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Working Body of the Machine for Sowing Cereals on Slopes

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Abstract. The study aims to justify the parameters of the ripper tine of the machine for tillage and sowing of grain seeds on sloping fields. The scheme and parameters of the loosening foot of the machine are given. The basic principles and methods of classical mechanics, mathematical analysis, and statistics were used in this study. The ripper foot consists of a stand, a bit, and a ripper blade. Analytical dependencies for determining the parameters of the bit and ripper blade and the traction resistance of the ripper blade are obtained. It has been established that to ensure high-quality chopping of soil with low energy consumption, the angle of penetration of the plasticizer blade into the soil is within 26-28°, width and length of the working surface of at least 46 and 105 mm respectively, the height of the blade installation relative to the blade in the range 130-150 mm, the installation angle in the range 30-32° relative to the direction of the softening movement of the blade, the width of the cover must be 10 cm. Plasticizer tensile strength depends on its parameters, processing depth, machine speed, and physical and mechanical properties of the soil and ranges from 1.24 to 1.22 kN in the speed range of 1.67-2.22 m/s.

INTRODUCTION

Studies on the development of technologies and technical means preventing water erosion were conducted by K.Alexandrian [1], A.Vagin [2], N.Nagorny [3], T.Pazova [4], F.Mamatov [8-10], B.Mirzaev [11, 12], Sh.Mardonov [8] and others. Studies of processes of interaction of no-till working tools with soil were conducted by I.Panov [5], P.Burchenko [6], V.Trufanov [7], and others. The till-less working tools with sloping legs preventing wind and water erosion were studied by L.Orsik [13] and others. N.Aldoshin [14], D.Chuyanov [15], A.Zhilyakov [18], and others studied the issues of improving working tools for anti-erosion tillage. A.Zhilyakov [24] has improved the method of sowing cereals on slopes by using a disk knife instead of a special lancet foot, which forms a furrow in the form of a trapezium in the transverse plane, creating a furrow in the form of an isosceles triangle. Despite the great attention paid worldwide to the problem of protecting the soil from erosion, in Uzbekistan not enough research on the development of combined seeding machines and their working tools that prevent water erosion and, accordingly, washing away of crops on the sloping fields. Therefore, there is a necessity for modernization of existing working bodies of seeding machines for seeding and anti-erosion treatment of sloping soils.

The research aims to justify the parameters of a ripper foot of a machine for tillage and sowing of grain seeds on sloping fields. The scheme and parameters of the loosening foot of the machine are given.

METHODS

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.

Soil cultivator (Fig.1) consists of stand 1, chisel 2 fixed on it, and mulching blade 3. Softener is used to till the soil to a depth of 25 cm without slope and soften the field surface to a depth of 10-12 cm.

Its quality and energy efficiency are influenced by the following parameters of the softener (Fig. 1): α_i is angle of incision (indentation) of the screed into the ground, degrees; b_i is width of the reamer, m; l_i is length of the working surface of the reamer, m; i_i is angle of blade sharpening, degrees; $2\gamma_u$ is angle of blade opening, degrees; h_p is blade

setting height, cm; γ_n is blade angle relative to movement direction, degrees; ε_n is blade entry angle (sharpening) into the ground, degrees; b_n is blade grip width, m; H_n is claw column height, m.

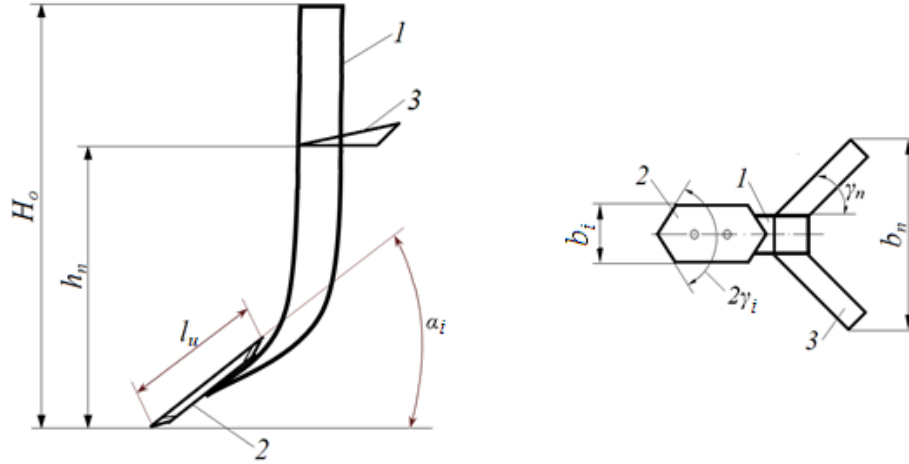


FIGURE 1. Basic parameters of the softener: 1 is column; 2 is scan; 3 is knife

The main criteria for substantiating the optimal values of the above parameters of plasticizer are the quality of soil compaction, weeding, absence of soil clods in front of the beak, i.e., softening of the soil with low energy consumption.

