ACADEMICIA

ISSN: 2249-7137 Vol. 11, Issue 6, June 2021 Impact Factor: SJIF 2021 = 7.492

ACADEMICIA
An International Multidisciplinary Research Journal
(Double Blind Refereed & Peer Reviewed Journal)

DOI: 10.5958/2249-7137.2021.01667.0

UNIVERSAL COTTON SEEDING UNIT

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ABSTRACT

This article presents sowing devices with elastic tedders and an experimental nesting device of a cotton seeder installed on a single-bar frame of the unit. In this case, an elastic agitator is installed above the feeder-agitator of the sowing device. Determined the length of the rod - the turner and its diameter.

KEYWORDS: *Seeders, Seeding Devices, Seeds, Industrial Crops, Furrows, Plant Density, Arch-Breaking Devices, Toothed Agitator-Feeder, Toothed Seeding Wheel, Flexible Elastic Agitator, Seed Guide, Dotted Sowing, Conical Nesting Device, Elastic Rod-Agitator, Schemes Sowing, Vault.*

INTRODUCTION

The main task of the seeding apparatus for industrial crops is to ensure their uniform supply into the grooves of the rows to obtain a given plant density.

The industry of the Republic of Uzbekistan produces seeders equipped with devices for sowing lowered or bare cotton seeds. In connection with the improvement of sowing technology, methods of preparing seeds for sowing, as well as labor productivity requirements during sowing, in recent years there has been a slight update of the fleet of seeders, including cotton. At the same time, the layout of the devices, the working bodies of the support-drive wheels changed, the volumes of the bunkers significantly increased, the conditions for the grasping of the coils of the pubescent seeds by the teeth changed, which required theoretical and experimental studies to select the optimal parameters of the seeding device [1].

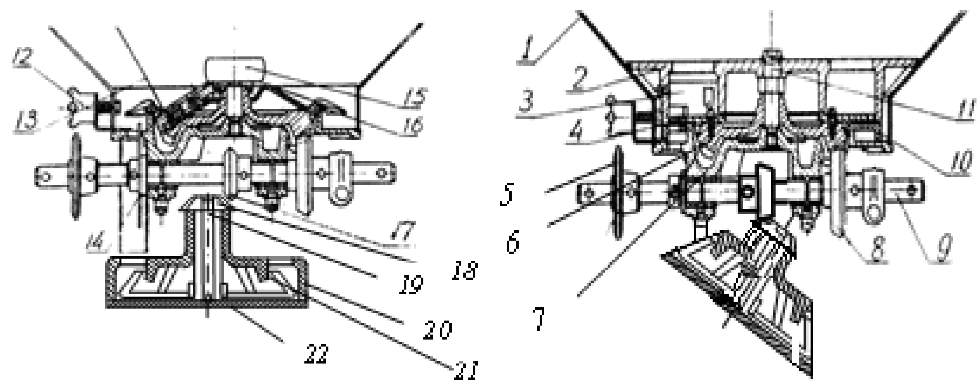
Therefore, the advantages and disadvantages of seeders in relation to the quality of the distribution of seeds in the row and in the sown field as a whole are mainly determined by the operation of the seeding devices.

The use of bridging devices as a means of reducing the adhesion of seeds to each other is the most promising. Therefore, research was carried out in this direction. For sowing lowered cotton seeds, the classic design of the sowing device was adopted for research, containing a bottom, a toothed agitator-feeder, a toothed seeding wheel, and an adjusting flap. This apparatus is shown in Figure (1.a)

At the end of the feeder, an axis is installed, on which a spring is fixed, one end abuts against the body of the crown - the feeder, and the other end is free, moving in the mass of seeds and is its own flexible elastic agitator.

Due to the complexity of the sowing sections, in the single-bar cotton seeders produced in the design, sowing of bare seeds is carried out using a direct seed guide (without a nesting device) only dotted sowing. To eliminate this drawback, we proposed a conical nesting device (conical blade disk) for the sowing section of a single-bar seeder, sowing bare cotton seeds (Fig. 1.b)

The experimental nesting device is installed in the seeding section at an angle 45^0 in the direction of the unit. In this case, the window of the nesting device is placed close to the seeding window of the cutter of the seeding device.



a) existing design b) experimental design

Fig. 1. Seeding units of cotton seeder

1-bunker; 2-safety disc; 3- intermediate ring; 4-seeding disc; 5-star; 6- conical sprocket; 7- the body of the apparatus; 8-lead sprocket; 9-shaft; 10-intermediate shaft; 11- axis; 12- adjusting screw; 13- reflector; 14-coil; 15-special bolt; 16-turner; 17-driven sprocket; 18- drive shaft; 19 - vertical axis; 20- housing of the nesting apparatus; 21-blade disc; 22-cover .

