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Traction Resistance of the Front Plow Angle

Kurbanov Sherzod Baxtiyorovich
Karshi Engineering Economic Institute, Karshi, Uzbekistan

Abstract: With the help of frontal plug housings, the left and right upper edges of the overturned panels are first cut with an angle cutter, which eliminates the difficulties in the overturning process and reduces the traction resistance. Calculations based on theoretical studies showed that the tensile strength of the angle grinder should be in the range of 0.36-0.39 kN in the speed range of 1,8-2,3 m/s. The pulling resistance of the plug depends on the processing depth and coverage width of the angle cutter, and it showed that the processing depth should be 10-12 cm and the coverage width should be 10-12 cm in order to ensure the high quality of the technological process with low energy consumption.

Keywords: pochva, frontalniy plug, korpus, gladkaya vspashka, uglosnim, diskoviy noj, trexgranniy klin.

1. Introduction

Angle cutters are directed to perform two main functions in the process of technological work: ensuring the quality of burial of plant residues; reduce unevenness on the surface of the plowed field. The purpose of installing an angle cutter on frontal plows is to ensure that the edges of the plows are completely located on the border of their place without touching each other, to improve the quality of the plow and to reduce the resistance to traction [1].

In analyzing the constructions of burchakkeskich, it is important to determine the parameters affecting its function and technological work process [2].

According to the analysis of scientific and technical and patent literature, angle cutters can be divided into the following types depending on the location, type and shape of the working surface and technological process performance characteristics: traditional construction; segmental; disk-shaped; in an unconventional construction [3].

Angle cutters of traditional construction consist of a tipper, a handle and a clamp, and are installed in front of the body at a certain angle along its surface. Burchakkeskich rests on the body tipper with its lower corner and occupies the volume of the breast part of the tipper. They differ from each other according to the shape of the working surface. In the process of Burchakkeskich's technological work, the upper part of the overturned soil is cut off and thrown into the bottom of the plow. The use of angle cutters of traditional design increases the depth of burial of plant residues in the soil by 14,9-20,5% and the degree of burial by 6,4-9,5%.

A segmental angle cutter is an angle cutter whose tipping surface consists of one or more segments (joints), it has a helicoidal surface, the plug body is wrapped in front of the tipper, and the lower part is connected to the body blade. In the working process of the segmental cutter body, the soil is first rolled through the segmental cutter and then sequentially on the surface of the body tipper. The main disadvantage of this angle cutter is that it pushes the open surface of the soil sheet, even its upper corner, to the surface of the deep layer of soil and directs it to the furrow. A disc-shaped bevel is made in the form of a spherical disc. The main advantage of the disc angle cutter is that it has a low energy consumption compared to other angle cutters. The disadvantage of the disc-shaped angle cutter is that it mainly cuts the side surface of the blade during the work process, has a complex construction and consumes a lot of metal compared to traditional angle cutters [4-5].

Floyd Laster [6] proposed an angle cutter designed in the form of an elastic rod through which soil can pass easily as an angle cutter with an unconventional design. In this case, plant stems are separated and only plant remains are buried at the bottom of the soil. In addition, such an unconventional angle grinder additionally crushes the soil. In addition, as a continuation of the angle cutter when plowing at high speeds, it offers an unconventional angle cutter with a long elastic rod attached to its reverse side in order to direct plant residues not to the side of the plow, but to the bottom of the plow. According to the analysis of scientific and technical literature, it can be noted that the issues of substantiating the parameters of the angle cutters of the plows, which turn the plows flat on the edge of their edge, have not been sufficiently studied.

According to the results of the research on the choice of the type of angle cutter to be installed on the frontal plow, the angle cutter in the form of a three-sided pone-thrower is the most suitable [7].

Method

Since Burchakkeskich is in the form of a three-sided pone, its tensile strength can be generally expressed as follows.

$$R_{бx} = R_{1x} + R_{2x} + R_{3x}, \quad (1)$$

In this R_{1x} – soil displacement resistance, kN;

R_{2x} – the resistance created by the rising of the soil along the surface of the bevel, kN;

R_{3x} – resistance created by the inertial force of the soil rising along the surface of the bevel, kN.

Based on Fig. 1, we determine the sliding surface in closed cutting conditions $F = \frac{a_б AE}{2\sin\psi_{1л}}$, (2)

$$AE = \frac{b_б}{\sin\gamma_б},$$

$$F = \frac{a_б b_б}{2\sin\gamma_б \sin\psi_{1л}}. \quad (3)$$

In this, the shear resistance force

$$S_q = \tau F_1 = \frac{\tau a_б b_б}{2\sin\gamma_б \sin\psi_{1л}}. \quad (4)$$

In this τ – is the relative resistance to breaking the soil, Pa;

