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Modernization of The Technological Process of A Centrifugal Disk Apparatus for Applying Mineral Fertilizers and Substantiation of Parameters

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MODERNIZATION OF THE TECHNOLOGICAL PROCESS OF A CENTRIFUGAL DISK APPARATUS FOR APPLYING MINERAL FERTILIZERS AND SUBSTANTIATION OF PARAMETERS

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Abstract:
In article are brought information about the design, the technological process of new pneumo -centrifugal apparatus for application of mineral fertilizers and their mixtures, as well as the results and analysis of theoretical researches, in particular, the radius of fertilizer supply to apparatus.

Key words: Centrifugal apparatus, mineral fertilizers, construction, technological process, windage , radius.

МОДЕРНИЗАЦИЯ ТЕХНОЛОГИЧЕСКОГО ПРОЦЕССА ЦЕНТРОБЕЖНО-ДИСКОВОГО АППАРАТА ДЛЯ ВНЕСЕНИЯ МИНЕРАЛЬНЫХ УДОБРЕНИЙ И ОБОСНОВАНИЕ ПАРАМЕТРОВ

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Аннотация:
В статье приведены конструкция, технологический процесс работы нового пневмоцентробежного аппарата для внесения минеральных удобрений и их смесей, а также результаты и анализ теоретических исследований в частности радиус подачи удобрений на аппарат.

Ключевые слова: центробежный аппарат, минеральных удобрений, конструкция, технологических рабочий процесс, парусность, радиус.

Introduction

Production of technical facilities and technology for distribution of mineral fertilizers across surface of the field in a uniform and a predetermined amount of the distribution is the key to increasing use of fertilizers in the world. "Given that about 60% of all worldwide mineral fertilizers are sprayed on the field," development of high-quality fertilizer machines and apparatus is an important task [1]. At the same time, much attention is paid to improving the constructive scheme of fertilizer machines and substantiating the technological process, improving quality of work during the interaction of working parts with mineral fertilizers and their environmental movement.

Related work and discussion

It is known that scattering technological process of mineral fertilizers fertilizer hopper sole poured through holes in centrifugal devices. Speed of mineral fertilizers poured into the centrifugal apparatus from bunker hole [2],

$$V_T = \sqrt{2gh} \tag{1}$$

where g - is acceleration of free fall, m/s^2; h - height of fertilizer spillage, m.

Given that distance between bottom of the bunker hole and apparatus is

h=0.03-0.05 m, the spill rate of fertilizer grains of different sizes and shapes can be assumed to be the same.

Mineral fertilizers, grains of specified distance and the speed and angle of throw, they received disk depends on distance r_0 (Figure 1). When determining distance r_0, it is important to note that the friction force of centrifugal force $m\omega^2 \cos\psi$ acting on mineral fertilizer grains is greater than that of $fm\omega^2 \cos\psi$. When this condition is met, fertilizer grains move across the spade to its edge.

In this context, r_0 is minimum value of distance [3],

$$r_{0\min} \geq R\sqrt{1+f^2}\ \sin \tag{2}$$

where R- is the radius of centrifugal disk, m; f- coefficient of friction mineral fertilizer on shovel; ψ-angle between the tangent and radius vector to the point where the fertilizer grain meets the shovel, degrees. (2) expression R=0.30; f=0.5 and ψ=35°—40° when calculated by the values are r_o=0.034-0.066 m. (2) The calculation scheme of expression is shown in Figure 1, as well as provision of condition

$$m\omega^2 r_0 cos \geq mf\,\omega^2 r_0 cos \tag{3}$$

Using mathematical operations and taking coefficient of friction in the range

f=0.35-0.5, expression (3) was achieved. Analysis of expression (3) showed that the value of centrifugal force is 2.0-2.2 times greater than the value of frictional force generated.

