Parameters of the angle-lift of the front plow for smooth, rowless plowing

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Abstract. To improve the quality and energy indicators on the front plow in front of the housings, the angle axes are installed in the form of a triangular wedge. The purpose of the study is to substantiate the parameters of the angle-lift of the front plow, which provides high-quality performance of the technological process according to agrotechnical requirements with the lowest energy costs for smooth, rowless plowing. The research uses the laws and rules of theoretical mechanics, mathematical statistics, mathematical planning of experiments, and methods of strain measurement, as well as the methods given in existing regulatory documents. Based on the study of the process of interaction of the carbon monoxide with the soil, analytical dependences are obtained that allow us to determine the parameters of the carbon monoxide. According to the results of theoretical and experimental studies, it was found that the required quality of tillage with a front plow following the established agrotechnical requirements with minimal energy consumption is provided at the height of 22 cm, a length of 27 cm, a wing angle of 32° and an angle of inclination of the side face of 36°.

1 Introduction

Agriculture is the main branch of the economy of our republic. In this regard, research works are being conducted aimed at developing new scientific and technical bases of resource-saving technologies for tillage [1-23], sowing [6, 13], harvesting [2, 9-10, 18-19], and processing [21-22] of grain and re-crops products and technical means for their implementation. It is known that the use of smooth plowing technology in the main tillage of the soil allows eliminating the disadvantages of the widely used traditional plowing with the turnover of layers in the adjacent. The use of plows for smooth plowing makes it

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possible to eliminate high irrational costs for carrying out additional passes of the unit for leveling the pile ridges and collapse furrows, to abandon the costs associated with the division of the field into corrals, to improve the working conditions of agricultural machinery in subsequent operations. At the same time, the volume of annual planning work can be reduced by 30% or more [38-40].

In this direction, particularly the development of ploughs for smooth, rowless plowing and the justification of the technological process of their working bodies, ensuring resource conservation in the processes of their interaction with the soil is relevant.

V. Sakun [24, 31, 33], V. Sharov [32], Ya. Lobachevsky [26-33], S. Zolotarev [25], L. Kaufman [37], D. Totten [37], F. Mamatov [1-23], I. Ergashev were engaged in the development and improvement of ploughs for smooth, rowless plowing and research to substantiate the parameters of their working bodies [1, 5, 11, 23, 27]. N. Aldoshin [2, 9, 10, 18, 19], H. Ravshanov [3, 4, 5, 19] and others.

The purpose of the study is to substantiate the parameters of the angle-lift of the front plow, which provides high-quality performance of the technological process according to agrotechnical requirements with the lowest energy costs for smooth, rowless plowing.

2. Method

The research uses the laws and rules of theoretical mechanics, mathematical statistics, mathematical planning of experiments, and methods of strain measurement and the methods given in existing regulatory documents [41-42].

The angle brackets 3, made in the form of a triangular wedge, are installed in front of the body 4 with the butt plates 5 [33-35]. In the process of operation, the angle-pickers 3 cut off the upper corner of the formation and wrap it around it. In this case, a polygonal formation is formed; thus, the rotation of the formation by 180° into its own furrow is facilitated under the combined influence of the body 4 and the plow 5.

**Fig. 1.** Diagram of the front plow: 1 is frame; 2 is disc knife; 3 is angle-lift; 4 is body; 5 is plowshare

The main parameters that affect the work process of the angle grinder include the angle of entry of the front edge of the cutter into the ground $\alpha_b$, the angle of rotation of the angle cutter $\beta_b$, the angle of inclination of the side edge of the cutter $\delta_b$, the opening angle of the angle grinder $\gamma_b$, the angle of inclination $l_b$ of the working edge $N_b$ (Fig.2).
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During the operation of the angle cutter (Fig. 2), a small triangular plate \( ABC \) with width \( b_b \) and height \( a / 2 \) should be cut from the edge of the \( AEKM \) rectangular plate and placed on top of the \( AEKM \) plate. To do this, the initially cut \( ABC \) blade rises to a certain \( h_2 \) height along the \( BS \) edge. The ascent process continues until the center of gravity of the \( ABC \) plate falls on a vertical line passing through the \( B \) edge. The pallet then begins to rotate around point \( ABC \) \( B \). Under the action of the angle cutter, the \( ABC \) plate is pushed to the side as it rotates around \( B \), and the \( AEKM \) is placed on top of the plate.

**Fig. 2.** The main parameters of the image capture: \( a \) – side view; \( b \) – front view; \( c \) – top view

Based on the scheme shown in Figure 3, we determine the maximum lift height of the slab cut with an angle cutter. Basically

**Fig. 3.** Scheme for determining the height of the reservoir lift under the action of the angle lift
\[ H_b = AC + A_2B = a_b + h^2, \]  
\[ A_2B = A_1B = h_2, \]  
\( A_1, A_2, E \) from the triangle

\[ A_2B = h_2 = \sqrt{b_0^2 + h_1^2}. \]  

In this case, \( b_0 \) is the triangle \( ABC \), i.e., the coordinate of the center of gravity of the cross-section of the plate cut by the angle cutter.

\( ABC \) triangle

\[ b_0 = \frac{1}{3} b_b. \]  

From the similarity of \( AEK \) and \( MEL \) triangles

\[ h_1 = \frac{a_b (b_b - b_0)}{b_b}. \]  

\( h_1 \), and we can set the values of \( b_0 \) to (2) according to (3)

\[ h_2 = \frac{1}{3} \sqrt{b_b^2 + 4a_b^2}. \]  

Substituting the values of \( h_2 \) and \( b_0 \) on (4) to (1), we obtain the following final expression to determine the maximum elevation of the slab cut with an angle cutter.

\[ H_b = a_b + \frac{1}{3} \sqrt{b_b^2 + 4a_b^2}. \]  

According to expression (6), when \( a_b = 12 \text{ cm} \) and \( b_b = 8-10 \text{ cm} \), the height of the angle cutter is in the range \( N_b = 21.24-21.48 \text{ cm} \). We take it 22 cm.