In this case, the projection of the shear force acting on this surface onto the horizontal plane

$$F_1 = S_q \cos\psi_{1л}.$$

Projection of F_1 onto the X-axis

$$F_{1x} = S_q \cos\psi_{1л} \sin\gamma_б. \quad (5)$$

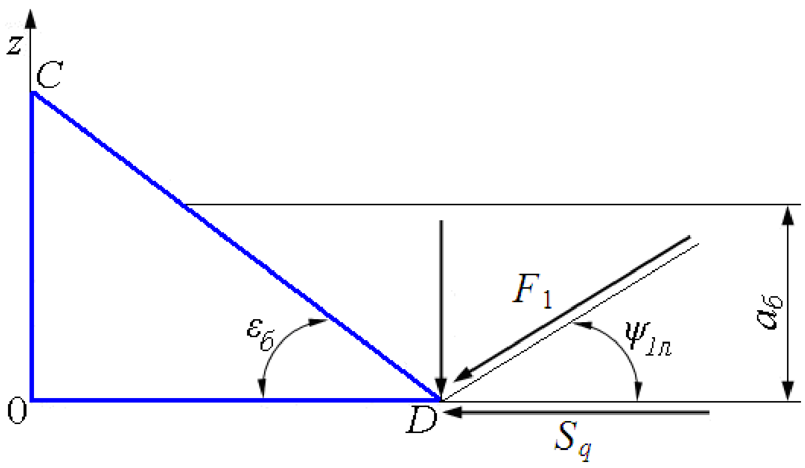

Figure 1. Burchakkeskich and the scheme of moving the blade in an orthogonal section to its blade

In addition, the sliding resistance force S_q creates the frictional force *fN* on the surface of the bevel

$$R_{1x} = S_q \cos\psi_{1л} \sin\gamma_б + F_x, \quad (6)$$

$$F_x = fN \cos\alpha_1 \cos\gamma_1,$$

$$N = F_1 \sin(\varepsilon_б + \psi_{1л}).$$

or

$$R_{1x} = S_q[\cos\psi_{1л} \sin\gamma_б + f \sin(\varepsilon_б + \psi_{1л}) \cos\alpha_1 \cos\gamma_1]. \qquad (7)$$

We determine the resistance created by the rise of the soil along the surface of the angle cutter according to the method suggested by A.T.Vagin.

According to A.T.Vagin, when the earth passes the distance *OA*, moving along the *X* axis, the bottom point *O* of the earth moves to the point *YE* along the straight line *AYEYE'*. The remaining lower points of the palaxa also deviate from the longitudinal plane *xOz* at an angle γ_1 along a straight line parallel to *AYE'* at an angle a1 to the horizon [4].

$$\sin\alpha_1 = tg\alpha_б \cos\varepsilon_б, \quad (8)$$

$$tg\gamma_1 = \frac{(1-\cos\varepsilon_б)tg\gamma_б}{1+tg^2\gamma_б \cos\varepsilon_б}, \quad (9)$$

We can put the values of S_q, α_1 and γ_1 in expression (10) according to (5), (8), (9)

$$R_{1x} = \frac{\tau a_б b_б l_б}{2\sin\gamma_1 \sin\psi_1}[\cos\psi_{1л} \sin\gamma_б + f \sin(\varepsilon_б + \psi_{1л})\sqrt{1-(tg\alpha_б \cos\varepsilon_б)^2} x$$

$$x \cos[\arg tg \frac{(1-\cos\varepsilon_б)tg\gamma_б}{1+tg^2\gamma_б \cos\varepsilon_б}]. \qquad (10)$$

We determine the resistance to traction, which is formed by the rise of the soil along the surface of the diagonal, and the projection on the *x* axis using the formula obtained by A.T. Vagin [4]

$$R_{2x} = G_1(\sin\alpha_1 + f \cos\gamma_б)\cos\alpha_1 \cos\gamma_1, \qquad (11)$$

$$G_1 = \frac{1}{2}\gamma a_б b_б l_б, \quad (12)$$

where G_1 – is a three-sided pile, that is, the weight of the soil on the surface of the diagonal, kN.

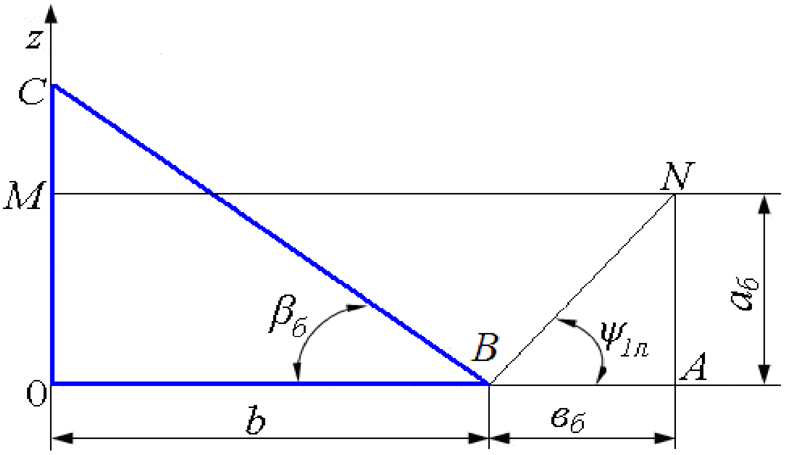

Figure 2. The scheme of moving the blade with an inclined plane in the transverse-vertical plane

