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Cleaning process simulation of the dielectric sorting device

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Abstract. The article presents theoretical studies to substantiate some parameters of the dielectric sorting device of alfalfa seeds, in particular: the width of the outlet slot of the hopper, the step and depth of the metering groove, the length of the limiter and the angle of its installation. When developing a theoretical study to substantiate the parameters of the sorting device, the physical and mechanical properties of a heap of alfalfa seeds were taken into account. Substantiated parameters make it possible to improve the design and thereby improve the technological process of sorting and cleaning of alfalfa seeds of a dielectric sorting device.

1. Introduction

Considering that today "... more than 30 million hectares are sown with alfalfa all over the world" [1], then an important task is the development of energy-saving technologies and technical means aimed at reducing the irrecoverable loss of seeds during harvesting and improving the quality of processing seed heap. In this direction, the development of a constructive scheme and theoretical studies of a dielectric sorting device for alfalfa seeds is relevant.

At present, for the conditions of Uzbekistan, the technology of harvesting alfalfa seed plants with the processing of the seed heap at a stationary point is recognized as the most rational [5]. In this case, the threshing of a heap is usually carried out by grain harvesters or a thresher-winnower MV-2.5A, which is associated with high costs and seed losses that exceed 10 ... 15%. Further, the primary cleaning of seeds is carried out using complex seed cleaning machines OVS-28, the principle of which is based on the difference in the physical and mechanical properties of alfalfa seeds and weeds (specific weight, windage, dimensions, etc.). After this operation, the yield of cleaned alfalfa seeds is about 80%. Final cleaning is carried out on an electromagnetic seed cleaning machine EMC-1, based on the ability of weed seeds (due to their surface roughness) to be enveloped with a special coal-metal powder, which is produced by the chemical industry and has a high cost [2].

In real economic conditions, in the presence of a large number of small farms and dekhkan farms in the republic, for effective preliminary cleaning of alfalfa seeds it is necessary to develop and use a mobile, small-sized grating machine, and for final cleaning - a simple and reliable device that provides sufficient productivity with minimal manual labor, high quality seed cleaning, environmental friendliness and low cost [3].

The carried out researches made it possible to determine the most rational technology for post-harvest processing of alfalfa seed heaps and purification of its seeds from weeds and quarantine inclusions.

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The use of this technology does not provide for the use of traditionally used seed cleaning machines, due to their absence, physical wear and tear of the existing ones, as well as high metal and energy consumption and the significant cost of new ones. This leads to an increase in material costs, which is unprofitable for most small farms.

The proposed technology differs from the existing simplicity and the number of machines used, their low cost and mobility. It provides for the use of the following set of machines: thresher MV 2.5A - for processing seed biomass; grating machine K-05M - for grinding seed pods and separating seeds, as well as a dielectric seed cleaning device - for sorting and final cleaning of seeds [4].

The purpose of the research is to increase the efficiency of the sorting device for cleaning alfalfa seeds by improving its design and optimizing technological and design parameters.

2. Materials and Methods

The theoretical prerequisites for substantiating the parameters of the dielectric device dispenser are fulfilled in accordance with the basic principles of mechanics and higher mathematics, taking into account the technological features of the process of dispensing alfalfa seeds, as well as its physical and mechanical properties. Differential equations were solved by numerical methods "Runge-Kutta-Felberg" with automatic step selection [5].

3. Results and Discussion

The feed hopper of the dielectric sorting device is a hopper with an outlet slot (Figure 1).