In the existing apparatus, the length of the axis on which the turner spring is located is structurally determined by the feeder crown. According to the diameter of the feeding rim (Fig. 1.a)

($d_{вп}$ = 200 мм) the length of the spring is $1np \leq 50$ мм.

When calculating a spring, the first step is to select the length of the bar, the diameter of the springs and the diameter of the bar.

In the process of operation, the elastic rod-agitator creates a certain pressure on the cotton seeds located in the hopper during the rotation of the agitator-feeder, on which the lower end of the spring rod is fixed, and the rod itself experiences resistance from the seeds. With a large depression of cotton seeds and their moisture, the height of the loosened layer must be greater, and therefore there must be a greater moment required for tedding the seeds, which can lead to slipping of the support wheel and a violation of the sowing pattern.

When the agitator-feeder rotates and point 0 deflects forward by an angle α, the rod deviates from the initial position tangentially at point 0 by an angle β due to wedging of seeds near the hopper wall (Fig. 2).

With a sufficiently large length of the agitator rod of weak rigidity and a deviation of 0 from the AO1 axis, the end of the rod (B) will take a stable position of the vertical axis passing through point 01, forming a cone above the feeder with a gear ring that promotes bridging.

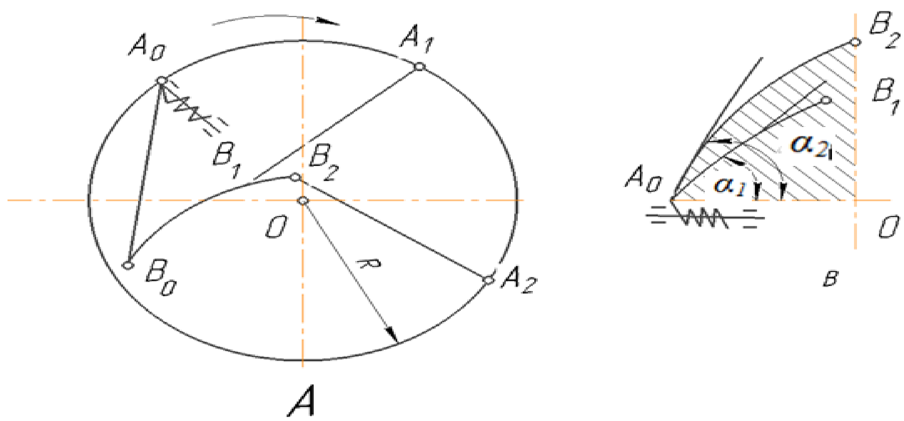


Fig.2. The trajectory of the rod end "B" in the mass of seeds (top view); B_0,B_1,B_2 - sequential bar end position.

The formation of a conical vault is most undesirable, because the vault has the greatest stability, and in this case the turner will practically be inactive.

From the analysis of Fig. 2 it follows that in order to prevent the formation of such a cone, it is necessary:

a) either increase the rigidity of the agitator spring to eliminate the deflection of the rod by an angle α, but this, in turn, can lead to an increase in the required torque and damage to the seeds;

b) either reduce the length of the rod to a certain size with a constant spring [2].

To calculate the length of the agitator, we take the path to reduce its length at a constant spring rate.

From the condition of eliminating the formation of a conical arch, the length of the turner rod should be within

$$r \leq l \leq Z_{кр} \quad \text{or} \quad 100мм \leq l \leq 200мм$$

Where $Z_{кр}$ – minimum height of the cylinder formed by the agitator shaft. r – feeder rim radius, r = 100мм

$$Z_{кр} = \frac{r}{\cos\alpha} \qquad (1)$$

Where, α- angle at the base of the tine feeder $\alpha = 35^0 \ldots\ldots 60^0$

Then

$$Z_{кр1} = \frac{r}{\cos\alpha_1} = \frac{100}{\cos 35^0} = 122 \text{ мм} \quad Z_{кр2} = \frac{r}{\cos\alpha_2} = \frac{100}{\cos 60^0} = 200 \text{ мм}$$

This means that the length of the turner rod is taken equal in terms of 120… .200mm.

