PAPER • OPEN ACCESS

Aeromechanical purification of freshly harvested seed heaps of desert fodder plants

View the article online for updates and enhancements.

Aeromechanical purification of freshly harvested seed heaps of desert fodder plants

E Farmonov[1], Sh Lakaev[1], R Khalilov[2] and I Gorlova[2]

[1]Tashkent Institute of Irrigation and Agricultural Mechanization Engineers, Tashkent, Uzbekistan
[2]Tashkent State Agrarian University, Tashkent, Uzbekistan

erkinfarmonov2009@mail.ru

Abstract. It is stated in the paper that the difficulty in cleaning freshly harvested seed heaps of desert fodder plants and in the creation of cultivation equipment for their sowing is due to specific features of the physical-mechanical properties of seed heaps of desert fodder plants. The high content of weeds (up to 70%) in the composition of freshly harvested seed heaps collected manually or by mechanized methods makes them loose, leading to the impossibility to sow these seeds without preliminary cleaning. A proposed technological process of aeromechanical cleaning of freshly harvested seed heaps of desert fodder plants is as follows. First of all, it is necessary to provide for the enrichment of the heaps by separating the coarse-sized fractions. The enriched heaps of seeds are subjected to stage-by-stage separation. At the first stage, coarse impurities are singled out by a mechanical working body, and at the second stage - separation of seeds and small impurities is conducted by an airflow. A technological process of aeromechanical separation of freshly harvested seed heaps of desert fodder plants was investigated, as a result, the final velocities of particle motion along the working surfaces which have the form of a straight line, a parabola, and a semicircle were determined. The most acceptable form of the working body was identified — a circular semi-ring installed in an aeromechanical separator. The effectiveness of seed cleaning by an aeromechanical separator was determined.

1. Introduction

Desert and semi-desert fodder plants in Uzbekistan represent the main fodder supply for sheep breeding (including astrakhan husbandry), camel breeding, stockbreeding, horse breeding, which are kept on pasture almost all year round and represent a solid potential for solving the problems of providing the population with livestock products, and light industry with raw materials. Meanwhile, the feeding plant community is a fragile ecosystem. Various technogenic and anthropogenic pressures, overloading in feeding, global climate changes lead to a decrease in the productivity of pasture degradation. In this connection, the fodder productivity of pastures should be systematically maintained by improving the sowing and replanting of seeds with local shrubs, and perennial grasses [1].

It has been proven that the improvement of natural desert and semi-desert pastures with promising forage crops allows increasing their productivity to 10 times in comparison with natural forage lands [2].

2

The solution to the problem is constrained by the lack of advanced technologies and special machinery for the production processes mechanization, first of all, the mechanization of seed cleaning and sowing.

The difficulties in creating sowing machinery are determined by the specific features of the physical-mechanical properties of seeds of desert fodder. The seed heap collected manually or by mechanized methods contains a high content of weeds. The heap contains up to 70% of twigs, fragments of stems, and other related elements (generative and vegetative shoots, small impurities, leaves, and dust). The seeds are small, light, fragile, sensitive to mechanical damage, low-flowing, they have wings. They have a small absolute weight (2.1-16.1 gr per thousand pcs) and a small volume mass (36-252 kg/m^3), which determines their low standard quantity of seed per hectare (3-10 kg/ha) [3, 4, 5, 6].

The practice of using existing sowing units and machines converted for this purpose showed the impossibility of sowing seeds of desert fodder plants without their preliminary cleaning, as well as without improvement of sowing units [7, 8, 9, 10, 11, 12, 13]. The studies on operation efficiency increase of seeder units were carried out in China and positive results were obtained [14]. However these studies were related to sowing agricultural crop seeds, which differ greatly from desert fodder plant seeds in their physical-mechanical characteristics.

In connection with the noted problems, the main goal of our research is the preliminary cleaning of freshly harvested seed heaps to the requirements of the technical standards for the mechanized sowing of seeds of desert fodder plants.

The above-mentioned features of freshly harvested seed heaps of desert fodder plants collected manually or by mechanized methods, such as multi-component composition, poor flowability, high water-content, strong (60-70%) weediness, as well as small absolute and volume mass of seeds, high sensitivity to mechanical damage, low velocity of hovering, and others greatly complicate the choice of the separation method.