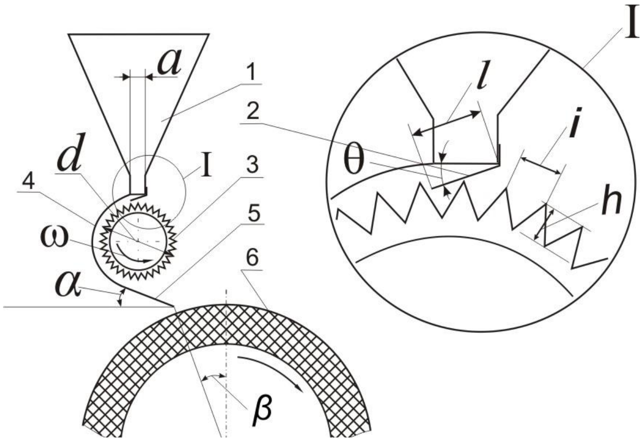

Figure 1. Technological diagram of a dielectric sorting device

To ensure a continuous flow of a heap of alfalfa seeds through the slot of the hopper, the width (*a*) of the outlet slot should be equal to or greater than the maximum value of the largest arch-forming dimensions $D_{н.св.}$ of the outlet openings, i.e. $a > D_{n.sv.}$ [6].

The maximum size of alfalfa seed bridging above the bunker slot can be determined by the formula [4]:

$$D_{н.св.} = \frac{d_ч [A_0 (2a_0 \eta + 3\gamma) tg(\beta_y + \varphi) + 3\gamma \sin 2\beta_y tg\chi]}{6\gamma \sin \beta_y (1 + \delta tg\chi)}, \quad (1)$$

where $d_ч$ is the diameter of alfalfa seeds, m; A_0 - coefficient of proportionality between vertical and horizontal forces acting along the length of the perimeter of the cross-section of the flow sliding surface;

$$A_0 = ctg(\beta_y + \varphi), \quad (2)$$

a_0 – coefficient of proportionality between the force of pressure of the "leading" layer on the "intermediate" layer to the external axial force acting on the "driven" layer; η – density of alfalfa seeds, kg/m^3; γ – seed heap density, kg/m^3; β_y – Alfalfa seed laying angle, degree (Figure-2); ϕ –angle of internal friction of the seed heap, degree; χ – the angle between the tangent to the curved arch at the pivot point and the horizontal, degree; δ – proportionality coefficient between the height of the arch and the size of the hole in the longitudinal section of the hopper;

$$\delta = \sqrt{A_o^2 ctg^2 \chi + A_o} - Actg\chi \, , \qquad 3)$$

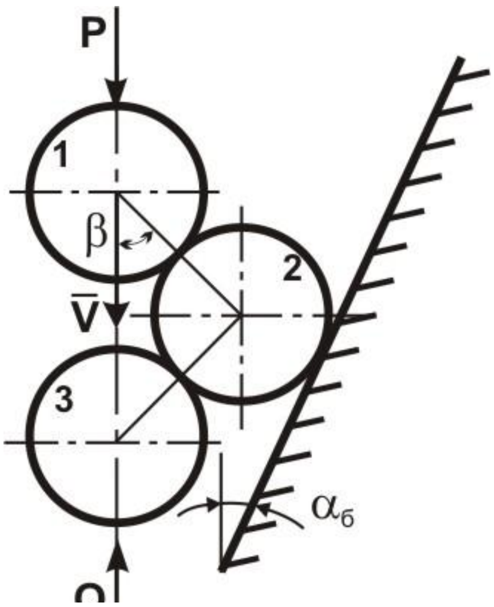

Figure 2. Scheme of forces acting on an elementary volume of bulk material: 1-leading layer; 2-intermediate layer; 3-driven layer; P- axial force; V- the vector of the velocity of the layer; Q- external force opposite to the speed of movement; β- laying angle; $\alpha_б$ - the angle of inclination of the wall of the bottom of the hopper to the vertical.

A – proportionality coefficient between vertical ρ and horizontal, ρ'- efforts in any section of the hopper (Figure 3).