The tedder shaft, during its movement, experiences pressure from both sufficiently densely packed seeds, as well as loose ones, which depends on the methods of filling and the method of preparing the seeds for sowing (moistening, languishing). Therefore, its fluctuations will have a variational character [3].

Let us consider the movement of the turner rod based on the system for determining the bending of a cantilever elastic rod, while the model of the system under consideration includes [4]:

1. A model elastic bar with a mass intensity defined as

$\frac{\pi d^2 \gamma_c}{4g} \cdot \frac{d^2 U}{dt^2}$; (2) When d – rod diameter, m:

γ_c - core material density, kg / m^3

g – acceleration of gravity, m/s^2

In this case, the first term is the mass of a unit length of the rod, and the second is a function of dynamic acceleration.

1. The bending stiffness of the bar is determined according to the expression:

2. EJ = E$\frac{\pi d^4}{64}$;; (3)

and the distributed elastic force: $F_{упр} = EJ\,\frac{d^4 Y}{dZ^4}$; (4)

When $\frac{d^4 Y}{dZ^4}$ – the fourth partial derivative with respect to the length of the rod in the section under consideration.

1. The generalized coordinate taking into account dynamic bending U (t, Z) is a function of time t and coordinates of the section under consideration Z.

2. The intensity of the external force, ie the variability of the impact of seeds on the rod q (t, Z) (N / m).

This function is characterized by a dependence on time, for which we consider the pressure from the weight of the seeds on the wall of the hopper and the turner.

Based on the above, we obtain the following differential equation:

$$\frac{\pi d^2 \gamma_c}{4g} \cdot \frac{d^2 U}{dt^2} + EJ\,\frac{d^4 U}{dZ^4} = \left(q_1 \sin\frac{\pi Z}{2 I_o} + q_2 \sin\frac{\pi Z}{I_o}\right)\left(1 - \cos\frac{2\pi t}{\tau_B}\right) \quad (5)$$

We find a solution to the problem by designating

$\mu = \frac{\pi d^2 \gamma_c}{4g}$ (кг· *сек*^{2} /м^2); $C^2 = \frac{EJ}{\mu}$; $q_m = \frac{q_1}{\mu}$.

Then the equation for the first mode of vibration takes the form

$$\frac{d^2U_1}{dt^2} + C^2\frac{d^4U_1}{dZ^4} = q_m \sin\frac{\pi Z}{2I_o}\left(1 - \cos\frac{2\pi t}{\tau_B}\right). \quad (6)$$

Then

$$U_{max} = \frac{2q_m \sin(\pi Z/2I_o)}{a^2} \ (м) \quad (7)$$

Given some constructive values of quantities and previously determined, the values of the function for 1_0 ═150; 200 и 250 mm and from there we preliminarily determine the diameter of the turner rod. The operation of the rod-turner can occur under various conditions, when the rod is subjected to a sudden concentrated load, evenly distributed and constant, etc. We believe that from the point of view of long-term operability of the agitator rod, the calculation must be made from the condition of a suddenly applied concentrated load at the free end of the agitator

$$Umax = \frac{2q_m}{a^2} sin\frac{\pi Z}{2I_o}, \text{ м} \quad (8)$$

When

$$2q_m = \frac{2q_1}{\mu}, \frac{M}{C^2};$$

$$a^2 = c^2\frac{\pi^4}{16{I_o}^4} = \frac{EJ\pi^4}{\mu 16{I_o}^4}, \frac{1}{C^2}.$$

Then

$$Umax = \frac{125 \cdot q_1 \cdot {I_o}^4}{\pi^4 E \cdot {d_o}^4}. \quad (9)$$

When 1_0 = 150 мм,

Get

$$d_o = \sqrt[4]{\frac{5{,}39}{10^{12} \cdot I_o}} \text{ м}$$

From here

$$d = \sqrt[4]{5{,}39/(0{,}150 \cdot 10^{12})} = 0{,}00245 \text{ m}.$$

or 2,45 mm.

