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Detection of vertical load on the base drive with a plug-in drive

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Abstract. When the disc plug is in operation, its straight line movement is considered important. The reason for this is that the plug bodies are angled, all pointing in the same direction, so they will attempt to rotate the plug during operation. To prevent this from happening, the plug incorporates a support disc which, by resting on the base formed by the end housing, ensures that the plug operates horizontally without tilting to the side, i.e. in a straight line movement. Based on this, it was found in theoretical studies that the vertical load applied to the disc connector depends on its parameters. According to the obtained expression, it was shown that the steepness of load on the support disc depends on its radius (diameter), depth of immersion in the bottom, thickness, thickness of the crucible, angles of sharpening and installation relative to the steepness, as well as friction and volume crushing coefficients of the ground.

1 Introduction

Soil is the main resource for growing cotton, wheat, soybeans and other crops [1-6]. The yield of these crops depends on good soil preparation. This, in turn, will lead to the development of the food industry, animal husbandry and fish farming [7-15].

In the following years, due to the widespread introduction of energy-efficient technologies and techniques in agricultural production, the use of disc stoppers, i.e. stoppers with a spherical disc-shaped working tool, in the main tillage (ploughing) of land has gained importance. Because they are less tension-resistant than tilting discs, are more efficient and don't get blocked by plant debris and weeds. Based on this, we developed a disc plug used in the main tillage (ploughing) of land for the cultivation of cereals, rye and other crops, and conducted research to justify its parameters suitable for the soil and climatic conditions of our region [16].

During operation, the plug is moved aggregatively through the front frame suspension 1 2 to the tractor and the disc body 3 cuts the ground and turns it over. At the same time, the support disc 4, resting on the egat base formed by the end body, ensures that the plug operates in the horizontal plane without tilting to the side, i.e. in a straight line movement.

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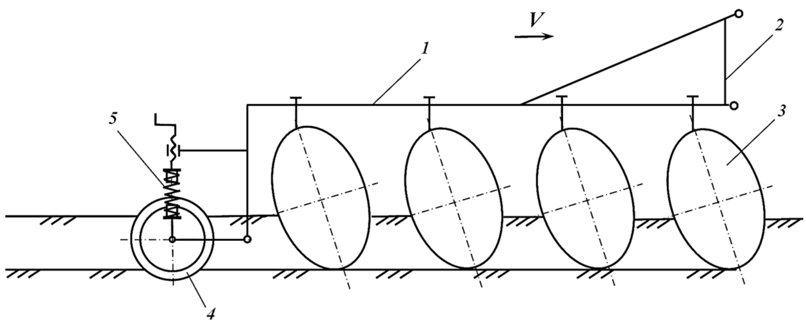
This paper presents the results of theoretical studies to determine the dependence of the vertical load applied to the base disc of the disc plug on its parameters.

The disc plug, like other plugs, consists of frame 1, suspension device 2, disc body 3, support disc 4, spring-loaded adjusting screw 5 (Figure 1).



1-frame; 2-suspension device; 3-disc body; 4-supporting disc; 5-spring adjusting screw

Fig. 1. Disc connection diagram.

2 Materials and methods

To determine the parameters of the working parts of the disk plug M. Alam, A.K.Srivastava, B.Panagrai, M.J.J.Hahn, R.Manian, G.N.Sineokov, V.F. Strelbitsky, F.M.Kanarev, P.S.Nartov, G.Tesliuk, F.M.S.Mamatov, A.T.Tukhtakuziev, S.P.Chirsov, A.N.Khudoyarov, H.T.Kirgizov and others conducted studies [1,3,5, 16-22]. Theoretical studies on determining the vertical load that the disk fork exerts on the base plate have not been sufficiently investigated in the works of the researchers mentioned above.

The rules of analytical analysis of higher mathematics as well as the laws of theoretical mechanics and resistance of materials were used in the research.

The total steep load required for the base disc to sink to a given depth was determined by determining the steep loads required to ensure that the ground part of the disc, i.e. its edge, sinks to a given depth.

Based on the analysis of the expression for the detection of the vertical load applied to the disc connector of the base disc, the dependence of the vertical load applied to the base disc on the design and technological parameters of the connector was analysed.

3 Results and discussion

Our study shows that in order for the plug to act in a straight line in the horizontal plane, the disc must operate by sinking to a certain depth into the bottom of the basket. This requirement is achieved by a vertical load (force) acting on the disc by a pressure spring.

As the edge of the disc is ground, the total load that is applied to it can be expressed as

$$Q_u = Q_m + Q_{sh}, \tag{1}$$

there Q_u- total steep load required to plunge the disc to a given depth;

Q_m- the steep load required for the disc to sink to a given depth;

Q_{sh}- the steep load required to ensure that the sharpened part (fascia) of the disc plunges to the specified depth.

