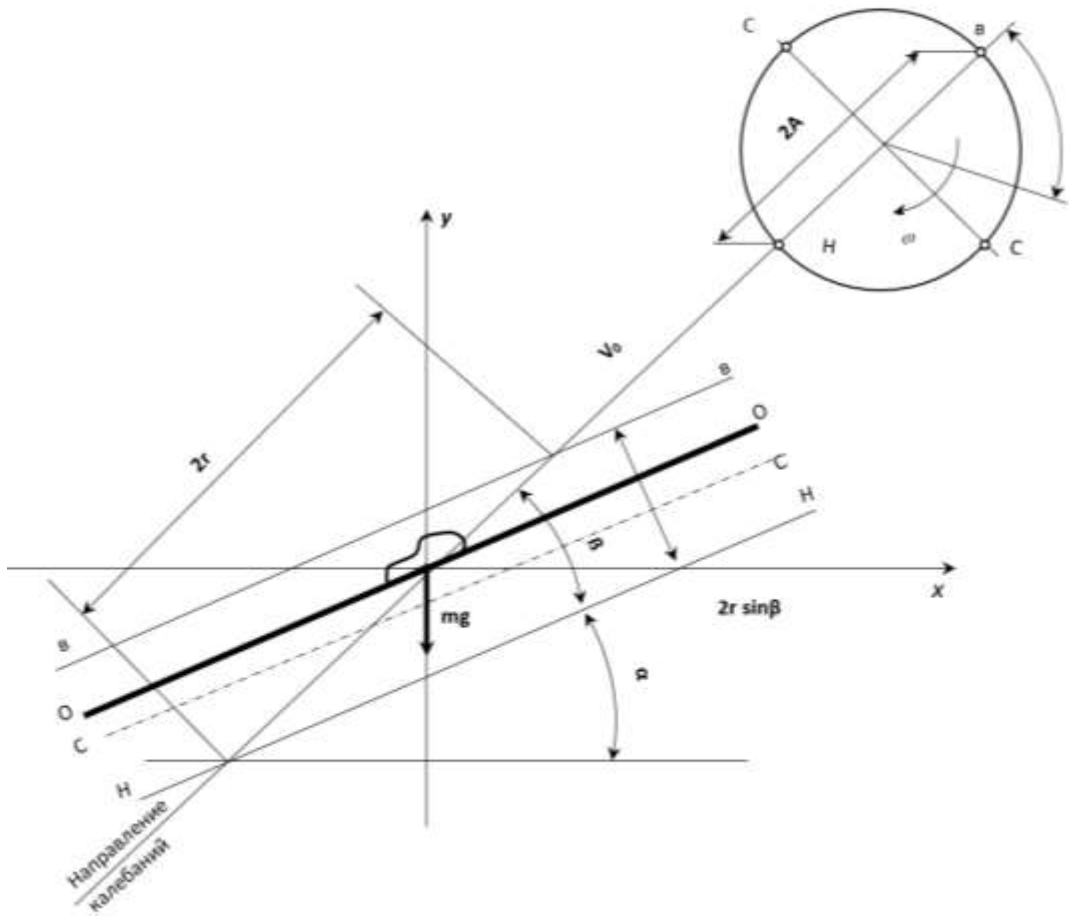

Figure 7. Scheme of motion of an inclined plane with an angle of oscillation β (tumbling rumble) with the particle lying freely on it

By substituting the values of v0 and cosωt3 into this expression and by carrying out the transformation, we get

$$\frac{\omega^2 A}{g} = k\frac{cos\alpha}{sin\beta} \tag{23}$$

By substituting in this expression the value of the gap phase ωt3 of the coefficient k according to the expression (10) and cosωt3 and solving the equation relative to ωt3, we get

$$tg\omega t_3 = \frac{\frac{(\omega t)^2}{2} + cos\omega t - 1}{\omega t - \sin\omega t}$$

A comparison of this expression with equation (11) shows that the connection between the disconnect phase ωt3 and the flight phase ωtfor the inclined plane with the vertical plane (α≠0 и β≠0). It will be the same as for the horizontal plane with vertical oscillations, i.e. α = 0and β = 0

CONCLUSIONS

From the motion analysis of the particle lying freely on:

A horizontal plane with vertical oscillations and an inclined plane with an angle α>0 with an angle of β>0° variation results in the following conclusions:

1. The relationship between the gap phase ωt3 and the flight phase ωtfor the horizontal plane with vertical oscillations, for the inclined plane with an angle of oscillation β>0 is the same and expressed in the same equation

$$tg\omega t_3 = \frac{\frac{\omega t^2}{2} + cos\omega t - 1}{\omega t - sin\omega t}$$

where

ωt- is the free-flight phase of the particle from the moment it is removed from the plane of the sieve to the contact with the plane;

ωt3 is the phase of detachment of the particle from the plane of the sieve defined by the following equations:

For horizontal plane with vertical oscillations

$$cos\omega t_3 = \frac{g}{\omega^2 A}$$

- for an inclined plane at an angle α>0, with an angle β>0

$$cos\omega t_3 = \frac{gcos\alpha}{\omega^2 A\ sin\beta}$$

2. Kinematic mode coefficient

- for the horizontal plane with vertical oscillations k=(ω^2 A)/g

- for a plane inclined at an angle α>0, with an angle of oscillation β>0

$$K = \frac{\omega^2 A\ sin\alpha}{g\ cos\alpha}$$

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