2. Methods

Preliminary studies of the process of cleaning seeds of desert fodder plants, for example, izen, on the sieve and airflow showed that due to the non-flowability, high moisture-content and clogging, as well as a significant coincidence of the rates of seeds and weed impurities (twigs, fragments of stems up to 5-7 in length) separation of these components by airflow is very difficult. In this case, the aeromechanical separation of the heap is most suitable.
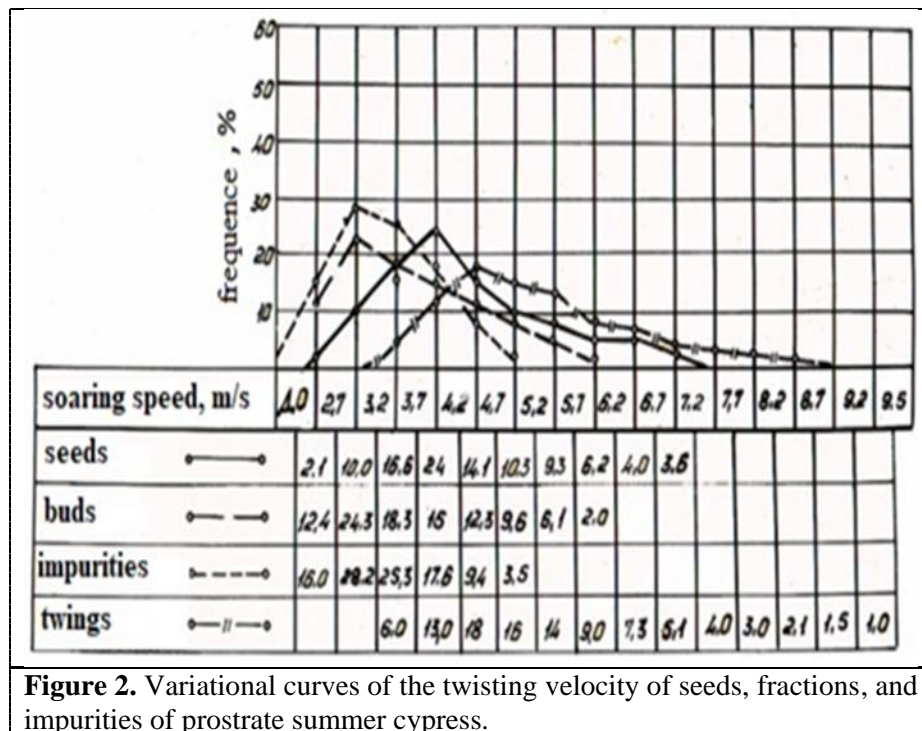
Our proposed process for aeromechanical separation of seed heaps of desert fodder plants

Figure 1 shows the technological process of aeromechanical separator operation.

Figure 1. The diagram of the technological process of aeromechanical separator operation; 1 - discharge tray, 2, 5 - inlet

3
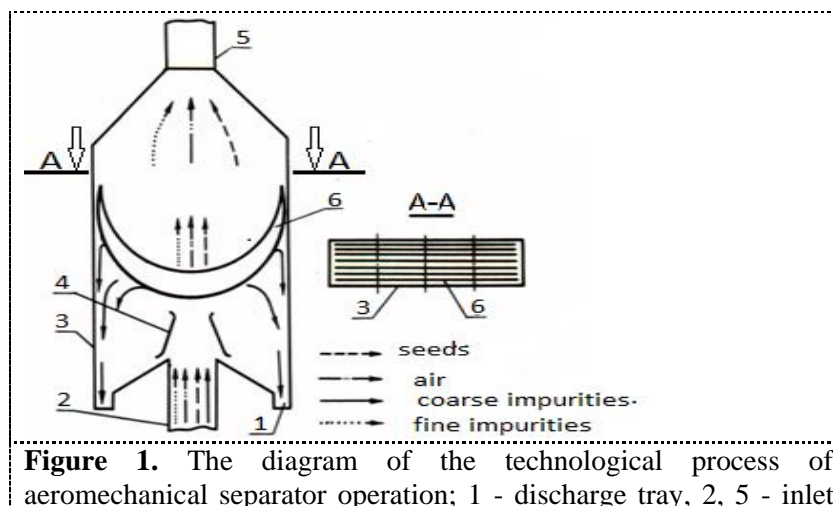
| and outlet pneumatic conveyors, 3 - aeromechanical separator, 4 - flow regulator |

We have determined the velocity values of seeds, twigs, and other components of freshly harvested seed heaps of desert fodder plants (by the example of prostrate summer cypress) in order to separate them by aerodynamic properties. Figure 2 shows the variational series and curves.

