Chapter 2
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Grounding of the Longitudinal Distance from the Plow Corps to the Center of the Disk Skimmer

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ABSTRACT

The article discusses the theoretical grounding of the longitudinal distance from the plow corps to the center of the disk skimmer. Theoretically substantiated the longitudinal distance (I) from the tip of the ploughshare to the center (O_d) of the disk and the determination of the distance (y) of the discarding of the soil. The dependence of the longitudinal distance is considered (l) from the angle (α) of attack, depth (h_g) stroke, the radius (r) of the sphere, the radius (R) of the disk and the angle ($\gamma_к$) of the ploughshare installation to the furrow wall.

Keywords: Soil; mass; particle; ploughshare; disk; width; depth; angle; rotation; speed; rejection; plowing; furrow; face; range of rejection; movement; angle of attack; plant residues.

1. INTRODUCTION

Currently, in our Republic about 1 million hectares of irrigated land is sown with grain. On these lands, after harvesting, a significant amount of plant mass remains in the form of stubble and straw. When plowing them, existing plows are often clogged and, as a result, the quality of arable land deteriorates, the performance of arable units decreases due to the time required to eliminate the faces. To avoid this, farms plow the fields from grain plows with removed pre-plows or upper bodies, which significantly worsens the completeness and depth of embedding plant debris or burn them before plowing, causing great harm to soil, microorganisms and the environment, while high-quality plowing of plant residues result from anaerobic decay to improve soil structure [1,2].

It follows from the foregoing that studies aimed at substantiating the parameters of a plow for plowing fields with a significant amount of crop residues of grain crops, ensuring their complete and deep incorporation into the soil without bottom faces, are relevant and have great economic importance.

The technological process of working a reversible plow with a spherical disk skimmer and fairings mounted on the field edge of the left and right-handed buildings, dump surfaces of which are interconnected, is as follows. Plant debris on the soil surface and roots in the upper layers of the formation are cut by a spherical disk skimmer and, together with the upper soil layer, are discharged into the furrow formed by the previous building, clearing the path of the field cutoff of the subsequent building from the fairing mounted on it. Roots raised along the field edge from the lower layers of the formation fall onto the fairing, which eliminates their breakage and helps the broken off roots to slip off of the part of the field edge located below the fairing [1,2,3].

To date, the question of eliminating the faces of plows has been studied by many researchers, as a result of which the directions that contribute to solving this issue have been identified. Basically, the problem was solved by removing the racks from the field edge of the buildings towards the plowed field, removing them from under the plane of the frame and installing additional working bodies. However, this issue was not completely resolved, and when plowing fields with a significant amount of

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plant residues and weeds on the surface, the existing plows become clogged, which worsens the quality indicators of their work and reduces productivity due to the time spent on cleaning the working bodies [1,4,5,6].

The technological process of working a reversible plow with a spherical disk skimmer and fairings mounted on the field edge of the left and right-handed buildings, dump surfaces of which are interconnected, is as follows. The plant debris on the soil surface and the roots in the upper layers of the formation are cut by a spherical disk skimmer and, together with the upper soil layer, are discharged into the furrow formed by the previous building, clearing the path of the field cutoff of the subsequent building from the fairing mounted on it. The roots that are raised along the field edge from the lower layers of the formation fall on the fairing, which eliminates their breakage and helps the broken off roots to slip off of the part of the field edge located below the fairing [4,5,7,8,9].

2. MATERIALS AND METHODS

The theoretical researches were spent with use of the basic rules of the classical mechanics and of the mathematical analysis. To exclude inhibition of the rotation of the disk from the impact on its non-working (back) surface of the soil aggregate, sheared off by a ploughshare and rising on the dump surface of the latter, as well as to ensure the operation of the buried part of the blade of the disk in an under formed soil environment, which excludes soil unloading in front of the disk and provides reliable support for cutting plant residues, so that the trace (OBCD) (Picture 1) [10,11] of the vertical plane of soil cleavage by the ploughshare in the plan is shifted relative to the axis of rotation of the disk toward the share of the share by a distance (L) not less than K, i.e..

$$L \geq K \tag{1}$$

$$K = \sqrt{h_g\left(2R - h_g\right)} \tag{2}$$

where h_g - is the depth of stroke of the disk skimmer;

K is the half of the chord formed at the intersection of the plane of the circumference of the disk blade with the soil surface. The assumption is made here that the vertical plane (OBCDO') soil cleavage perpendicular to the plane (O'DD'C') spalling, located at an angle (ψ_n) to the horizon and starts from the boundary line (O'D) of the latter.