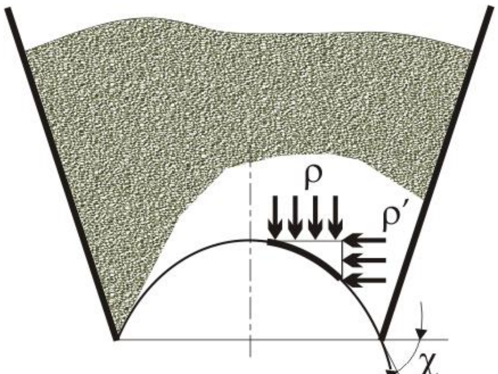

Figure 3. Diagram of forces acting on an element of a statically stable vault

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Coefficients a_o and A at hydraulic flow of bulk materials (if $\chi = \alpha_б$) are determined from the following formulas [7, 8]:

$$a_0 = \frac{tg(\varphi + \alpha_б)tg(\beta_y + \phi)}{[1 + tg(\varphi + \alpha_б)tg(\beta_y + \phi)]\cos\beta_y}, \tag{4}$$

$$A = 2[ctg(\beta_y + \phi) + tg(\alpha_б + \varphi)], \tag{5}$$

where $\alpha_б$ – angle of inclination of the wall of the bottom of the bunker to the vertical, degree;
φ – angle of friction of particles against the wall of the bin, degrees. At normal expiration, if:

$$\chi = 90^o - \phi - \beta_y - \varphi_{пр}$$

where $\varphi_{пр}$ – reduced angle of internal friction, degree.

Then:

$$a_0 = \frac{1}{2\cos\beta_y}, \tag{6}$$

$$A = 4ctg(\beta_y + \phi), \tag{7}$$

The critical angle of inclination of the bunker wall, characterizing the transition of the hydraulic type of outflow of bulk material to normal, is the angle:

$$\alpha_{кр} = 90^o - \phi - \beta_y - \varphi_{пр}, \tag{8}$$

Provided when $0^o < \alpha_б \le \alpha_{кр}$ we have the case of hydraulic, and under the condition when $\alpha_{кр} < \alpha_б \le 90^o$ – the case of a normal type of flow of bulk material.
The numerical value of the stacking angle, the particle shape of which is close to an ellipsoid, is $\beta_y = 17$. [9, 10]. Formula (1) gives the smallest value of the width of the hopper slot, at which the roof does not form, which leads to a continuous flow of bulk material through the slot of the hopper.
Substituting expression A_0 into formula (1), we obtain a more simplified expression for determining the maximum size of bridging:

$$D_{н.св.} = \frac{d_ч [2a_0\eta + 3\gamma(1 + \sin 2\beta_y tg\chi)]}{6\gamma \sin\beta_y (1 + \delta tg\chi)}, \tag{9}$$

In order to ensure a continuous outflow of the seed heap, it is necessary that the width of the slot a of the hopper satisfies the following condition:

$$a > \frac{d_ч[2a_0\eta + 3\gamma(1 + \sin 2\beta_y tg\chi)]}{6\gamma \sin\beta_y (1 + \delta tg\chi)}, \tag{10}$$

Substituting the values: $d_ч = 0,00166$ m, $a_0 = 0,52$, $\eta = 785\ кг/m^3$, $\gamma = 575$ kg$/m^3$, $\beta_y = 17^o$, $\delta = 0,29$, and $\chi = 31^o$ by incorporating into equation (2), we receive following indicative parameters a: $a \ge 0,0044$ m or a ≥ 4,4 mm.

On the surface of the metering drum, grooves are made along the entire length with a step i and a depth *h*. For uniform and single-layer feeding of the seed heap to the surface of the dielectric drum, it is necessary that the alfalfa seeds are placed in the grooves [11].
Suppose that the longitudinal section of alfalfa seeds is approximately an ellipse in shape with major semiaxes a_c and b_c.

Let us find the conditions under which an ellipse with principal semiaxes a_c and b_c fits into the figure *AMBC*, which consists of a triangle ABC and a segment AMB (Figure 4).