In the experimental design of the seeding device, when the seeding disc rotates, the cells filled with seeds come to the seeding window, above which a reflector is installed and removes excess seeds. The seeds fall out of the cells into the window under the influence of their own weight, as well as with the help of a pusher. The seeds dropped out of the window are picked up by the blade by the nesting disc and thrown into the opener cavity. Then the covering implements produce closed grooves and the press roller forms a convex ridge of soil above the seeds.

The nesting device must be able to sow compact, unstretched nests located at specified distances along the row length. For this, it is necessary to correctly select the operating modes and parameters of the nesting apparatus. The movement of single seeds into the housing of the nesting apparatus and the flight of seeds inside the opener should be investigated.

Let us consider the case of a seed located at the outer end of the blade and at the wall of the apparatus body. (Fig. 2)

Let us introduce the following notation:

m- the mass of the seed;

r_0- the radius of the inner end of the blade;

r_1- the radius of the outer end of the blade;

f_1,f_2 и f_3 – the coefficients of friction of the seed, respectively, on the surfaces of the bottom of the body, the blade and the wall of the body;

V_r – the speed of the relative movement of the seed along the blade;

V_n - the peripheral speed of the blade.

We accept the origin of the rectangular coordinate system at point 0, located in the center of rotation of the disk, the Z axis, passing through the axis of rotation of the disk, and the X and Y axes, located in the plane of the bottom of the body, and the X axis coincides with the radius of the blade [2].

At the moment the movement begins, the forces act on the seed:

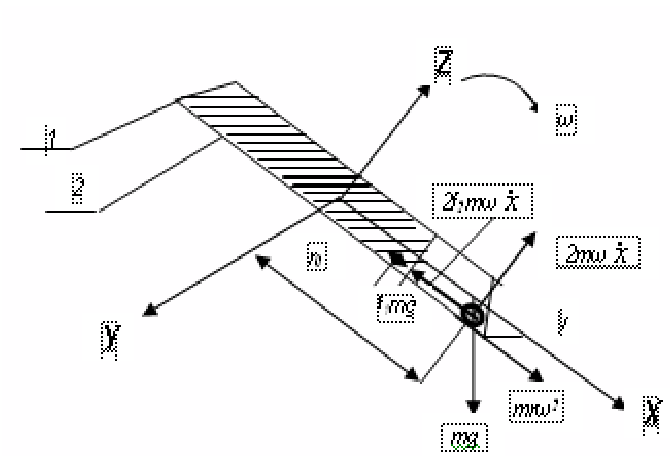


Fig-2. Scheme of the action of forces on the seed in the nesting apparatus

1- blade disc; 2- disc walls;

mg is the strength of the weight of the seed. The projection of the force on the X-axis is 0. The projection relative to the horizontal plane creates an angle α.

$mr\omega^2$ - centrifugal force;

***f_1mg*-** friction force of the seed on the surface of the bottom of the body;

f_1,$f_2$mg - friction force of the seed on the blade surface;

$2\omega\vartheta_r m$ - Coriolis force;

$2f_2\omega\vartheta_r m$ - friction force of the seed on the surface of the blade, arising from the action of the Coriolis force.

Let's compose the differential equation of the seed movement in projections on the X-axis: $m\ddot{x} = mg\cos\alpha + mr\omega^2 - f_1 mg - f_2 f_1 mg - 2f_1\omega V_r m$, (10)

$$\ddot{x} = g\cos\alpha + r\omega^2 - f_1 g - f_2 f_1 g - 2f_1\omega V_r, \quad 11)$$

Or $V_r = \dot{x}$

$$\ddot{x} = g\cos\alpha + r\omega^2 - f_1 g - f_2 f_1 g - 2f_1\omega\dot{x}, \quad (12)$$

Figure 2 shows that for a given position of the blade

$$r=r_0+x, \quad (13)$$

where x is the distance traveled by the seed from the inner end of the blade.

Substituting equation (4) in (3), we represent it in the following form: $\ddot{x} + 2f_1\omega\dot{x} - \omega^2 x = \omega^2 r_0 - f_1 g(1+f_2) + g\cos\alpha$, (14)

The resulting equation is a linear inhomogeneous differential equation of the second order.

