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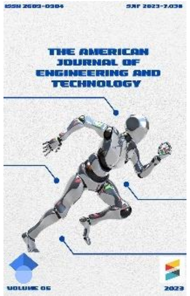

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Research Article

JUSTIFICATION OF THE SLIDING CUTTING ANGLE OF THE KNIFE OF THE MOWER-BUCKER KPP- 3.0

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ABSTRACT

The article presents studies of the interaction of the working bodies of agricultural machines with plants. The study of theoretical and applied issues of cutting desert-pasture stems. Theoretically proved the shape of the cutting element in the form of a parallelogram with an angle of oblique or sliding cutting with the optimal value of the cutting angle in the range of 30°- 35°.

KEYWORDS

Working bodies, plant stems, edge, cutting, blades, constant value, stem thickness, stem density, stem elasticity modulus, sliding cutting angle.

INTRODUCTION

As is known [1], in studies of the mechanization of the interaction of the working bodies of agricultural machines with processed or technological materials (soil, plant, marketable crop, etc.), the study of theoretical and applied issues of cutting plant stems, including desert-pasture ones, occupies a sufficient place.

In the literature [1], the cutting process is divided into two types:

- in one case, the knife blade moves in the direction of the cut only in the direction normal to its edge;
- in the other - in the same time with the movement in the normal direction, it also moves along the edge.

The first process is called cutting, the second - sliding cutting.

The author of [2] believes that all cases of cutting can be divided into three groups:

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- cutting with normal pressure P_H without the participation of a tangential force P_C and without moving along the edge S_C;
- cutting with the participation of a tangential force P_C and movement along the edge S_C, but without sliding. Such cutting takes place when the angle α_C between the normal to the edge of the blade and the direction of its movement does not exceed the angle φ_{mp} of friction of the knife blade along the plant stem;
- cutting with the participation of force P_K and with sliding. In this case α_C, the angle is greater than the angle of friction φ_{mp}.

Considering that the dynamic coefficient of friction of metal on wood is 0.4, we conclude that the angle of sliding cutting $\alpha_C > 22^O$, since

$$\varphi_{mp} = arctg0{,}4 \approx 22^O$$

Figure 1 shows a proposed cutting element in the form of a parallelogram, with a cutting angle α_C, which is called the angle of oblique cutting or sliding cutting [2]. Cutting the stem with a straight motion requires a lot of effort, while the same cut can be obtained with a little effort using a sliding motion.

The authors of [3] proposed a relationship between the forces required to cut the material and the movement of the blade over the material s_C in the form of the following equation:

$$P_{\text{н}}^3 \cdot S_c = A \qquad (1)$$

where A is a constant value (constant) for a specific blade and a specific material (stalk) with unchanged properties.

In the process of cutting m, the knife hits the stem with a mass and slightly changes its speed. The impact time t_y is much less than the cutting time t_p, which are determined by the following expressions:

$$t_y = 2b\sqrt{\rho / E}\,; \qquad (2)$$

$$t_p = b / V_{н}\,, \qquad (3)$$

where b - is the stem thickness; ρ - is the stem density; E - is the modulus of elasticity of the stem; $V_н$ - is the normal component of the knife speed after impact.

Now we write expressions for the parameters of equation (1):

$$P_н t_y = \frac{1+k_в}{1-k_в} mV_н\,; \qquad (4)$$

$$s_c = V_c t_p\,, \qquad (5)$$

where $k_в$ - is the recovery factor when the knife hits the stem; V_c - is the tangential component of the knife speed after impact.

Since is the α_c - sliding cutting angle, the following expressions can be written [4]:

$$V_н = V_{abc}\cos\alpha_c; \qquad (6)$$

$$V_c = V_{abc}\sin\alpha_c, \qquad (7)$$

where $V_{абс}$ is the absolute speed of the knife after impact.

From the previous expressions (1) - (7) we have:

$$A = \left(\frac{mV_{abc}\cos\alpha_c}{2b\sqrt{\rho/E}}\cdot\frac{1+k_в}{1-k_в}\right)^3 \sin\alpha_c\cdot\frac{b}{\cos\alpha_c}. \qquad (8)$$

After some minor transformations, we get:

$$A = \left(\frac{mV_{abc}}{2b\sqrt{\rho/E}}\cdot\frac{1+k_b}{1-k_b}\right)^3 b\cos^2\alpha_c\sin\alpha_c. \qquad (9)$$

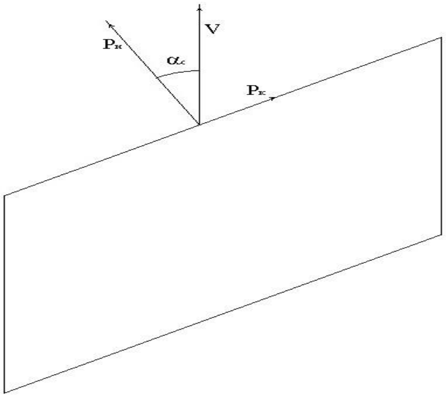
The greater the value of the parameter A, the better the cut of the stem. Since for a larger value of this parameter, a larger value of the normal force or a larger displacement corresponds. Therefore, we solve the following maximization problem: determine the angle α_c at which the parameter A will have a maximum value.

