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JUSTIFICATION OF THE FORM OF THE CUTTING EDGE OF THE KNIFE OF THE EXPERIMENTAL WORKING BODY OF THE CULTIVATOR

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Abstract

The satata presents the results of theoretical studies to substantiate the shape of the cutting edge of the knife of the experimental working part of the cultivator. Calculations carried out based on the derived analytical dependencies showed that to ensure the sliding of particles along the cutting edge of the knife, its installation angle should be in the range of 145...1500.

Keywords: Experimental working body of a cultivator, spacing of cotton rows, shape of the cutting edge of the knife, angle of entry of loosening plates into the soil, speed of particle sliding along the cutting edge of the knife.

Introduction

After vegetation irrigation, two soil backgrounds are formed between the rows, differing from each other in the physical and mechanical properties of the soil. The same working elements are used to process these two different backgrounds. In addition, the number of working bodies installed on one cultivator beam, depending on the row spacing of the cotton plant, can be from 5 to 7 pieces. This leads to an increase in the overall dimensions and weight of the beam. In addition, they are not perfect in design and do not provide high-quality tillage in the middle of the row.

The working tools used, their number and placement patterns between rows do not provide the required degree of loosening of the soil, especially after vegetation irrigation.

Based on a review of the literature and the results of a study of the physical and mechanical properties of the soil in the inter-rows of cotton crops after vegetation irrigation, a prototype of a hemispherical cultivator loosening arm was developed and manufactured, allowing for cultivating the soil in a furrow.

Figure 1 shows a diagram of the developed ripping paw in two projections and its placement on the beam.

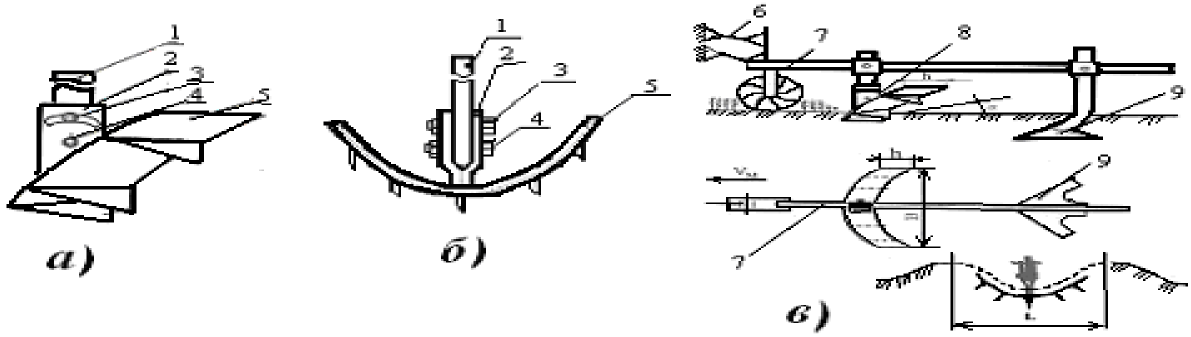


Fig. 1 Diagram of the experimental cultivator paw

a) Side view b) Front view; c) Arrangement diagram of the experimental working body, 1-stand, 2-bracket, 3 and 4-bolts, 5-razor, 6-hitch mechanism; 7-beamer; 8-experimental paw; 9-pointed paw.

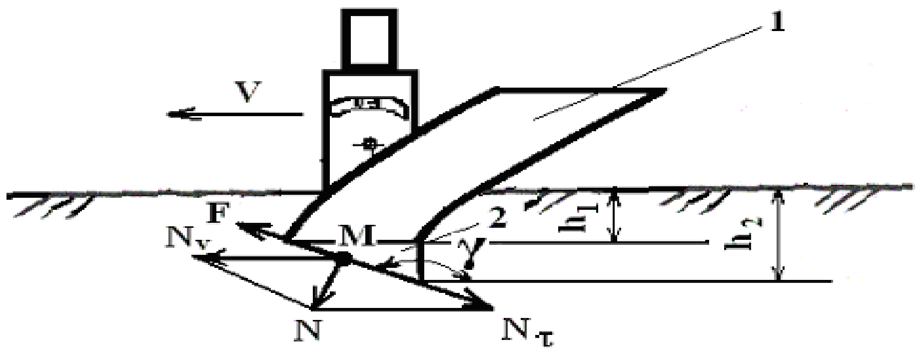
The parameters of the razor are determined depending on the size of the row spacing of the cotton plant, and it works in conjunction with a deep loosening paw.

