Modeling The Motion Of Alferia Seeds In The Sorting Device

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Abstract

The article presents theoretical studies on modeling the movement of a heap in a dielectric sorting device for alfalfa seeds. The components of the heap of alfalfa seeds, depending on the mass and size, at each moment of time, have different trajectories, therefore, the dosed heap must be localized and sent using an additional device. Justified options allow you to define connection points for an optional device.
Keywords *– research, alfalfa seeds, beans, alfalfa seeds cleaning process, dielectric sorting device, dispenser, limiter, hopper, groove, angular velocity, location coordinates of the casing and the tray.*

Introduction

In the agricultural production of the Republic of Uzbekistan, large-scale measures are being taken to reduce labor and energy costs, save resources, process agricultural products based on advanced technologies and develop energy-saving machines, in particular, special attention is paid to the development of new technical means that ensure high-quality performance of technological processes for cleaning alfalfa seeds when minimum material costs. In this direction, it is considered important to develop a dielectric sorting device that allows you to clean alfalfa seeds from quarantine inclusions.

If we take into account that today "... more than 30 million hectares are sown with alfalfa around the world" [1], then an important task is the development of energy-resource-saving technologies and technical means aimed at reducing irretrievable losses of seeds during harvesting and improving quality processing seed heap. In this direction, it is relevant, in particular, to develop a constructive scheme and justify the parameters of a sorting device for cleaning seeds from quarantine inclusions. In this aspect, the development of a sorting device for cleaning alfalfa seeds in agricultural production is important and in demand.

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 structural parameters.

Methods and analysis

Theoretical studies were performed using the general laws of mechanics, mathematical modeling and statistics [2-6].

Results and discussion

As a result of periodic strokes of the dispenser against the limiter, the part of the seed heap is taken out of the hopper by the dispenser, which later moves along the dispenser groove with an angular velocity ω (Fig. 1).

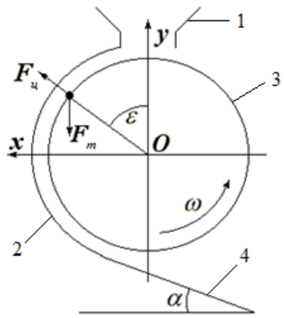

Fig. 1. To the determination of the separation conditions of the particles of seed heap
1-hopper; 2-casing; 3-dispenser; 4-pitch board

The seed heap located in the grooves of the metering drum will be considered as a particle with mass m. Then, when a particle moves along the edge of the metering drum, the centrifugal force F_s and gravity F_m act on it [7, 8].

Separation of the seed heap particles from the surface of the metering drum will occur under the condition [9, 10]:

$$F_s \geq F_m cos\varepsilon, \quad (1)$$

where F_s - centrifugal force, N; F_m - gravity, N; ε is the separation angle of the seed heap particle, degrees.

After substituting the corresponding expressions in the formula (1), we obtain the following inequality:

$$m\frac{d}{2}\omega^2 \geq mgcos\varepsilon, \quad (2)$$

where g - is the acceleration due to gravity, m/s2.

After the transformation, inequality (2) takes the form:

$$cos\varepsilon \leq \frac{d\omega^2}{2g}. \quad (3)$$

Hence, the separation angle of the seed heap particles from the surface of the metering drum is equal to:

$$\varepsilon \geq arccos\frac{d\omega^2}{2g} \text{ или } \varepsilon = arccos\frac{d\omega^2}{2g}. \quad (4)$$

With known values of the input parameters d = 120 mm and ω = 5.22 rad / s, the separation angle of the seed heap particle from the surface of the metering drum is 80 °.

Therefore, it is necessary to localize the dosed heap, i.e. catch and direct them to the surface of the dielectric drum using an additional device - a casing with a tray. Therefore, it is necessary to determine and justify the location coordinates of the casing and the tray (pitched board).

Let us determine the time to the movement of a particle of seed heap together with a metering drum:

$$t_0 = \frac{\varepsilon}{\omega}. \quad (5)$$

When the particle reaches the separation angle ε, it breaks away from the surface of the metering drum and goes into free flight with an initial speed and after some time falls onto the surface of the casing. The radius of the casing is:

$$r_k = \frac{\left(\frac{d}{2}+b\right)}{cos\alpha_0}. \quad (6)$$

With known values of the input parameters: d = 120 mm, b = 3 mm and $\alpha_o = 2^o$, the radius of the casing is: r_k = 63.04 mm.

We draw the rectangular coordinate system so that the beginning of the system coincides with the center of the metering drum, the ordinate axis is directed vertically upward, and the abscissa axis is horizontal in the direction of particle motion. Then the equations of motion of a particle of a heap can be written in the following form:

$$\begin{cases} \ddot{x} = 0 \\ \ddot{y} = -g \end{cases}. \quad (7)$$

Solving differential equation (7) we obtain an equation that describes the motion of a particle of seed heap in free flight:

$$\begin{cases} x = C_1 t + C_2 \\ y = -g\frac{t^2}{2} + C_3 t + C_4 \end{cases}. \quad (8)$$

The initial conditions for solving the differential equation are:

$$\begin{cases} x(0) = \frac{d}{2} sin\varepsilon \\ y(0) = \frac{d}{2} cos\varepsilon \\ \ddot{x}(0) = \frac{d}{2}\omega cos\varepsilon \\ \ddot{y}(0) = -\frac{d}{2}\omega sin\varepsilon. \end{cases} \quad (9)$$

Using the initial conditions, we find solutions to the differential equations of motion of the heap particle after detaching it from the surface of the metering drum in the direction of the casing.