We find the general solution using the homogeneous equation of the additional function (u) and the particular solution of this equation ϑ according to the formula:

$$x = u + \vartheta. \quad (15)$$

To solve the homogeneous equation, we use: the characteristic equation $K^2 + 2f_1\omega R - \omega^2 = 0$, (16)

The roots of which are equal:

$$K_1 = -\omega\left(f_1 + \sqrt{1+f_1^2}\right), \quad K_2 = -\omega\left(f_1 - \sqrt{1+f_1^2}\right).$$

The complementary function equation would be:

$$u = c_1 e^{K_1 t} + c_2 e^{K_2 t} = c_1 e^{-\omega t\left(f_1 + \sqrt{1+f_1^2}\right)} + c_2 e^{-\omega t\left(f_1 - \sqrt{1+f_1^2}\right)}, \quad (17)$$

When c_1 и c_2 – arbitrary constants.

A particular solution to the inhomogeneous equation is $\vartheta = A$

where coefficient A is determined as follows:

$\vartheta = A \quad \dot{\vartheta} = 0$ and $\ddot{\vartheta} = 0$.

Substituting these values into the original equation, we find

$$\vartheta = A = -\left(r_0 - \frac{f_1 g(1 + f_2) - g\cos\alpha}{\omega^2} \right), \qquad (18)$$

The general solution to the equation will be:

$$x = c_1 e^{K_1 t} + c_2 e^{K_1 t} + c_2 e^{K_2 t} - r_0 + \frac{f_1 g(1 + f_2) - g\cos\alpha}{\omega^2}, \qquad (19)$$

Arbitrary constants are determined from the initial conditions of motion at

$t = 0,\ x = 0,\ \dot{x} = 0$

$$C_1 + C_2 = r_0 - \frac{f_1 g(1 + f_1) - g\cos\alpha}{\omega^2},$$

$$\mathrm{K}_1 C_1 + \mathrm{K}_2 C_2 = 0.$$

Solving the equation, and determine the value C_1 and C_2 :

$$C_2 = \frac{K_1}{K_1 - K_2}\left[r_0 - \frac{f_1 g(1 + f_1) - g\cos\alpha}{\omega^2} \right],$$

$$C_1 = \frac{K_2}{K_2 - K_1}\left[r_0 - \frac{f_1 g(1 + f_1) - g\cos\alpha}{\omega^2} \right].$$

Substituting into equation (19), we get after transformations:

$$x = \left[r_0 - \frac{f_1 g(1 + f_1) - g\cos\alpha}{\omega^2} \right]\left[\frac{1}{K_2 - K_1}\left(K_2 l^{K_1 \cdot t} - K_1 l^{K_1 \cdot t} \right) - 1 \right], \qquad (20)$$

Or

$$\dot{x} = \vartheta_r = \left[r_0 - \frac{f_1 g(1 + f_1) - g\cos\alpha}{\omega^2} \right]\left[\frac{K_1 K_2}{K_2 - K_1}\left(l^{K_1 \cdot t} - l^{K_1 \cdot t} \right) \right], \qquad (21)$$

From the condition when

$t = 0,\ x = 0,\ \dot{x} = 0,$

then

$$r_0 - \frac{g\left[f_1(1 + f_2) - \cos\alpha \right]}{\omega^2} = 0$$

From the formula, you can determine the angular velocity of the vehicle:

$$\omega = \sqrt{\frac{g\left[f_!\left(1 + f_2\right) - \cos\alpha\right]}{r_0}}, \qquad (22)$$

With slip coefficient values $f_1 = 0{,}53$ (для чугуна), $f_2 = 0{,}39$ (for steel), blade radius $r_0 = 6{,}6$ *см* (for cotton seeders) and the angle of inclination of the installation of the nesting device $\alpha = 45^0$, define

$$\omega = \sqrt{\frac{g\left[0{,}53\left(1 + 0{,}39\right) - \cos 45\right]}{6{,}6}} = 2{,}3\,рад/сек.$$

Thus, for experimental verification, the length of the rod

of the agitator, we take equal in terms of 120… .200 mm, to ensure sufficient rigidity of the rod, we accept springs with a diameter of d = 2.45… 3.0 mm, the angular velocity of the nest apparatus should be 2.3 rad / sec.

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