The main parameters of the working bodies that influence their quality and energy performance indicators are: the width of the working body (B), the width of the shelf (h), the number of loosening plates (n), the angle of entry into the soil of the loosening plates (γ), the angle of entry of the working bodies (α), the radius of curvature of the razor blade (R_B) and the speed of the unit (V).

When operating the working body, it is important to ensure the free sliding of soil particles and weeds (including their roots) along the cutting edges of its razor and knives. Otherwise, soil and weeds will be loaded in front of the working body, contributing to its clogging and increasing traction resistance.

Let us consider (for a knife with a straight cutting edge) the conditions under which free sliding of soil particles and weed roots along the cutting edge of the knife will be ensured.

When the working body moves from the side of the cutting edge of the knife, the normal force N (Fig. 2) and the friction force F act on the particle M interacting with it at point A. We will decompose the normal force N into two components: N_v and N_τ, acting respectively in the direction of movement unit and along the cutting edge of the knife.



Rice. 2. Diagram of forces acting on a soil particle

1-shaving part of the working body; 2-knife working body.

From the diagram in Fig. 2 we have

$$N_V = N/\sin(\pi-\gamma) \quad и \quad N_\tau = Nctg(\pi-\gamma), \qquad (1)$$

where γ – is the angle of entry of the cutting edge of the knife into the soil.

The force N_τ tends to move the particle along the cutting edge of the knife, but this is prevented by the friction force

$$F = f\ N = N\,tg\varphi, \qquad (2)$$

where f– coefficient of soil friction on the knife.

At

$$N_\tau = Nctg(\pi-\gamma) \succ F = Ntg\varphi, \qquad (3)$$

or

$$\gamma \succ \frac{1}{2}\pi + \varphi, \qquad (4)$$

soil particles will slide along the cutting edge of the knife.

Thus, to ensure the sliding of soil particles along the cutting edge of the knife, condition (4) must be met, i.e. the angle of its entry into the soil should be greater

$$\frac{1}{2}\pi + \varphi,$$

The above is also true for ensuring the sliding of weeds and their roots along the cutting edge of the knife. In this case, condition (4) has the following form.

$$\gamma \succ \frac{1}{2}\pi + \varphi_c, \qquad (5)$$

where φ_c–the angle of friction of weeds and their roots along the cutting edge of the knife.

Expressions (4) and (5) determine the condition under which the sliding of soil and weeds along the cutting edge of the knife is ensured. However, it is impossible to determine from them what shape of the cutting edge of the knife provides the best conditions for the sliding of soil and weeds along it. To solve this issue, we determine in general terms the time of sliding of particle M along the cutting edge of a knife, which has a curved shape, from the starting point A to the ending point O (Figure 4). To do this, on the AO curve we select an elementary segment

$$ds = \sqrt{dx^2 + dz^2}. \qquad (6)$$

Then, using the inversion method, we obtain

$$t = \int_0^{x_1} \frac{\sqrt{dx^2 + dy^2}}{V_c}, \qquad (7)$$

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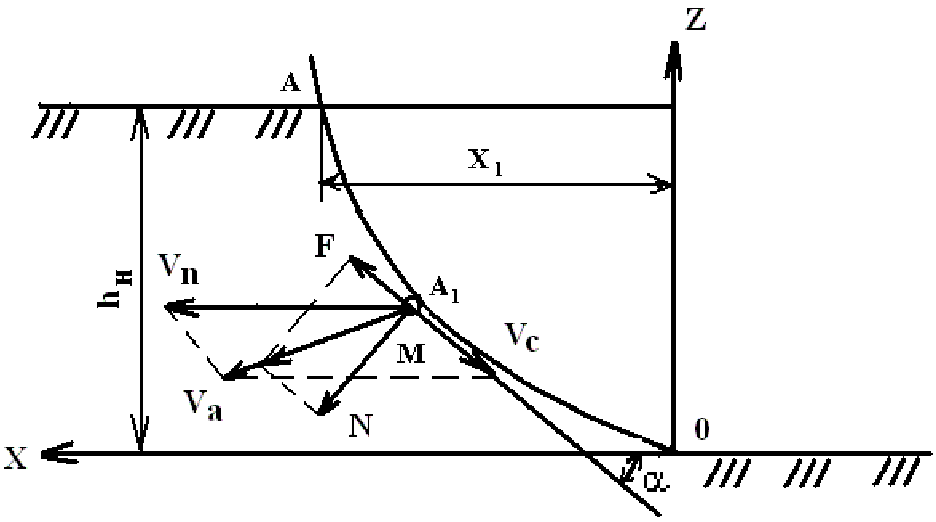
where V_c–the sliding speed of the particle M along the cutting edge of the knife.
X_1 – coordinate of the starting point along the X axis.
Using the diagram shown in Fig. 3, we determine the sliding speed of particle M along the cutting edge of the knife.

$$V_c = \frac{V_n \cos(\alpha+\varphi)}{\cos\varphi} = V_n(\cos\alpha - \sin\alpha tg\varphi), \tag{8}$$

where V_n – forward speed of movement of the working body (unit), m/s
α - is the angle between the X axis and the tangent drawn at point A_1 to the cutting edge of the knife.



