

# Study of the profile of a flat-cutting working body of a plough

*Eugeny A. Saprykin*<sup>1, \*</sup>, and *Evgeny S. Gusak*<sup>1</sup>

<sup>1</sup>FSBEI HE Kuban State Agrarian University named after I.T.Trubilin, Krasnodar, Russian Federation

**Abstract.** The work is devoted to the main tillage, namely the theoretical substantiation of the profile of a flat-cutting working body of a plough. The article has a research character, which is expressed in the fact that the theoretical analysis of the method of determining the angle of sharpening of soil-processing working bodies according to the degree of gradual wear of working bodies were shown in works on this problem. There was also substantiated the type of the proposed design, there were given its description and flow of a technological process. As a result of the work done, there were obtained the theoretical dependence of the sharpening angle of working bodies and influence of the degree of wear on traction resistance of an arable unit. The conclusions set out the main results achieved so far.

Designing of tillage equipment and units is a complex technological and production process. From the whole complex of field works the most energy-stable process is ploughing. According to long-term data of leading scientists and research institutes up to 35-40% of energy and 22-30% of labor costs are required to perform ploughing. In recent years there are more and more metal-intensive and technological machines and units for tillage. So, recently again many producers return to traditional technologies of crop cultivation, and deep soil processing occupies one of important places both with a turn, and without a turn of layer.

In order to justify the most rational form of a new, worn and so-called stabilized profile and shape of a flat-cutting working body, it is necessary to consider the processes of its interaction with soil and find forces acting on them [1].

To comply with cutting condition it is necessary that the force  $\overline{P}_{xx}$  acts proportionally to the volume of soil crushing by the formula:

$$\overline{P}_{xx} = kqt, bS \tag{1}$$

Values can be applied to our working conditions at processing depth of 20 cm, the working depth of a flat-cutting working body is 12 cm, since the working body is fixed hard to the body of a plough.

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\* Corresponding author: [sergey.belousov.87@mail.ru](mailto:sergey.belousov.87@mail.ru)

Undercutting of soil by a wedge is made under the angle  $\alpha_{31} + \alpha_3$ , because these values are constant and the initial influence on soil amounts for a cutting wedge [2].

As a result of disruption of compacted soil layer up on the edge of a blade (cutting edge) from the force  $P_{ix}$ , there was appeared the force of friction  $P_{iz}$  which was equal:

$$P_{iz} = P_{ix} \operatorname{tg} \varphi = K_{o/in} b \delta \operatorname{tg} \varphi \quad (2)$$

The total force  $P_{ax}$  of separation and pushing the wedge and deformation of a layer at a = 12 cm and there was obtained  $P_{ax} = 225H$  at a preliminary cutting of a layer in a horizontal plane, and the friction of a blade against the furrow wall  $P_{as} = 90H$ . The vertical components give recessing force that balances an arable unit, which contributes to the smooth flow of technological process of a layer-by-layer main tillage with turnover of a layer [3,4].

In the presence of grinding of a working body with the front part, which affects the soil layer, the nature of soil deformations will change. In turn, it will change the coefficient K in the formula (1). In the result of shift on  $\delta_{max}$  of the pressure diagram to the cutting edge,  $dP_{ix}$  in the point A to zero will change, the Figure 1 of the force  $dP_{ix}$  at this case in the point B will be equal:

$$dP_{ix} = KqdV = KqSdF = Kqda'db \quad (3)$$

where  $dV$  - volume of soil crushing,  $\text{cm}^3$

$da'; db$  - height and width of a working body's sharpening.

In accordance, the equal force  $P_{ix}$  is determined by the way of integration of the expression (4)

$$P_{ix} = \int_0^b \int_0^\delta Kq\delta f'(\delta) db d\delta \quad (4)$$

where  $f'(\delta)$  – first derivative function of a profile of a working body's sharpening.