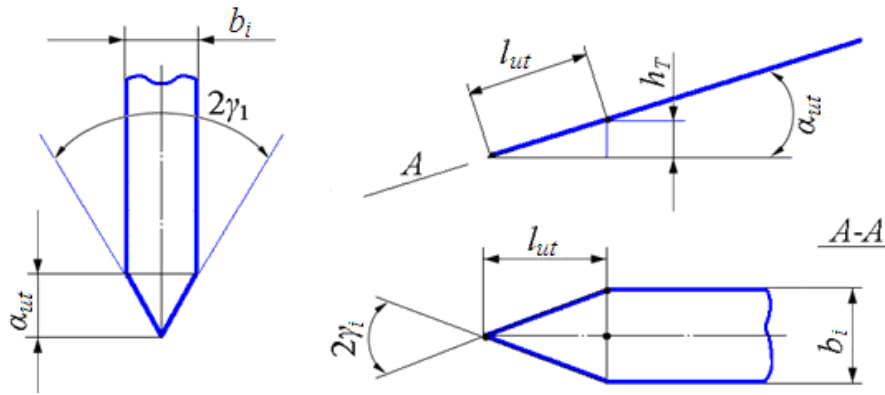


FIGURE 2. Chisel parameters

The softener should be set relative to the horizon so that the treated soil is lifted and moved on its working surface and minimal energy costs. We determine the angle of the claw by the following expression proposed by K.Imamkulov [25]

$$\alpha_i = \arctg \left(\sqrt[3]{-q + \sqrt{q^2 + p^3}} + \sqrt[3]{-q - \sqrt{q^2 + p^3}} - \frac{m}{3n} \right) \quad (1)$$

where φ is the angle of friction of the soil on the working surface of the tine, degrees; p , m , n , and c are dimensionless coefficients.

$$p = \frac{3nc - m^2}{9n^2}; \quad q = \frac{m^3}{27n^3} - \frac{mc}{6n^2} - \frac{m}{2n}; \quad m = tg\varphi; \quad n = 1 + tg^2\varphi; \quad c = 2tg^2\varphi.$$

Considering that on slopes $\varphi = 25-30^\circ$, it follows from expression (1) that the angle of claw entry into the soil

should be within 26-28°.

We determine the tine width (Figure 2) provided that the working depth is less than the critical cutting depth. Otherwise, instead of the cutting process, the soil will be crushed to the sides. This drastically increases the energy consumption during tillage.

Taking into account the above and using the ratio between the width of the plasticizer and the depth of critical cut according to G.Plyushev [26], we determine the width of the protrusion by the following expression.

$$b_i \geq \frac{2tg\gamma_i(4.2 + ctg\alpha_i)}{2Atg\gamma_i + 4.2 \sin \alpha_i + \cos \alpha_i}. \quad (2)$$

in terms of (2):

$$A = \left[0.1 \frac{T_e}{[\tau_k]} (1 + 3tg\varepsilon) - 2.5 \right] \quad (3)$$

where T_e is specific resistance to soil compaction, Pa; $[\tau_k]$ is critical resistance of soil to disintegration (shear), Pa; ε is angle of inclination of impact force acting on the softening separator by soil relative to the horizon, degree; a_n is critical depth of foot treatment, see.

$a_{max} = 0.25$ m, $\alpha_i = 30^\circ$, $\gamma_u = 35^\circ$, $\varphi = 30^\circ$, $T_e = 14.4-105$ Pa and $[\tau_k] = 1.2 \cdot 10^4$ Pa, and calculations carried out by expression (2) showed that the foot width should be at least 46 mm.