Hole opening in the bottom of bunker location in rela-

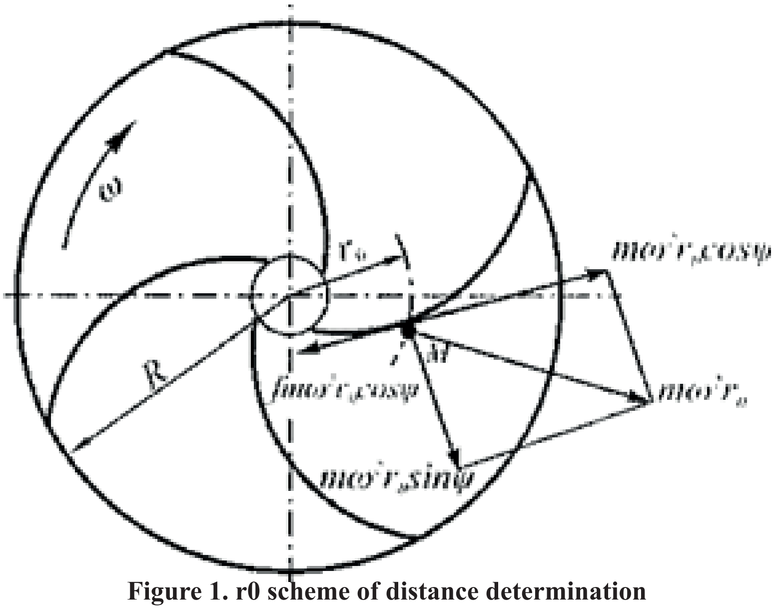

Figure 1. r0 scheme of distance determination

tion to the working surface and shovels of centrifugal disk affect the values of fertilizers outlet and scattering corners.

Academician P.M.Vasilenko detailed the movements and equations of mineral fertilizer grains in system of different coordinates on shovels with different shapes [4].

As is known, shovels are mounted in the radial direction on disk in centrifugal devices of existing fertilizer machines. Installation of shovels in this way poses constructive problem with installation of additional air bubbles under each of them. This is because the absolute velocity direction of fertilizer grains is inconsistent with direction of additional airflow, which means that the process of technological operation of apparatus is not fulfilled. Taking into account the foregoing, shovels in the form of logarithmic spirals were selected (Figure l).

Methodology

A worldwide literature review known that of centrifugal discs' production with a diameter of 400-700 mm. Disk centrifugal apparatus with diameter of 400-500 mm are usually installed in two fertilizers per machine. Disk apparatus with diameter of 600-700 mm are mounted on each fertilizer machine one piece [5].

Based on the above and size of fields on farms of the Republic, we also received 600 mm diameter disk centrifugal apparatus and decided to install one fertilizer machine.

It is widely used in centrifugal apparatus that the number of shovels is four and that they are placed symmetrically on disk surface. This is because the apparatus disk is balanced with large number of rotations and requires reliability for safety reasons. However, there are differences in the shape of shovels and their adjustment to the disk radius. The basis of this diversity lies in the way technology is implemented. In particular, shape of the shovels is chosen as packing form to reduce friction force during the movement of fertilizer grains through shovels [6], It is well known that the spirals are logarithmic, archaemidic , and hyperbolic (Fig. 2).

In a logarithmic spiral, the angle between the tangent point and the radius vector held at each point is constant. In this case, it is possible to select any part of logarithmic spiral with a central angle of 90°.

When constructing logarithmic spiral and selecting required section, position of radius-vector length is equal 'to the radius of centrifugal disc and corresponding branch OA0D4.