At sharp blade  $f'(\delta) = \operatorname{tg} \varepsilon_0$  correspondingly

$$P_{ix} = 0,5Kqb\delta^2 \operatorname{tg} \varepsilon_0 \quad (5)$$

In our case  $\varepsilon_0$  if the angle of a working body's sharpening is 30 C\* at present values in the formula (6) we will obtain:

$$P_{ix} = 0,5Kqt_n b\delta \quad (6)$$

From here we get the force of the normal soil pressure  $P_n$  at the sharpening angle

$$P_{ix} = 0,5Kqt_n b\delta \sin \varepsilon_0 \quad (7)$$

Taking into account the friction force F, the resultant  $P'$  and its components on X and Z axes are determined by formulas:

$$P'_x = 0,5Kqt_x b \delta \frac{\sin \varepsilon_0}{\cos \varphi} \tag{8}$$

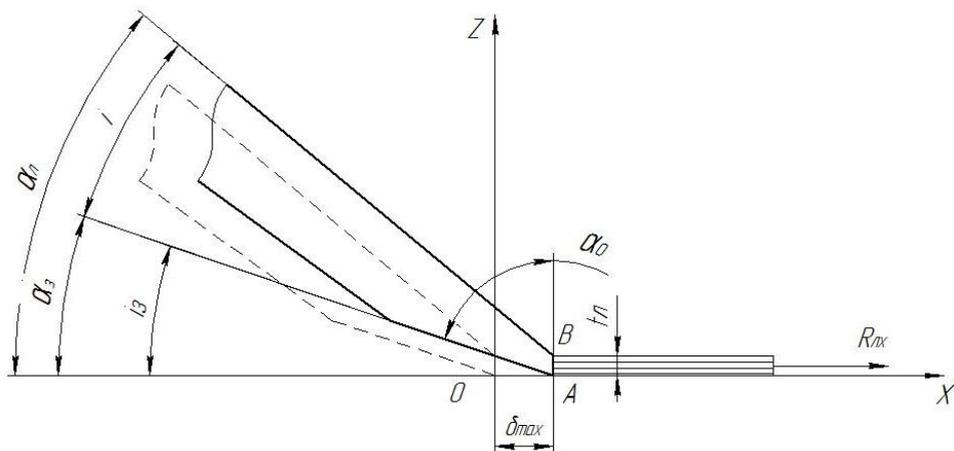
$$P_{.xx} = 0,5Kqt_x b \delta \frac{\sin \varepsilon_0 \sin(\varepsilon_0 + \varphi)}{\cos \varphi} \tag{9}$$

$$P_{.xz} = 0,5Kqt_x b \delta \frac{\sin \varepsilon_0 \cos(\varepsilon_0 + \varphi)}{\cos \varphi} \tag{10}$$

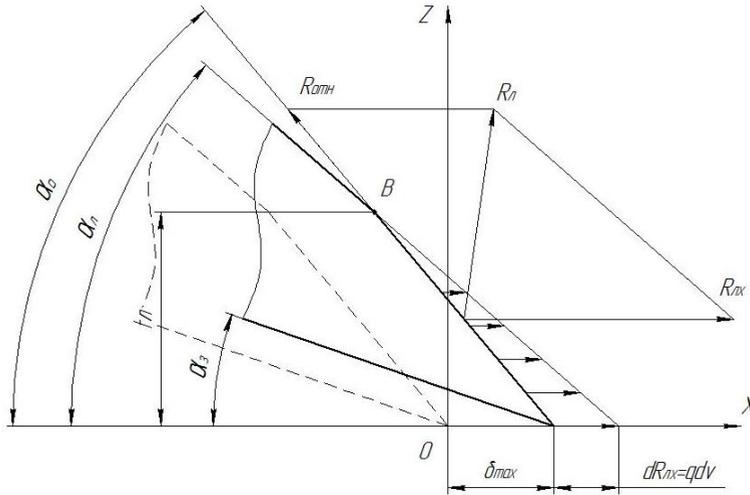
With regard to our working body:

As the analysis of researches of leading scientists showed increasing the width of a sharpening profile of a working body from 0 (zero) to a value close to the width of an opposite angle of sharpening and constant unchanged width of a working body and its profile, the vertical force  $P_{.xz}$  contributes to the deepening of an arable unit, stabilizes its movement as in horizontal and as in vertical direction [5].