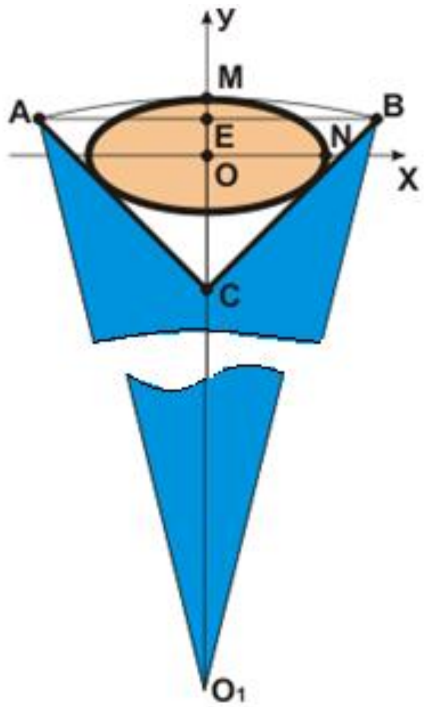

Figure 4. To determine the pitch and depth of the groove dosing drum

For convenience, we denote that: $AB = i,\ CE = h,\ ON = a_c,\ OM = b_c,\ O_1M = \frac{d}{2}$

where d is the diameter of the dosing drum, m.
From the right-angled triangle BEO_1, you can determine the leg O_1E:

$$O_1E = \sqrt{\left(\frac{d}{2}\right)^2 - \left(\frac{i}{2}\right)^2}, \qquad 11)$$

We denote by m the length of the CM segment and then:

$$m = \frac{d}{2} - \sqrt{\left(\frac{d}{2}\right)^2 - \left(\frac{i}{2}\right)^2} + h, \qquad (12)$$

Let's introduce the notation:

$$EM = j = \frac{d}{2} - \sqrt{\left(\frac{d}{2}\right)^2 - \left(\frac{i}{2}\right)^2}, \qquad (13)$$

Therefore, the coordinates of the point $C(0; b_c - m)$, and the coordinates of the point $B(\frac{i}{2}; b_c - m + h)$, therefore, for the line BC to be tangent to the ellipse, it is necessary that the line and the ellipse have a single common point.

The equation of the tangent to the ellipse passing through points B and C has the following form:

$$\frac{x - 0}{(i/2) - 0} = \frac{y - (b_c - m)}{h} \text{ or } x = \frac{i(y - b_c + m)}{2h}, \qquad (14)$$

Equation of an ellipse with principal semiaxes a_c and b_c can be represented as a classic expression:

$$\frac{x^2}{a_c^2}+\frac{y^2}{b_c^2}=1, \tag{15}$$

Substituting the value of X from formula (14) into formula (15), we obtain a quadratic equation:

$$\frac{\left(i(y+m-b_c)/2h\right)^2}{a_c^2}+\frac{y^2}{b_c^2}=1, \tag{16}$$

After transforming the quadratic equation (16), we get the following expression:

$$\frac{i^2(y+m-b_c)^2}{4h^2a_c^2}+\frac{y^2}{b_c^2}-1=0, \tag{17}$$

Hence:

$$\left(\frac{i^2}{4h^2a_c^2}+\frac{1}{b_c^2}\right)y^2+\frac{2(m-b_c)i^2}{4h^2a_c^2}y+\frac{(m-b_c)^2i^2}{4h^2a_c^2}-1=0, \tag{18}$$

Quadratic equation (18) has one unique solution when its discriminant is zero:

$$\left(\frac{(m-b_c)i^2}{4h^2a_c^2}\right)^2-\left(\frac{i^2}{4h^2a_c^2}+\frac{1}{b_c^2}\right)\left(\frac{(m-b_c)^2i^2}{4h^2a_c^2}-1\right)=0, \tag{19}$$

For a quadratic equation to have at most one solution, it is necessary that its discriminant be non-positive.
Transformation of expression (19) will lead to the following form:

$$\frac{i^2}{4h^2a_c^2}+\frac{1}{b_c^2}=\frac{(m-b_c)^2i^2}{4h^2a_c^2b_c^2}, \tag{20}$$