When constructing logarithmic spiral and selecting required section of

radius- vector length centrifugal disc that is equal to the

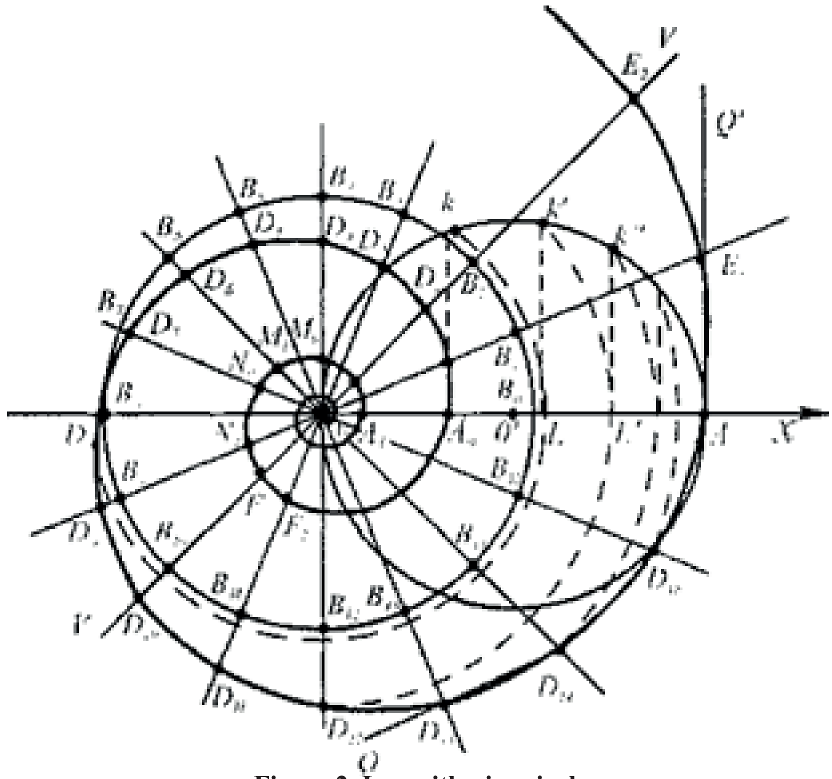

Figure 2. Logarithmic spiral.

radius R and corresponding piece of OA0D4. were selected.

Experimental results

Relative and displacement velocities of mineral fertilizer grains calculated for shovel in form of logarithmic spiral, used their vector sum to give absolute velocity, and determined absolute velocity direction of fertilizer grains (Figure 3).

Determining absolute velocity direction shown in Figure 3 and corresponding additional airflow diagram allow determine position of device to generate additional airflow. It is required to select the direction of additional airflow produced in such a way that it is in parallel with absolute velocity of fertilizer grains. Only then will use of additional airflow be more effective. To achieve this, the K.K line at the absolute speed of fertilizer grains throwing is passed through the bottom of disc. The line AD is perpendicular to KK. The AD line length is selected based on disk diameter. In this case, 0.15 m was selected. We will pass parallel ad line to AD from the logarithmic spiral shovel of disc at the point where it ends, and obtain a length of 0.05 m. Then AD: ad=3. The resulting AadD shaped trapeze is schematic view of device that generates additional airflow.

Given that fertilizer grains thrown from centrifugal disk in horizontal plane, we direct additional airflow and velocity vector along the horizontal plane. To do this, disk edge of base taken parallel to the disk plane. This condition was achieved by selecting the height access point of device 0.10

