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A Theoretical Attempt to Determine the Angular Velocity of a Spherical Disc

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ABSTRACT: The article presents the results of laboratory experiments to determine the productivity and some other parameters of the disk working body, working with the scheduler bucket in order to improve the process of leveling fields that meet the agrotechnical requirements of pre-sowing background.

KEY WORDS: productivity, disk, bucket filling coefficient, disk diameter, drawing prism. water saving, furrow irrigation, disk space, innovative technologies, the mechanic, long-base scheduler.

I. INTRODUCTION

The Resolution of the Cabinet of Ministers of the Republic of Uzbekistan dated February 24 , 2014 No. 39 "On additional measures to ensure the unconditional implementation of the State Program for the improvement of the ameliorative state of irrigated land and rational use of water resources for 2013-2017" was adopted [1]. One of the technologies used to enforce this solution, i.e. crop irrigation, efficient use of water resources, is a smooth surface. It can be concluded that the area of machine-tractor units is even, if the landing area is above the plane of the surface.

Spherical discs have found wide application in various agricultural tools for surface treatment. For example, there are disc ploughs, harrows, cucumbers, where a spherical disc serves as a working device. In disc ploughs and harrows, a spherical disc is the main working device that affects the soil. The decisive requirement for discs is a reduction in traction resistance, if the main purpose of cultivation is fulfilled satisfactorily.

In our researches the spherical disk worked as a plough-hole in the soil prepared for sowing, which was in loose condition, was sunk to the depth of 5-7 centimeters. Traction resistance is not of main importance due to under loading of tilled tractor type TTZ-80.10 during sowing. It is important to know the trajectory of flight of particles, thrown by disc, the distance of their throwing. In the theoretical determination of the trajectory of particles on the spherical surface, a significant role in determining the moment of particle velocity failure is played by the angular velocity of the spherical surface of the disk. In order to determine the influence, causes affecting the angular velocity, we have conducted research. The spherical disk, buried in loose soil, comes into interaction with it and moves with certain angular velocity W. The soil particles enter the inner cavity of the sphere, then come off the disc and fall down at a certain distance.

The angular velocity of W is influenced:

1.The ratio of disc inertia moments to soil

2.Bearing friction

3. Resistance to cutting into the front edge of the sphere and release of the rear edge from the soil

4. Angle of attack.

The moment of inertia of the disk relative to the axis of rotation Z (Fig.1) is:

$$J_Z = \frac{MR}{2},$$

Where:

M is disk weight ;

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R is radius of disk ;

To determine the angular velocity W, we apply the theorem of change relative to the rotation axis Z of the kinetic moment of the system consisting of soil and disc. For this purpose, we depict the system "disk-soil" and the external forces acting on the system (Fig. 1).

This system is affected by only one external force applied to the spherical disc from the moving soil.

Let's make an equation of moments:

$$L_z - L_{oz} = \sum M_z \left[S^e\right],$$

Where:

L_{oz}-kinetic torque relative to the axis of rotation of the disc of the soil-disc system until it touches. For simplicity of solving the problem, let's assume the disk standing in place at an angle and the soil layer moving progressively.

Then

$$L_{oz} = m\vartheta\rho \cdot \cos\alpha,$$

where m second - the mass of the formation is determined by the equation

$$m = \frac{s \cdot \vartheta \cdot \gamma}{g},$$

S-area in cross-section, normal to trajectory, dm2

ϑ -progressive movement speed .m/sec:

g -acceleration, m/sec2;

$\cos\alpha$, is a coefficient that takes into account the amount of movement per disc rotation;

- Distance between the axis of rotation of the disc and the center of gravity of a segment of disc buried in the soil;

L_{oz} - the kinetic moment in relation to the rotational axis after contact.

After touching the disc will have angular speed W and the soil layer will move together with the disc because of soil looseness.

