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THE STRAINS FIELDS OF MATERIAL DURING ROUGH PLANING

Abstract*: The calculated two-dimensional contour strains fields of structural steel in the condition of rough planing with the cutter with the rake angle of 60 degrees and the nose radius of 1 mm are presented in the article. The recommendations for choosing the cutting tool geometry for reducing deformation of the billet material are given.*

Key words*: the cutter, strain, the billet, material, planing.*

Language*: English*

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Introduction

The solution of actual problems of machining metal materials with the edge tools is given in the scientific works [1-10]. The value and configuration of the rake angle of the cutter is responsible not only for chip formation, but also for the quality of the surface layer of the billet material. The large positive rake angles improve the cutting process, but reduce strength of the cutting tool. During planing, material and the tool are not subjected to high temperature and variable loads, such as during turning or milling. This means that strains in processed material will not change during the entire planing time. This assumption can be taken when analysis of cutting of the billet with the planing cutter and strains occurrence in processed material.

Materials and methods

The calculation of the billet strains during planing was implemented by the method of finite element modeling. The planing process of structural steel (the cutting depth of 3 mm) was modeled. Planing was performed by the model of the cutter with the following geometry: the rake angle – 60 degrees, the clearance angle – 5 degrees, the nose radius – 1 mm, the cutter width – 20 mm. The length and width of the billet model were accepted by 100 mm, the billet height – 25 mm. Only the billet model was subjected to deformation, because the cutter model was accepted by the absolutely solid body.

Results and discussion

The simulation results are presented in the Fig. 1.

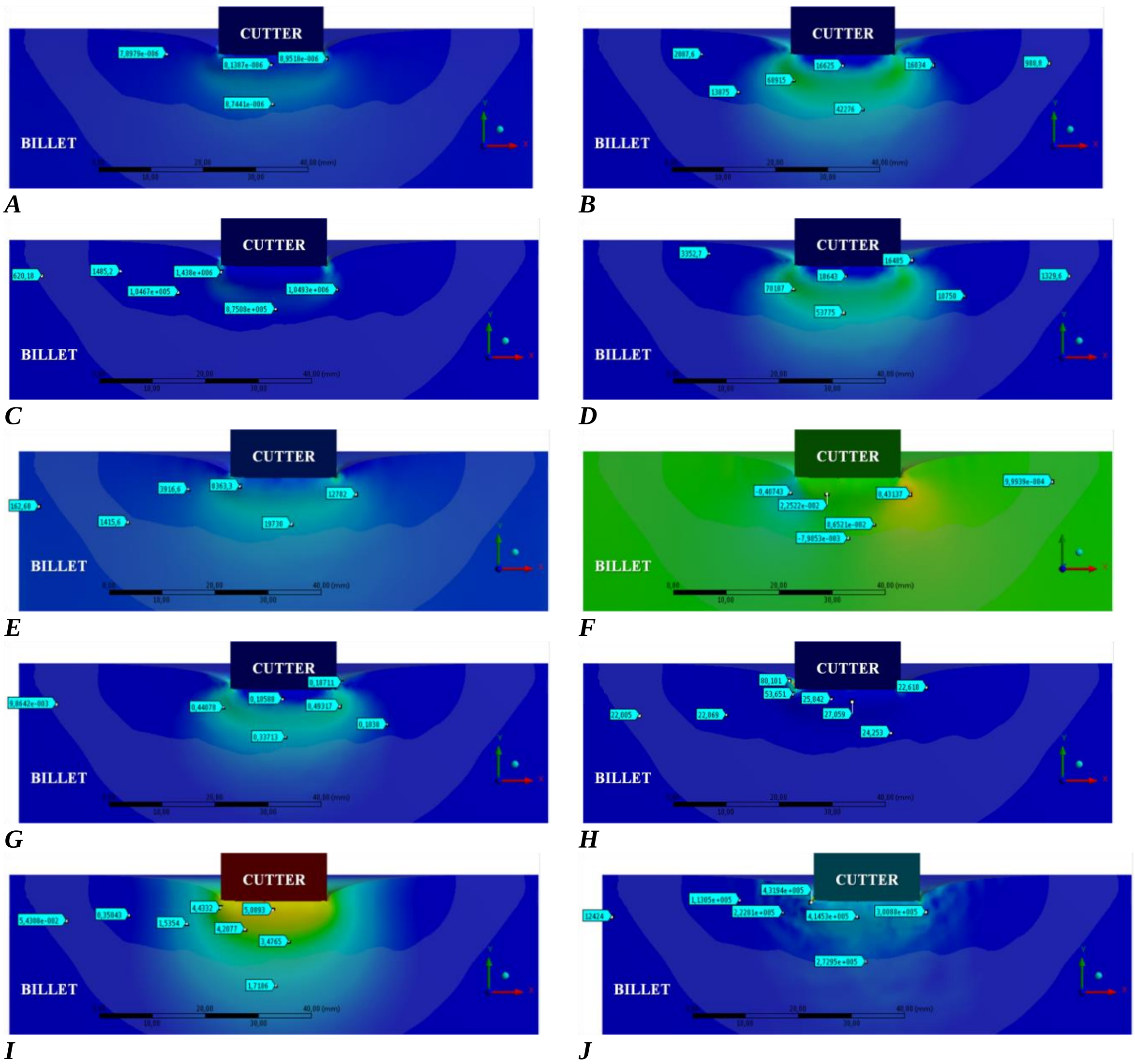

Figure 1 – Deformation of the volume of the billet material during cutting with the cutter: *A* – changing density; *B* – changing equivalent stress; *C* – changing internal energy; *D* – changing internal stress; *E* – changing pressure; *F* – changing shear elastic strain; *G* – changing elastic strain intensity; *H* – changing temperature; *I* – changing total deformation; *J* – changing total velocity.

The deformed model of the billet at the moment of cutting by the model of the planing cutter is shown. Stress-strain state of the billet material (including changing density and the temperature) is presented in the two-dimensional view by the color contours. The probes were randomly plotted on the billet model for determining intensity of the calculated parameters.

It is determined that material of the billet, which is in contact with the main cutting edge of the cutter, practically does not subjected to deformation according to the computer modeling results. This can be observed on the billet model, on which were marked the contours of changing density, equivalent stress, internal energy, internal stress and elastic strain intensity. The maximum deformed local volumes of material are located near the two side cutting edges of the planing cutter. The value of material stress near the side cutting edges is 4-5 times more than material stress near the main cutting edge of the cutter. Material is only subjected to compression deformations during cutting. When considering shear elastic strain, it can be noted that the coefficient of deformed material on one side of cutting with the side cutting edge has the positive values, and on the other has the negative values. Thus, the process of material deformation occurs asymmetrically. The temperature can reach 100 °C in the cutting zone. Significant deformation of material during cutting is observed at the depth of up to 10 mm from the surface layer of the billet. Material deformation reaches its maximum in the cutting zone on the side of the main cutting edge of the cutter.

Conclusion

The volumes of material located at the depth equal to ½ of the cutting depth (from the processed surface) are deformed during rough planing. For reducing stress in the billet material, it is recommended to perform machining in two stages:

1) the rough pass with the cutter with the rounded side cutting edges, taking into account allowance for the finishing pass;

2) the finishing pass with the necessary geometry of the cutting tool.

The measurement units of the parameters:

Density – kg/mm^3
Equivalent stress – MPa
Internal energy – J/kg
Internal stress – MPa
Pressure – MPa
Shear elastic strain – mm/mm
Elastic strain intensity – mm/mm
Temperature – °C
Total deformation – mm
Total velocity – mm/s

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