soaring speed, m/s	1.0	2.7	3.2	3.7	4.2	4.7	5.2	5.7	6.2	6.7	7.2	7.7	8.2	8.7	9.2	9.5
seeds	2.1	10.0	16.6	24	14.1	10.3	9.3	6.2	4.0	3.6						
buds	12.4	24.3	18.3	15	12.3	9.6	6.1	2.0								
impurities	16.0	28.2	25.3	17.6	9.4	3.5										
twings				6.0	13.0	18	16	14	9.0	7.3	6.1	4.0	3.0	2.1	1.5	1.0

Figure 2. Variational curves of the twisting velocity of seeds, fractions, and impurities of prostrate summer cypress.

Consider the first stage - the mechanical separation of coarse impurities (twigs, fragments of stems up to 5-7 cm long).

3. Results and discussion

Let the forming surface of the separator actuator in the vertical channel be described by some function *y=f(x)* (figure 1).

In a vertical air channel, the particle is affected by the airflow force R and gravity G, the difference of which determines the particle motion of mass m from the center to the periphery of the air separation channel.

In a vertical air channel, the particle is affected by the airflow force R and gravity G, the difference of which determines the particle motion of mass m from the center to the periphery of the air separation channel.

At the periphery, where there is a gap of about 7-10 mm, R is already less than G. At the initial moment, the particle had a certain velocity ϑ_0 with the horizontal component. In the process of moving along the generatrix, the horizontal component of the velocity $\dot{x}(t)$ changes, and if at the moment t_k the particle enters the gap zone, its horizontal velocity $\dot{x}(t_k)$ only slightly exceeds $\dot{x}_0$ or is even less than it, the particle under by the effect of resulting force G - R falls along the parabola. If $\dot{x}(t_k)$ greatly exceeds $\dot{x}_0$, then the particle slips the gap, not having time to fall, and is pressed against the wall, clogging the gap.

4

Thus, when choosing the form of an aeromechanical separator actuator, the particle's speed at the final point of its motion should be taken as the basic criterion:

$$\dot{x}(t_k) \leq \dot{x}_0 \qquad (1)$$

that is, the best form of the actuator is the one at which the particle velocity at time t_k is closer to $\dot{x}_0$.

Derive the differential equation of particle motion and calculate the horizontal component first for the surface of general form $y = f(x)$, and then separately for the triangle $y = \pm kx$, parabolic semi-ring $y = kx^2$ and circular semi-ring $y = r - \sqrt{r^2 - x^2}$.

To study the point motion, consider two coordinate systems. $NM\tau$ is the movable coordinate system; it moves together with a point. XOY is the fixed coordinate system.

The resulting force $R - G$ acts on the particle in the vertical direction, and combined with the support N response acting perpendicular to the tangent at point $x = x(t)$, determines the upward motion long the generatrix; the friction force F_{fr}, which acts downward the tangent prevents it (figure 3).
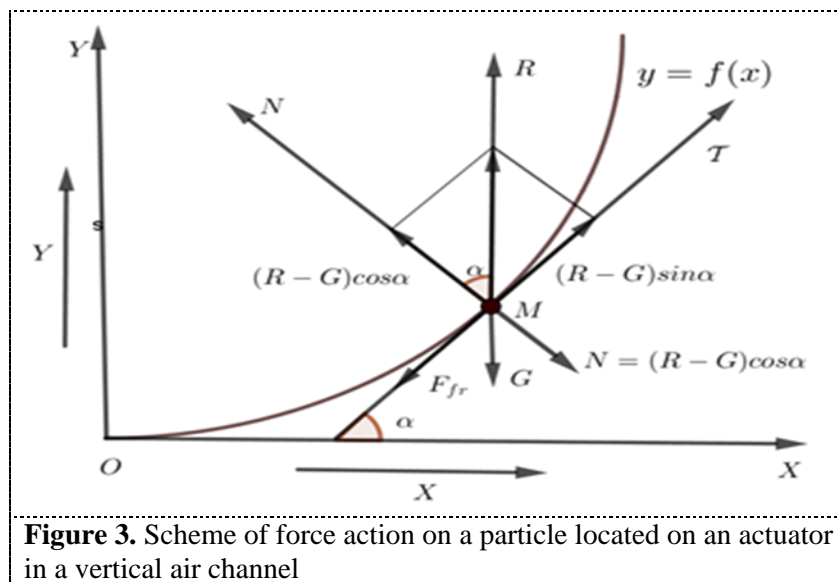