For the general case of disk location, when its axis of rotation is not parallel in terms of the OBCD trace (Picture 1 shows a special case, i.e., the OBCD trace in plan is parallel to the disk rotation axis), we determine the value of *L* from the following derived expression:

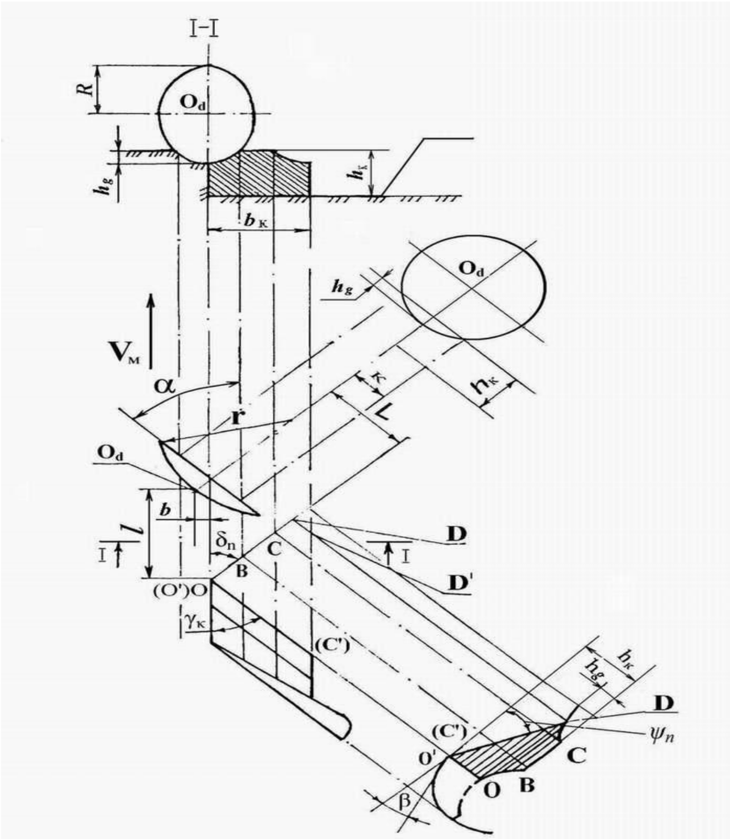
$$L = \frac{\left(l + btg\ \alpha\right)\sin\ \delta_n}{\sin\left(\alpha + \delta_n\right)}, \tag{3}$$

where is $\delta_n = \frac{\pi}{2} - \gamma_\kappa$ the angle between the direction of movement of the plow and a horizontal projection of the boundary line O'D chipping plane O'DD'C', deg. [12,13];

γ_κ - angle of installation of the share blade to the furrow wall, deg.

Substituting in (3) the value of δ_n and expression (1), which determines the transverse displacement (b) of the disk, and transforming it, we obtain

$$L = \frac{\left[l + \left(r - \sqrt{r^2 - R^2} \right) \sin \alpha \right] \cos \gamma_\kappa}{\cos \left(\alpha - \gamma_\kappa \right)}. \tag{4}$$



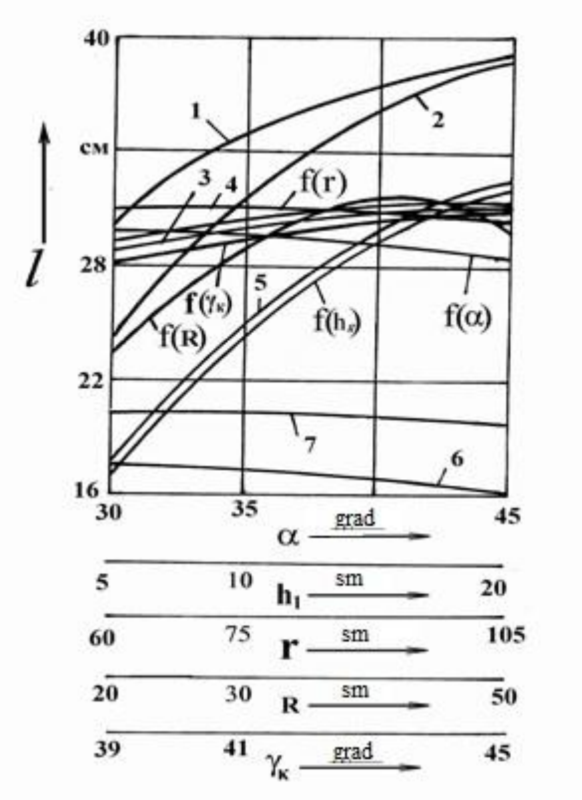
Picture 1. Scheme to justify the longitudinal distance (l) from the toe cap to the center (O_d) of the disc and the definition casting distance (*y*)

