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SPATIAL POSITION OF A CONVENTIONAL SHEAR PLANE IN TREATMENT BY CUTTING

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The technique of a numerical experiment that allows prediction of the position in space of the main heat-liberation source in treatment of materials by cutting is presented.

It is assumed that heat liberation in cutting takes place mainly in the zone of the largest plastic deformations, in the so-called shear plane [1]. Therefore, determination of its position in space is an urgent problem.

Usually the problem mentioned is reduced to determination of the angle of slope β of the conventional shear plane N–N to the velocity of the main motion of cutting $\mathbf{v}$ (Fig. 1) and is solved by most authors either experimentally [2] or by the methods of similarity theory [3] or using variation principles [4]. Each of the methods mentioned has its own advantages and disadvantages, which are widely known. The suggested technique of determination of the position of the conventional shear plane is based on numerical simulation by the finite-element method [5].

Assignment of calculated loads that are maximally close to actually existing ones formed the basis of numerical experiments. In this case, probably, the angle β in cutting will be such that values of stresses acting in the treated material reach the limit of the shearing stress. This assumption was verified by analysis of the stressed-deformed state of a chip element in the ANSYS5.6 medium (training version).

The computational domain (a chip element) was approximated by 125 tetrahedral elements using 272 nodes of the computational grid. Zero-displacements for the nodes of the computational grid that belong to the conventional shear plane and zero-displacements for the nodes that are in contact with the tool surface were taken as boundary conditions. It is adopted that the same surface is also affected by the distributed load from the cutting force, and other surfaces are taken to be free of loads. Steel with a carbon content of 0.13% and a limit shearing stress of 480 MPa was used as the treated structural material. The area of the shear surface was 5 mm^2. The value of the shearing force F_τ = 2400 N was specified by two components, F_x and F_z (Fig. 1), which in magnitude are equal to the corresponding forces of cutting resistance [2].

Figure 2 gives a general pattern of distribution of stresses in a deformed chip element for the conditions of operation with cooling [5] at zero values of the angle of the cutting edge, the angle of slope of the cutting edge, and the primary angle in plane.

The calculations in the interactive mode showed that for the selected scheme of treatment at $\beta \approx 10^{\circ}$ and F_x/F_z = 0.25–0.3 maximum stresses acting in the conventional shear plane begin to exceed the limit of shearing stress, which is in good agreement with experimental data on determination of the angle of shear [4].

Thus, we can draw a conclusion that for the considered scheme of cutting (see Fig. 1) the technique suggested for determination of the spatial position of a conventional shear plane gives satisfactory results.

NOTATION

F_x, component of the force of cutting resistance along the x axis, N; F_z, component of the force of cutting resistance along the z axis, N; F_τ, force acting in a conventional shear plane, N; $\mathbf{v}$, velocity of the main motion of cutting, m/min; β, angle of slope of a conventional shear plane to the direction of the velocity of main motion of cutting, deg.

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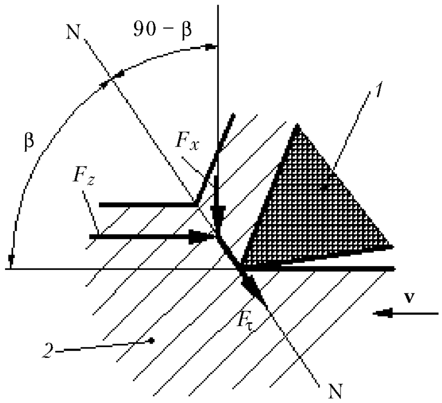

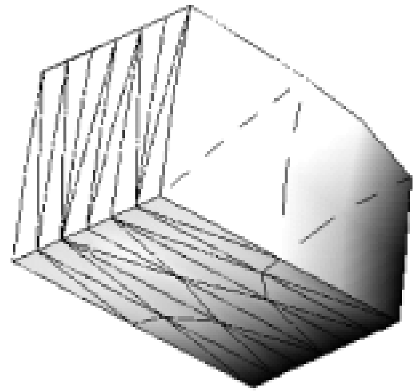

Fig. 1. Scheme of cutting: 1) cutting wedge; 2) treated material.

Fig. 2. General pattern of stresses and deformations in a chip element.

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