Further transformation of formula (20) will lead to the form:

$$b_c^2i^2+4h^2a_c^2=(m-b_c)i^2 \text{ or } 4h^2a_c^2=(m^2-2mb_c)^2i^2, \tag{21}$$

The condition for placing alfalfa seeds in the groove is the following inequality:

$$4h^2a_c^2\le(m^2-2mb_c)i^2, \tag{22}$$

Given that $m=j+h$, expression (22) will take the form:

$$4h^2a_c^2\le((j+h)^2-2(j+h)b_c)i^2, \tag{23}$$

Well then:

$$(i^2-4a_c^2)h^2+2i^2(j-b_c)h+(j^2-2jb_c)i^2\ge0, \tag{24}$$

Figure 4 shows that:

$$i>2a_c.$$

We define the discriminant of the quadratic equation (24):

$$D/4=(i^2(j-b_c))^2-(i^2-4a_c^2)(j^2-2jb_c)i^2, \tag{25}$$

After transformations we get:

$$D/4=i^4b_c^2+4a_c^2(j^2-2jb_c)i^2, \tag{26}$$

Further transformation of expression (26) will lead to an equation of the form:

$$D/4=i^4b_c^2+4a_c^2(j-b_c)^2i^2-4a_c^2b_c^2i^2 \text{ or } D/4=i^2b_c^2(i^2-4a_c^2)+4a_c^2(j-b_c)^2i^2>0, \tag{27}$$

The discriminant of this equation (27) is positive; therefore, the corresponding quadratic equation has two solutions.
Therefore, in order for alfalfa seeds to fit in the groove, the following conditions must be met:

$$i > 2a_c \text{ or } \left| h + \frac{i^2(j-b_c)}{i^2-4a_c^{\,2}} \right| \geq \frac{\sqrt{i^4b_c^{\,2}+4a_c^{\,2}(j^2-2jb_c)i^2}}{i^2-4a_c^{\,2}}, \tag{28}$$

Considering that the groove depth cannot be a negative number, we have:

$$h \geq \frac{\sqrt{i^4b_c^{\,2}+4a_c^{\,2}(j^2-2jb_c)i^2}-i^2(j-b_c)}{i^2-4a_c^{\,2}}, \tag{29}$$

Since $b_c > j$, the final formula for determining the depth of the metering drum groove will be as follows:

$$h \geq \frac{\sqrt{i^4b_c^{\,2}-4a_c^{\,2}(2jb_c-j^2)i^2}+i^2(b_c-j)}{i^2-4a_c^{\,2}}, \tag{30}$$

Substituting the known parameter values: $i = 4$ mm, $a_c = 1{,}175mm$, $b_c = 0{,}7mm$, $j = 0{,}033mm$ into the formula (3.6.30), we find the depth of the groove of the dosing drum: $h \geq 2{,}1mm$.
At the outlet of the bunker there is a stop made of a metal plate (section BK), which, under the action of periodic impacts of the dosing drum, vibrates between the dosing drum and the casing (bottom of the bunker). Thus, the limiter either passes or stops the flow of the seed heap [10].
For even distribution of the seed heap in the grooves of the metering drum, the length and angle of the stopper are very important. Under the influence of the oscillating movement of the limiter, the alfalfa seeds try to take a more stable position in the grooves of the metering drum (Figure 5).

