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| Research Article

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Frontal Plow Equipped with a Corner Cutter

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Annotation
The existing plows of smooth furless plowing do not provide a full turnover of layers within their own furrow and the incorporation of weeds, they have a high energy consumption. The aim of the study is to substantiate the parameters of the frontal plow cut-off, which ensures a high-quality performance of the technological process according to agrotechnical requirements with the lowest energy consumption during smooth furless plowing. An improved technology of smooth furrowless plowing has been developed, in which at first the seam is given a polygonal shape, then turned 180° within its own furrow.

Keywords: smooth plowing, technology, frontal plow, constructive scheme, ridge, open furrow, layer, body, heath, disc knife, angled.

The plows created as a result of these studies are used with some positive results in agricultural production [1]. However, in these studies, the issues of substantiating the parameters of the frontal plow for smooth furless plowing, providing high quality work with minimal energy consumption, have not been sufficiently studied. The existing plows of smooth furrowless plowing have a number of disadvantages, including they do not provide a full turnover of layers within their own furrow and the incorporation of weeds, they have a high energy consumption [2]. This results in poor quality soil cultivation and reduced productivity. The analysis of studies [3] showed that improving the quality of soil crumbling and the degree of incorporation of plant residues, as well as a decrease in fuel consumption, labor and other costs for smooth, furless plowing, can be achieved by applying coal removal on a frontal plow, which provides an improvement in the turnover of layers within its own furrow with the smallest costs.

The aim of the study is to substantiate the parameters of the frontal plow cut-off, which ensures a high-quality performance of the technological process according to agro technical requirements with the lowest energy consumption during smooth furless plowing [4].

The studies applied the laws and rules of theoretical mechanics, mathematical statistics, mathematical planning of experiments and methods of strain gauging, as well as the methods given in the existing regulatory documents.

On the basis of the analysis of the research work carried out, an improved technology of seams turnover within its own furrow and a structural diagram of a frontal plow with off-take plows were developed [5].

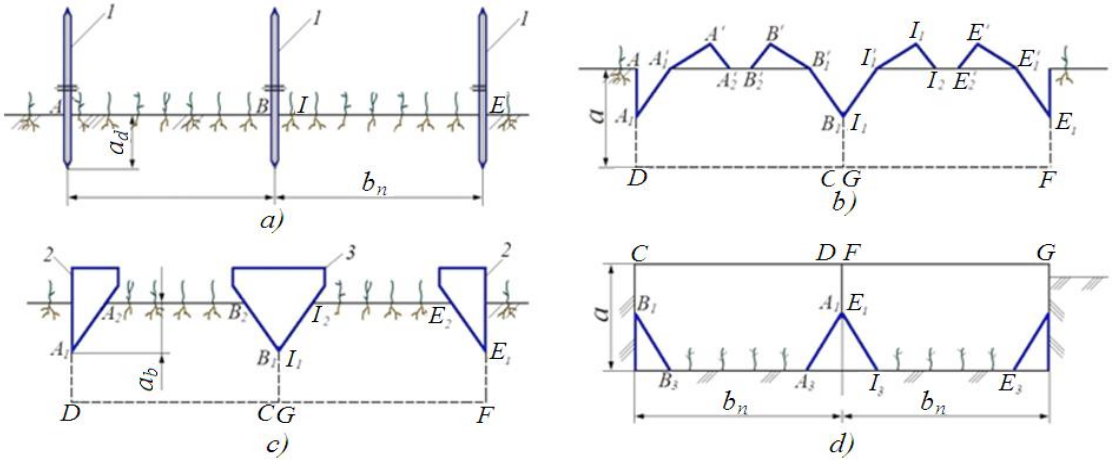

Figure 1. Scheme of the formation turnover technology within its own furrow:

a – cross-sectional view of the field after cutting with a circular knife; *b* – a cross-sectional view of the field with located angle images; *c* – a view of the cross-section of the field after turning the cut edges of the soil layer with coal images;

d – view of the cross-section of the field after turning the layers within its own furrow

In the proposed technology, in order to facilitate the turnover of the seam within its own furrow and reduce its energy consumption, the left and right edges of the seam are first cut off and wrapped in its middle, after which the seam is turned 180 ° within its own furrow (Fig.1).

