# Based on the shape of the frontal surface of the column of the working body of the chisel-cultivator

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ABSTRACT

In this article was revised theoretical research forms of stand on agro- energetical indicators of chisel cultivator's work. For exception of clogging up of stands with plant remainders it is important to change their configuration, so that the opportunity of stand self-cleaning from plant remainders during the work itself would appear. In order to find optimal forms of cross cut there was studied different existing and experimental forms of stand frontal covers. The conducted researches show that asymmetrical frontal cover of stand better cleans from litter, and notably decreases the traction resistance of soil.

**Keywords:**

## 1. Introduction

Clogging of the working bodies of tillage machines with plant residues reduces the reliability of the technological process and worsens the agrotechnical and energy performance of its work. As numerous studies show, the clogging and sticking of working bodies largely depends on the shape and parameters of the frontal surface and the cross-section of their racks. /1-8/ However, to date there are no original technical solutions that exclude clogging of the racks of working organs with plant residues. In this regard, the task was set to develop and substantiate the shape and parameters of the cross-section of the rack of the working bodies of tillage machines, ensuring its self-cleaning from plant residues. A number of cross-sectional shapes of the racks of working bodies are known /9 /

Now consider the condition for the removal of plant residues from the rack. It depends on the shape and parameters of the cross-section of the frontal surface of the rack. The racks of the working bodies of chisel and other tools always work in loosened soil, i.e. after deformation of the formation with a paw. Working in a loose environment, racks, even with a sharpened cutting edge, cannot provide cutting of plant residues due to the lack of an anti-cutting stop. Therefore, the frontal working side of racks with a non-streamlined shape can be enveloped by powerful plant residues, contributing to the general clogging of working organs, especially on soils with high humidity.

## 2.Materials and methods

Racks of working bodies with a rectangular shape of the frontal surface are not subject to enveloping with plant residues when working mainly on dry soils and in fields with a low content of high-stemmed plant residues. When working on wet soils, the sliding of plant residues from the racks is sharply reduced due to their fracture at the sharp corners of the frontal surface, as a result, the working organs are periodically clogged.

The most intensive sliding of plant residues of all types occurs when working with racks with a semicircular and oval shape of the frontal surface. However, with an increase in the speed or humidity of the soil, clogging with plant residues occurs.

The force of pressing the plant with soil to the frontal surface of the rack in all known forms of cross-section, except for the asymmetric one, is the same on both sides of the top of the cross-section. This prevents the sliding of plant residues to the side and their descent from the rack, which leads to the enveloping of plant residues of the latter. In a rack with an asymmetric wedge-shaped cross-section, due to the displacement of the cutting edge from the middle of the thickness of the rack and the difference in the angles of sharpening of the faces, the forces acting on the stem that envelope the rack have different values on opposite faces, and the greater width of one of the faces and a smaller angle of its inclination ensure the sliding of the stems along this face and, ultimately as a result, self-cleaning of the rack from plant residues. However, in this form of cross-section, when meeting with the sharp cutting edge of the rack, the plant residues break and as a result, the sliding of plant residues along its edges becomes difficult, and consequently, their convergence worsens.

Taking into account the noted disadvantages of the existing forms of the cross-section of the racks, we have developed, at the level of the invention /10,11/, variants of the rack of the working bodies of the chisel cultivator with an asymmetric frontal surface having a rounded top and various forms of side faces (Fig.1).

Option 1. The rack 1 of the working body (Fig. 1, a) has a main bearing body 2 and a frontal surface 3 having an asymmetric shape in cross-section. The frontal surface 3 has a flat face 4, which is smoothly mated with the opposite side face 5 of the rack by an arc 6 with a radius of gm and with the adjacent side 7 and an arc 8. The side faces 5 and 7 of the rack are flat.

Option 2. The rack 1 of the working body (Fig. 1, b) also has a bearing body 2, an asymmetric one consisting of small 4 and large 5 side faces, a frontal surface 3, a concave side face 6 and a convex side face 7 of the rack. The side faces 4 and 5 of the frontal surface 3 are convex and of different sizes. Face 4 is of greater curvature, and face 5 is of lesser curvature. The side face 5 of the frontal surface is smoothly conjugated with the smaller face 4 and the side face 7. The side face 6 of the rack is concave to the equidistant face 5 at a distance of double the radius of curvature of the face 4.