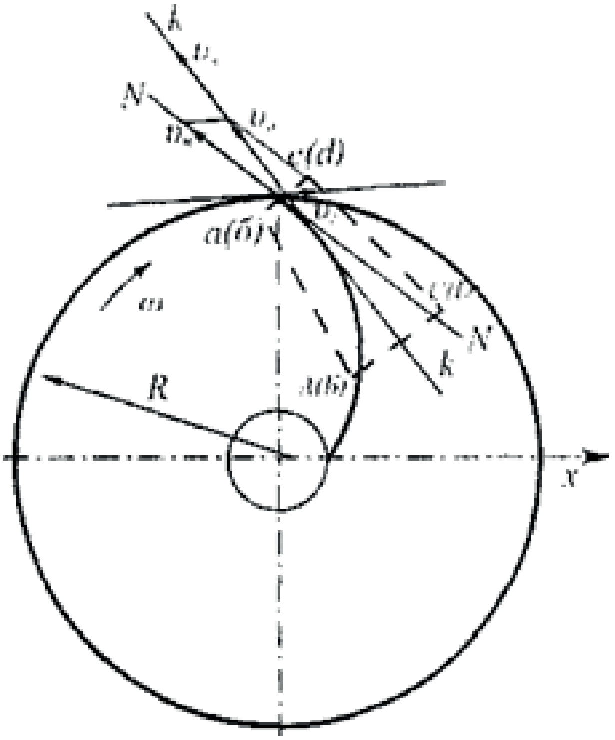

Figure 3. Scheme for selecting additional airflow direction by adjusting the absolute velocity of fertilizer grain

m. Accordingly, height of outlet hole was selected at 0.03 m. Based on the analysis and analysis of constructive technical solutions, access hole is 0.15 m wide, 0.1 m high, outlet hole is 0.05 m wide and 0.03 m high.

It has been reported in previous studies to apply of shovel in form of logarithmic spiral that convex in the direction of rotation and on short release of fertilizer grains from disk. The positive side of logarithmic spirals is that firstly, mineral fertilizer grains move with minimal friction, preventing segregation and, secondly, providing minimum value of output angle [4]. More, importantly, generated additional airflow force is parallel to tangent made to the points of shovel. This will ensure efficient use of additional air power. All of these factors provide the basis for the uniform distribution quality of mineral fertilizer grains.

Differential equation of fertilizer pieces' motion along logarithmic blade

$$\ddot{S} = \omega^2 r \cos\psi_0 - fg + f\omega^2 r \sin\psi_0 - 2f\omega\dot{S}_r \quad (4)$$

here ψ_o – angle, between relative velocity and the centrifugal force;

S – distance traveled along the blade, m.

Solution of equation (7)

$$S = C_1 e^{P_1 t} + C_2 e^{P_2 t} + \frac{fg\sqrt{1+a^2}}{(a+f)\omega^2} \quad (5)$$

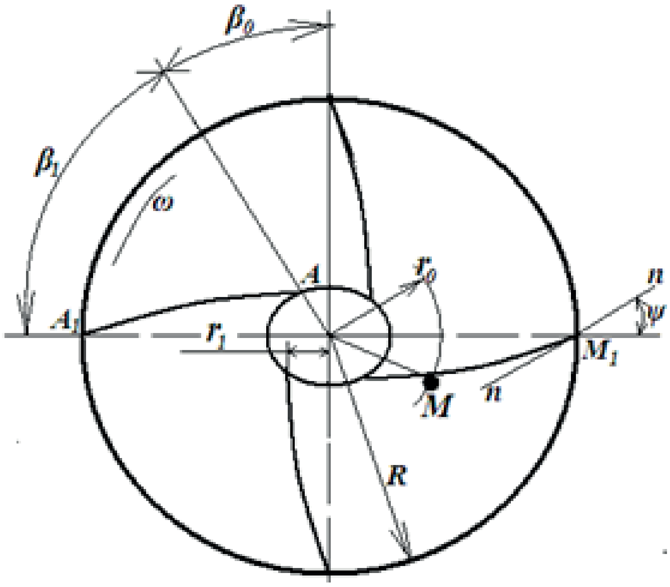

Figure 4. A scheme for determining the length of blade fertilizer grains have passed

here P_1 and P_2 - roots of equations; C_1, C_2 - initial conditions of movement, constant magnitudes $s=r_o$, S=0 determined by the initial conditions of the motion when t=0 (8).

Outlet angle β of fertilizer apparatus is a direct indicator that affects the uneven scattering of fertilizers. This indicator depends on fertilizer transmission distance to the disk ro, the blade length S and angular velocity ω of disk.

The S expresses the total length of the formula (5). However, mineral fertilizers pieces are given away from the center of disk to ro distance, not at the beginning of blade, r_1 initial radius of logarithmic spiral shaped blade (Fig. 4). As can be seen from picture $r_o > r_1$.

