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DETERMINATION OF RATIONAL VALUES OF ANGLE PLACES INSTALLATION TO THE BOTTOM OF THE FURROUND AND THE RADIUS OF THE GUIDING CURVE OF THE DUCT OPERATING BODY

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Abstract

The main parameters and shape of the plow-type working body for cutting temporary sprinklers should be selected considering obtaining the necessary justified dimensions of the sprinkler cross-section and the minimum possible traction resistance. In the process of research, it turned out that in the known works, the parameters of the working bodies of canal diggers were justified without sufficient coordination with the technology of cutting temporary sprinklers. In particular, they are substantiated without considering the possibility of reducing the "dead" depth of excavation of the sprinkler and wedging the soil in the furrow, which leads to excessive energy consumption of existing canal diggers. Based on the foregoing, the goal of this work is to reduce water losses in the zone of a temporary sprinkler and the traction resistance of the canal digger by improving its design and parameters. According to this goal, a working hypothesis was put forward, the essence of which is to reduce water losses and improve the quality of subsequent technological operations it is possible by reducing the difference in the levels of the position of the bottom of the sprinkler and irrigation furrows, and to reduce the traction resistance of the canal digger by eliminating wedging of the cut layer in the excavation zone. Theoretical and experimental studies substantiated the main parameters of the temporary sprinkler - the width of the excavation bottom, the height of the dam and the width of its base, the required excavation depth, which provide a reliable command water level with a minimum "dead" depth. Considering the necessary parameters of the sprinkler, rational parameters of the working body of the canal digger were substantiated - the height of the body, the angles of installation of the share to the bottom of the furrow and the radius of the guide curve of the dumps.

Keywords: *canal digger, installation of a ploughshare to the bottom of the furrow, radius, dump, upper edge of the dump, open area, factors, slope placement, tensor beam, intervals. variations, regression equations, two-dimensional sections.*

Introduction

In accordance with the research objectives and the results of theoretical prerequisites for substantiating the parameters of the canal digger, the following questions were included in the experimental research program:

- Study of the technological process of cutting temporary sprinklers and the quality of the existing tools.

- Carrying out laboratory studies to optimize the parameters of the canal digger working body

- Justification of the angle (ε_f) of installation of the share to the bottom of the furrow and the radius (r) of the guide curve of the dumps of the working body of the canal digger.

- Determination of the traction resistance of the canal digger.

Materials and methods

As a result of theoretical studies, it was found that in order to exclude the formation of a "dead" depth, the width of the temporary sprinkler along the bottom should be (0,30 ... 0,50 m), the excavation depth should not exceed 0,18 m, and the slope should be 1:1 In this case, the area of the free cross-section should be ω = 0,16 ... 0,19 m^2 [1, 2].

The possibility of cutting temporary sprinklers with the indicated dimensions was experimentally tested using the existing KBN-0.35A canal digger.

To determine the shape of the profile of the cut temporary sprinkler and its dimensions, the cross-sectional area was determined by taking the profiles of the soil surface before and after the passage of the tool. The data obtained were applied to graph paper. Then the dimensions and cross-sectional area of the sprinkler were determined using a planimeter.

Result and discussion

The results of the experiments showed that the existing canal digger KBN-0.35A cuts temporary sprinklers of an unstable triangular-trapezoidal shape (Fig. 1) with the following main dimensions: guard depth 0,42 m, width along the bottom 0 ... 0,13 m when laying slopes 1: 1, free area 0,11 m^2 at a depth of cut 0,18 (table 1).