Figure 3. Scheme of force action on a particle located on an actuator in a vertical air channel

The forces with respect to the moving coordinate system, according to Newton's Law, are projected on the coordinate axis

$$\left.\begin{array}{l} ma_\tau = (R - G)\sin\alpha - F_{fr} \\ ma_N = (R - G)\sin\alpha \end{array}\right\} \qquad (2)$$

Here $F_{fr} = \hat{f}N, N = (R - G)\cos\alpha$ taking $\alpha = const$ from system (2) we obtain

$$\frac{dv}{dx} = \frac{(R-G)}{m}(\sin\alpha - \hat{f}\cos\alpha) \qquad (3)$$

So, at $t = 0, v = v_0$, we get

$$v = \frac{(R-G)}{m}(\sin\alpha - \hat{f}\cos\alpha + v_0) \qquad (4)$$

It is known that $F_{fr} = \hat{f}N$ and is directed tangentially downward.

Then proceed to the fixed coordinate system.

Then

$$\begin{cases} m\ddot{x} = (R - G)\,sin\alpha\,cos\alpha - \hat{f}(R - G)\,cos^2\alpha \\ m\ddot{y} = (R - G)sin^2\alpha - \hat{f}(R - G)cos\alpha\,sin\alpha \end{cases} (5)$$

taking into account trigonometric identities, system (5) can be reduced to the form

$$x(0) = 0;\ y(0) = 0 \quad (6)$$

or

$$\dot{x}(0) = \dot{x}_0.\ \dot{y}(0) = \dot{y}_0 (7)$$

Since the geometric sense of the derivative is tangent to the motion trajectory, we write

$$tg\alpha = f'(x)$$

In this case, the problem is reduced to the integration of systems of differential equations. Here m is the particle mass, g; a is the particle acceleration, m/s^2; $\hat{f}$ is the coefficient of friction; α is the angle between the tangent to the curve and the x-axis; F_{fr} is the friction force, N;

R is the flow force, N; G is the gravity, N.

Key assumptions:

a single particle on the actuator is considered;

particles of impurities and the actuator are taken as absolutely rigid bodies.

$$\ddot{x} = \frac{(R - G)}{m} cos^2\alpha \big(tg\alpha - \hat{f}\big)$$
$$\ddot{y} = \frac{(R - G)}{m} sin^2\alpha \big(1 - \hat{f} ctg\alpha\big).$$

Since

$$ctg\alpha = \frac{1}{tg\alpha};\ cos^2\alpha = \frac{1}{1+tg^2\alpha};\qquad sin^2\alpha = \frac{1}{1+tg^2\alpha} = \frac{tg^2\alpha}{1+tg^2\alpha}$$

$$\begin{cases} \ddot{x} = \frac{(R-G)}{m}\frac{1}{1+tg^2\alpha}\big(tg\alpha - \hat{f}\big) \\ \ddot{y} = \frac{(R-G)}{m}\frac{tg\alpha}{1+tg^2\alpha}\big(tg\alpha - \hat{f}\big) \end{cases} (9)$$

Considering $tg\alpha = f'(x)$, the system (9) gets a final form:

$$\begin{cases} \ddot{x} = \frac{(R-G)}{m}\frac{1}{1+(f'(x))^2}\big(f'(x) - \hat{f}\big); \\ \ddot{y} = \frac{(R-G)f'(x)}{m(1+f'(x)^2)}\big(f'(x) - \hat{f}\big). \end{cases} (10)$$

Since further only the horizontal component of velocity will be of interest, consider the first part of the differential equation (10). The velocity value is sought as a function of x.

$$\dot{x}(t) = f(x)$$

Then $\ddot{x}(t) = f'(x) \cdot \dot{x}(t) = f'(x) \cdot f(x)$, and the first differential equation (10) has the form

6

$$f'(x) \cdot f(x) = \frac{(R-G)}{m(1+(f'(x))^2)} \cdot \left(f'(x) - \hat{f}\right) \qquad (11)$$

Hence

$$fdf = \frac{(R-G)}{m(1+(f'(x))^2)} \cdot \left(f'(x) - \hat{f}\right)dx$$

Integrating the left and right sides, we obtain a solution for $\dot{x}^2 = f^2$ in the form of an indefinite integral

$$\dot{x}^2(x) = f^2 = 2\frac{(R-G)}{m}\int \frac{1}{1+(f'(x))^2}\left(f'(x) - \hat{f}\right)dx \quad (12)$$

