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Researching the parameters of the disc plough and its smooth run throughout the tillage depth

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Abstract. The purpose of the study is to substantiate the parameters of a disc plough and to study its uniformity of stroke along working depth. Basic principles and methods of classical mechanics, mathematical analysis and statistics were used in this study. Equality of running disk plough throughout tillage depth is studied theoretically and experimentally. In accordance with the implemented studies, in order for disc plough to operate at the required level on soil with low energy consumption, its operating elements should be installed in the range of 35-40° relative to direction of movement, and 15-18° relative to steep, cross-section between them should be 28-32 cm, and longitudinal distance should be at least 60 cm, and vertical distance from base plane to bottom tie point should be between 62-70 cm in order for disc plough to sink to specified depth and walk evenly at the same depth, as well as to ensure the required transport hole.

1. Introduction

In the world, scientific-research activities focused on development of new, scientific and technical bases, resources-saving technologies for soil processing (tillage) and technical means for their implementation are being carried out. In this sphere, the most relevant is to implement scientific researches on the development of soil tillage machines with disk operating elements. Researching on creation and applying machines with disk operating elements, the study of their demonstrative work and parameters substantiation, as well as the study of the processes of interaction following scientists were involved: D. N. Sineokov [1], F. Mamatov [2-8, 10-16, 18, 19], U.Umurzakov [4, 16], B. Mirzaev [4-6, 7-19], G. Mardonov [9], I. Ergashev [2, 3, 6, 12, 19], N.V.Aldoshin [3, 10, 11, 16, 17], A. Tukhtakuziev and M.Ergashev [20].

In recent years, in connection with widespread introduction of energy-saving technologies and equipment in agricultural production, use of disc plows in the main tillage (plowing), i.e., a operating element in the form of a spherical disc has become increasingly important. Because they have less resistance to gravity than tipping ploughs, they work efficiently and operate without clogging up with plant debris and weeds. In our Republic disk plough used jointly with the 1,4-2 class tractors is manufactured and researches on substantiating its appropriate parameters onto soil-climatic conditions of our continent were implemented.

In this article, the research results performed to determine the installation angles in regard with movement and perpendicular of the operating element, as well as transverse and longitudinal distances

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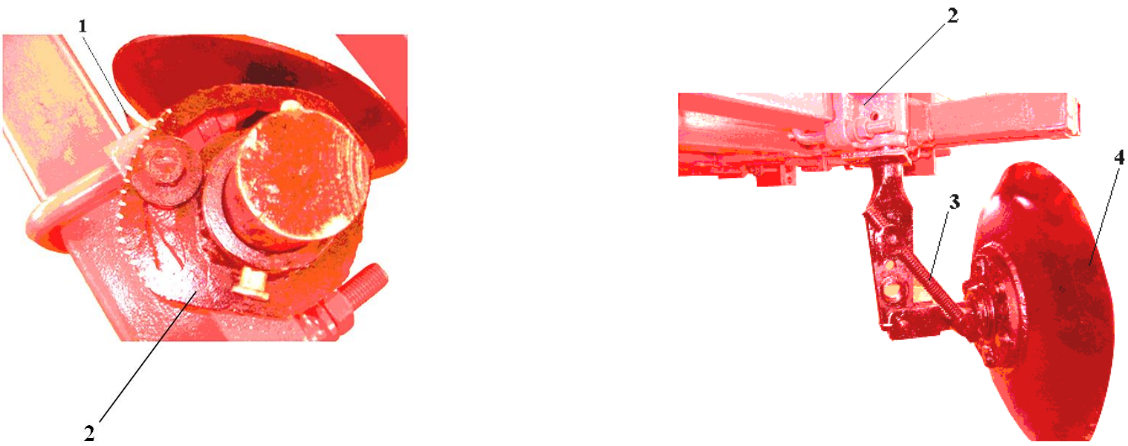
between them are specified. Moreover, in order to ensure that tillage depth of the plough is constant (stable) in order to provide low energy consumption and soil tillage at the required level.

2. Materials and methods

In implementation trial research, the plough was applied in addition to the Claas ARES 697 FTZ tilled tractor.