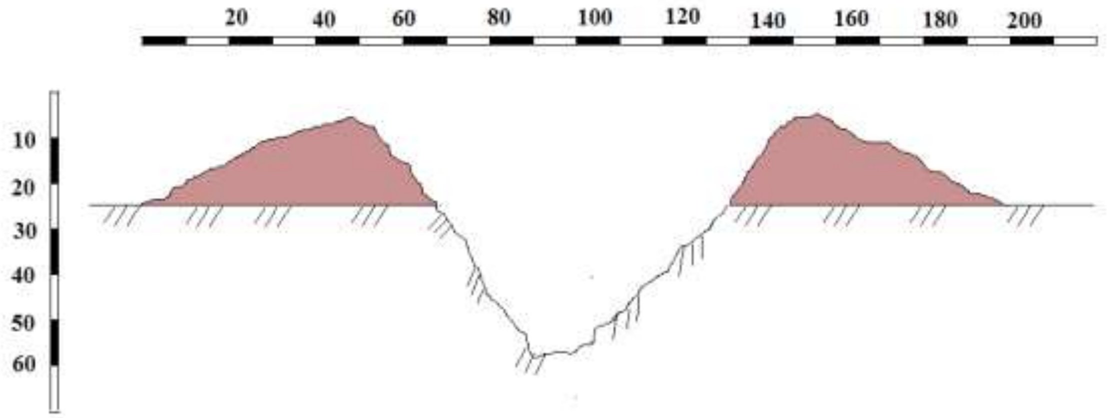

Figure - 1. Cross-section of the sprinkler cut by the existing KBN-0,35A furrow ditch digger

At the same time, the "dead" depth (at a depth of irrigation furrows of 0,12 ... 0,18 m) was 0,06 ... 0,14 m.

Attempts to exclude the formation of "dead" depth by changing the cutting depth with the existing canal digger KBN-0,35A did not give positive results (Table 1.).

Table 1

The main dimensions of the temporary sprinkler with

changing the depth of the cut

Construction depth, m $\mathbf{H_к}$	Excavation depth, m h_ $\boldsymbol{h_{b.o}}$	Bottom width, m $\boldsymbol{b}$	Occupied bandwidth m $\mathbf{B_2}$	Dam height, m $\boldsymbol{h_\partial}$	Dead depth, m $\Delta\boldsymbol{h}$	Free flow area, m^2 $\boldsymbol{\omega}$
0,42	0,26	0,13	1,92	0,16	0,08-0,14	0,18
0,33	0,18	0,10	1,20	0,15	0-0,06	0,11
0,22	0,11	0,09	0,95	0,11	0	0,06

From table -1 it can be seen that with a decrease in the excavation depth of the temporary sprinkler, the value of the "dead" depth decreases and at a excavation depth of 0,11 m it is equal to zero. However, with a change in the depth of the excavation, the cross-sectional area of the temporary fill decreases rapidly.

With a decrease in the cross-sectional area, the temporary sprinkler will not be able to provide the required water flow for irrigating crops.

Based on the results of the experiment, it can be concluded that the existing channel-digger-furrower KBN-0,35A cannot cut temporary sprinklers with the selected cross-sectional dimensions without changing the parameters of its working body.

Theoretical studies have found that the angle of installation of the share ($\mathcal{E}_b$) and the radius ($\boldsymbol{r}$) of the guide curve significantly affect the traction resistance of the working body of the canal digger [2, 8, 9].

To determine the rational values of these parameters, considering the theoretical prerequisites, experimental studies were carried out in the soil channel with models of the working body. At the same time, geometric, physical and mathematical modeling was used, based on the principles of similarity. [7, 10]

The scale factor i_1 was determined from the known dependence:

$$\ell_H К_d^{-1} d^{-1} \geq \boldsymbol{i_1} \leq (F_H\, \mathcal{E}\, F_{wd}^{-1}\, К_{ia}^{-1} 100)^{1/(e+0,5e_r)} \qquad (3.1)$$

where $\ell_H = 0{,}5$m- is the determining linear size of the working original;

$К_d$=10- coefficient depending on the nature of the process under study;

d=0,0002 м- maximum linear size of soil fractions;

F_H= $1\cdot10^4$ H- effort characterizing the workflow of the original;

Ɛ = 0,1- relative error of experience;

$\boldsymbol{F}_{wd}$ = 150 H – measurement limit on the scale of the working device;

$К_{ia}$ = 5% - instrument accuracy class;

$Е_{\boldsymbol{r}}$ =2 – exponent, depending on the statistical properties of the soil;

E = 3 – exponent, depending on the nature of the similarity of objects.