The rational place for installing the angle pickup is taken to be behind the disk along the axis of its symmetry (Fig.2). In this position, the front edge of the fillet moves along the slot formed by the disc, which improves its working process [6].

To protect the toe cap from wear and reduce its traction resistance, the lower edge *C* can be set at the level of the lower point *E* of the non-sharpened surface of the disc. Then the longitudinal distance between the circular knife and the angle knife can be determined proceeding from the exclusion of touching the front face of the angle cutter on the disk blade

$$l_1 = (R+S)\sin\alpha - [R - \frac{1}{2}t_o ctg\frac{i_1}{2} - (R+S)\cos\alpha\ ]ctg\alpha\ , \quad (1)$$

where R – is the radius of the circular knife, cm; S – the gap between the blade of the circular knife and the front edge is removable, cm; α – angle of entry of the front facet into the soil, degree; t_o – thickness of the circular knife, cm; i_1 – angle of sharpening of the circular knife, degree.

With R=22,5 cm, S=2 cm, α=50°, t_d=0,5 cm and i_1 = 25°, according to expression (1), the longitudinal distance from the axis of the circular knife to the nose must be at least 16 cm.

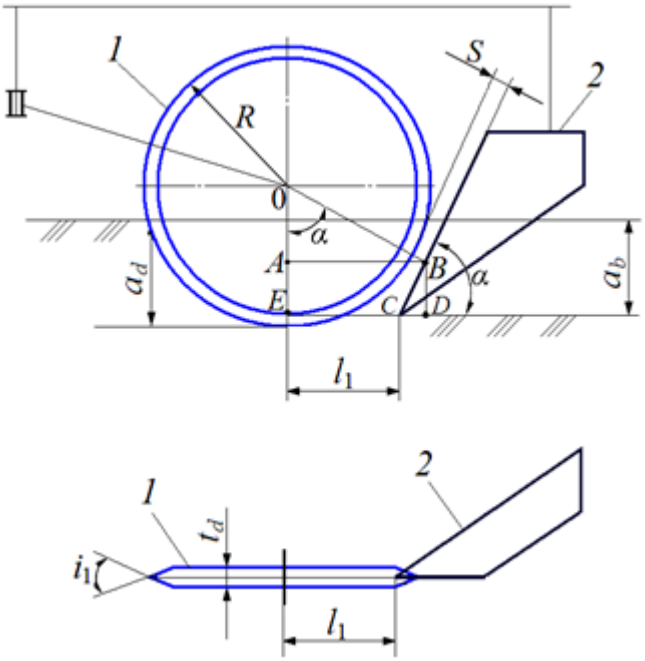

Figure 2. Scheme for determining the longitudinal distance (l_1) between the circular knife and the angle pick:

1 – circular knife; 2 – carbon removal

The longitudinal distance between the coal removal and the body (Fig.3) was determined based on the condition that the soil deformation zone treated by the body did not reach the structural elements.

$$L_2 \geq b_b ctg\gamma + (a - \frac{1}{2} b_k \sin\varepsilon_1) ctg\psi_{1l} \sin(\gamma_1 + \varphi) - \frac{b_l \sin\varepsilon_1}{\sin\gamma_1}, \quad (2)$$

where b_b – is the capture width of the grip, m; γ – angle of the aperture can be removed, degree; ε_1 – angle of installation of the share to the horizon, degree; ψ_{1l} – is the angle of the seam shearing in the plane in the direction of the resultant force on the share, degree; b_l – is the width of the body share, m; a – processing depth of the case, m; γ_1 – angle of installation of the share blade to the furrow wall, degree; b_k – width of capture of the body, m; φ – soil friction angle, degree.

With a =25 cm, b_b=10 cm, b_k =52,5 cm, γ=32°, γ_1= 45°, φ =25°, ε_1=33° and b_l =12,2 cm according to expression (2), the longitudinal distance between the angle the body must be at least 27 cm.

The main parameters of the offset are: the height of the offset H_b, cm; length can be angled l_b, cm; the angle of entry of the front facet is removable into the soil α, degree; the angle of inclination of the side face is offset δ, degree; aperture angle γ, degree; rotation angle β, degree; the angle of inclination of the working face is angular to the horizontal plane ε, degrees.