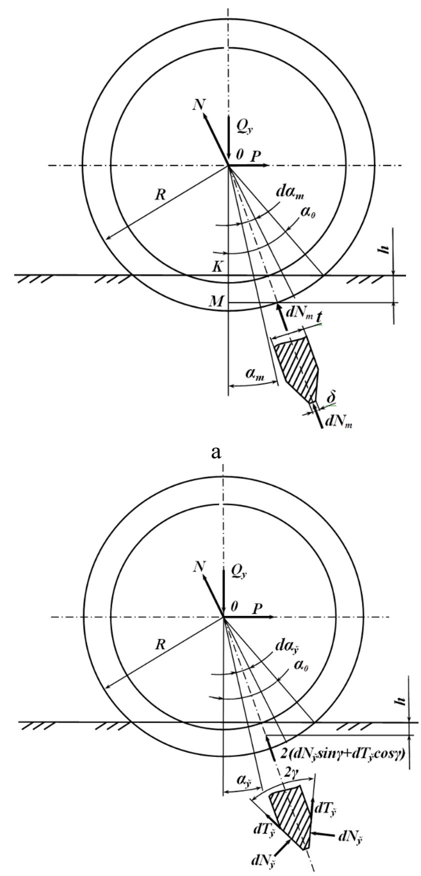
Determine these components of the total vertical load on the disc using the diagrams shown in Figure 2.

To determine Q_m, we separate the elementary surface $ds = R\delta d\alpha_m$ (where R-radius of the disc; δ -disc thickness; $d\alpha_m$-elementary angle) from the part of the incisor disc (diagram a in Figure 2) that interacts with the soil.

The following elementary normal force acts on this surface

$$dN_m = q_m ds = q_m \delta R d\alpha_m, \quad (2)$$

there q_m - the specific pressure exerted by the ground on the disc surface.



b

Fig. 2. Schematics for determining the vertical load required to sink the disc to a given depth into the bottom of the egat.

The sum of the vertical components of the elementary normal forces acting on the disc axis gives Q_m, i.e.

$$Q_m = \sum dN_m^m = \int_0^{\alpha_0} dN_m \cos\alpha_m = \int_0^{\alpha_0} q_m \delta R \cos\alpha_m \, d\alpha_m, \quad (3)$$

there dN_m^m- the torque of the elementary normal force acting on the disc axis.

(3) cm in the expression is defined as the volumetric soil crush factor q_m and its represent deformation at the point in question through h

$$q_m = q_0 h. \quad (4)$$

According to diagram *a* in the figure

$$h = OM - OK = R(\cos\alpha_m - \cos\alpha_0), \quad (5)$$

there α_m and α_0- central angles.

Taking expressions (4) and (5) into account, integrating expression (3), we obtain

$$Q_m = \frac{1}{2} q_0 \delta R^2 (\alpha_0 - \sin\alpha_0 \cos\alpha_0). \tag{6}$$

Representing $\sin\alpha_0, \cos\alpha_0$ and α_0 in this expression by R and h_d (where h_d is the immersion depth of the disc in the bottom of the land), we obtain the following result

$$Q_m = \frac{1}{2} q_0 \delta R^2 \left[arccos\frac{R-h_\partial}{R} - \frac{(R-h_\partial)\sqrt{(2R-h_\partial)h_\partial}}{R^2} \right]. \tag{7}$$

The vertical load required to plunge the sharpened part of the disc into the soil was determined by the diagram b in Figure 2 in the order stated above

$$Q_{sh} = \frac{q_0}{2cos\gamma}(1+fctg\gamma)\left(R - \frac{t-\delta}{4}ctg\gamma\right) \times \times \left[R^2 - \left(R - \frac{t-\delta}{2}ctg\gamma\right)^2\right]\left[\arccos\frac{R-h_\partial}{\left(R-\frac{t-\delta}{4}ctg\gamma\right)} - - \frac{(R-h_\partial)\sqrt{\left(R-\frac{t-\delta}{2}ctg\gamma\right)^2-(R-h_\partial)^2}}{\left(R-\frac{t-\delta}{2}ctg\gamma\right)^2}\right], \tag{8}$$

there γ - half of the disc sharpening angle;

f- coefficient of friction of the ground on the sharpened part of the disc;

t- disc thickness.

Substituting the values of Q_m and Q_o in expressions (7) and (8)into expression (1), we obtain the following final result

$$Q_u = \frac{1}{2} q_0 \left\{ \delta R^2 \left[arccos\frac{R-h_\partial}{R} - \frac{(R+h_\partial)}{R^2} \times \times \sqrt{(2R-h_\partial)h_\partial}\right] + \frac{1+fctg\gamma}{cos\,\gamma}\left(R-\frac{t-\delta}{4}ctg\gamma\right) \times \times \left[R^2 - \left(R-\frac{t-\delta}{2}ctg\gamma\right)^2\right]\left[arccos\frac{R-h_\partial}{\left(R-\frac{t-\delta}{4}ctg\gamma\right)} - - \frac{(R-h_\partial)\sqrt{\left(R-\frac{t-\delta}{4}ctg\gamma\right)^2-(R-h_\partial)^2}}{\left(R-\frac{t-\delta}{4}ctg\gamma\right)^2}\right]\right\}. \tag{9}$$

4 Conclusion

Thus, the torsional load created by the disc, according to the results of the studies, depends on its radius(diameter), depth of penetration into the bottom, thickness, surface thickness of the disc, angles of sharpening and setting relative to the steepness, as well as friction and volumetric crushing coefficients of the ground.

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