Having accepted this data, we received:

$$24{,}3 \geq \boldsymbol{i_1} \leq 3{,}402$$

We take a linear scale factor equal to

$$\boldsymbol{i_1}=3$$

The linear dimensions of the research object are determined by the formula

$$\boldsymbol{\ell_m}=\ell_H \boldsymbol{i}_1^{-1} \tag{3.2}$$

The angular dimensions are determined by the formula:

$$\boldsymbol{\varepsilon_b} = \boldsymbol{\varepsilon_M} \tag{3.3}$$

The speed of the model is determined by the formula:

$$\vartheta_{м}=\vartheta_H \mathbf{i}_1^{(1-0{,}5п)} \tag{3.4}$$

For example: the cutting depth of a temporary sprinkler by the working body model is determined as follows:

$$\boldsymbol{h}_{\mathbf{m}}=h_H \mathbf{i}_1^{-1}=0{,}06 \text{ m}$$

where h_H=0,18 m is the depth of cutting of the temporary sprinkler with natural a sample of a canal digger.

To conduct experiments at the experimental plant UzMEI, models of the working body of the canal digger were made in the amount of 9 pcs. (Fig. 2) with different geometric parameters (table - 2) and an installation for conducting experiments (Fig. 3.3) [12].

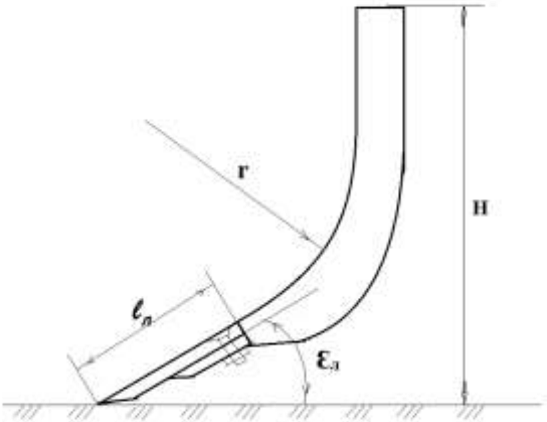

Figure - 2. The main dimensions of the working body model canal digger

Table 2

Geometric dimensions of models of the working body of the canal digger

№ Working body	Share length $\boldsymbol{\ell}_л$, m	Stand height H, m	Guide radius **r**,m	The angle of installation of the share to the bottom of the furrow, Ɛл degree
1	0,035	0,350	0,100	20
2		0,350	0,100	30
3		0,350	0,100	40
4		0,350	0,140	20
5		0,350	0,140	30
6		0,350	0,140	40
7		0,350	0,180	20
8		0,350	0,180	30
9		0,350	0,180	40

It is known that it is rational to take the line of connection of the front edges of the dumps as the guiding curve of a double-moldboard working body. In our case, the blades are connected on the rack, so the curve of the front (frontal) edge of the rack was taken as the guide curve.

The working body I, with the help of clamps 2 and plates 3, is fixed on the strain gage 4, and the strain gage on the frame 5 of the mobile trolley of the soil channel, which has the ability to move in the vertical and transverse planes (Fig. 3).

For strain gauging of the models of the working body of the canal digger, an L-shaped strain gauge 4 with attached sensors (Fig. 3) was used to measure the longitudinal R_b and vertical R_b components of the cutting resistance forces.

Before the experiment, the laboratory setup was calibrated. The strain gauge unit for measuring the traction resistance of the working body of the canal digger was calibrated by step loading using a DPU-01-2 spring dynamometer (maximum error 0,01). Stepped loading and unloading was carried out using a threaded brace.

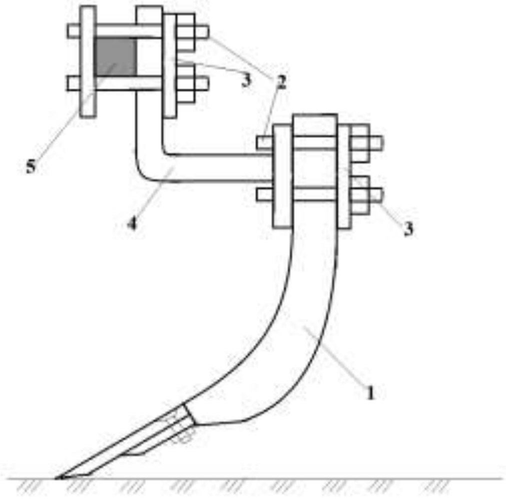

Figure - 3. Installation for laboratory research: 1- working body; 2 clamps; 3-plates; 4-strain gauge; 5-cross bar of the trolley of the soil channel

The preparation of the soil of the soil channel consisted of continuous loosening, leveling and compaction before each variant of the experiment.