To determine the length of the working surface of the softening claw, we find that it has a rotating claw, and its beak is shaped like a sharp tooth. Based on figure 2, we determine its total length according to the following expression

To determine the length of the working surface of the softening foot, we find that it has a rotating foot, and its beak has the shape of a sharp tooth. Based on Figure 2, we determine its total length by the following expression

$$L_i \geq 2 \left(\frac{[\tau_k] \left[b_i \cos \frac{1}{2}(\alpha_i + \varphi_1 + \varphi_2) + atg\left(\frac{\pi}{4} - \frac{\varphi_2}{2}\right) \right] a \cos \frac{1}{2}(\varphi_1 + \varphi_2 - \alpha_i)}{q_0(1 + K_v V_n) b_i \cos^2 \frac{1}{2}(\alpha_i - \varphi_1 + \varphi_2) [\cos(\alpha_i + \varphi_1) + \cos \varphi_2] \sin \alpha_i} \right)^{1/2} + \frac{b_i}{2tg\gamma_i}. \quad (4)$$

where $[\tau_k]$ is the critical resistance of soil to decomposition, Pa; q_0 is the coefficient of volumetric compaction of soil, N/m³; V_n is the unit movement speed, m/s; φ_1 , φ_2 are the angles of external and internal soil friction, degrees; K_v is the coefficient taking into account the change in the coefficient of soil compaction depending on the speed; $2\gamma_u$ is the cam opening angle, deg.

$\varphi_1 = 30^\circ$, $\varphi_2 = 40^\circ$, $\gamma_u = 30-35^\circ$, $b_i = 0.046$ m, $K_v = 0.1$ c/m, $q_0 = 1 \cdot 10^7$ N / m³, and the calculations were performed by expression (4) 1. At an operating speed of 67-2.22 m/s scale softener showed that the working surface should be at least 105 mm.

The sharpening angles i_i and $2\gamma_u$ of the scissor blade were compared with previous studies; we basically take 25° and 70°, respectively.

Gravity resistance of the softening blade. Total tensile strength of the softening blade

$$R_{ux} = R_{ux} + R_{yx} + R_{zx} \quad (5)$$

The sharpening angles i_u and $2\gamma_u$ of the scissor blade were compared with previous studies; we basically take 25° and 70°, respectively.

Gravity resistance of the softening blade. Total tensile strength of the softening blade

$$R_{ux} = R_{1x} + R_{2x} + R_{3x} + R_{4x} + R_{5x} \quad (6)$$

where R_{1x} is resistance of soil to penetration of blades, N; R_{2x} is resistance of soil to deformation under the action of

screens, N; R_{3x} is resistance of soil to deformation under the action of scaffolding, N; R_{4x} is resistance due to soil lifting on working surface, N; R_{5x} is resistance of soil inertial force rising on working surface, N.

In the plane of the working surface of the scaffold, we determine the resistance of the soil from one side, for example, from the right side (Figure 3) as follows.

$$R_1 = \frac{b_i}{2 \sin \gamma_i} t_i \sigma_o \sqrt{1 + f^2} \cos(\gamma_i + \varphi), \quad (7)$$

where σ_o is temporary specific resistance of soil compaction by the blade, Pa; t_i is blade thickness, m.

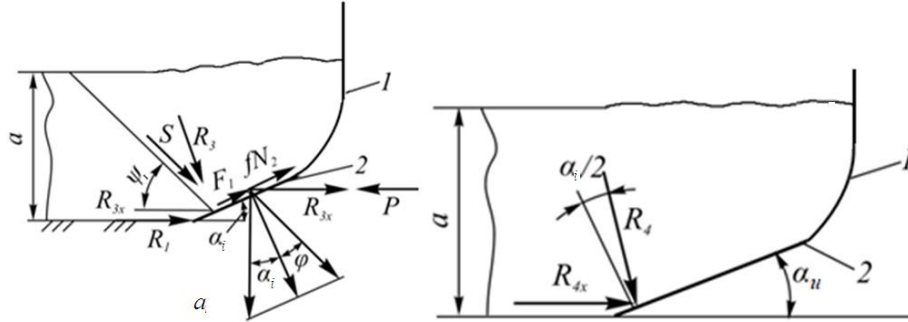


FIGURE 3. Scheme of forces acting on the plasticizer from the soil: 1 is column; 2 is chisel

In this case, the soil resistance of the blade on both sides of the chisel working surface

$$R_1 = \frac{b_i}{\sin \gamma_i} t_i \sigma_o \sqrt{1 + f^2} \cos(\gamma_i + \varphi), \quad (8)$$

Considering the above, the horizontal component of the resistance of the ground to penetration of the blades is as follows.

$$R_{1x} = \frac{b_i}{\sin \gamma_i} t_i \sigma_o \sqrt{1 + f^2} \cos(\gamma_i + \varphi) \cos \alpha_i. \quad (9)$$

