ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
Vol. 6, Issue 6 , June 2019

Terms of Microtune Single Prong

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ABSTRACT: In this article the analysis of sliding cutting by a single micro-tooth, in the horizontal plane and working height of the tooth, which determines the diameter of the circle of its section, is given. In the vertical plane, the zone of micro-cutting, as a rule, is absent and the formation of a new surface will occur with the successive action of the system of micro-teeth of the blade in the mode of elastic-plastic contact.

KEY WORDS: cutting of food materials, empirical dependence, cutting tool, cutting modes, sharpening mode, cutting machine, blade profilogram, microdent, blades.

I.INTRODUCTION

Cutting of food materials is studied mainly from the standpoint of establishing empirical dependences of the main parameters of the process (productivity, energy costs, waste, etc.) on the factors caused by the type of cut material, processing mode and cutting tool. This direction of research is important, as it allows within the study area of the factor space more objective approach to the selection of rational cutting conditions, the characteristics of the existing cutting tool, as well as the design parameters of cutting machines. However, the available empirical dependences do not always give a satisfactory solution in terms of radical improvement of the cutting process, without sufficiently revealing the features of the interaction of the blade with the cut material, the mechanism of destruction and the accompanying phenomena.

In sliding cutting, the blade micro-teeth are the main element contributing to the formation of new surfaces [1,2]. The location of the micro teeth on the blade, their shape predetermine the cutting and resistance properties of the knives and depend primarily on the steel grade, its microstructure, sharpening modes, characteristics of the abrasive tool, etc. [2,3,4]. In General, the profilogram of the blade, taken in the longitudinal direction, can be considered as an implementation of a stationary random function [5].

In the methodical plan the most efficient study of the physical essence of the process of moving cutting by modelling the interaction of a single microtube with the material being cut in the form of continua, endowed with elasto-plastic properties.

As the main parameters characterizing the angular and linear dimensions of a single cone-shaped microtubule with a spherical vertex, we can take: the angle at the vertex 2ε, the radius of rounding ρ, the diameter of the circle d_h in the section located at the working height h of the microtubule:

$$d_h=2\sqrt{2ph-h^2} \quad \text{by } h\leq(\rho-\rho\sin\varepsilon);$$

$$d_h=2tg\varepsilon\left(h+\frac{\rho}{sin\ \varepsilon}-\rho\right) \quad \text{by } h>(\rho-\rho\sin\varepsilon).$$

The working height of the micro-teeth depends on the kinematics of the sliding cutting and determines the contact zone in the form of a convex curved surface of the conical surface of the conical shape [6].

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To simplify the analysis, replace the spatial force interaction of the microdent and the material with a flat one. Select the material element adjacent to the surface of the microtubule at point X (Fig. 1).

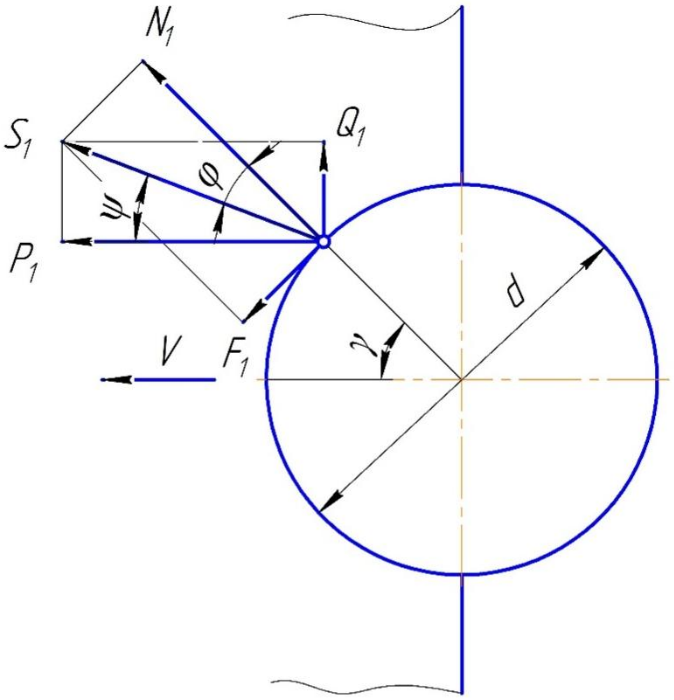

Fig.1.

On this element of the material the microdent acts in normal and tangential directions. The value of the normal force N1, ceteris paribus, depends on the cutting direction. The friction force F1 depends on the value N1 and the coefficient of friction:

$$F_1 = f N_1 \quad (1).$$

The forces F_1 and N_1 give the resultant S_1. This force expresses the effect of the microdent on the material element at the point *X*. It forms a certain angle φ with the vector N_1, $tan\varphi = f$. In addition, the vector S_1 forms an angle with the direction of sliding of the blade. This angle is called the angle of action ψ [7] and if *f*. Does not depend on N_1, it determines the angle between the direction of action of the working zone of the microdent on the material and the direction of sliding.

From the condition of equilibrium of forces at the point X we have:

$$F_1 = P_1 sin\,\Upsilon - Q_1\ cos\,\Upsilon$$
$$N_1 = P_1 cos\,\Upsilon + Q_1\ sin\,\Upsilon \quad (2)$$

Where: N_1, F_1 - respectively, normal and tangential reactive forces of the material on the microdent at the point X;

P_1 - the force of the microdent on the material at X in the cutting direction;

Q_1 is the lateral compression force of the material at x, acting normally in the sliding direction;

Υ - is the current angle for the upper contour of the microdent.