We determine the length of the angle cutter using Figure 4. Basically

\[ l_b = OA = H_b \cot \alpha_b. \]  

We can set the value of \( H_b \) to (8) according to (7)

\[ l_b = (\alpha_b + \frac{1}{3} \sqrt{b_b^2 + 4a_b^2}) \cot \alpha_b. \]  

According to expression (8), when \( a_b = 50^\circ \), \( a_b = 12 \text{ cm} \) and \( b_b = 8-10 \text{ cm} \), the length of the angle cutter is in the range of \( l_b = 25.3-26.6 \text{ cm} \). We accept it 27 cm.
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3 Results and Discussions

To conduct experiments to justify the width of the capture and the depth of processing of the angle image, a laboratory and field installation was developed. Experimental studies were conducted in two stages. In the first stage, we studied the influence of the angle of the side faces and the depth of aglaonema and operating speed on the quality and the tractive resistance of aglaonema. At the second stage, multivariate experiments were carried out using mathematical planning of experiments. The experiments were carried out in the grain fields of the experimental area of the Research Institute of Mechanization and Electrification of Agriculture (IMESH).

The angle of inclination of the side edge of the angle grinder is one of the main parameters that affect its performance. Therefore, experimental studies were conducted to determine its optimal value. The study results showed that as a result of the angle of inclination of the side edge of the angle grinder, the distance to throw the soil to the side at both operating speeds increased according to the law of concave parabola (Fig. 5a). This can be explained by an increase in the volume of soil cut with an angle cutter. It is known that as the angle of inclination of the side edge of the angle cutter increases, its coverage width also increases. Increasing the coverage width leads to an increase in soil volume.

![Fig. 4. To determine the length of the angle pickup](image)

![Fig. 5. Graphs of the dependence of the distance of the soil spread (S) and the traction resistance of the slope (R) from the angle of inclination of the side face of the slope: (δb): operating speed 1 and 2 (6.5 and 8.5km/h), respectively](image)
Fig. 6. Graphs of the dependence of the height of the ridge \((h)\) on the angle of inclination of the side face of the angle pickup \((\delta_b)\): 1 and 2, respectively, at a speed of movement \((6.5\) and \(8.5\) km/h).

In the next stage of the experiments, the effect of the angle cutter's gravitational resistance on increasing the angle of inclination of the cutting edge was studied (Fig. 5b), and the results showed that the gravitational resistance of the rectangular cutter increased at both operating speeds according to the concave parabola law. In this case, the angle cutter operates in a closed zone on the surface of the uncultivated field in the footsteps of a disc blade. Of course, as the angle of inclination of the side edge increases, the coverage width of the angle cutter increases. This, in turn, leads to increased resistance to gravity.

According to a one-factor experiment found that when the speed of the front plow \(6.5\)–8.5 km/h to ensure the required quality of work with minimum expenditure of energy, the angle of the working edge of aglaonema should be \(36^\circ\), the depth of cut and width of aglaonema respectively \(12.5\) and \(10\) cm.

The multivariate experiments were conducted according to the Hartley-4 plan. At the same time, the longitudinal distance between the angle bracket and the body \((X_1)\), the width of the angle bracket \((X_2)\), and the speed of the unit \((X_3)\) were chosen as the main factors.

When conducting a multivariate experiment, the degree of soil crumbling, that is, fractions of at least \(50\) mm in size \((Y_1)\) and the traction resistance \((Y_2)\) of the angle lift, were taken as evaluation criteria.

Based on the results of experimental studies, regression equations are obtained that adequately describe the evaluation criteria:

for the degree of soil crumbling, %;

\[
Y_1 = +85.533 + 1.427X_1 + 1.183X_2 + 2.090X_3 - 6.067X_1^2 - 0.367X_1X_3 - 1.317X_2^2 - 1.108X_2X_3 - 1.517X_3^2
\]  \(14\)

for the traction resistance of the angle-lift, N;

\[
Y_2 = +358.834 - 16.550X_1 - 3.983X_2 + 10.233X_3 + 20.750X_1^2 - 2.800X_1X_2 - 2.817X_1X_3 + 53.550X_2^2 + 9.266X_3^2
\]  \(15\)

The analysis of the obtained regression equations showed that all factors significantly impacted the evaluation criteria. The regression equations were solved using the MSEexcel and PLANEX programs from the conditions that the criterion \(Y_1\), i.e., the amount of fraction with a size of at least \(50\) mm, should be at least \(80\)%, and the criterion \(Y_2\), i.e., the
traction resistance of the angle pickup should be the minimum value.

According to the results obtained when the speed of the front plow with 6.5-8.5 km/h to ensure the required quality of work with minimum energy consumption when the depth of processing of aglaonema 12.0-12.5 cm, the angle of the working edge of aglaonema in the range of 36°. The results obtained correspond to the results of theoretical studies.

4 Conclusions

Based on the study of the process of interaction of the carbon monoxide with the soil, analytical dependences are obtained to determine the parameters of the carbon monoxide.

By results of the conducted researches, it is established that the required quality of the soil with a plow in front accordance with agrotechnical requirements at a minimum cost of energy is achieved when the height of aglaonema 22 cm, length 27 cm, angle wing solution 32° and the angle of inclination of the side faces 36°.

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