In the course of implementing test experiments the resistance of the device to gravity Tst 63.03.2001 "Testing of agricultural machines and equipment. Method of energy assessment " [1] applied to the tenso metric fingers.



a b

Figure 1. Device adjusts the movement direction (a) and steep plane the angles of installation (b) of the operating element: 1 – a pointer indicating the specified value of installation angle with respect to to the movement direction of operating element; 2 –chronograph on which the column of the operating element is installed; 3- screw adjusting the installation angle of the operating element relative to the steep plane; 4- operating element of the disc

Table 1. Definition of the field where experiments are performed

t/r	Name of indicators	Indicators value
1.	Soil moisture throughout the layers (cm), %:	
	0-10	11,9
	10-20	15,0
	20-30	17,1
2.	Soil hardness throughout the layers (cm), MPa:	
	0-10	0,63
	10-20	1,82
	20-30	2,88
3.	Depth of watering row-spacings:	
	$M_{ў}$	14,6
	$\pm\sigma$	2,3
4.	Plant residues at the open area of 1 m^2, kg	0,489
5.	Stubble height, cm:	
	$M_{ў}$	24,3
	$\pm\sigma$	4,2

(Figure 2), agrotechnical indicators TSt 63.02.2001 "Testing the agricultural machines and equipment. Machines and devices for deep soil tillage. The program and method of the testing [2].

Before and after implementing experiments, tensor fingers were calibrated (Figure 3). In the pictures 4 and 5, cases of tenso fingers installed on device and connected to tractor are described.

According to the first step when trials were implementing the operating elements

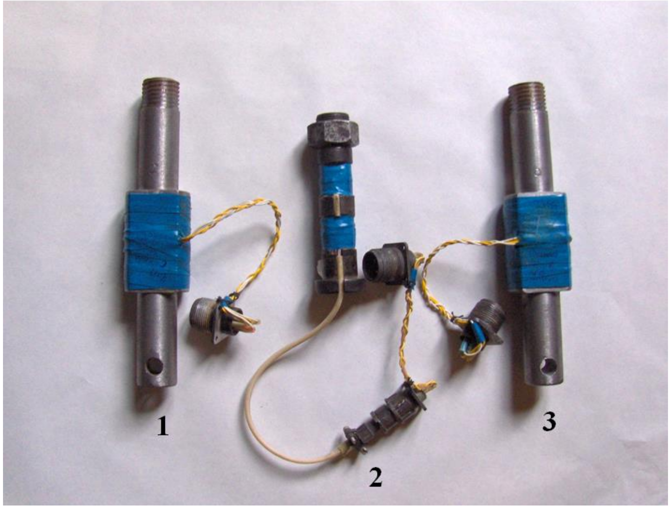
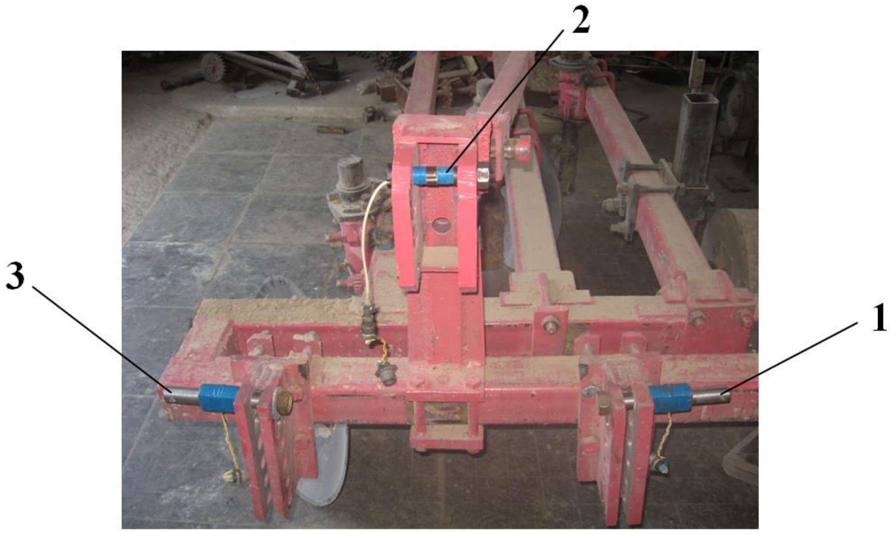