$$\begin{cases} x = \frac{d}{2}\omega t cos\varepsilon + \frac{d}{2} sin\varepsilon \\ y = -g\frac{t^2}{2} - \frac{d}{2}\omega t sin\varepsilon + \frac{d}{2} cos\varepsilon \,. \end{cases} \quad (10)$$

A heap particle will reach the casing surface at that moment in time $t_к$, when its coordinates will satisfy the equation:

$$x^2 + y^2 = r^2. \quad (11)$$

Differentiating the equations from (10) we obtain:

$$\begin{cases} \dot{x} = \frac{d}{2}\omega cos\varepsilon \\ \dot{y} = -gt - \frac{d}{2}\omega sin\varepsilon \,. \end{cases} \quad (12)$$

To determine tk, it is necessary to substitute the expressions from (10) into formula (11). The obtained 4th degree algebraic equation can be solved by numerical methods. In this case, as a solution, you need to choose the positive least root. Substituting the value of tк into formulas (10), we determine the coordinates ($x_к$, $y_к$) of the casing point from which the particle begins to move along the casing surface. Moreover, a heap particle is affected by: centrifugal force F_c, gravity F_m and friction force F_{mp} (Fig. 2).

The path of movement of a particle of heap over the surface of the casing from the point to the point at which the casing smoothly passes into a pitched board is connected with the angle by the following formula:

$$s = r_k(\varepsilon_t - \varepsilon_1), \quad (13)$$

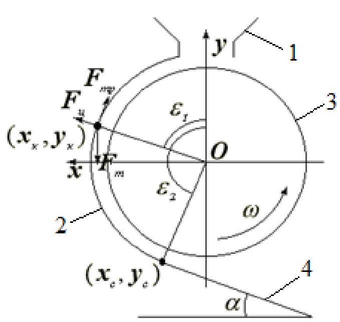

Fig. 2. On the determination of particle motion along the casing and pitched board
1-hopper; 2-casing; 3-dispenser; 4-pitch board

где $\varepsilon_1 \le \varepsilon_t \le \varepsilon_2$, $\varepsilon_1 = arstg\frac{x_k}{y_k}$, $0 < \varepsilon_1 \le \pi$, $\varepsilon_2 = arstg\frac{x_c}{y_c}$, $0 < \varepsilon_2 \le \pi$,

$$F_m = mg, \tag{14}$$

$$F_s = m\frac{\dot{s}^2}{r_k}, \tag{15}$$

$$F_{tr} = (F_s - F_m cos\varepsilon_1)f, \tag{16}$$

where f – is the coefficient of friction of the seed heap particles on the surface of the casing and pitched boards.

From the formula (13) it follows:

$$\varepsilon_t = \frac{s + r_k\varepsilon_1}{r_k}. \tag{17}$$

Then the equation of motion is written as follows:

$$m\ddot{s} = F_m sin\varepsilon_t - F_{tr}. \tag{18}$$

Given the formulas (14) - (17), we obtain the differential equation of motion of the particle along the casing

$$\ddot{s} = g\left(sin\frac{s + r_k\varepsilon_1}{r_k} + f cos\frac{s + r_k\varepsilon_1}{r_k}\right) - f\frac{\dot{s}^2}{r_k}. \tag{19}$$

We find the initial conditions, taking into account formulas (12) and (13):

$$\begin{cases} s(0) = 0 \\ \dot{s}(0) = \left|\frac{d}{2}\omega sin\varepsilon_1 + (-gt_k - \frac{d}{2}\omega t sin\varepsilon_1)sin\varepsilon_1\right| \end{cases}. \tag{20}$$

The solution of differential equation (19) with initial conditions (20) is analytically impossible, therefore, it is solved by numerical methods of "Runge-Kutta-Felberg" with automatic step selection [11].

The angle of installation of the ramp board is chosen from the condition of its equality to the angle of friction of the particle on the ramp board, i.e.

Then the equation of the line, of which the pitched board is a part, will look like this:

$$y = f_x + C, \tag{21}$$

where $C < 0$ – is an unknown constant.

At the point of contact of the ramp to the casing, the system below should have a unique solution.

$$\begin{cases} y = f_x + C \\ x^2 + y^2 = r^2 \end{cases}. \tag{22}$$

We solve the system:

$$x^2 + (f_x + C)^2 = r_k^2, \tag{23}$$

$$(1 + f)^2x^2 + 2fC_x + C^2 - r_k^2 = 0.$$

The discriminant is zero:

$$f^2C^2 - (1 + f^2)(x^2 - r_k^2) = 0, \tag{24}$$

$$C = -r_k\sqrt{(1 + f^2)}. \tag{25}$$

Substituting the values: r_k = 63.04 mm and f = 0.4245 in the formula (25) we obtain the value of the parameter C = –68.48 mm.

Find the coordinates of the point (x_c, y_c):

$$x_C = \frac{-fC}{(1+f^2)} \quad \text{and} \quad y_C = fx_C + C. \tag{26}$$

Substituting the value C = –68.48 mm and f = 0.4245 in the formula (26) we find the coordinates of the points:

x_c = 24,63 mm, y_c = –58,02 mm.

The obtained values x_c and mustache allow us to determine the connection points of the ramp board with the casing of the metering drum.

Conclusion

The components of a heap of alfalfa seeds, depending on the mass and size, coming off the surface of the metering drum at each moment in time, have different trajectories. Therefore, the dosed heap must be localized and directed to the surface of the dielectric drum using an additional device - a casing equipped with a ramp board. The obtained values of x_c and mustache allow you to determine the connection points of the ramp board with the casing of the metering drum.

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