Rice. 3 Scheme for determining the time and speed of particle sliding along the cutting edge of a knife

Taking into account (8), expression (7) has the following form

$$t = \int_0^{x_1} \frac{\sqrt{dx^2 + dz^2}}{V_n(\cos\alpha - \sin\alpha tg\varphi)} \quad . \tag{9}$$

Obviously, to avoid clogging of the working parts with soil and weeds, the time they slide along the cutting edge of the knife should probably be minimal.
The expression by which the angle of installation of the knife to the direction of movement is determined is one-sided and does not reveal the optimal relationship between angles γ and φ.
The optimal relationship between angles γ and φ can be established using equation (7). For a knife with a straight cutting edge it will look like this:

$$t = -\frac{l_p}{V_n(\cos\gamma + \sin\gamma tg\varphi)} \quad . \tag{10}$$

where l_p - length of the cutting edge of the knife.
From the diagram shown in Fig. 3,

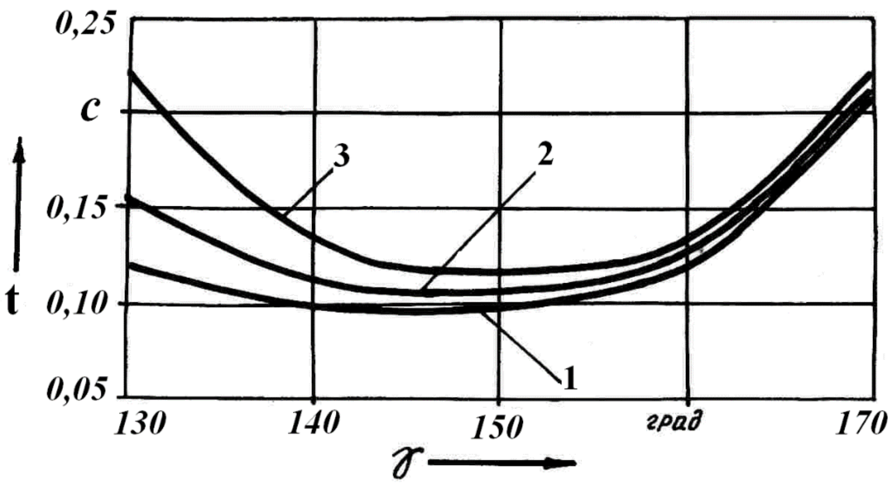
$$l_p = \frac{h_H}{\sin(\pi - \gamma)} = \frac{h_H}{\sin\gamma}\ , \qquad (11)$$

where $h_н$ - height (depth of stroke) of the knife.
Substituting the value of l_p from (11) into (10), we have

$$t = -\frac{h_H}{V_n(\cos\gamma + \sin\gamma tg\varphi)\sin\gamma}\ . \qquad (12)$$

Using this expression, Fig. 4 shows graphical dependences of the change in t on γ for $h_н$ = 5 cm, V_n= 1.5 m/s and various values of the friction angle φ. From these dependencies it follows that at certain values of the angle γ time t, i.e. the time for particles to slide along the cutting edge of the knife is minimal.

Dependence of t on γ at φ = 200(1), 250(2) and 300(3)



Rice. 4.

To determine the value of the angle γ at which t has a minimum value, we examine expression (12) for γ to the extremum, i.e.

$$\frac{dt}{d\gamma} = \frac{h_H}{V_n} \cdot \frac{(\cos^2\gamma - \sin^2\gamma + 2\sin\gamma\cos\gamma tg\varphi)}{(\cos\gamma + \sin\gamma tg\varphi)^2 \sin^2\gamma} = 0 \qquad (13)$$

This is possible with

$$\cos^2\gamma - \sin^2\gamma + 2\sin\gamma\cos\gamma tg\varphi = 0\,. \qquad (14)$$

Solving this equation for , we get

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$$\gamma = \frac{3\pi}{4} + \frac{\varphi_1}{2} \quad . \tag{15}$$

Substituting the known values φ_1=20...300 into (15), we obtain γ=145...1500.

Thus, to ensure the sliding of particles along the cutting edge of the knife, its installation angle should be in the range of 145...150^0.

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