Figure 2. Right-side (1), middle-side (2) and left-side (3) tensor fingers

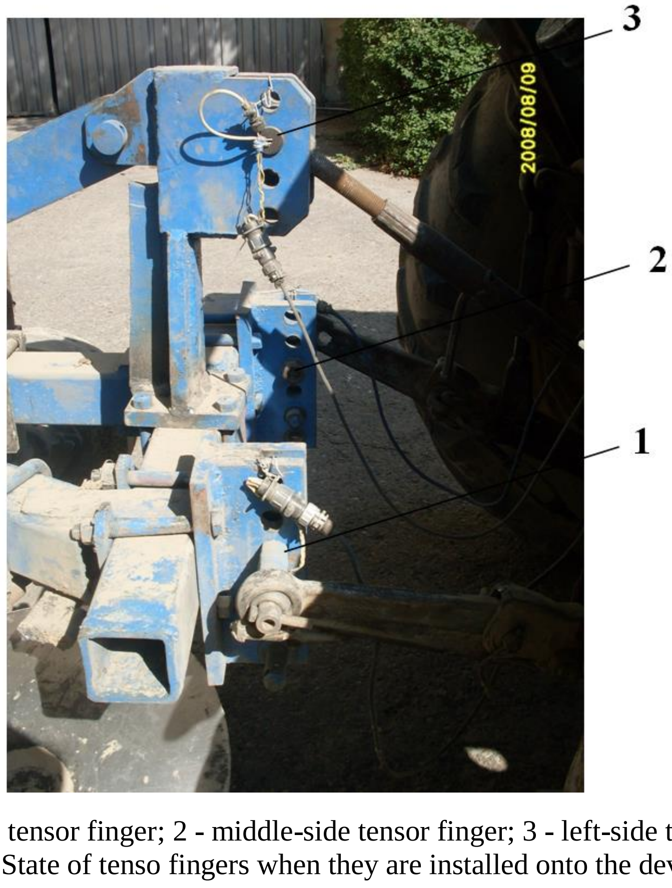
1 – tensor finger being calibrated; 2 – dynamometer; 3 – pulling screw; 4 – measuring device EMAP-2

Figure 3. The process of tensor fingers calibration



1-right-side tensor finger; 2 - middle-side tensor finger; 3 - left-side tensor finger.

Figure 4. State of tensor fingers when they are installed onto the device hanger



1-right-side tensor finger; 2 - middle-side tensor finger; 3 - left-side tensor finger.
Figure 5. State of tenso fingers when they are installed onto the device hanger

The installation angle with respect to the movement direction ranges from 25° to 45° with an interval of 5°, and installation angle with regard to steep plane is from 0° to 20° with an interval of 5°, cross-distance between them is from 25 cm to 40 cm with an interval of 5 cm, and the longitudinal changed from 70 cm. Each option was conducted at speeds of 6 and 9 km/h of unit. In addition, when one parameter was changed, other parameters became constant, that is, remained unchanged. For all variants, the depth of drive is the same and is set as 25 cm.

3. Results

It is known that [1] the following condition must be met in order for the plough to sink to a given depth and to ensure a smooth flow at this depth.

$$Q > 0, \qquad (1)$$

Here Q-is the reaction force acting on the base wheel of the plough by ground.
(1) When condition is met, base wheel of the plough is constantly pressed against the field surface and it sinks to specified depth.
(1) Consider factors at which the condition can be satisfied. To do this, assuming that forces acting on plough housing are applied to its middle or conditional center corpus, we construct the equation of moments acting on the plough in longitudinal plane perpendicular to the π in longitudinal plane of the plane and solve it with respect to Q. we have the following:

$$Q = \sqrt{1+\mu^2}\Big[\ Gl_1 - R_Z l_2 - R_Z^T l_4 + \left(G - R_Z - R_Z^T\right)X_\pi -$$

$$- R_X\left(H_1 - 0{,}5D_\partial\right) - R_X^T H_2 - \left(R_X - R_X^T\right)Z_\pi\ \Big]:$$

$$:\left[\left(l_3 + X_\pi\right) + \mu\left(H_1 - a - 0{,}5D_T + Z_\pi\right)\ \right], \qquad (2)$$

Here μ – rolling coefficient of the plough support wheel

G – gravity of the plough;

R_Z – vertical component of the force acting on the plough housings;

R_Z^T – vertical component of the reaction forces acting on the plough support disk;

R_X – horizontal component of the forces acting on the plough housings;

R_X^T - horizontal component of the reaction forces acting on the plough base disk;

l_1 , l_2 and l_4 - are the horizontal distances from the points where the forces are applied, G, R_Z , R_Z^T respectively, to the tie points of the plough;

X_π - horizontal distance from the plough connection points to its instantaneous center of rotation;

H_1 - vertical distance from the base plane of the plough to its lower tie point;

D_∂ - diameter of the plough housing;

H_2 - vertical distance from the point of connection of the plough base disc to its lower tie point;

Z_π - vertical distance from the bottom point of the plough to its center of instantaneous rotation;

l_3 - horizontal distance from the axis of rotation of the plough base wheel to its mounting points;

a - specified machining depth of the plough;

D_T - diameter of the plough base wheel.