Now we determine the final horizontal velocity for the generatrix of the surfaces Let the generatrix of the surface of the actuator be $y = kx$ that is, $f(x) = kx$ and $f'(x) = k$. Then the integral (12) is transformed into an expression

$$\dot{x}^2(x) = 2\frac{(R-G)}{m}\int \frac{1}{1+k^2}\left(k - \hat{f}\right)dx \quad (13)$$

Since the integral is independent of x, the integral (13) can easily be calculated from the point to constant C

$$\dot{x}^2(x) = 2\frac{(R-G)\left(k - \hat{f}\right)}{m\,(1+k^2)}\,x + C$$

Its value is determined from the initial condition

$$\dot{x}^2(0) = \dot{x}_0 = 0 + C$$

Particle velocity when moving along the straight line is

$$\dot{x}^2(x) = \dot{x}_0^2 + 2\frac{(R-G)\left(k - \hat{f}\right)}{m\,(1+k^2)}\,x \quad (14)$$

Formula (14) shows that the square of horizontal velocity increases in direct proportion to the horizontal movement in x, if $k > \hat{f}$

Determination of the final horizontal velocity for a parabolic semi-ring

Let the generatrix of the surface of the actuator be a parabola $y = kx^2$ i.e. $f(x) = kx^2$ and so

$$f'(x) = 2kx.$$

Then the integral (12) takes the form

$$\dot{x}^2(x) = 2\frac{(R-G)}{m}\int \frac{2kx - \hat{f}}{1+4k^2x^2}dx \quad (15)$$

and its integrand is a constant. Divide this integral into two integrals, i.e.

$$I_1 = \int \frac{2kx}{1+4k^2x^2}dx, I_2 = \int \frac{dx}{1+4k^2x^2},$$

That is

$$\dot{x}^2(x) = 2\frac{(R-G)}{m}(I_1 - I_2).$$

7

The first is calculated by the substitution $u^2 = 4k^2x^2$

$$I_1 = \frac{1}{4k} ln(1 + 4k^2x^2)$$

The second substitution $u = 2kx$ is reduced to the arctangent

$$I_2 = \frac{1}{2k} arctg\, 2kx.$$

Thus, the integral (15) is determined up to a constant

$$\dot{x}^2(x) = \frac{(R-G)}{2mk}\left[ln(1 + 4k^2x^2) - 2\,\hat{f} arctg\, 2kx\right] + C$$

The constant C is found from the initial condition

$$(\dot{x}(0))^2 = C = \dot{x}_0^2$$

From here we can derive a formula for calculating the horizontal velocity of particles

$$(\dot{x}(x))^2 = \frac{(R-G)}{2mk}\left[ln(1 + 4k^2x^2) - 2f arctg\, 2kx\right] + +\dot{x}^2{}_0 \qquad (16)$$

It is seen that when moving along a parabola, the velocity increases in a logarithmic manner, i.e. much slower than in a directly proportional manner, as in the case of moving along a straight line.

Determination of the final horizontal velocity for a circular semi-ring.

Suppose that the surface of the actuator is formed by a semi-circle $y = r - \sqrt{r^2 - x^2}$, that is $f(x) = r - \sqrt{r^2 - x^2}$ and $f'(x) = \frac{x}{\sqrt{r^2-x^2}}$.

Integral (12) in the right-hand side has the form

$$\dot{x}(x)^2 = 2\frac{(R-G)}{m}\int \frac{1}{1+\frac{x^2}{r^2-x^2}}\left(\frac{x}{\sqrt{r^2-x^2}} - \hat{f}\right) dx = 2\frac{(R-G)}{m}\int \frac{r^2-x^2}{r^2}\left(\frac{x}{\sqrt{r^2-x^2}} - \hat{f}\right) dx (17)$$

To calculate this integral we divide it two integrals.

$$\int \frac{r^2-x^2}{r^2}\left(\frac{x}{\sqrt{r^2-x^2}} - \hat{f}\right) dx = I_1 - I_2 \,;$$

$$I_1 = \int \frac{(r^2-x^2)x}{r^2\sqrt{r^2-x^2}} dx = \frac{1}{r^2}\int \left(\sqrt{r^2 - x^2}\right) x dx;$$

$$I_2 = \frac{\hat{f}}{r^2}\int (r^2 - x^2) dx$$

The first is calculated by a substitution $u = r^2 - x^2$

$$I_1 = -\frac{1}{3r^2}\left(\sqrt{r^2 - x^2}\right)^3 + C \quad (18)$$

The second is found by

$$I_2 = \frac{\hat{f}}{r^2}\left(r^2 x - \frac{1}{3}x^3\right) = \frac{\hat{f}}{r^2} x \left(r^2 - \frac{1}{3}x^2\right) \qquad (19)$$