Consequently,

$$L_1 = L_{1z} + L_{2z}$$

But $L_{1z} = L_{1z} \cdot w$ - disc kinetic moment, $L_{2z} = L_{2z} \cdot w$ - the kinetic moment of the formation,

Where

W-angle disc speed, I/s.

Considering expression (I), we shall result the equation

$$L_{1z} = \frac{MR^2}{2} \cdot W,$$

$a\ \Sigma M\left|S^e\right| = 0 -$ the sum of external force moments relative to the z-axis because the system's kinematic torque is maintained.

The moment of inertia of the moving part of the layer with respect to the z-axis will be:

$$J_{2z} = m\rho^2$$

That way;

$$L_z = \left[\frac{MR^2}{2} + m\rho^2\right]W$$

After substitution of the found values in the equation [2] we obtain.

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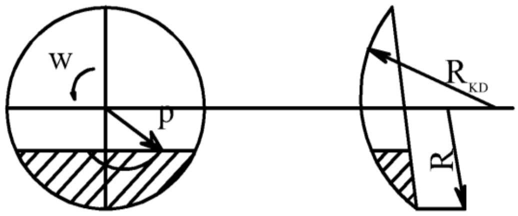

Fig. 1. Spherical disc, sunk into the soil.

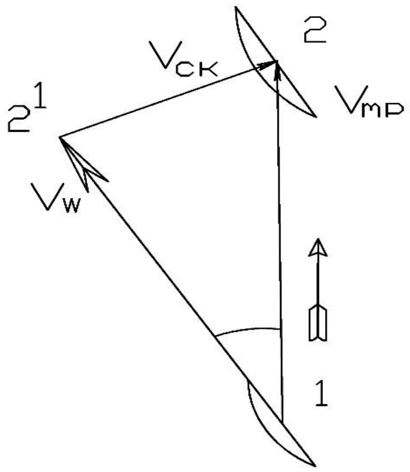

Fig.2. To determine the angular speed of the disc standing at an angle α to the trajectory

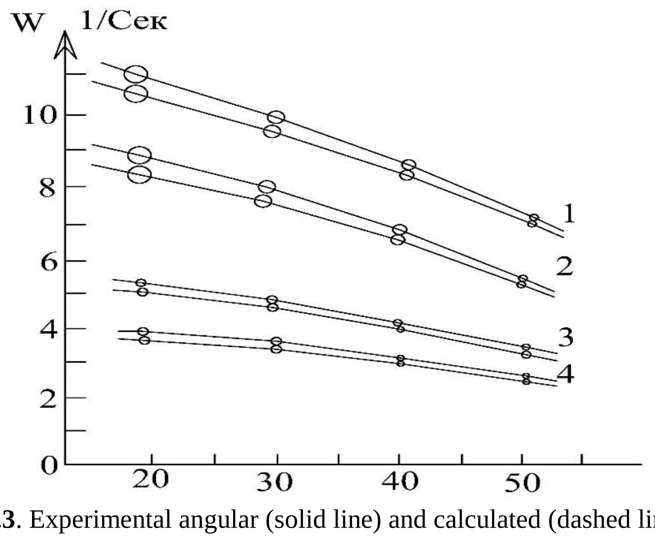

Fig.3. Experimental angular (solid line) and calculated (dashed line) by formula w= $\frac{\vartheta \cdot \cos\alpha}{R}$

Disk Speed w_{cp} : I-in V_1=613,8 m/s, 2-V_2=808,3, 3- V_2=1330,5 and 4=V_4=1672,2 m/s.