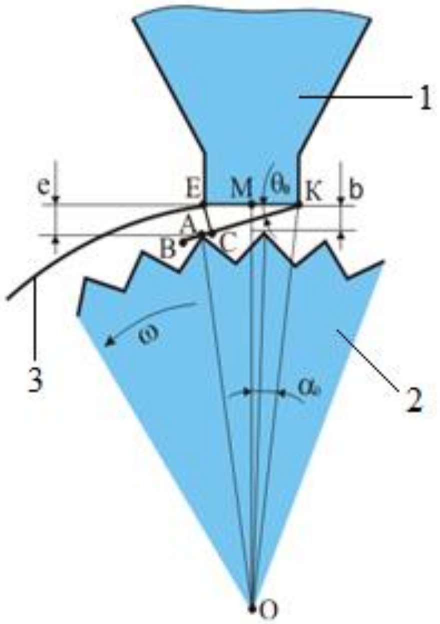

Figure 5. To determine the length of the limiter and the angle of its installation: 1-bunker; 2-dispenser; 3-casing, *BK*=*l*– limiter length; θ_0– angle of installation of the limiter; l_0– segment length *AK* at the point of impact *A*; θ_t– angle between limiter and horizontal at time *t*; EC– distance between the casing and the stopper; *b*– distance between dosing drum and hopper bottom; α_0– angle between lines *OK and OM*; β_t–angle *AOM* at the moment *t.*

Angle *AOM* (β_t) at time t is determined by the formula:

$$\beta_t = \omega t, \tag{31}$$

where ω– dosing drum angular speed, m / s;

Angle α_0 is determined from the tangent formula:

$$tg\alpha_0 = (a/2)/[(d/2)+b], \tag{32}$$

where *b*– distance between the dosing drum and the hopper outlet, m
Transformation of expression (32) will result in the following form:

$$\alpha_0 = arctg\frac{a}{d+2b}, \tag{33}$$

Assuming that the differential equation of the oscillatory motion of the limiter is similar to the differential equation of a mathematical pendulum, one can write [12]:

$$\ddot{\theta}_t = -k_y \sin(\theta_t - \theta_0), \tag{34}$$

Where k_y – proportionality coefficient characterizing the elasticity of the stopper material.
Since the vibrations of the limiter can be considered very small, the angle difference can be represented in the form $sin(\theta_t - \theta_0) \approx \theta_t - \theta_0$, then the differential equation will take the following form:

$$\ddot{\theta}_t = -k_y(\theta_t - \theta_0), \tag{35}$$

The solution to the differential equation (35) are the functions:

$$\theta_t - \theta_0 = A sin(kt + \alpha), \tag{36}$$

$$\dot{\theta}_t = -Ak\,cos(kt + \alpha), \tag{37}$$

$$\ddot{\theta}_t = -Ak^2 sin(kt + \alpha), \tag{38}$$

Comparing the obtained expressions (36), (37) and (38), we determine the relationship of the proportionality coefficient:

$$k = \sqrt{k_y}, \tag{39}$$

By the sine theorem for the triangle *AOK* at the moment of impact $t = t_y$ have [11]:

$$\frac{d/2}{sin(90^\circ - \theta_t - \alpha_0)} = \frac{\sqrt{(d/2 + b)^2 + (a/2)^2}}{sin(90^o - \beta_t + \theta_t)}, \tag{40}$$

After transformation, expression (40) will take the following form:

$$\frac{d}{cos(\theta_t + \alpha_0)} = \frac{\sqrt{(d+2b)^2 + a^2}}{cos(\theta_t - \beta_t)}, \tag{41}$$

Assuming that at the moment of impact at $t = t_{ó}$, the angles are also equal, i.e. $\theta_t = \theta_o$, then expression (41) can be represented as:

$$\frac{d}{cos(\theta_0 + \alpha_0)} = \frac{\sqrt{(d+2b)^2 + a^2}}{cos(\theta_0 - \omega t_y)}, \tag{42}$$

Hence, from expression (42), we find the time at the moment the drum hits the restrictive plate:

$$t_y = \frac{1}{\omega}\left(\theta_0 - \arccos\frac{\cos(\theta_0+\alpha_0)\sqrt{(d+2b)^2+a^2}}{d}\right), \qquad (43)$$

When $t = t_y$ have $\theta_t = \theta_o$, so:

$$\theta_t - \theta_0 = A\cdot\sin(\sqrt{k}_y \cdot t + \alpha) = 0, \qquad (44)$$

Then, the value of the initial phase is:

$$\alpha = -\sqrt{k}_y \cdot t_y, \qquad (45)$$

Let us find the time derivative of expression (44) t:

$$\frac{-\dot{\theta}_t\sin(\theta_t+\alpha_0)}{d} = \frac{-(\dot{\theta}_t-\omega)\sin(\theta_t-\beta_t)}{\sqrt{(d+2b)^2+a^2}}, \qquad (46)$$