It can be determined by the following expression of logarithmic spiral shaped blade MM1 arc length [8]:

$$L = \frac{r_1 - r_o}{\cos\psi} \quad (6)$$

here r_1 - initial radius of blade, m;

ψ - angle , between tangential and radius vectors passing to any point.

It is shown in the line graph, influence to passed length of fertilizer grains over blade indexes in expression (7).

The graph shown in Fig.5 is constructed with radius R = 0.3 m, r1 = 0.05 m and ro = 0.11 m of disc. As shown in Fig.5, when the angle ψ increases, the width of blade is increasing according to with curvature regularities. The length is increasing in return decreasing logarithmic spiral of curvature radius. In this case, increased movement time of fer-

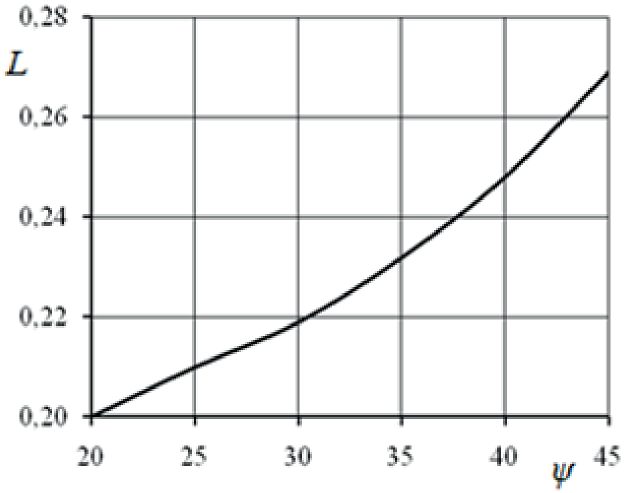

Figure 5. The line graph of change depending on angle ψ to the blade length

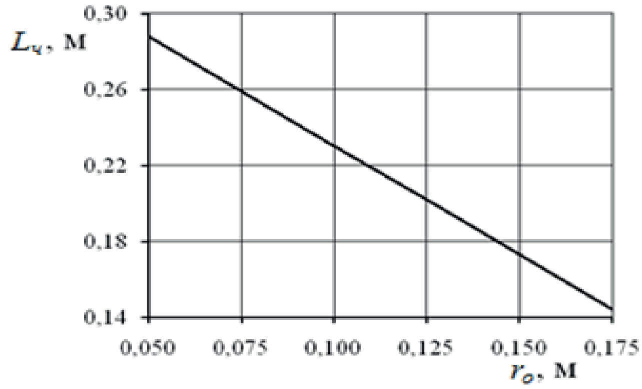

Figure 6. A line chart of change depending on blade length ro to fertilization distance

tilizer grains by the blade. This allows the fertilizer grains to be fractionated. In this context, the length of blade is adopted 0.22-0.23 m corresponding to the angle ψ = 30-35o. Fig.5 shows a line chart of change depending on blade length ro to fertilization distance.

The shown line chart in Fig.4 is constructed at a disc radius R = 0.3 m,

r1 = 0.05 m and ψ = 30o. As can be seen in Fig.6, fertilizer radius increases as fertilizer grains movement of blade length decreases according to the linearity law. Therefore, the radius of fertilizing is enlarged and it is close to length of disc radius. Based on the results of theoretical and experimental researches, radius of fertilizing was adopted between 0,100-0,125 m.

Conclusions

To develop the technological process of centrifugal apparatus enhances the quality of field scattering of mineral fertilizers and their mixtures with different aerodynamic properties, by mounting shovels on the top and additional airflow on the bottom.

The shovels are in the form of logarithmic spiral, with angle between the tangent and radius vector at its peripheral angles ranging between 30-35°. The proposed centrifugal apparatus is designed to simultaneously scattering the mineral fertilizers, to generate additional airflow, and redirect them after scattered fertilizing grains, blades in form of logarithmic spirals and fertilization radius will be in the range of 0.1-0.125 m.

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