

# Study of the Soil Cutting by Knife Flat Active Rippers – Milling Cutter

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### Abstract

The results of comparative experimental study of combined front plough with an active working body, the front plough with passive working bodies and plough PLN-5-35 in the unit with the tractor T-50K are given. It was found that the use of active working bodies, in addition to performing the function of technological and propulsion, allows improving the quality of work and energy indices of the front of the plough in the processing of soil with low humidity content and plant remains.

**Keywords:** Plough, Smooth ploughing, High-power wheeled tractor, Active working body, The quality of ploughing

### Introduction

Increased productivity of plough sets is possible by increasing the capture width and operating speed. Width of capture of modern serial ploughs has reached 3,15 m, its further increase is connected with overcoming of a number of considerable difficulties. The length of the plough with the number of its housings increases to a greater extent than the width, as distance in the longitudinal direction between the housings 2-3 times greater than their width of capture. When the plough length increases quality of ploughing deteriorates, as the plough worse adapts to field microrelief and so deviations from the desired depth of ploughing width increases his capture, maneuverability of plough set deteriorates, the specific gravity of the plough dramatically increases.

Operating speed of ploughing currently ranges from 7-9 km/h, since further increase leads to the spreading of the soil and a sharp rise in the traction resistance of the plough.

Active working body receiving the drive from the tractor produces Shredders and loosening the topsoil, thereby preventing clogging of the space intercase cameos and blocks the processing of fields with a significant amount of crop residues and improves the quality of treatment. Elements of technology and combined plough with active and passive working bodies are protected by patents [1-4].

### Materials and Methods

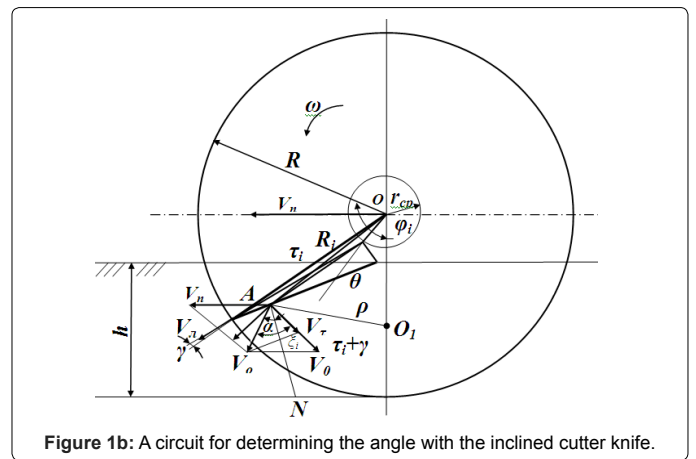
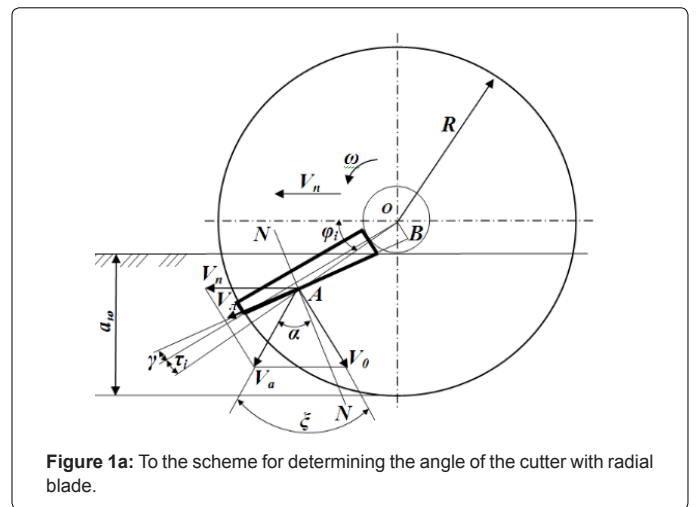
For loosening and compacted upper soil layers, as well as shredding crop residues on the combined offer frontal plough install active cutter with flat blades. Flat blades at the lowest possible energy costs provide the required crumbling of the soil as the soil after the mill processing is exposed to the ploughing.

