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Micro-cutting of single-crystal metal: finite-element analysis of deformation and material removal

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Abstract

This paper presents analysis of mechanics in a micro-cutting process of a single-crystal metal – mechanisms of deformation and material removal related to an anisotropic crystallographic structure of a work-piece. A crystal-plasticity theory was implemented in a finite-element (FE) modelling scheme to consider inherently anisotropic deformation of a single-crystal metal at micro-scale. A new shear-strain-based criterion and several conventional strain-based criteria were employed to simulate the material removal process, and their effect on the anisotropy of cutting forces was studied. Subsequently, the micro-cutting process of single-crystal copper was predicted using FE modelling by combining the crystal-plasticity theory and the proposed criterion of material removal. The validity of the present FE modelling methodology was corroborated through a comprehensive comparison between FE simulations and experimental data in terms of cutting forces, chip morphology, deformation field, pile-up patterns and misorientation angle in the work-piece.

Keywords: micro-cutting, single crystal plasticity, finite-element modelling

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