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JUSTIFICATION OF THE FORM OF THE WORKING SURFACE OF THE SEALING PART OF THE EQUALIZER OF THE DEVICE FOR PRE-SEEDING PREPARATION OF THE SOIL

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ABSTRACT

The article proposes a theoretical calculation for determining the form for the working surface of the of the sealing part of the leveling working body (equalizer) of the device for preparing the soil for sowing. It has been found that the form/shape of the working surface of the sealing part of the leveling working body depends on the minimum time of sliding of soil particles over the working surface of the sealing part of the leveling device. A mathematical calculation method was employed to calculate the shape of the working surface of the sealing part of the leveling working body of the unit (device).

Based on the findings of theoretical studies, it was determined that a flat surface installed at an angle of $\gamma^{/}$ = 25...300° to the horizon is the best form of the working surface of the sealing part of the equalizer.

Keywords: form, equalizer (leveler), soil particles, sliding, sealing, working surface, integrative function, installation angle.

The sealing part of the leveling working body (hereafter referred to as the equalizer) of the unit for preparing the soil for sowing has a working surface that is shaped in such a way that the soil particles slide over it in the shortest amount of time possible, ensuring soil compression and leveling without the soil sticking and using the least amount of energy possible /1/.

We will consider the movement of a soil particles interacting with the working surface of the sealing part of the equalizer (leveler). It consists of two motions (Figure 1): translational motion with a speed of $V_п$ (where $V_п$ - the translational speed of the equalizer) and relative with the speed of V_o (where V_o - the speed of particle sliding along the working surface of the sealing part of the equalizer).

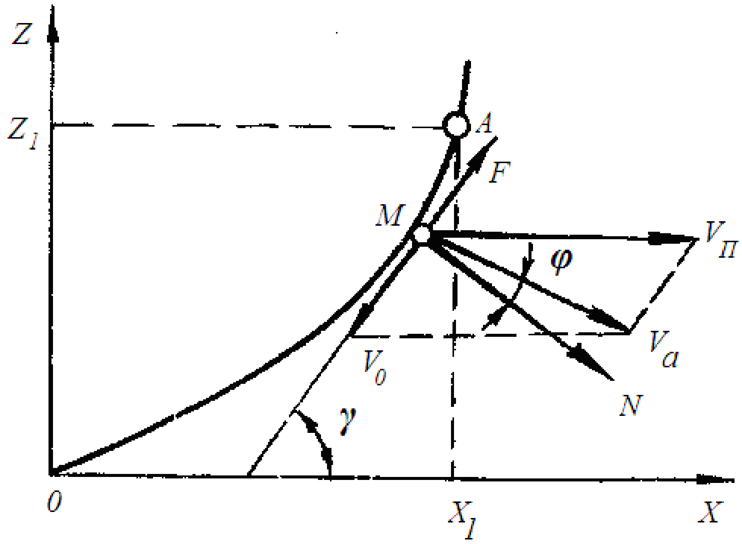

Figure 1
Justification of the shape of the working surface of the sealing part of the equalizer

With the help of the formula in Figure 1, we determined the sliding speed of soil particles on the working surface of the sealing part of the equalizer:

$$V_0 = \frac{V_П \cos(\varphi + \gamma)}{\cos\varphi} = V_П (\cos\gamma - \sin\gamma \cdot tg\varphi), \quad (1)$$

where: φ - angle of friction between soil and steel, gon;
γ - angle of slope respective to axes x, gon.

We determine the time t, during which the soil particle M travels from point A to point O of the working surface of the sealing part of the equalizer. To do this, on the AO curve, we select an elementary segment $DS = \sqrt{dx^2 + dz^2}$.
In this case

$$t = \int_0^{x_1} \frac{\sqrt{dx^2 + dz^2}}{V_O} = \int_0^{x_1} \frac{\sqrt{dx^2 + dz^2}}{V_П (\cos\varphi - \sin\gamma \cdot tg\varphi)} dx. \quad (2)$$

It is known that /2/

$$\sin\gamma = \frac{dz}{\sqrt{dx^2 + dz^2}} = \frac{Z'}{\sqrt{1 - (Z')^2}}; \quad (3)$$

$$\cos\gamma = \frac{1}{\sqrt{1 + (Z')^2}} \quad (4)$$

Considering that (3) and (4) formula (2) has the following form:

$$t = \frac{1}{V_П} \int_0^{x_1} \frac{1 + (Z')^2}{1 - Z' tg\varphi} dx. \quad (5)$$

Based on the principles of the calculus of variations /2/, for the extreme value of t, the function Z = f(x) must satisfy the following equation

$$\frac{d}{dx}(F_{z'} - F_z) = 0, \quad (6)$$

where: $F_{z^/}$, F_z - partial derivatives of F with respect to $Z^/$ and Z;

F – integrand function.