Active flat cutter knives can be set [1-4] radially (Figure 1a) with an inclination of the blade in the rotational direction of radius, or vice versa (Figure 1b). When installing the blades with a slope of the radius of rotation on the go jamming deteriorates of cut plant residues, so this type of interaction cutter knives we have not seen. It is well known that the nature of the interaction of the blade and the force required to cut the material largely depends on the angle  $\alpha$  between the absolute speed  $V_0$  cutting blade points and the normal  $NN$  to it.

For milling with radial blades.

$$\alpha = \xi - \tau_i - \gamma \tag{1}$$

where  $\xi$  - the angle between the peripheral speed  $V_a$  and an absolute velocity  $V_0$  cutting point of the knife blade.



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$\tau_i$  - the angle between the peripheral velocity  $V_0$  of the knife blade point and the normal  $N - N$  him.

From Figure 1, a), we have

$$tg \xi = \frac{V_n}{V_\tau} = \frac{V_n \cos(\phi_i + \tau_i + \gamma)}{V_{oi} - V_n \sin(\phi_i + \tau_i + \gamma)} = \frac{\cos(\phi_i + \tau_i + \gamma)}{\lambda_i - \sin(\phi_i + \tau_i + \gamma)}$$

$$\sin \tau_i = \frac{OB}{OA} = \frac{b_n}{2R_i} \tag{2}$$

where  $b_n$  - width of the blade;

$\lambda_i$  - the kinematic parameters for this point of the cutter blade

$$\lambda_i = \frac{V_{oi}}{V_n} = \frac{\lambda R_i}{R} \tag{3}$$

where  $R_i$  - the distance from the cutter to the axis of rotation of the point of the knife blade.

Substituting the values of  $\epsilon_i$ ,  $\gamma$  and  $\tau_i$  to obtain:

$$\alpha = \left[ \arctg \frac{\cos(\phi_i + \arcsin \frac{b_n}{2R_i} + \arctg \frac{b_n}{2\epsilon_n})}{\lambda_i + \sin(\phi_i + \arcsin \frac{b_n}{2R_i})} - \arcsin \frac{b_n}{2R_i} - \arctg \frac{b_n}{2\epsilon_n} \right] \tag{4}$$

Then the knife slip ratio  $i$  on the material being cut is determined by the following formula

$$i = tg \left[ \arctg \frac{\cos(\phi_i + \arcsin \frac{b_n}{2R_i} + \arctg \frac{b_n}{2\epsilon_n})}{\lambda_i + \sin(\phi_i + \arcsin \frac{b_n}{2R_i})} - \arcsin \frac{b_n}{2R_i} - \arctg \frac{b_n}{2\epsilon_n} \right] \cos \phi - \sin \phi. \tag{5}$$

For cutters with blades tilted back at an angle of  $\theta$  (Figure 1b)

$$d = \xi - \tau_i \tag{6}$$

$$\xi = \arctg \frac{\cos(\phi_i + \tau_i + \gamma)}{\lambda_i - \sin(\phi_i + \tau_i + \gamma)}$$

$$\tau_i = \arcsin \frac{r_\phi \sin \theta}{R_i} \tag{7}$$

where  $r_\phi$ -the radius of the blade attachment.