Equating the left and right parts in the expression (1), taking into account (2) and (4), we find the smallest longitudinal distance (l) between the share of the share and the center (O_d)of the disk, satisfying condition (1), which for any structural and technologically acceptable factors included in the formula (5) will provide the minimum longitudinal dimensions of the plow.

$$l = \frac{\sqrt{h_g \left(2R - h_g \right)} \cos \left(\alpha - \gamma_\kappa \right) - \left(r - \sqrt{r^2 - R^2} \right) \sin a \cos \gamma_\kappa}{\cos \gamma_\kappa}. \tag{5}$$

3. RESULTS AND DISCUSSION

Analysis of graphical dependencies (Pic. 2), constructed according to the formula (5) shows that the rational values of the longitudinal distance (l) between the toe of the ploughshare and the center of the disk, satisfying condition (1), excluding inhibition of disk rotation by the soil aggregate, chipped off by the plow corps, increase with increasing depth (h_g) of the disk stroke, its radius (R), radius (r) of the sphere, the angle (γ_κ) of setting the share to the furrow wall and decreases with increasing angle (α) of the disk attack. Moreover, the most intensive influence on the longitudinal distance (l) is exerted by the depth (h_g) of the stroke of the disk and its radius (R). As the radius (R) of the disk increases, the intensity of the influence of the radius (r) of the sphere on the longitudinal distance (l) increases, and, conversely, as r increases, the intensity of the effect on the radius R increases. So for R = 30 cm, an increase in r from 60 cm to 105 cm leads to an increase in the value from 29,3 cm to 31,6 cm, i.e. 2,3 cm, and at R = 50 cm from 30,1 cm to 39,2 cm, i.e. 9,1 cm. Similarly, for r = 50 cm and r = 60 cm, the change in R is from 20 cm to 40 cm leads to an increase of 8.1 cm and 11.9 cm, respectively.



Picture 2. The dependence of the longitudinal distance (l) on the angle (α) of the attack, depth (h_g) of the course, radius (r) of the sphere, radius (R) of the disk and angle (γ_κ) of setting the share to the furrow wall

Other things being equal: α = 40^0; h_g = 15 см; r = 60 см; R = 30 см; γ_κ = 41^0.

1 – l = f(r) at R = 50 cm; 2 – l = f(R) at r = 105 cm;

3 – l = f(γ_κ) at α = 30^0; 4 – l = f(α) at γ_κ = 44^0;

5 – l = f(h_g) at α = 30^0; 6 – l = f(α) at h_g= 5 см;

7 – l = f(α) at γ_κ = 39^0; h_g = 10 см; R = 20 cm.

Picture 2 shows that the mutual influence of other parameters (α, γ_κ, h_g) insignificantly, they also have little effect on the intensity of changes in the longitudinal distance (l) depending on the radius (R) of the disk and the radius (r) of its sphere. The curve l = f (R) has a maximum at R = 41 cm, a further increase in radius (R) leads to a decrease in the longitudinal distance (l).This is explained by the fact that an increase in R more than 41 cm (at r = 60 cm) leads to the fact that the intensity of the increase in the distance from the center (O_d) the disk to the plane of its blade becomes larger than the distance increases from the vertical plane passing through the axis of rotation of the disk to the point of intersection of its blade and the plane of the soil surface.

When installing on a plow with POT corps 01.000 ($\gamma_к$ = 40^0) spherical disk from a disk harrow (*R* = 32, 5 см, *r* = 60 см) with angle of attack α = 40^0 (average limit value $35…45^0$, recommended by Kanarev F.M. [14]), equal to $\gamma_к$, and the calculated (minimum required) depth of its stroke, determined by the formula

$$h_g = h_б = \frac{B_б tg\,\varphi_0}{2}, \qquad (6)$$

Where is $h_б$ theoretical value of the depth of the irrigation furrow after harvesting wheat, cm;

$B_б$ is the average value of the width of the irrigation furrow, determined new as a result of measurements;

φ_0 is average slope of the irrigation furrow, determined as a result of measurements the necessary longitudinal distance (*l*) will be 29.2 cm, and with a rational radius (R = 34 cm) of the disk *l* = 29.6 cm. Based on the foregoing, it follows that it is necessary to determine the minimum possible values of the stroke depth (h_1) of the disk skimmer and its radius (R) (provided that the technological process is of high quality), which most significantly affect the longitudinal distance (l), and therefore the dimensions and weight of the plow.

4. CONCLUSIONS

The quality of embedding plant residues depends on the range of soil rejection by a spherical disk, which grows with an increase in the plowing speed, decreases with an increase in the radius of the sphere, and with the radius of the sphere *r* = 0.6 m, the depth of travel h_1 = 0.13 m with increasing radius (*R*) the disk first decreases, then increases, having a minimum in the range of its change from 0.32 m to 0.33 m.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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