The experiments were carried out at a soil moisture content of 16.1%, a soil hardness of 0.571 MPa, and a soil density of 1.47 g / cm3.

To carry out experimental studies using the well-known method of mathematical planning, the plan of the full-factor experiment B3 was chosen. To vary the variable factors at three levels, an experiment planning matrix has been compiled. The longitudinal force R_p (traction resistance) acting on the working body was chosen as the response function. It most fully reflects the physical meaning of the process being performed [11].

The intervals for factoring were chosen considering the influence of each factor on the optimization criterion.

The basic level of the speed of movement of the models of the working body of the canal digger was determined according to the well-known formula of V.I. Balovnev and adopted $\boldsymbol{\vartheta_m}$= 0,9 m/s.

The levels of factors and the intervals of their variation are shown in Table 3.

All variants of the experiments were carried out in triplicate with appropriate randomization. For the convenience of calculations and graphic interpretation of the research results, before the start of the experiment, the values of the factors were coded. Factors were encoded according to a well-known technique.

The results of the experiments were processed on a computer in the modeling laboratory of the Agricultural Mechanization Research Institute (UzAMRI).

The hypothesis of variance homogeneity with the same number of repeated experiments was tested using the Cochran test, and the significance of the regression coefficients was determined by the Student's test at a significance level of $q = 0.05$.

The adequacy of the process model was checked by Fisher's criterion.

After processing the results of the experiments and assessing the significance of the regression coefficients, the following regression equation was obtained, which adequately describes the traction resistance of the models of the working body of the canal digger.

Table - 3.

Factor levels and variation intervals

The main factors	The code. Designations	Variation intervals	Levels		
			lower (-)	basic (0)	upper (+)
The angle of installation of the share to the bottom of the furrow $Ɛ_{\boldsymbol{b}}$**,** degree	X_1	10	20	30	40
Guide curve radius r, mm	X_2	40	100	140	180
Working body speed $\boldsymbol{\vartheta_m}$**,** m/s	X_3	0,3	0,6	0,9	1,2

$$У_R=223,31+36,887x_1-26,49x_2+34,553\ x_3+79,31x_1^2-21,05\ x_1x_2+11,87\ x_1x_3+ +20.888x_2^2-12,97\ x_2\ x_3\ ,\ H \qquad (3.5)$$

Equation (3.5) is analyzed using two-dimensional sections. At the same time, a compromise problem was solved, in which it was required to find the values of the factors that give the minimum traction resistance when cutting a temporary sprinkler that meets the original requirements.

To determine the possible minimum traction resistance at the speed of movement of the canal digger, corresponding to the initial requirements, it is of interest to study the interaction of the angle of installation of the share to the bottom of the furrow ($Ɛ_b$) and the radius of the lateral profile of the strut ($\boldsymbol{r}$) of the working body of the canal digger.

Therefore, with a fixed value of the factor x_3 at the zero level ($\boldsymbol{\vartheta_m = 0,9 m/s}$) two-dimensional sections of the response surfaces were constructed, characterizing the traction resistance of the working body of the canal digger, depending on the factor x_1 and x_2.

Substituting the value $x_3 = 0$ into equation (3,5), we have:

$$У_R=223,31+36,887x_1-26,49x_2+79,31x_1^2-21,05\ x_1x_2+20.888x_2^2,\ H \qquad (3.6)$$

After differentiating equation (3,6) with respect to x_1 and x_2, we obtain a system of equations:

$$\begin{cases} \frac{\partial y}{\partial x_1} = 36,887 + 158,71x_1 - 21,05x_2 = 0 \\ \frac{\partial y}{\partial x_2} = -26,49 - 21,05x_1 + 41,776x_2 = 0 \end{cases} \qquad (3.7)$$

Solving the resulting system of equations (3,7), we find the coordinates of the center of the surfaces in the old axes:

$$\boldsymbol{x_{1s}} = -O,1589; \qquad \boldsymbol{x_{2s}} = 0,554$$

The angles of rotation of the new coordinate axes relative to the old ones are determined by the formula:

$$\mathrm{tg}2\alpha = \frac{b_{ij}}{b_{ij}-b_{jj}} \qquad (3.8)$$

we get $\alpha = -10^{\circ}$.