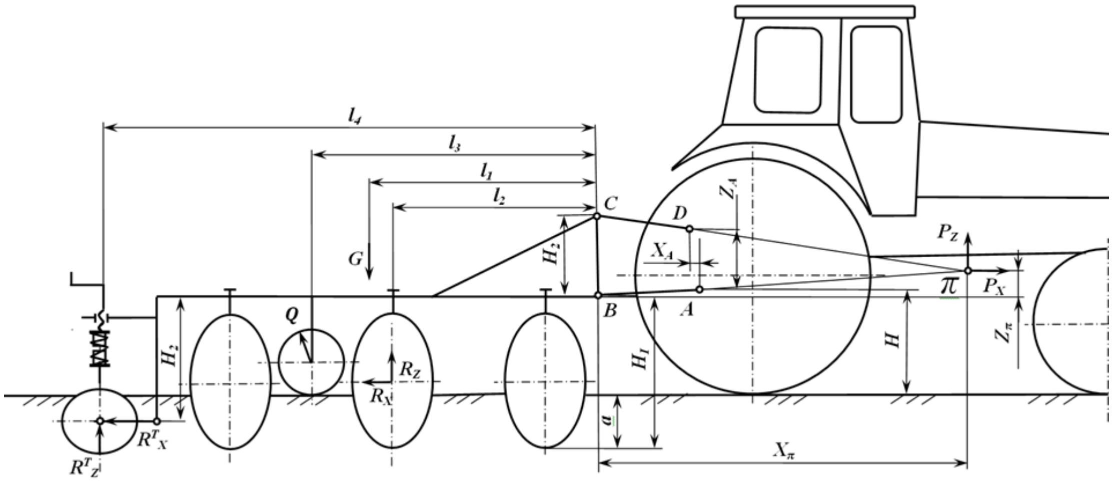


Figure 6. Schematic of the study of a flat stroke of the disc plough along the plowing depth.

Expressing distances and by dimensions and parameters of the plow hoist and tractor hoist, we obtain the following final expression

$$Q=\sqrt{1+\mu^2}\{Gl_1-R_Zl_2-R_Z^Tl_4-R_X(H_1-0{,}5D_o)-$$

$$-R_XH_2+\left[G-R_Z-R_X^T-\mu\frac{H+a-H_1}{\sqrt{l_{\text{б}}^2-(H+a-H_1)^2}}(R_X+R_X^T)\right]X$$

$$\left.X\frac{H_3\sqrt{l_{\text{б}}^2-(H+a-H_1)^2}\left[\sqrt{l_{\text{б}}^2-(H+a-H_1)^2}-X_A\right]}{(H_3-Z_A)\sqrt{l_{\text{б}}^2-(H+a-H_1)^2}-X_A(H+a-H_1)}\right\}:$$

$$;\left\{\left[\; l_3+\mu(H_1-a-0{,}5D_T)+\left(1+\mu\frac{H+a-H_1}{\sqrt{l_{\text{б}}^2-(H+a-H_1)^2}}\right)X\right.\right.$$

$$\left.X\frac{H_3\sqrt{l_{\text{б}}^2-(H+a-H_1)^2}\left[\sqrt{l_{\text{б}}^2-(H+a-H_1)^2}-X_A\right]}{(H_3-Z_A)\sqrt{l_{\text{б}}^2-(H+a-H_1)^2}-X_A(H+a-H_1)}\right\}, \qquad (3)$$

here H_3 – vertical distance between the lower and upper tie points of the plough;

$l_{\text{б}}$ – length of lower longitudinal traction of the tractor suspension mechanism;

H – vertical distance from base plane of the tractor to fixed hinges *A(A₁)* of lower longitudinal traction of the suspension mechanism;

X_A, Z_A - longitudinal and vertical distances between hinges A and D, respectively, of the tractor suspension mechanism.

Given that forces acting on the plow are given and known [1], its size and parameters are determined from conditions of reliable and quality performance of the specified technological process, vertical distance between lower and upper tie points of the hoist N3 and size and parameters of the tractor hoisting mechanism are standardized [2] assuming that (3) analysis of expression (3) ensures that plough sinks to a specified depth and that a straight line at that depth is provided mainly by changing the vertical distance N1 from its base plane to lower tie point.