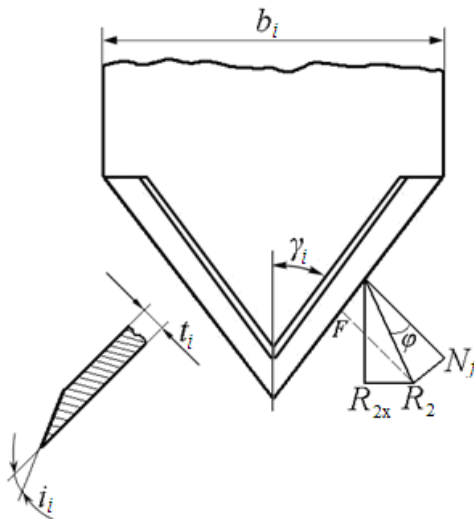


FIGURE 4. Diagram of forces acting on the blade

The equivalent action of the elementary normal forces acting on the bevel on one side of the scaffolding can be determined by the following formula, using the research of G.Sineokov.

$$N_f = \frac{q_0 b t_i^2}{4 \sin^2 i_i \sin \gamma_i}. \quad (10)$$

The sum of the normal and transverse forces N_f and the frictional force R_2 on the chamfering surface can be determined by the following expression:

$$R_2 = \frac{q_0 b t_i^2}{4 \sin^2 i_i \sin \gamma_i \cos \varphi}. \quad (11)$$

In this case, the resistance of the ground to deformation under the influence of the scaffolding chambers

$$R_{2x} = \frac{q b t_i^2}{2 \sin^2 i_i \cos \varphi}. \quad (12)$$

The resistance of the ground to deformation under the action of the scan is determined by the shear force S_3 and the frictional force created by this force by the protrusions of the horizontal axis, i.e.

$$R_{3x} = S [\cos \psi_1 + f \sin(\alpha_i + \psi_1) \cos \alpha_i], \quad (13)$$

where ψ_{s1} is the angle of longitudinal refraction of the ground, deg; f is the coefficient of friction of the ground against the metal.

Since the shear force is equal to $S = [\tau] \cdot F$

$$R_{3x} = [\tau] F [\cos \psi_1 + f \sin(\alpha_i + \psi_1) \cos \alpha_i], \quad (14)$$

where $[\tau]$ is the displacement factor; F is the sliding surface, m^2 .

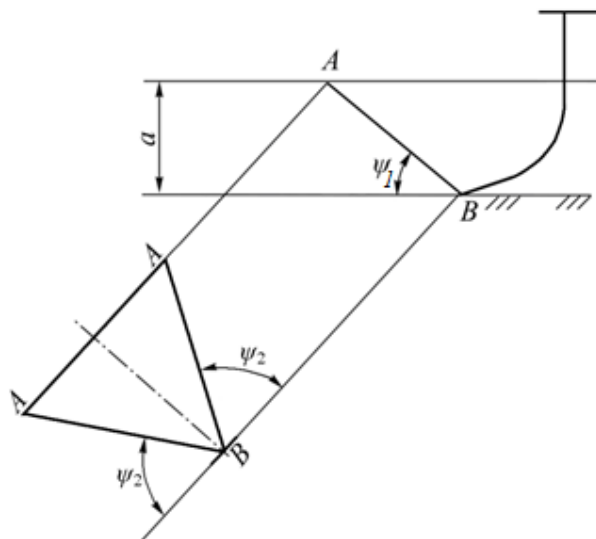


FIGURE 5. Scheme for determining the soil surface in the displacement plane with the claws of the plasticizer of the first row

Under the action of the softening claw, the soil on the sides of the claw in the transverse plane is torn at an angle ψ_{s1} . (Figure 5). As shown in Figure 6, the first-row work tools interact with the soil under fully closed cutting

conditions, while the second-row work tools interact with the soil under semi-closed cutting conditions. The surface area of the shear plane is as follows:

under closed cutting conditions

$$F = \frac{a^2 \operatorname{ctg} \psi_2}{\sin \psi_1}; \quad (15)$$

in semi-closed cutting conditions

$$F = \frac{ab_p}{\sin \psi_2} - \frac{b_p^2}{2} \operatorname{tg} \psi_2. \quad (16)$$

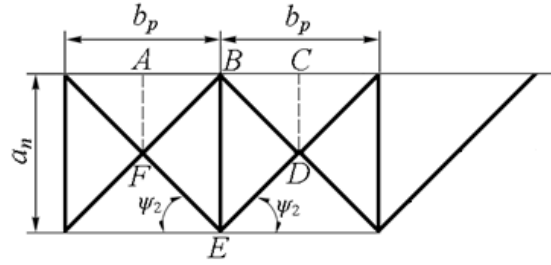


FIGURE 6. Scheme for determining the cross-sectional area of the deformed soil with second row plasticizer