From formula (44), if $t = t_y$ have:

$$\dot{\theta}_t = -A\sqrt{k_y}, \qquad (47)$$

Substituting expression (47) into formula (46), we obtain:

$$\frac{A\sqrt{k_y}\sin(\theta_0+\alpha_0)}{d} = \frac{(A\sqrt{k_y}+\omega)\sin(\theta_0-\omega t_y)}{\sqrt{(d+2b)^2+a^2}}, \qquad (48)$$

Formula (48) implicitly determines the value of the angular amplitude (A). In this case, it should be noted that the angular amplitude cannot be a positive value, i.e. $A < 0$. Thus, the expression for the function from formula (36) is fully defined.
The oscillation period is determined by the well-known formula:

$$T = \frac{2\pi}{\sqrt{k_y}}, \qquad (49)$$

The minimum of function (36) is reached at an angle of rotation equal to 90^0:

$$kt + \alpha = (t - t_y)\sqrt{k_y} = \frac{\pi}{2}, \qquad (50)$$

Moment of time t, during which the impact occurs is determined from the expression:

$$t = t_y + \frac{\pi}{2\sqrt{k_y}}, \qquad (51)$$

At this point in time:

$$\theta_{min} = \theta_0 + A$$

Consequently, the size of the gap between the stopper and the casing will vary within:

$$a\,sin(\theta_{min}) \le e \le a\,sin(\theta_0), \qquad (52)$$

The angle of installation of the limiter should be chosen in such a way that the following inequalities are satisfied:

$$a\sin(\theta_{\min}) \le 2b_c, \qquad (53)$$

$$2b_c \leq a\sin(\theta_0), \tag{54}$$

The fulfillment of the inequality condition means that the oscillatory movement of the limiter, supported by periodic strikes of the metering drum, then delays the flow of the seed heap, then passes it.

From expression (54) we find the value of the angle of installation of the limiter:

$$\theta_0 \geq arcsin\frac{2b_c}{a}, \tag{55}$$

Substituting the known values of the parameters $b_c = 0,7mm$ and $a = 4,5mm$ included in the formula (55), by calculation we determine the angle of installation of the limiter:

$$\theta_0 \geq 18^o 13'$$

Therefore, to determine other parameters, the value of the angle of installation of the limiter is taken equal to 19 degrees.

The next impact of the dosing drum on the limiter will occur after a period of time τ, equal:

$$\tau = \frac{2\pi z}{\omega q}, \tag{56}$$

where q – the number of grooves in the dosing drum, pcs;

ω – angular speed of the dosing drum, m / s;

z – the number of grooves of the dispensing drum passed between impacts on the restrictive plate, pcs.

At a moment in time t_y и $t_y + \tau$ angle value θ_t must be the same with precision π.

Therefore

$$\theta_0 = \theta_0 + A\sin(\sqrt{k_y}(t_y + \tau - t_y)) = \theta_0 + A\sin(\tau\sqrt{k_y}), \tag{57}$$

here:

$$\tau\sqrt{k_y} = \pi, \tag{58}$$

Substituting the value τ и from expression (56) into formula (58) we obtain:

$$\sqrt{k_y}\frac{2\pi z}{\omega q} = \pi, \tag{59}$$

Find the natural value z, satisfying equality (59):

$$z = \frac{\omega q}{2\sqrt{k_y}}, \tag{60}$$

It should be noted that this equality value z determines approximately.