Assuming sizes $G = 6400\,H$, $R_X = 7500\,H$, $R_X^T = 450\,H$, R_Z=3750H, $R_Z^T = 900$ H, $D_\partial = 0,65m$, $D_T = 0,5m$, l_1 =1,1m, l_2 =0,9m, l_3 =1,2m, l_4 =2,0m, a =0,25m, H_3 =0,61m, H =0,52 m, X_A = 0,2m, and Z_A= 0,37m calculations performed on expression (3) showed that distance H_1 must be at least 62 cm for the condition (1) to be fulfilled. However, it is necessary to note that if this distance is longer than 70 cm, when the plough is moved to transport mode, it does not provide the transport gap required by the normative documents.

4.Conclusion

Implemented theoretical and experimental studies show that disc plough in order for the soil to be processed at the required level, having spent less energy in the range of 6-9 km/h, its operating element should be installed in the range of 35-40° relative to direction of movement, and 15-18° relative to steep, cross-section between them should be 28-32 cm, and longitudinal distance should be at least 60 cm, and vertical distance from base plane to bottom tie point should be between 62-70 cm in order for disc plug to sink to specified depth and walk evenly at the same depth, as well as to ensure the required transport hole.

References

[1] Sineokov G N, Panov I M 1977 *Theory and calculation of tillage machines* (Moscow: Mashinostroyeniye)
[2] Mamatov F, Ergashev I, Ochilov S, Pardaev X 2020 *Jour of Adv Research in Dynamical & Control Systems* **12 (07)** 2154-2161
[3] Aldoshin N, Mamatov F, Ismailov I, Ergashov G 2020 *19th international scientific conference engineering for rural development Proceedings, Jelgava* **19** 1691-5976.
[4] Umurzakov U, Mirzaev B, Maмatov F, Ravshanov H, Kurbonov S 2019 *IOP Conf. Series: Earth and Environmental Science* **403** 012163
[5] Mirzaev B, Mamatov F, Chuyanov D, Ravshanov X, Shodmonov G, Tavashov R and Fayzullayev X 2019 *IOP Conf. Series: Earth and Environmental Science* **403** 012158
[6] Mirzaev B, Mamatov, F, Ergashev I, Ravshanov H, Mirzaxodjaev Sh, Kurbanov Sh, Kodirov U and Ergashev G 2019 *E3S Web of Conferences* **135** 01065
[7] Mamatov F, Mirzaev B, Shoumarova M, Berdimuratov P, Khodzhaev D 2019 *International Journal of Engineering and Advanced Technology (IJEAT)* **9 (1)** 4824-4826
[8] Mamatov F, Mirzaev B, Batirov Z, Toshtemirov S, Tursunov O, Bobojonov L 2020 *IOP Conf. Series: Materials Science and Engineering* **883** 012165
[9] Mirzaev B, Mamatov F, Avazov I, Mardonov S 2019 *E3S Web of Conferences* **(97)** 05036
[10] Aldoshin N, Didmanidze O, Mirzayev B, Mamatov F 2019 *Proceeding of 7th International Conference on Trends in Agricultural Engineering* Prague Czech Republic 20-26
[11] Mirzaev B, Mamatov F, Aldoshin N and Amonov M 2019 *Proceeding of 7th International Conference on Trends in Agricultural Engineering* Prague Czech Republic 391-396
[12] Mirzaev B, Maмatov F, Ergashev I, Islomov Yo, Toshtemirov B, Tursunov O 2019 *Procedia Environmental Science, Engineering and Management* **6** 395-404
[13] Mamatov F, Mirzaev B, Berdimuratov P, Turkmenov Kh, Muratov L, Eshchanova G 2020 *IOP Conf. Series: Materials Science and Engineering* **883** 012145
[14] Mamatov F, Mirzaev B, Tursunov O 2019 **E3S Web of Conferences 97** 05035
[15] Mamatov F, Mirzaev B, Tursunov O, Ochilov S and Chorieva D 2020 *IOP Conf. Series: Earth and Environmental Science* **614** 012169
[16] Umurzakov U, Mamatov F, Aldoshin N, and Mirzaev B 2020 *IOP Conf. Series: Earth and Environmental Science* **614** 012168
[17] Mamatov F, Aldoshin N, Mirzaev B, Ravshanov H, Kurbanov Sh and Rashidov N 2021 *IOP Conf. Series: Materials Science and Engineering* **1030** 012135

[18] Mamatov F, Mirzaev B, Mirzahodzhaev Sh, Uzakov Z and Choriyeva D 2021 *IOP Conf. Series: Materials Science and Engineering* **1030** 012164
[19] Mamatov F, Ergashev I, Mirzaev B, Pardaev X, Chorieva D 2020 *Journal of Physics: Conference Series* **1779**, 012002
[20] Tukhtakuziev A, Ergashev M M 2017 *European science review* **11(12)** 150-153