Substituting values F into expressions (14) and (15) (13), we determine the ground deformation resistance R_{3x} for closed and semi-sliding conditions:

for indoor cutting conditions

$$R_{3x} = [\tau] \frac{a^2 \operatorname{ctg} \psi_2}{\sin \psi_1} [\cos \psi_1 + f \sin(\alpha_i + \psi_1) \cos \alpha_i]; \quad (17)$$

for semi-closed cutting conditions

$$R_{3x} = [\tau] \left(\frac{ab_p}{\sin \psi_2} - \frac{b_p^2}{2} \operatorname{tg} \psi_2 \right) [\cos \psi_1 + f \sin(\alpha_i + \psi_1) \cos \alpha_i]; \quad (18)$$

The resistance created by the rise of the soil softener on the working surface can be determined by the following formula

$$R_{4x} = ab_i \rho V^2 \sin \alpha_i \operatorname{tg}(\alpha_i + \varphi) \left(1 + \frac{W}{100}\right), \quad (19)$$

where ρ is soil density, kg/m^3 ; W is soil moisture, %.

The resistance to the inertial force of the soil rising on the working surface can be determined by the following formula

$$R_{5x} = G \cos \alpha_i (\sin \alpha_i + f \cos \alpha_i), \quad (20)$$

where G is the weight of the bit.

In the case of closed cutting, the weight of the rod is determined by the following formula:

$$G = \gamma g a \left(\frac{b_i^2}{2 \operatorname{tg} \gamma_i} + L_i a \operatorname{ctg} \psi_2 \right) \left(1 + \frac{W}{100}\right). \quad (21)$$

Under semi-closed cutting conditions, the weight of the rod is determined by the following formula:

$$G = \gamma g a \left[\left(\frac{b_i^2}{2tg\gamma_i} + L_i actg\psi_2 - \frac{1}{2} (a - h_u)^2 ctg\psi_2 \right) \right] \left(1 + \frac{W}{100} \right), \quad (22)$$

where g is the acceleration of free fall, m/s^2 .

We can set the value of h_u (35) equal to (22)

$$G = \gamma g a \left[\left(\frac{b_i^2}{2tg\gamma_i} + L_i actg\psi_2 - \frac{1}{2} \left(a - \frac{b_p}{2} tg\psi_2 \right)^2 ctg\psi_2 \right) \right] \left(1 + \frac{W}{100} \right). \quad (23)$$

Taking into account expressions (21) and (23), we determine the resistance due to the force of inertia of the ground rising on the working surface of the screed by the following expressions:
for the cutting conditions indoors

$$R_{5x} = \gamma g a \left[\left(\frac{b_i^2}{2tg\gamma_i} + L_i actg\psi_2 \right) \right] \cos\alpha_i (\sin\alpha_i + f \cos\alpha_i) \left(1 + \frac{W}{100} \right); \quad (24)$$

For semi-closed cutting conditions

$$R_{5x} = \gamma g a \left[\left(\frac{b_i^2}{2tg\gamma_i} + L_i actg\psi_2 - \frac{1}{2} \left(a - \frac{b_p}{2} tg\psi_2 \right)^2 ctg\psi_2 \right) \right] \cos\alpha_i (\sin\alpha_i + f \cos\alpha_i) \left(1 + \frac{W}{100} \right). \quad (25)$$

Substituting the values of R_{1x} , R_{2x} , R_{3x} , R_{4x} and R_{5x} in expressions (9), (12), (17), (18), (19), (24) and (25) in (6), to determine the plasticizer strength limit of the scanner, we obtain the following final result

For a first-row softener scanner operating under closed mowing conditions

$$\begin{aligned} R_{ux} = & \frac{b_i}{\sin\gamma_i} t_i \sigma_o \sqrt{1+f^2} \cos(\gamma_i + \varphi) \cos\alpha_i + \frac{qb_i t_i^2}{2\sin^2 i \cos\varphi} + [\tau] \frac{a^2 ctg\psi_2}{\sin\psi_1} x \\ & x [\cos\psi_1 + f \sin(\alpha_i + \psi_1) \cos\alpha_i] + ab_i \rho V^2 \sin\alpha_i tg(\alpha_i + \varphi) \left(1 + \frac{W}{100} \right) + \\ & + \gamma g a \left[\left(\frac{b_i^2}{2tg\gamma_i} + L_i actg\psi_2 \right) \right] \cos\alpha_i (\sin\alpha_i + f \cos\alpha_i) \left(1 + \frac{W}{100} \right), \end{aligned} \quad (26)$$