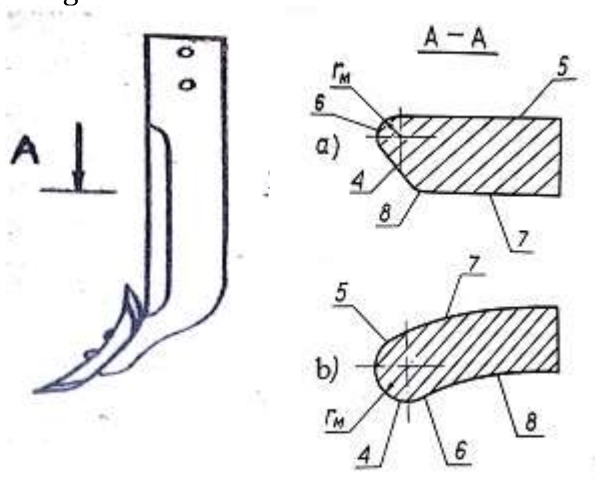


Fig.1.An asymmetricexperimental rack with a rounded top of the frontal surface: a) option 1 – with flat side faces; b) option 2 – with convex-concave side faces,

### 3. Results and discussions

Let's consider the condition of weeds coming down from the frontal surface of the developed racks with the translational movement of the working body, plant residues collide with the front rounded top of the frontal surface of the rack, bend around it and begin to move with it in the direction of movement (Fig. 2.4), while the force of the drag of the soil gives a component directed along a flat (large) face to the side, the opposite direction of movement.

This force tends to move plant residues along the frontal surface of the rack. However, this is prevented by the friction force arising from the interaction of the rack with the soil and plant residues To ensure their descent from the rack, the force causing the plant residues to slide along its flat face must be greater than the force preventing them from sliding, i.e.

$P_c \geq P_n$ (1)

where Pc is the force contributing to the descent of the sliding of plant residues along the frontal surface of the rack to the side;

$\mathbf{P}_n$ – the force preventing the descent on the frontal surface.

From Fig.2. we have

$P_c = N_T = N\ ctg\beta_1$ (2)

Let's determine the normal force acting on the plant residue from the side of the flat face of the frontal surface of the rack. To do this, we assume that the specific pressure arising on the cross-section of the rack from the resistance of the soil is evenly distributed throughout its perimeter.

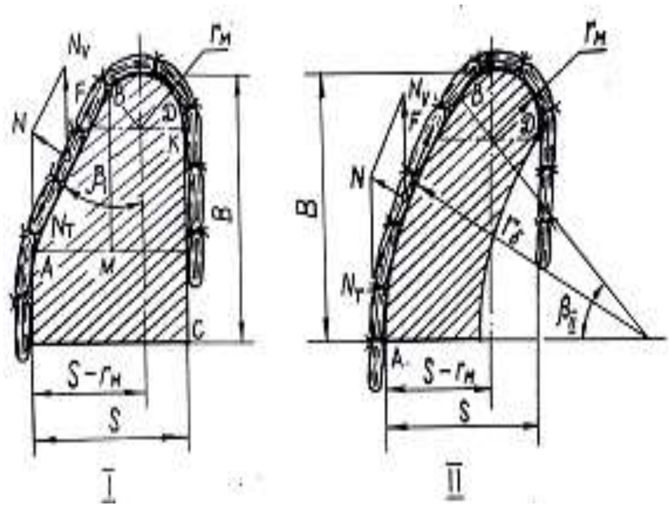

Fig.2. Scheme of interaction with plant residues of an asymmetric rack with a rounded top of the frontal surface: I – with flat side faces; II – with convex-concave side faces, where N is the normal force acting on the soil and plant residue from the side of the flat face of the frontal surface of the rack; – the angle of inclination of the flat face of the frontal surface racks to the direction of movement.

Then, according to Fig. 2

$N = q \cdot l \cdot t,$ (3)

where q is the specific pressure of the soil on the frontal surface of the rack;

– length of the flat face of the rack;

t is the thickness of the weed stem.

We express by S, rM and . of

$\boldsymbol{l} = AB = \frac{MA}{cos(90^0 - \beta_1)} = \frac{MA}{sin\ \beta_1},$ (4)

Because

$MA = S = r_M - r_M\ cos\beta_1 - S - r_M\ (1 - cos\,\beta_1)$ (5)

$\boldsymbol{l} = \frac{S - r_M(1 - cos\,\beta_1)_M}{sin\,\beta_1},$ (6)

Taking into account (3) and (6), expression (2) has the following form

$P_c = q \frac{S - r_M (1-\cos\beta_1)_M}{\sin\beta_1}\ t \cdot ctg\ \beta_1$ (7)

where S is the width of the cross–section of the rack.

The descent of the plant residue from the rack is prevented by the friction forces arising in the AB, VC and CS sections, i.e.