Substituting (18) - (19) into (17), we get,

8

$$\dot{x}(x)^2 = 2\frac{(R-G)}{m}\left(-\frac{(r^2-x^2)\sqrt{r^2-x^2}}{3r^2} - \frac{\hat{f}}{r^2}x\left(r^2 - \frac{x^2}{3}\right) + C\right) \quad (20)$$

Constant C is determined from the initial condition

$$(\dot{x}(0))^2 = \frac{2(R-G)}{m}\left(-\frac{r}{3}\right) + C = \dot{x}^2{}_0;$$

$$C = \dot{x}^2{}_0 + \frac{2(R-G)r}{3m}$$

Then the formula to obtain horizontal velocity of motion in point x has the form

$$(\dot{x}(x))^2 = \frac{2(R-G)}{m}\left[\frac{r}{3} - \frac{(r^2-x^2)}{3r^2}\sqrt{r^2-x^2} - -\frac{\hat{f}}{r^2}x\left(r^2 - \frac{x^2}{3}\right)\right] + \dot{x}^2{}_0$$

or

$$(\dot{x}(x))^2 = \dot{x}^2{}_0 + \frac{2(R-G)}{3m}\ r\left[1 - \left(1 - \frac{x^2}{r^2}\right)\sqrt{1 - \frac{x^2}{r^2}} - \hat{f}\frac{x}{r}\left(3 - \frac{x^2}{r^2}\right)\right]$$

Let's study the final velocities of the particle when moving in a straight line, a parabola, and a semicircle.

Determine the final horizontal components of the particle velocity along the working face when the plate has the form of a triangle (Figure 4a), a parabolic (Figure 4b), and a circular (Figure 4c) semi-rings. The final horizontal velocity components at the point $x = r$ can be determined by formulas (14), (16), and (22), respectively. These calculated values are summarized in Table 1. Since the point M_k for all generatricesis the same and has the coordinates $x_k = r y_k = r$ (Figure 5), we can determine the coefficient k for the generatrix of the straight line $y = kx$ from equation $kr = r$,

or $k = 1$, and for the generatrix of the parabola $y = kx^2$ from equation

$$kr^2 = r, \text{ or } k = \frac{1}{r}$$

Denote the increase in velocity of coarse impurities $(R - G)r$ by Δ. Taking into account the values of friction coefficient which we get experimentally, we obtain the various intervals of f; 1.37 f and 2.0 f, for the triangular surface of the actuator, of parabolic and circular semi-rings, respectively:
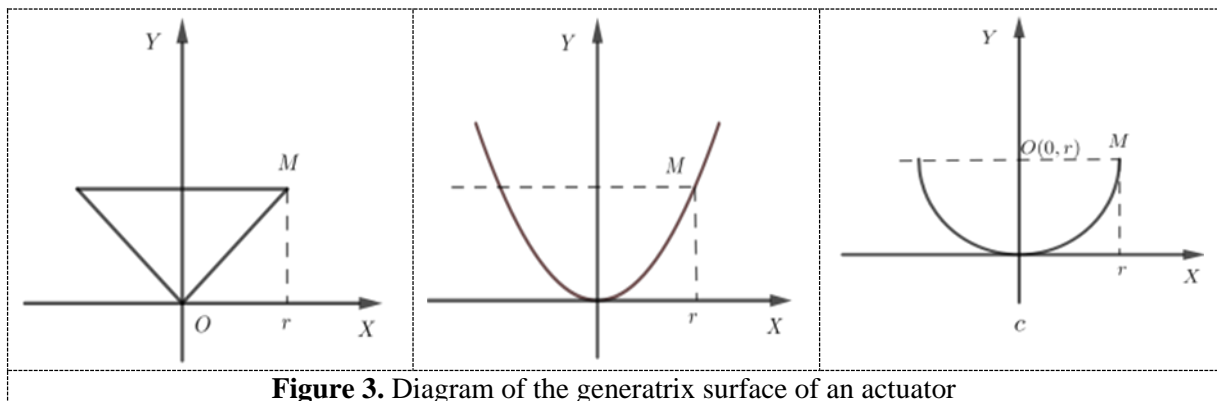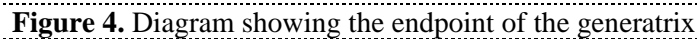

Figure 3. Diagram of the generatrix surface of an actuator

9

Figure 4. Diagram showing the endpoint of the generatrix

$$0.53 \leq f \leq 0.628 \qquad (23)$$

$$0.728 \leq f \leq 0.856 \qquad (24)$$
$$1.063 \leq f \leq 1.25 \qquad (25)$$

From table 1 and expressions (23) - (25), we can draw the following conclusions.