for a second row softener bit operating in semi-closed cutting conditions

$$\begin{aligned} R_{ux} = & \frac{b_i}{\sin\gamma_i} t_i \sigma_o \sqrt{1+f^2} \cos(\gamma_i + \varphi) \cos\alpha_i + \frac{qb_i t_i^2}{2\sin^2 i \cos\varphi} + [\tau] \frac{a^2 ctg\psi_2}{\sin\psi_1} [\cos\psi_1 + \\ & + f \sin(\alpha_i + \psi_1) \cos\alpha_i] + ab_i \rho V^2 \sin\alpha_i tg(\alpha_i + \varphi) \left(1 + \frac{W}{100} \right) + \gamma g a \left[\left(\frac{b_i^2}{2tg\gamma_i} + \right. \right. \\ & \left. \left. + L_i actg\psi_2 - \frac{1}{2} \left(a - \frac{b_p}{2} tg\psi_2 \right)^2 ctg\psi_2 \right) \right] \cos\alpha_i (\sin\alpha_i + f \cos\alpha_i) \left(1 + \frac{W}{100} \right). \end{aligned} \quad (27)$$

Gravitational resistance of the clawed softening column. The leading edge of the claw column works like a blade. Consequently, the traction resistance of the softening claw column is equal to the sum of the traction resistance of its blade, leading edge, and lateral edges, i.e.

$$R_y = R_l + R_{ok} + R_{uk}. \quad (28)$$

Pulling resistance of the soft foot post

$$R_l = (a - h_i)t_i\sigma_o = (a - L_i \sin \alpha_i)t_i\sigma_o. \quad (29)$$

The equivalent effect of the elementary normal forces acting on the front edges of the softening column can be determined by the following formula using the study of G.Sineokov.

$$R_{ok} = \frac{q(a - L_i \sin \alpha_i)t_y^2}{\sin \gamma_y \cos \varphi}. \quad (30)$$

Gravity resistance of the softening column with

$$R_{uk} = 2N_2f = qFf, \quad (31)$$

where F is the surface area of the column sides, m^2 .

$$F = (a - L_i \sin \alpha_i)(2b_y - t_y \operatorname{ctg} \gamma_y). \quad (32)$$

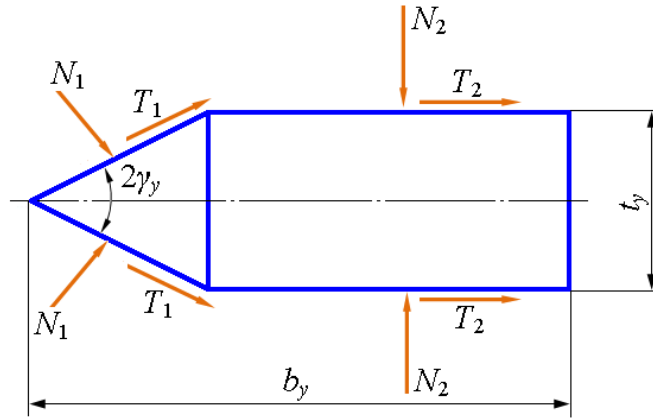


FIGURE 7. Scheme of forces acting on the column

We set the value of F (32) to (31)

$$R_{uk} = q(a - L_i \sin \alpha_i)(2b_y - t_y \operatorname{ctg} \gamma_y)f. \quad (33)$$

Substituting the values of R_l , R_{ok} , and R_{uk} (29), (30), and (33) into (28), we obtain the following expression for determining the gravitational resistance of the column.

$$R_{yx} = (a - L_i \sin \alpha_i)t_i\sigma_o + \frac{q(a - L_i \sin \alpha_i)t_y^2}{\sin \gamma_y \cos \varphi} + q(a - L_i \sin \alpha_i)(2b_y - t_y \operatorname{ctg} \gamma_y)f. \quad (34)$$

Basic parameters of the softener blade for the softener. The main parameters affecting the quality and resistance of the blade include (Fig. 8): h_n and b_n are height of the blade in the softener and its width; ε_n is angle of blade sharpening; γ_n is angle at which the blade is set relative to the direction of motion.

The blade should be set at such height relative to the beak of the plasticizer so that it would not break the ridges formed at the bottom of the plough, and secondly, soften the top layer to a thickness of 10-12 cm and kill the weeds. According to the first condition

$$h_n > h_y = \frac{b_p}{2} \operatorname{tg} \psi_2. \quad (35)$$

Given that $b_p=0.15$ m and $\psi_2= 60^\circ$, (35) should be $h_p > 0.13$ m.
Under the second condition

$$h_n = a - (0.1 - 0.12) m. \quad (36)$$

At $a = 0,25$ m the blade should be mounted at a height $h_p = 0,13-0,15$ m relative to the beak.