We put the values of G_1, α_1 and γ_1 in expression (11) according to (12), (8) and (8)

$$R_{2x} = \frac{1}{2}\gamma_б a_б b_б l_б (tg\alpha_б \cos\varepsilon_б + f\cos\gamma_б)\sqrt{1-(tg\alpha_б\cos\varepsilon_б)^2}\, x$$
$$x\cos[arctg\frac{(1-\cos\varepsilon_б)tg\gamma_б}{1+tg^2\gamma_б\cos\varepsilon_б}]. \quad (13)$$

We determine the resistance created by the inertia force of the soil rising along the angle surface according to the following formula [8]

$$R_{3x} = \frac{\rho}{g}F_2\upsilon^2\sin\gamma_б\cos\psi_{1л}(1-i_{макс})[\sin\gamma_б\cos\psi_{1л} + f\sin(\varepsilon_б+\psi_{1л})\cos\alpha_1\cos\gamma_1], \quad (14)$$

in which F_2 – is a three-sided oblique pone, that is, it breaks under the influence of a bevel real cross-sectional area of the slab, m^2;

ρ – volumetric weight of soil, kg/m^3;

i_{max} – maximum settlement of the soil in front of the loaded plane coefficient.

From Figure 2 [4]

$$F_2 = \left(\frac{1}{2}a_б b_б\right), \quad (15)$$

We put the values of F_2, α_1 and γ_1 in (14).

$$R_{3x} = \frac{\rho}{2g}a_б b_б V_n^2\sin\gamma_б\cos\psi_{1л}(1-i_{макс})\{[\sin\gamma_б\cos\psi_{1л} +$$
$$+ f\sin(\varepsilon_б+\psi_{1л})\sqrt{1-(tg\alpha_б\cos\varepsilon_б)^2}\cos[arctg\frac{(1-\cos\varepsilon_б)tg\gamma_б}{1+tg^2\gamma_б\cos\varepsilon_б}]\}, \quad (16)$$

Putting the values of R_{1x}, R_{2x}, and R_{3x} into expression (1) according to (7), (8), (13) and (16), we get the following formula

$$R_{бx} = \frac{\tau a_б b_б l_б}{2\sin\gamma_1 \sin\psi_1}[\cos\psi_{1л}\sin\gamma_б + f\sin(\varepsilon_б + \psi_{1л})\sqrt{1-(tg\alpha_б\cos\varepsilon_б)^2}x$$

$$x\cos[\arg tg\frac{(1-\cos\varepsilon_б)tg\gamma_б}{1+tg^2\gamma_б\cos\varepsilon_б}] + \frac{1}{2}\rho\ a_б b_б l_б(tg\alpha_б\cos\varepsilon_б + f\cos\gamma_б)\sqrt{1-(tg\alpha_б\cos\varepsilon_б)^2}x$$

$$\cos[\arg tg\frac{(1-\cos\varepsilon_б)tg\gamma_б}{1+tg^2\gamma_б\cos\varepsilon_б}] + \frac{\rho}{2g}a_б b_б V_n^2\sin\gamma\cos\psi_{1л}(1-i_{макс})\{[\sin\gamma_б\cos\psi_{1л} +$$

$$+ f\sin(\varepsilon_б + \psi_{1л})\sqrt{1-(tg\alpha_б\cos\varepsilon_б)^2}\cos[\arg tg\frac{(1-\cos\varepsilon_б)tg\gamma_б}{1+tg^2\gamma_б\cos\varepsilon_б}]\}. \quad (17)$$

Results and Discussions

Under the influence of the inclined surface of the orthogonal section of Burchakkeskich, which is located at an angle of eb with respect to the horizon, the displacement of the soil occurs at an angle [9-11]. The peculiarity of Burchakkeskich is that when its tip enters the specified depth, the depth of the field edge decreases with the decrease of the depth of processing and is equal to *0* on the surface of the field. Based on literature sources and our own research, taking τ=2·10^4 Pa, a_b=0,12 m, b_b=0,1m, l_b=0,27m, γ_b=32°, ψ_{1l}=45°,f=0,5, ε_b=31°, α_b=50°, ρ=1480 kg/m^3, φ=45°, g-=9,8 m/s^2 and i_{max}=0,15 expression (17) the calculations showed that in the speed range of 1,8-2,3 m/s, the angle cutter's resistance to traction is in the range of 0,36-0,39 kN.

Conclusions

Calculations based on theoretical studies showed that the tensile strength of the angle grinder should be in the range of 0,6-0,39 kN in the speed range of 1,8-2,3 m/s. The pulling resistance of the plug depends on the processing depth and coverage width of the angle cutter, and it showed that the processing depth should be 10-12 cm and the coverage width should be 10-12 cm in order to ensure the high quality of the technological process with low energy consumption.

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