In the case of a triangular plate, the horizontal component of the square of final velocity is always greater than the initial one

$$\gamma = \Delta(1 - f) \qquad (26)$$

and varies in the range

$$0.375\,\Delta \leq \gamma \leq 0.470\Delta \qquad (27)$$

In the case of a parabolic semi-ring, the horizontal component of the square of final velocity is always greater than the initial one

$$\gamma = 0.804\,\Delta\,(1 - 1.37f) \qquad (28)$$

and, according to formula (24), varies in the range

$$0.116\,\Delta \leq \gamma \leq 0.219\Delta \qquad (29)$$

Comparing (29) and (27), it can be seen that an increment in velocity is positive but less than when using a triangular plate.

3. In the case of using a circular semi-ring, it follows from (25) that the final horizontal velocity is less than the initial one

$$\gamma = 0.66\,\Delta\,(1 - 2f) \qquad (30)$$

that is, an increment in velocity is negative and varies in the range

$$0.165\,\Delta \leq \gamma \leq -0.0416 \qquad (31)$$

The data obtained are summarized in Table 2 and shown in figure 6.

10

Table 1. Increment interval of velocities squares for different versions of an actuator

Form of generatrix surface of an actuator	Design formula to determine an increment in horizontal final velocity γ	Increment sign	Increment interval of horizontal final velocity γ m/s
Triangle	$\Delta (1 - f)$	Positive	0.375 Δ ...0.470 Δ
Parabolic semi-ring	$0.804 \, \Delta \, (1 - 1{,}37f)$	Positive	0.116 Δ ... 0.219 Δ
Circular semi-ring	$0.66 \, \Delta \, (1 - 2f)$	Negative	-0.165Δ… 0.0416 Δ

4. From the point of view of criterion (1), a circular semi-ring is preferable as a surface of an actuator.
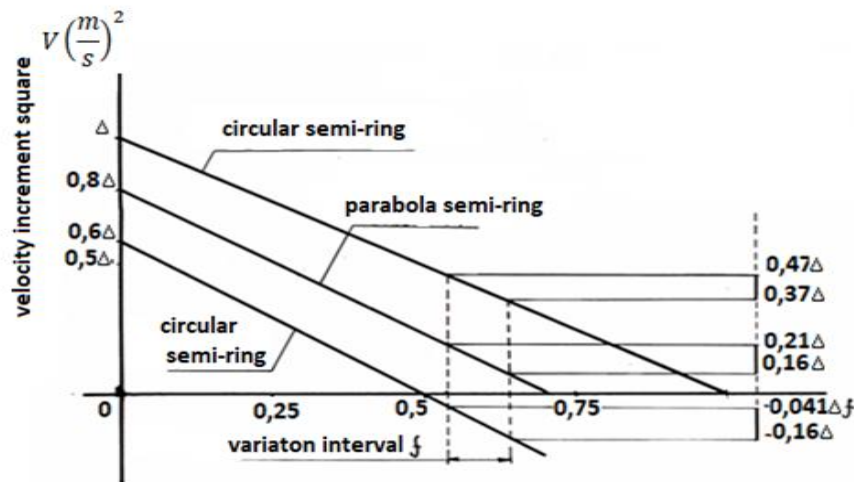
Figure. 5. Graph of change in the square of horizontal final velocity depending on the coefficient of friction

Consider the second stage – the selection of seeds from light impurities. Seeds and small impurities are carried out from the separator into the bunker by airflow through the slots in the mechanical actuator. The airflow velocity in the separation zone should be equal to the velocity of seed twisting or slightly exceed it ($\vartheta \geq \vartheta_{\text{BT}}$). Subsequently, in the bunker, due to a lower twisting velocity, light impurities (leaves, balls, rot, dust) are blown out through the openings of the seed trap mesh, and the seeds settle in the bunker.