To do this, we find the derivative of A and equate to zero:

$$A' = \left(\frac{mV_{abc}}{2b\sqrt{\rho/E}}\cdot\frac{1+k_b}{1-k_b}\right)^3 b\left[\cos^2\alpha_c(\sin\alpha_c)' + (\cos^2\alpha_c)'\sin\alpha_c\right] = 0,$$

or $$A' = \left(\frac{mV_{abc}}{2b\sqrt{\rho/E}}\cdot\frac{1+k_b}{1-k_b}\right)^3 b\cos\alpha_c(\cos^2\alpha_c - 2\sin^2\alpha_c) = 0$$

From here $\alpha_c = arctg\frac{1}{\sqrt{2}}$ or $\alpha_c = 35{,}3^o$



$P_к$ – *tangential force*;
$P_н$ – normal strength.

Figure 1. Scheme of the cutting knife

Based on the data [1], different values of the sharpening angle and slip coefficient η correspond to different ε_c values of the coefficients k_1 and k_2. The first coefficient k_1, in accordance with its value, shows to what extent the cutting force is reduced due to the kinematic transformation of the sharpening angle with an increase in the slip coefficient. The second k_2 - one shows to what extent, with an increase in the coefficient ε_c, the share increases, by which the cutting force decreases due to other factors of sliding cutting, such as the transfer of friction resistance from the normal direction to the tangential, sawing action of the blade edge, etc.

The equality of these coefficients ($k_1 = k_2 = 0{,}5$) characterizes the conditions under which both the effect of the transformation of the sharpening angle and the effect of other sliding cutting factors are equally involved in the process of reducing the cutting force.

For a blade with $\eta = 60^o$ such a condition is the value of the slip coefficient $\varepsilon_c = 2{,}366$; for blade with $\eta = 50^o$ value $\varepsilon_c = 1{,}701$ and for $\eta = 40^o$ value $\varepsilon_c = 1{,}077$.

The calculation was performed using literature data [1]:

- at the angle of sharpening $\eta = 60^o$:

$$\varepsilon_c = 2{,}136 + \frac{3{,}032 - 2{,}136}{0{,}352 - 0{,}551} \cdot (0{,}5 - 0{,}551) = 2{,}366$$

- at the angle of sharpening $\eta = 50^o$:

$$\varepsilon_c = 1{,}487 + \frac{2{,}014 - 1{,}487}{0{,}361 - 0{,}595} \cdot (0{,}5 - 0{,}595) = 1{,}701.$$

- at the angle of sharpening $\eta = 40^o$:

$$\varepsilon_c = 0,916 + \frac{1,25-0,916}{0,362-0,631}\cdot(0,5-0,631) = 1,077.$$

For a blade with a sharpening angle $\eta = 35,5^o$, we approximate the available data and predict them for the desired value of the sharpening angle (Figure 2).

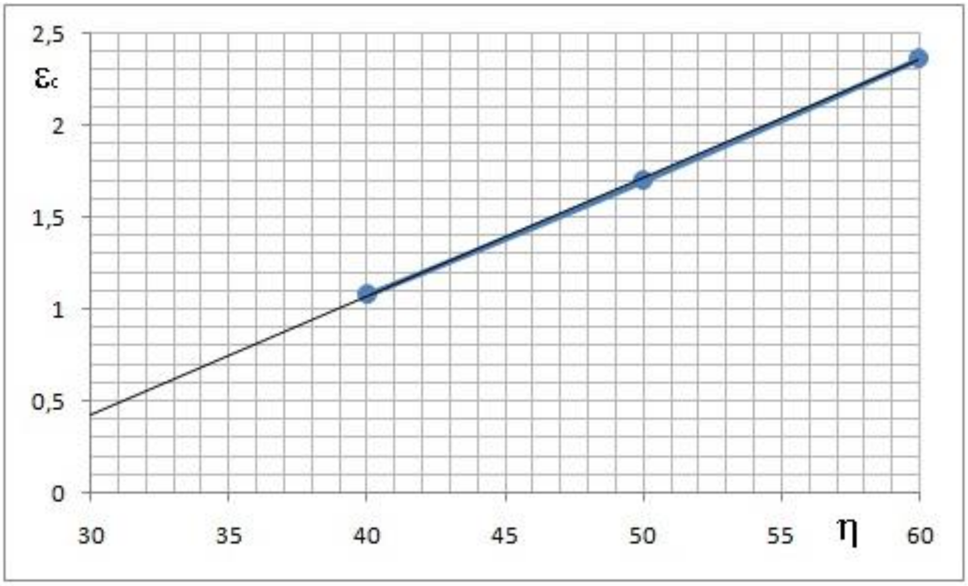


Figure 2. Graph of the dependence of the slip coefficient ε_c and the angle of sharpening η the knife

For a blade with a sharpening angle according $\eta = 35,5^o$ to Figure 2, we determine the rational value of the slip coefficient $\varepsilon_c = 0,75$, which corresponds to the sliding angle $\alpha_c = 36,9^o$.

According to [2], the smallest value of the specific cutting work for various materials lies within the value of the slip angle $\alpha_c = 30^o - 50^o$, after which there is a gradually accelerating increase in the specific work.

CONCLUSION

The shape of the cutting element is selected in the form of a parallelogram with a cutting angle α_c, called the angle of oblique cutting or sliding cutting. The optimal value of the cutting angle α_c is in the range of 30°-35°.

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