Since the integrand function

$$F = \frac{1+(Z^/)^2}{1-Z^/ \cdot tg\varphi} , \tag{7}$$

does not exactly depend on Z, then equation (6) has the following form:

$$\frac{d}{dx} F_{z^/} = 0 . \tag{8}$$

This can be done with

$$\frac{dF}{dZ^/} = const . \tag{9}$$

Taking the partial derivative of the integrand function (7) with respect to $Z^/$ taking into consideration (9) we obtain:

$$\frac{dF}{dZ^/} = \frac{2Z^/(1-Z^/ \cdot tg\varphi)+[1+(Z^/)^2]tg\varphi}{(1-Z^/ tg\varphi)^2} = C_1 , \tag{10}$$

where: C_1 - permanent quantity.

By solving the equation (10) with respect to $Z^/$, we can get in general a view

$$Z^/ = f(\varphi) = const . \tag{11}$$

Based on the above equation, we can confirm that the extreme value of the time t has a place with (occurs, exists with) a flat working surface of the sealing part; only in the case of $Z^/ = const$.

In order to obtain the nature of the extremum, commonly the Legendre conditions are used. According to these conditions, $Fz^/z^/ > 0$ we have a minimum, and at $Fz^/z^/ < 0$, we have a maximum.

From equation (7) after double differentiation with respect to $Z^/$, we get

$$Fz^/z^/ = \frac{2(1+tg^2\varphi)}{(1-Z^/ tg\varphi)^3} . \tag{12}$$

From this equation we have this formula, where fro $Z^/ tg\varphi > 1$ function t has a maximum, and for $Z^/ tg\varphi < 1$, it has a minimum. Thus $Z^/ = tg\gamma^/$ (where $\gamma^/$ - the installation angle of the sealing part of the equalizer to the horizon), the minimum of the function t is provided with the following formula

$$\gamma^/ < \frac{\pi}{2} - \varphi . \tag{13}$$

With a flat working surface, the sliding time of soil particles on it can be determined by the following formula:

$$t = \frac{h_o}{V_O \sin\gamma^/} = \frac{h_o}{V_П \cos\gamma^/ - \sin\gamma^/ tg(\varphi)\sin\gamma^/} , \tag{14}$$

where: h_0 - immersion depth of the equalizer in the soil, sm.

In the Figure 2 shown the change trends in the time of sliding of soil particles over the working surface of the sealing part of the equalizer depending on the angle of its installation to the horizon at various values of the friction angle φ and h_0 = 2,5 см, $V_П$ = 2 m/s.

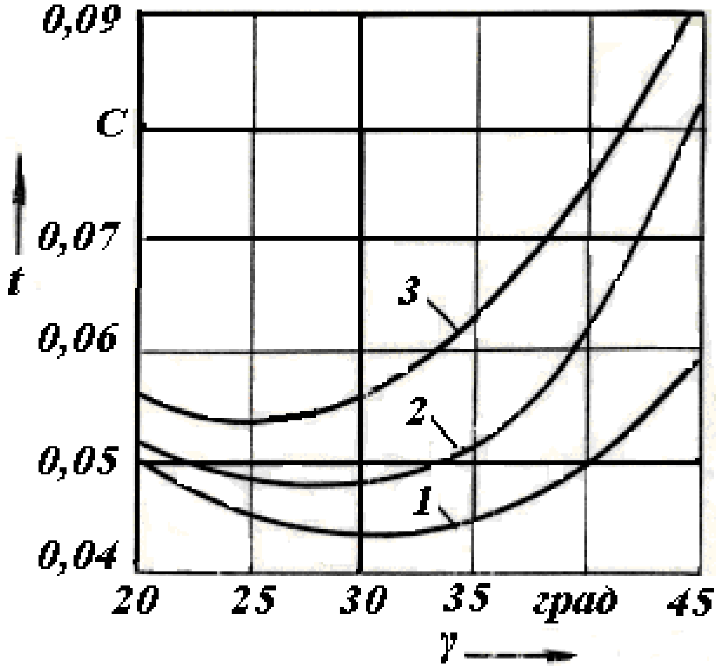

Figure 2
Trends of the time t of sliding of soil particles over the working surface of the sealing part of the equalizer on the angle γ of its installation to the horizon at:
1. $\varphi = 30^0$; 2. $\varphi = 35^0$; 3. $\varphi = 40^0$.

It can be seen from the graphs that the function $t = f(\gamma^/)$ has a minimum. Where, and the greater the friction angle φ, the smaller the equalizer installation angle to the horizon, at which the time of sliding of soil particles over its surface is minimal.
To determine the value of the angle γ, which ensures the minimum sliding time of soil particles on the working surface of the sealing part of the equalizer, we examine the equation (14) (in relation to γ) for an extremum, and we get

$$\gamma^/ < \frac{\pi}{4} - \frac{\varphi}{2}, \qquad (15)$$

By substituting known values of $\varphi = 30...40^0$ /3/ into this equation, we find that the working surface of the sealing part of the equalizer should be set to the horizon at an angle $25...30^0$.

Conclusion

Theoretical research has shown that a flat surface installed at an angle of $\gamma^/ = 25...30^0$ to the horizon is the best shape of the working surface of the equalizer sealing part is a flat surface.

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