Substituting the values  $\epsilon$  and  $\tau_i$  (6), we obtain

$$\alpha = \arctg \frac{\cos(\phi_i + \arcsin \frac{r_\phi \sin \theta}{R_i} + \arctg \frac{b_n}{2\epsilon_n})}{\lambda_i - \sin(\phi_i + \arcsin \frac{r_\phi \sin \theta}{R_i})} - \arcsin \frac{r_\phi \sin \theta}{R_i} - \arctg \frac{b_n}{2\epsilon_n};$$

$$i = tg \left[ \arctg \frac{\cos(\phi_i - \theta + \arcsin \frac{r_\phi \sin \theta}{R_i} + \arctg \frac{b_n}{2\epsilon_n})}{\lambda_i - \sin(\phi_i + \arcsin \frac{r_\phi \sin \theta}{R_i})} - \arcsin \frac{r_\phi \sin \theta}{R_i} - \arctg \frac{b_n}{2\epsilon_n} \right] \cos \phi - \sin \phi. \tag{8}$$

From these expressions (7) and (8) that the slip ratio  $i$  of the cut material knife blade has a variable numerical value, which depends on the blade position relative to the soil surface, kinematic parameter  $\lambda_i$ , the width of the blade  $b$ , the distance  $R_i$  from the blade point to the axis of rotation milling and friction angle of the cut material. On the value of  $i$  for the milling with inclined blade but these factors affect and angle  $\theta$ .

Substituting the values of  $\alpha$  in the corresponding dependence define “real” value of the angle of sharpening  $\beta_\alpha$ , the transformation ratio of the angle and shape of sharpening  $K_\beta$  blade.

$$\beta_\alpha = \arctg \sqrt{1 + tg^2 \left[ \arctg \frac{\cos(\phi_i + \arcsin \frac{r_\phi \sin \theta}{R_i} + \arctg \frac{b_n}{2\epsilon_n})}{\lambda_i - \sin(\phi_i + \arcsin \frac{r_\phi \sin \theta}{R_i})} - \arcsin \frac{r_\phi \sin \theta}{R_i} - \arctg \frac{b_n}{2\epsilon_n} \right]} \tag{9}$$

$$K_\beta = \frac{\beta_\alpha}{\beta} \tag{10}$$

$$\beta_\alpha = \arctg \sqrt{1 + tg^2 \left[ \arctg \frac{\cos(\phi_i + \arcsin \frac{r_\phi \sin \theta}{R_i} + \arctg \frac{b_n}{2\epsilon_n})}{\lambda_i - \sin(\phi_i + \arcsin \frac{r_\phi \sin \theta}{R_i})} - \arcsin \frac{r_\phi \sin \theta}{R_i} - \arctg \frac{b_n}{2\epsilon_n} \right]} \tag{11}$$

settlement of the obtained expression results at  $\lambda = 2,2$ ,  $\theta = 30^\circ$ ,  $R_i = 280$  mm,  $\beta = 20^\circ$  are shown in Table 1.

$R_i$ Sm	$\phi_i = 45^\circ$			$\phi_i = 85^\circ$		
	$\alpha$	$l$	$K_\beta$	$\alpha$	$l$	$K_\beta$
10	68°40	2,23	0,65	22°20	0,56	1,08
15	37°10	0,87	1,04	13°30	0,42	1,1
20	29°40	0,65	1,24	6°10	0,09	1,13
25	24°10	0,59	1,35	4°40	0,06	1,15

**Table 1:** Variation of the angle  $\alpha$ ,  $\epsilon$  coefficient  $K_\beta$  and depending on the angle  $\phi_1$  (blade position) and the distance  $R_i$  from the point of the knife blade rotational axis.

From the Table 1 it is seen that the various blades have different coefficients of terms of longitudinal displacement  $\epsilon$ , and accordingly, the angle  $\beta$  and sharpening blades form variously transformed.  $\epsilon$  coefficient with increasing angle of rotation  $\phi_i$  of the knife and the kinematic parameter  $\lambda$  decreases along the entire length of the knife blade.

### Conclusion

1) Application of active working bodies, in addition to performing the function of technological and propulsion, allows to improve the quality of work and energy indices of the front of the plough in the processing of soil with low moisture content and plant remains.

2) Optimal value of angle position accords with  $\phi_i$  and  $R_i$  distance from the point of the blade to the blade rotation axis.

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