$P_n = F_{AB} + F_{BK} + F_{KC}$, (8)

We determine the friction force arising along the flat face of the frontal surface of the rack:

$$F_{AB} = f \cdot N = f \cdot q \cdot l \cdot t, \quad (9)$$

where f is the coefficient of friction of plant residues on the rack material.

Taking into account (6), expression (9) has the following form

$F_{AB} = l \cdot q\ \frac{S - r_M (1-\cos\beta_1)_M}{\sin\beta_1}\ t,$ (10)

Next, we determine the friction force that occurs along the arc

$$F_{BK} = f \cdot q \cdot r_M \cdot t\ (\pi - \beta_1) \quad (11)$$

According to the research of A.N. Zelenin. /12/ the friction force arising on the side surface of the rack in comparison with the friction force arising on its frontal surface has an insignificant value. Therefore, we will not take it into account in the calculations.

Taking into account (10) and (11), the force preventing the plant residues from sliding towards the flat face of the frontal surface of the rack is equal to

$P_n = f \cdot q \cdot r_M \cdot t\ (\pi - \beta_1)\ f - \frac{1-\cos\beta_1}{\sin\beta_1}\ f \cdot q\ \frac{S}{\sin\beta_1} \cdot t$ (12)

Substituting the value of Pc and Rp in (1), we get

$$q\ \frac{S - r_M(1-\cos\beta_1)}{\sin\beta_1} \cdot t \cdot ctg \cdot \beta_1 \geq f \cdot q \cdot r_M \cdot t \left[ (\pi - \beta_1) - \frac{(1+\cos\beta_1)}{\sin\beta_1} \right] + f \cdot q\ \frac{S}{\sin\beta_1} \cdot t, \quad (13)$$

Or

$$\frac{S - r_M(1+\cos\beta_1)}{\sin\beta_1}\ ctg \cdot \beta_1 \geq f \cdot r_M \left[ (\pi - \beta_1) - \frac{(1+\cos\beta_1)}{\sin\beta_1} \right] + f\ \frac{S}{\sin\beta_1}, \quad (14)$$

From where, after some transformations and taking into account the fact that f = tg , we get

$$r_M \leq \frac{S\,(ctg\beta_1 - tg\varphi)}{(\pi - \beta_1)\, tg\varphi \sin\beta_1 + (1+\cos\beta_1)\,(ctg\beta_1 - tg\varphi)} \quad (15)$$

Thus, the condition for the sliding of plant residues towards the flat face of the frontal surface of the rack depends on the angle of its inclination to the direction of movement, the physical and mechanical properties of the soil and plant residues, as well as the thickness of the rack.

A prerequisite for the sliding of plant residues along the flat face of the rack, as can be seen from the analysis (15), is

$$ctg\beta_1 > tg\varphi \quad (16)$$

Or

$$ctg\beta_1 < 90^0 - \varphi \quad (17)$$

Similarly, for the second variant of the experimental rack, we obtain

$$r_M \leq \frac{B\left(\frac{\pi}{2} - \varphi\right) B\left(ctg\frac{\pi - 2\varphi}{4} - tg\varphi\right)}{\left(\frac{\pi}{2} + \varphi\right)\sin\varphi + \left(\frac{\pi}{2} - \varphi\right)\left(ctg\frac{\pi - 2\varphi}{4} - \varphi\right)(1 - \cos\varphi)} \quad (18)$$

$$r_M > \frac{B\left(\frac{\pi}{2} - \varphi\right) B\left(ctg\frac{\pi - 2\varphi}{4} - tg\varphi\right)}{\left(\frac{\pi}{2} + \varphi\right)\sin\varphi + \left(\frac{\pi}{2} - \varphi\right)\left(ctg\frac{\pi - 2\varphi}{4} - \varphi\right)(1 - \cos\varphi)} \quad (19)$$

where are the radii of curvature of the small and large faces of the frontal surface of the rack; B is the length of the cross section of the rack.

Calculations carried out according to formulas (15), (18) and (19) at = 30 °, = 45°, S= 30 mm and B = 60 mm show that to ensure the descent of plant residues and rhizomes from the rack, the radius value for the first variant of the rack should be no more than 9.1 mm, for the second one is 32.6 mm, and the radius value is at least 51.5 mm.

## 4. Conclusions

1. To ensure the sliding of plant residues on the frontal surface of the rack, the radius of its curvature must be at least 28 cm.

2. Taking into account the noted disadvantages of the existing forms of the cross-section of the racks, we have developed variants of the rack of the working bodies of the chisel cultivator with an asymmetric frontal surface having a rounded top and various forms of side faces.

3. The condition of sliding plant residues towards the flat face of the frontal surface of the rack depends on the angle of its inclination to the direction of movement, the physical and mechanical properties of the soil and plant residues, as well as the thickness of the rack.

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