The blade opening angle, i.e., the angle of its installation relative to the direction of smooth movement, is determined from the condition of soil shearing by the blade sliding γ_n .

$$\gamma_n = \frac{\pi}{4} - \frac{\varphi}{2}. \quad (37)$$

Considering that $\varphi = 25-30^\circ$, it follows from expression (37) that the blade opening angle should be within $30-32^\circ$. We take 30° .

We consider the angle of blade sharpening as the angle of axial cams. Based on $\varepsilon_n = 30^\circ$.

We determine the width of the blade by completely cutting the weeds:

$$b_n = \frac{b_p}{2} - \frac{t_y}{2} + \Delta b, \quad (38)$$

where Δb is the pavement width, m.

Taking into account that $b_p = 0,15$ m and $t_i = 0,02$ m, and assuming that $D_b = 0,03$ m, calculations carried out according to expression (38) showed that the blade cover width was 0.1 m.

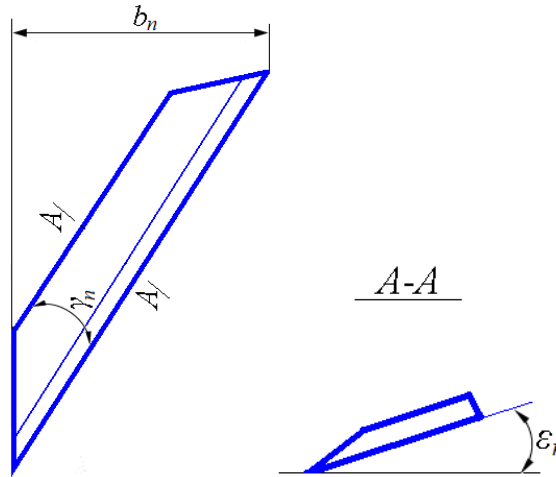


FIGURE 8. Knife parameters

Pulling resistance of the blade can be determined by its parameters and physical and mechanical properties of the soil, as well as by the speed of the machine by the following expression

$$R_{nx} = (K_n + E_n V^2) b_n a_n, \quad (39)$$

where K_n is specific resistance of soil to the blade, N; E_n is coefficient taking into account the effect of speed on the blade drag resistance; V is speed of movement, m/s.

Substituting R_{ux} , R_{yx} and R_{nx} values into expressions (26), (27), (24) and (39) in (5), we obtain the following final result for determination of total gravity drag of the blade

For the first row

$$\begin{aligned}
 R_{ux} = & \frac{b_i}{\sin \gamma_i} t_i \sigma_o \sqrt{1+f^2} \cos(\gamma_i + \varphi) \cos \alpha_i + \frac{q b_i t_i^2}{2 \sin^2 i_i \cos \varphi} + [\tau] \frac{a^2 \operatorname{ctg} \psi_2}{\sin \psi_1} x \\
 & x [\cos \psi_1 + f \sin(\alpha_i + \psi_1) \cos \alpha_i] + a b_i \rho V^2 \sin \alpha_i \operatorname{tg}(\alpha_i + \varphi) \left(1 + \frac{W}{100}\right) + \\
 & + \gamma g a \left[\frac{b_i^2}{2 \operatorname{tg} \gamma_i} + L_i a \operatorname{ctg} \psi_2 \right] \cos \alpha_i (\sin \alpha_i + f \cos \alpha_i) \left(1 + \frac{W}{100}\right) + (a - L_i \sin \alpha_i) x \\
 & x t_i \sigma_o + \frac{q(a - L_i \sin \alpha_i) t_y^2}{\sin \gamma_y \cos \varphi} q(a - L_i \sin \alpha_i) (2b_y - t_y \operatorname{ctg} \gamma_y) f + (K_n + E_n V^2) b_n a_n;
 \end{aligned} \tag{40}$$