The height of the grip H_b is determined depending on the depth of processing the grip ab and the width of the grip b_b according to the following formula

$$H_b = a_b + \frac{1}{3}\sqrt{b_b^{\,2} + 4a_b^{\,2}}. \quad (3)$$

With a_b=12 cm and b_b = 8-10 cm, according to expression (3), the height of the angular removal should be within H_b=21-22 cm.

The angle of entry of the front face into the soil α influences the shear and crumbling of the seam

cut out by the coal removal.

We determine it based on the condition of the shift of the soil particle according to the angle

$$\alpha \le \frac{\pi}{2} - \varphi. \quad (4)$$

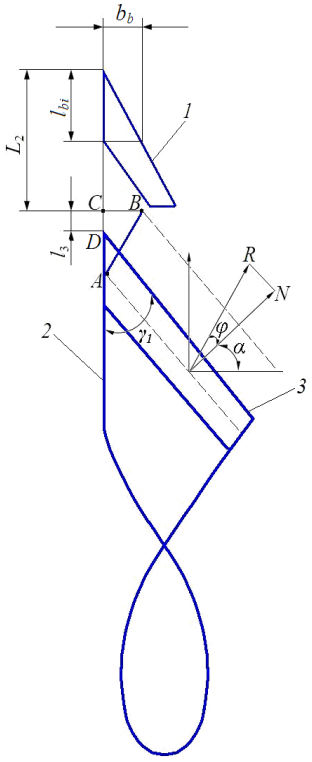

Figure 3. Scheme for determining the longitudinal distance (L_2) between the body and the offset:

1 – offset; 2 – case; 3 – share

At φ=25-30°, according to expression (4), the angle of entry of the front face of the angle into the soil should be in the range of α = 35-50°. We accept α =50°.

The angle of inclination of the lateral face is offset equal to the angle of inclination of the seam cut by it

$$\delta_b = arctg\frac{b_b}{a_b}. \quad (5)$$

With a_b = 12 cm and b_b = 8-10 cm, according to expression (5), the angle of inclination of the lateral edge of the angle should be within δ = 33-39°. We take δ =36°.

The angle of the opening is determined from the condition of the soil shift along the surface of the coal removal and the exclusion of unloading the soil in front of it

$$\gamma \le \frac{\pi}{4} - \frac{\varphi}{2}. \quad (6)$$

At φ=25-30° according to expression (6), the angle of the aperture angle should be within γ=30-32°. We accept γ=32°.

The angle of rotation is determined by the following formula

$$\beta = arctg\frac{tg\alpha}{tg\gamma}. \quad (7)$$

At α = 50° and γ = 32°, according to expression (7), the angle of rotation of the gantry should be β = 55°.

The value of the angle of inclination of the working face is angular to the horizontal plane ε depends on the angles α and γ, that is

$$\varepsilon = arctg\frac{\cos\gamma}{tg\beta}. \quad (8)$$

At β = 55° and γ = 32°, according to expression (8), the angle of inclination of the working face is angular to the horizontal plane to be ε = 31°.

The length of the grip lb is determined depending on the angle of entry of the front face of the grip α, the depth of processing ab and the width of the grip of the grip bb according to the following formula

$$l_b = (a_b + \frac{1}{3}\sqrt{b_b{}^2 + 4a_b{}^2})ctg\alpha_b. \quad (9)$$

According to expression (9), for a_b = 12 cm, α = 50° and b_b = 8-10 cm, the length of the fillet should be within l_b = 26-27 cm.

Placement on the frame of the frontal plow of circular knives, offsets, left and right wrapping bodies and a slatted roller, in an individual order and consistently allows it to be made compact and mounted.

When the frontal plow is removed in the form of a triangular wedge, its height is 22 cm, the wing opening angle is 32°, the angle of inclination of the side edge is 36°, the required quality of smooth plowing is ensured with the least energy consumption [7].

According to the results of the studies, it was found that the required quality of soil cultivation with a frontal plow in accordance with the established agrotechnical requirements with minimal energy consumption is ensured with longitudinal distances between the body share and the cutter of at least 27 cm and between the circular knife and the cutter 16 cm.

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