After substituting (1) into (2) and transforms the resulting formula to determine the angle of the action:

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$$tg\psi=\frac{tg\Upsilon-f}{1+ftg\Upsilon}. \qquad (3)$$

If $tg\Upsilon=f$, the angle ψ becomes 0. This means that the force Q_1 is also 0. If $tg\Upsilon<f$, the angle ψ changes to negative. Physically, this means that the force Q_1 began to brake the material element at the point X, which, when compacted, begins to move along with the micro-tooth in the sliding direction. The condition under which the material shifts in the direction of sliding of the counterbody, I. V. Kragelsky [8] called the boundary condition of the transition of elastic-plastic contact to micro-cutting.

Let's call the area where the self-inhibition of the material occurs, the zone of micro-cutting. The specified zone will be located in the Central part of the microdent between two symmetrically located boundary points in which the angle $\Upsilon=arctg\ f$. The width of the micro-cutting zone is equal to the length of the chord corresponding to the central angle 2γ, i.e.

$$l= d_h \sin\gamma = d_h \sin arctg\ f. \qquad (4)$$

If we take $f=0,3$, we get $l=0,3d_h$. Above this width, the material will be elasto-plastic pushed in both directions beyond the contour of the micro-tooth.

When the micro-teeth move, the hypothetical rod of the material with the cross section $l\times h$ will be compressed until the stress in it exceeds the compressive strength. While, as is known [9,10], the destruction occurs along the lines of shear (sliding), which are normal to the direction of compressive loads.

Consider the system of forces (Fig. 2) acting on the material in a vertical plane.

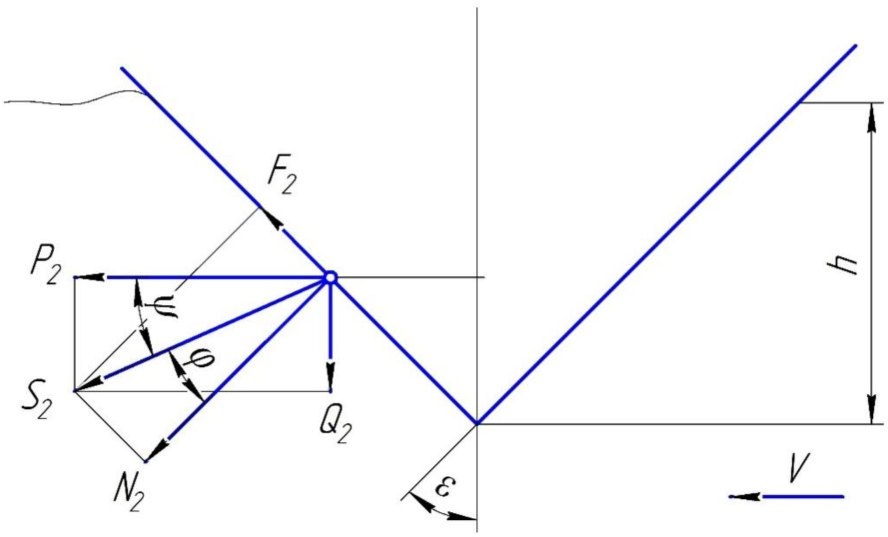

Fig.2.

To simplify the analysis, replace the curved surface of the microtubule in the zone of micro-cutting with a flat one. When moving the micro-teeth in the V direction, its working surface acts on the material with forces P_2 and Q_2. Upon contact, the normal reaction force N_2 and the friction force F_2 occur respectively.

From the equilibrium condition of forces has:

$$F_2= P_2\sin\varepsilon - Q_2\cos\varepsilon;$$
$$N_2= P_2\cos\varepsilon + Q_2\sin\varepsilon. \qquad (5)$$

From these equations, if we substitute $F_2=fN_2$ and $tg\psi=Q_2/P_2$ in them, we obtain:

ISSN: 2350-0328
International Journal of Advanced Research in Science, Engineering and Technology
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$$tg\psi = \frac{tg\varepsilon - f}{1 + f tg\varepsilon}. \quad (6)$$

Note that at $tg\varepsilon < f$ the angle of action changes sign. This starts the self-inhibition of the material in the contact zone and it begins to move with the micro-tooth. Since the positive value of the angle ψ we have taken on the basis of the condition that the deformable material moves relative to the micro-tooth in the direction from the base to its top, i.e. is crushed by the micro-tooth, the value of the angle ε , at which the angle ψ changes sign to negative, will determine the boundary condition of the transition from elastic-plastic deformations to cutting.

If we take $f = 1$, we obtain the limiting angle $\varepsilon = 45°$. For $\varepsilon \leq 45°$ will be the destruction of the material Microsystem (microreserve classification) [8].

Otherwise, the material is lifted by the microdent, i.e. it experiences elastic-plastic displacement. If the average probable value of the angle ε of the micro-teeth is greater than 45°, which the measurements show corresponds to the real values, their conical part will not be able to perform micro-cutting. In this case, the formation of a new surface will be performed with multiple re-forming of the friction track, leading to an increase in the number of wear products [8,9] and a decrease in the quality of sliding cutting. At any working height h and a radius of vertices ρ in the same way will affect the material and the spherical tip of the microdent.

Thus, the analysis of sliding cutting by a single micro-tooth shows that in the horizontal plane the width of the micro-cutting zone depends on the coefficient of friction and the working height of the tooth, which determines the diameter of the circumference of its section. In the vertical plane, the zone of micro-cutting, as a rule, is absent and the formation of a new surface will occur with the successive action of the system of micro-teeth of the blade in the mode of elastic-plastic contact.

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