Substituting the values $\boldsymbol{x_{1s}}$ *and* $\boldsymbol{x_{2s}}$ уравнение (3.6) equation (3.6), we obtain the value of traction resistance $У_s$=213,039H.

Equation (3.6) is written in canonical form:

$$У_R-У_s=81,14\ x_1^2+19,05\ x_2^2 \qquad (3.9)$$

Substituting into these equations different values of the criteria for optimizing the responses $У_R$ и $У_s$ we obtain the equations of the contour curves of the response surfaces of the Ellipse type (Fig. 4).

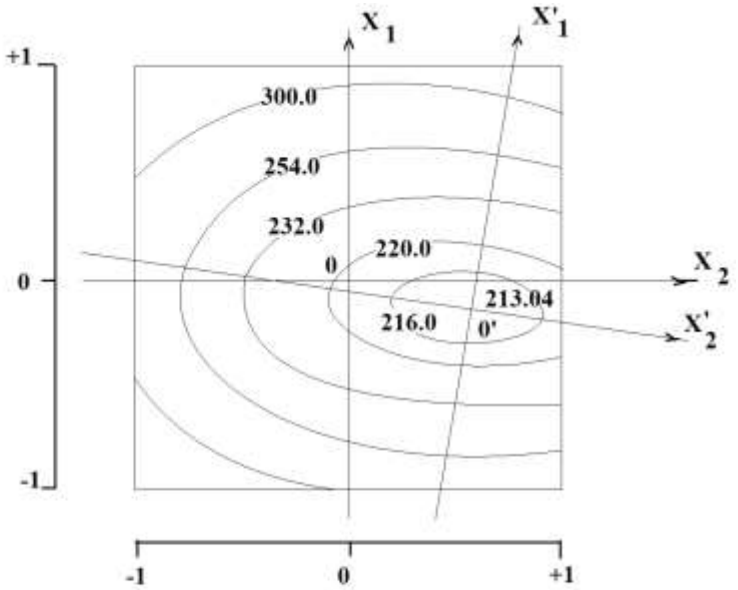

Figure - 4. Two-dimensional section for studying the influence of factors x_1 and x_2 (at x_3=0) on the traction resistance of the working body of the canal digger

The calculation results are shown in Table 4.

Table – 4.

Auxiliary table for calculating the coordinates of the main points when creating a two-dimensional section

Parameter value	x_1	x_2	Parameter value	x_1	x_2
213,04	0	0	232,00	±0,483	0
216,00	0	±0,394	254,00	0	±1,466
216,00	±0,191	0	254,00	±0,837	0
220, 00	0	±0,604	300,00	0	±2,136
220,00	±0,293	0	300,00	±1,035	0
232,00	0	±0,995			

Conclusion

From the analysis of the response surface, it follows that with an increase from +0,06 up to + 1 and a decrease from – 0,15 to - 1, the traction resistance increases. A similar phenomenon also occurs when the investigated factor x_2 increases or decreases.

Based on the analysis of the two-dimensional section constructed using the regression equation (1), we can consider the rational values of the factors x_1 = -0,15 ... 0,06, x_2 = 0,55 ... 0,7 at x_3 = 0 without a level of translational speed of the working body models $\vartheta_м$= 0,9 m/s.

The values of these factors when converted to natural values (according to formulas 3,2, 3,3 and 3,4) will be equal to x_1= Ɛ$_A$ = $28^0...31^0$; x_2= **r** = 0,49…0,51m and x_3 = ϑ_H = 1,5 m/s.

With rational values of the factors under study, the traction resistance of the models of the working body of the canal digger is in the range of 213 ... 215 H.

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