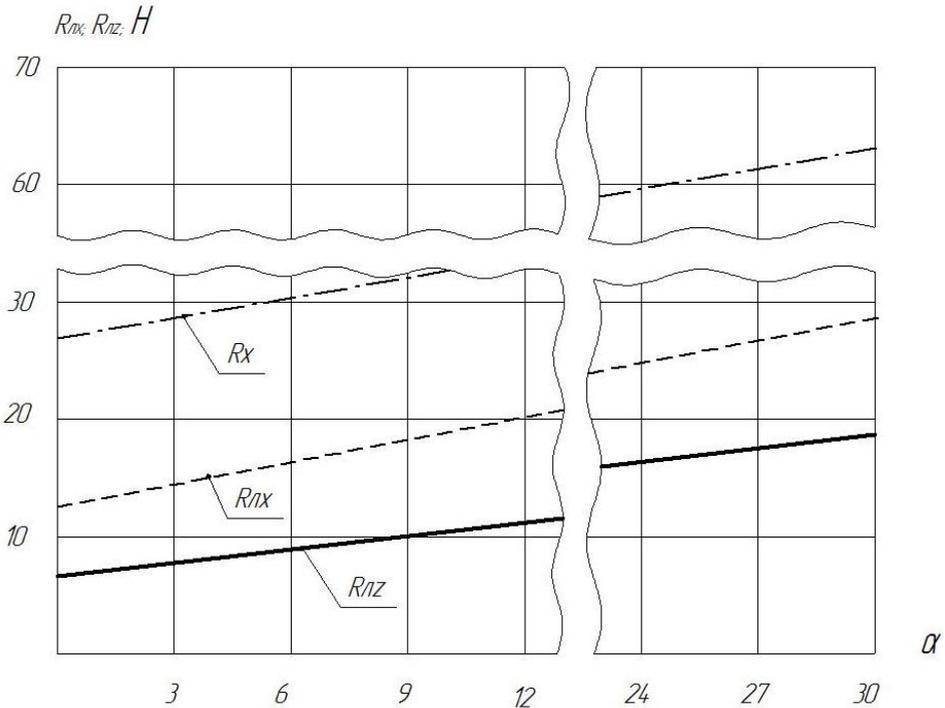
During operation, the profile of a cutting element wears out and turns into a parabolic shape. At the same time, the process of influence of a working body on soil changes significantly, there is an additional force  $P_{.xz}$  that affects the working body from the bottom up and tries to push the working body up [6].



**Fig. 1.** Scheme of determination of forces acting to a blade with classic sharpening.



**Fig. 2.** Scheme of determination of forces acting to a blade with applied type of sharpening



**Fig. 2.** Diagram of forces change depending on width of a cutting edge sharpening

The given data in the diagram were obtained by the theoretical method and it is necessary to conduct laboratory researches for more reliable information. However, according to researches of leading scientists, these dependences are linear and limited only by several factors: power of energy equipment, soil conditions and constantly changing conditions of sharpening of a working body [7,8].

According to the results of the work done, the following conclusions can be drawn:

- use of worn-out working bodies lead to decrease in qualitative and quantitative rates of an arable unit, consumption of fuels and lubricants increases.
- use of a working body with a sharpening profile the sum of angles of attack is less than the angle of installation of a working body on a body of a plough will help to stabilize the process of ploughing.
- use of a technically operable and sharpened additional working body for layer-by-layer processing helps to preserve original agronomic requirements to tillage with layer's turnover [9,10].

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