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$$\left[\frac{MR^2}{2} + MP^2\right] W - m \cdot \vartheta \cdot p \cdot \cos\alpha = 0.$$

Or

$$W = \frac{m \cdot v \cdot p \cdot \cos\alpha}{\frac{MR^2}{2} + mp^2}.$$

After dividing the numerator and denominator by mp we will finally get:

$$W = \frac{v * \cos\alpha}{P + \frac{MR^2}{2mp}}.$$

Besides, there's a dependency

$$\vartheta = WR_{nep}$$

In which,
$R_{пер}$ - rolling radius.
Comparing formulas (8a) and (9), we can see that:

$$P + \frac{MR^2}{2mp}. = R_{ntp}$$

But we do not take into account the friction torque in the bearing, the cutting resistance of the front of the disc, or the bulging of the rear [7]. Obviously, in reality, these factors increase rolling radius by a value oscillating within small limits which depends on bearing design, curvature of sphere, coefficient of soil friction against disk.

$$R_{nep} = R_{nep} + \Delta R \ .$$

Now let us determine the change of angular speed depending on the angle of disk installation - angle of attack (Fig. 2).

Spherical disc, moving together with the tractor and having the forward speed of the tractor when moving in a straight line makes a complex movement. It simultaneously participates in movement of pure rolling and pure sliding at moving on a straight line from position 1 to position II. The speed of this movement can be expressed in equality

$$\vartheta_{mp} = \vartheta_{ck} + \vartheta_{\omega}$$

Where:

ϑ_{ck} - tractor speed:

ϑ_{ω} - pure sliding speed :

ϑ_{mp} - pure rolling speed:

From a triangle I II II ' we have :

$$\vartheta_{\omega} = \vartheta_{mp} \cdot \cos\alpha$$

Considering the expression we will write down:

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$$W = \frac{v_{mp} \cdot \cos\alpha}{R_{nep}}$$

By substituting from equations (10) and (11) into expression (14) the value R_{nep} , we obtain :

$$W = \frac{\vartheta_{mp} \cdot \cos\alpha}{\left(\rho + \frac{MR^2}{2mp} + \Delta R \right)}.$$

For definition of actual rolling radius $R_{пер}$and also angular speed of a spherical disk, we have made spherical disks with various radiuses of curvature $R_{крив}$ at various thickness **t** (ϕ =300 mm).

$R_{крив}$,	500	700	900	Flat mm			
t ,mm	3	3	3	3	5	8	12

The rolling radius of the spherical disk is calculated as follows . On an optional device, which was manufactured at SAIME, the number of revolutions of the spherical disc, as well as parts of the revolutions up to I^0, is determined, the stopwatch time is counted to 0.01 . The device was strengthened on the running trolley of the soil channel that allowed fixing the spherical disk on the required angle of attack to the trajectory of movement in the range from 20 to 700 in 100 steps.

The trolley of the soil channel moved with four different speeds .

During the experiment, the number of disk revolutions N and time of movement t were calculated, and the number of revolutions N consisted of the whole number of revolutions n and the honor of revolutions.

Thatis

$$N = n + \Delta n$$

Experiments were conducted in the calculated area Z, the rolling radius is defined as

$$R^1{}_{\text{пер}} = \frac{z}{2\pi N}$$

the experiments were carried out in 4-fold repetition in each version.

Spherical discs with different moments of inertia and curvature radiuses were deepened to a depth of 30 : 60 : 90 : 120 mm and moved at different speeds [7].

After processing of experimental data it was found out that curvature of spherical surface, moment of inertia as well as burial of disk in soil practically does not influence on angular speed. Approximately the same data was obtained at other angles of attack.

The main factor influencing the rolling radius and accordingly the angular velocity was the angle of attack.

Calculation of rolling radius according to the above formula showed that rolling radius R_{nep} in all cases is close to R value (Fig. 1) .

Experiments have shown that the formula (15) can be simplified to the form :

$$W = \frac{\vartheta_{mp} \cdot \cos\alpha}{R} \qquad (16)$$

In fig. 3 given the dependencies of angular velocity W on the angle of installation. a. Here is shown the value of angular velocity of the spherical disk, calculated by the formula (16) and experimental data[3]. The angular velocity depends only on the setting angle of the disc to the trajectory, the velocity of movement and can be calculated using formula (16) .

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II. CONCLUSION

The angular speed of the spherical disc that moves in the soil prepared for sowing is independent of the disc curvature, the size of the burial, and the moment of inertia of the disc.

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