In turn, the number of grooves in the dosing drum is equal to:

$$q = \frac{2\pi}{2\,arcsin\frac{i/2}{d/2}} = \frac{\pi}{arcsin\frac{i}{d}}, \tag{61}$$

It should be noted that q as well z – natural number. This means that the resulting number after counting must be rounded to the nearest whole number. By the sine theorem for a triangle *AOK* at the moment of impact $t = t_y$ the expression for the angle of rotation becomes:

$$\frac{sin(90^o - \theta_t - \alpha_0)}{d/2} = \frac{sin(\beta_t + \alpha_0)}{l_0}, \quad (62)$$

or
$$\frac{sin(90^o - \theta_0 - \alpha_0)}{d/2} = \frac{sin(\omega t_б + \alpha_0)}{l_0}, \quad (63)$$

After conversion, the expression (63) will take the following form:

$$l_0 = \frac{d\sin(\omega t_y + \alpha_0)}{2\cos(\theta_0 + \alpha_0)}, \quad (64)$$

Stopper length l must be greater than the value l_0 segment length *AK* at the point of impact *A*, i.e.:

$$l > \frac{d\sin(\omega t_y + \alpha_0)}{2\cos(\theta_0 + \alpha_0)}, \quad (65)$$

Substituting the parameter values $d = 120$ mm, $\omega = 5,236$ radian / s, $t_y = 0,0073$ s, $\alpha_0 = 2^0$, $\theta_0 = 19^0$ into formula (3.130), we find the length of the limiter: $l >$ 4,74 mm

Dosing drum angular speed ω let us determine from the condition of ensuring the synchronicity of successive blows with oscillations of the limiter:

$$\tau = \frac{T}{2}, \quad (66)$$

Time interval τ the next impact of the dosing drum on the limiter is determined by the formula:

$$\tau = \frac{2\pi z}{\omega q}, \quad (67)$$

$$\boldsymbol{T} = \frac{2\pi}{\sqrt{\boldsymbol{k}_y}}, \quad (68)$$

therefore:
$$\frac{2\pi z}{\omega q} = \frac{\pi}{\sqrt{k_y}}, \quad (69)$$

Therefore, the angular velocity is determined from the condition:

$$\omega = \frac{2z\sqrt{k_y}}{q}, \quad (70)$$

Using known parameter values: $q = 94, z = 8, k_y = 941\ 1/c^2$ we get: $\omega = 5,22$ radian / s.

For the high-quality performance of the technological process, it is necessary that the dispenser provides the working body of the sorting device with a seed heap. Therefore, the capacity of the batcher must match the capacity of the sorting device. The performance of the dosing drum is determined by the formula of general mechanics and, taking into account the physical and mechanical properties of the seeds, as well as the dimensions and operating modes of the dosing drum [13, 14]:

$$W_д = \frac{L_д m_{av} qnk}{lav}, \quad (71)$$

Where L_∂ – dosing drum length, m; m_{cp} – weight of seeds, kg; q – the number of grooves in the dosing drum, pcs; n – dosing drum rotation speed, c^{-1}; k – *groove filling factor;* l_{cp} – average value of seed length, m.

Substituting the known parameter values: $L_\partial = 290mm,\ q = 94,\quad n = 50\ \min^{-1}$, l_{av}=1.875 mm $k = 0{,}66$, we finally get following results:

$$W_\partial = 949{,}95\ \text{g/min.} \quad \text{or} \quad \text{W}_д = 56{,}9\ \ \text{kg}/h.$$

4. Conclusions

Theoretical studies show that to ensure a continuous flow of a heap of alfalfa seeds, the width of the outlet slot of the loading hopper should be at least 4.37 mm. The dimensional characteristics of alfalfa seeds are much less than the width of the outlet slot, which requires the use of a limiter. With the parameters of the drum: the pitch of the groove is 4 mm, the depth is 2.1 mm, the angle of installation is 19 degrees, and a stopper length of 4.58 mm, uniform supply of a heap of alfalfa seeds to the surface of the dielectric drum of the sorting device is ensured and improves the quality of cleaning alfalfa seeds. The angular velocity of the dielectric drum exceeds the angular velocity of the dosing drum due to the difference in their circumferential speed; therefore, it is necessary to introduce the proportionality coefficient k_y, which characterizes the elasticity of the limiter material.

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