For the second row

$$\begin{aligned}
 R_{ux} = & \frac{b_i}{\sin \gamma_i} t_i \sigma_o \sqrt{1+f^2} \cos(\gamma_i + \varphi) \cos \alpha_i + \frac{q b_i t_i^2}{2 \sin^2 i_i \cos \varphi} + [\tau] \frac{a^2 \operatorname{ctg} \psi_2}{\sin \psi_1} [\cos \psi_1 + \\
 & + f \sin(\alpha_i + \psi_1) \cos \alpha_i] + a b_i \rho V^2 \sin \alpha_i \operatorname{tg}(\alpha_i + \varphi) \left(1 + \frac{W}{100}\right) + \gamma g a \left[\frac{b_i^2}{2 \operatorname{tg} \gamma_i} + L_i a \operatorname{ctg} \psi_2 - \right. \\
 & \left. - \frac{1}{2} \left(a - \frac{b_p}{2} \operatorname{tg} \psi_2\right)^2 \operatorname{ctg} \psi_2 \right] \cos \alpha_i (\sin \alpha_i + f \cos \alpha_i) \left(1 + \frac{W}{100}\right) + (a - L_i \sin \alpha_i) t_i \sigma_o + \\
 & + \frac{q(a - L_i \sin \alpha_i) t_y^2}{\sin \gamma_y \cos \varphi} + q(a - L_i \sin \alpha_i) (2b_y - t_y \operatorname{ctg} \gamma_y) f + (K_n + E_n V^2) b_n a_n.
 \end{aligned} \tag{41}$$

Analysis of these expressions shows that the gravitational resistance of the plasticizer is its parameters (t_u , b , β), the working depth (h), the speed of aggregate (V), and the physical and mechanical properties of the soil (T , φ , ρ , ε_e , ψ_e).

RESULTS AND DISCUSSION

Based on the above results and previous studies, $t_u=0.001$ m, $b_i=0.046$ m, $L_i=0.105$ m, $a=0.25$ m, $\alpha_i=30^\circ$, $\varphi=25^\circ$, $\varphi_2=40^\circ$, $\psi_2=60^\circ$, $\psi_1=45^\circ$, $\sigma_o=2 \cdot 10^6$ Pa, $\rho=1380$ kg/m³, $[\tau_k]=1.2 \cdot 10^4$ Pa, $W=16$ %, $f=0.5$, $q=1 \cdot 10^7$ N/m³, $K_n=15 \cdot 10^3$ Па, $b_p=0.15$ m, $b_y=0.1$ m, $t_y=0.02$ m, $\gamma_i=30^\circ$ is assumed, calculations by expressions (40) and (41) show that the tensile strength of a plasticizer operating in closed cutting conditions with a speed of 2.22 m/s is $R = 1.28$ kgN, the resistance of a plasticizer operating in semi-automated mode. -closed cutting conditions showed that the gravity resistance will be $R = 0.91$ kgN. Analysis of these data shows that the main part of the claw plasticizer traction resistance of the developed machine forms the ground deformation resistance, which is 66% of the total resistance.

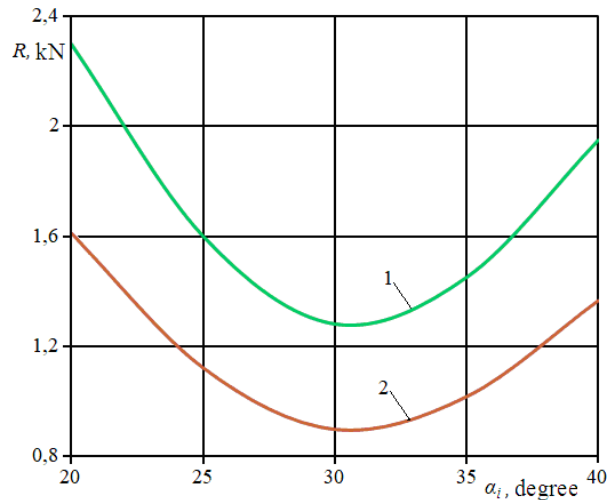


FIGURE 9. Resistance to gravity of softening claw force changes depending on the angle α_i :
1 is under closed cutting conditions; 2 is under semi-open cutting conditions

In Fig. 9 (40) and (41), the graph of change of total tensile strength of softening cams working in closed and semi-open shear conditions, depending on angle α_i is plotted. From this graph, one can see that in both conditions, the minimum energy required to soften the soil is when the softening foot penetration angle into the soil is in the range of 30-32°.

CONCLUSIONS

1. According to the results of theoretical studies, the angle of softening pad penetration into the soil should be in the range of 26-28°, the width and length of the working surface should be at least 46 and 105 mm, respectively. To ensure the qualitative soil crushing with low energy consumption, the blade installation height relative to the scanning nozzle should be within 130-150 mm, the blade installation angle relative to the blade movement direction should be in the range of 30-32°, the coverage width - 10 cm.

2. Breaking strength of softening sponge depends on its parameters, the depth of processing, the speed of the unit, and the physical and mechanical properties of the soil, in the range of speeds from 1.67 to 2.22 m / s 1.24-1.28 kN.

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