Choosing the most acceptable surface of the actuator - a circular semi-ring and using well-known formulas, it is possible to determine the effectiveness of seed cleaning with an aeromechanical separator by expression

$$E = 1 - e^{-2,5\lambda\vartheta} , \quad \lambda = \rho\mu \quad (32)$$

here: ϑ is the average velocity of motion of coarse impurities along the surface of an actuator;

λ is a coefficient characterizing the physic mechanical properties of seed heap of prostrate summer cypress; ρ is the coefficient taking into account the air suction in the separation zone; μ is the coefficient of aerodynamic characteristics of seed heap;

F_p and F are the cross-sectional area of the pneumatic conveyor and the pneumatic separating channel, respectively, depending on the twisting velocity of seeds and coarse weed impurities, m2;

ϑ_p is the air velocity in the pneumatic conveyor, m/s.

Taking into account the physical-mechanical properties of seed heaps of desert fodder plants, the following values of coefficient λ can be recommended: for prostrate summer cypress – 0.051, keireuk - 0.056, sexual – 0.054, eurotia – 0.059, saltwort – 0.055, chogon – 0.057.

Theoretical studies substantiated the most acceptable form of anactuator − a circular semi-ring mounted in an aeromechanical separator.

4. Conclusions.
A mathematical model of motion of coarse impurities in prostrate summer cypress seed heap along the surface of the operating element of an aeromechanical separator was developed. It was determined that of the three studied forms of operating element for the separation of coarse impurities - the triangle, the parabolic, and circular semi-rings − the most rational one is the circular form. A method of aeromechanical separation was proposed as a method of separating freshly harvested seed heaps of desert fodder plants; the separation of coarse impurities was carried out by mechanical operating element, and fine impurities and seeds were removed by an aerodynamic method.

References
[1]   Makhmudov M M Khaidarov K 2010 Yailovshunoslik (Pasture Management) *Samarkand* N Doba 291 p.
[2]   Mukimov T Farmonov T Mukhtorov A Abdusattorov R Khaidarov Kh 2019 Improvement of degraded pastures in the arid zone and reduction of the load on pastures Food Security *National and Global Factors Proceedings of the scientific and practical international conference* (Samarkand Uzbekistan) pp. **147-148**
[3]   Musaev T M Landsman M I 1968 To the question of the physic mechanical properties of stalk seeds (barley) *Sredaz NII Research Institute of Forestry* **8** pp 19
[4]   Urdiev Sh U 1972 Some of the physico-mechanical properties of Keiruk and Chogon seeds TIIIMSH "*Mechanization and Electrification of Agriculture of Uzbekistan*" Vol **51** - Tashkent pp 160-168
[5]   Abdullaev M 1974 Research of the technological process and parameters of machines for collecting seeds of fodder plants in the desert zone Abstract *Cand Diss* Tashkent pp 27
[6]   Turaboev AT 1980 Some physical and mechanical properties of saxaul seeds and weeds of saxaul heap *Materials of the tenth conference of young scientists in agriculture (forestry)* (Tashkent) pp **81-85**
[7]   Seeded saxaul-seeder Agricultural machinery *Catalog* Moscow TsNIIITETS 1975
[8]   Soldatov V T 1972 Investigation of the process of sowing seeds of desert fodder plants *Abstract of Ph.D. Diss* Alma-Ata pp **28**
[9]   Batyrshin A G 1972 et al Mechanization of desert pasture improvement processes. *Alma-Ata*, Kaynar pp **350**
[10]   Shamsutdinov Z Sh ShegaiV Y Rudakov G M 1987 and others Recommendations - On the mechanized harvesting of seeds of desert fodder plants *Tashkent* pp **11**
[11]   Scientific special institutions Rehabilitation of decayed desert pastures, improvement of low-yielding natural pastures Rationale for mechanized technologies for the cultivation of desert seeds. *Published house ITA press* Tashkent 2013 pp **22**
[12]   Of air-assisted centralized seed-metering device of direct seeding machine for rape and wheat. 2018 Nongye Gongcheng Xuebao Transactions of the Chinese Society of Agrocultural Engineering **34** (12) pp 16-26

12
[13]   Zhang M Wang Z Luo X Xing H Wang B Effect of double seed-filling chamber structure of combined type-hole metering device on filling properties   *Nongye Gong cheng Xuebao Transactions of the Chinese Society of Agrocultural Engineering* **34** (12) pp 8-15
[14]   2014Technical conditions Seeds of desert pasture plants *Sowing qualities* (Samarkand) pp **12**