Robust implementation of multi-slip crystal plasticity with implicit set search based on Fischer-Burmeister functions

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ABSTRACT

In conventional machining processes of cp-titanium the material behaviour can be assumed as isotropic. In contrast in micro machining the influence of the hexagonal closed packed (hcp) crystallographic structure of cp-titanium have to be taken into account. Simulations of micro machining processes with the finite element method involves several challenges. Challenges, for example are the contact between tool and chip, the separation of the material, large deformations and the influence of the crystallographic structure on the chip formation.

A robust implementation of the material model is very important in such simulations. The reversible elastic behaviour is described by a hyperelastic, compressible Neo-Hooke material model. In the plastic part of the material model, based on the multiplicative decomposition of the deformation gradient, the plastic slip coefficients are calculated by a predictor-corrector algorithm. Thereby the plastic slip coefficients have to satisfy the Karush-Kuhn-Tucker (KKT) conditions [1, 2]. Plastic slip in single-slip crystal plasticity material models is identified unambiguously by the predictor step. On the contrary, in multi-slip crystal plasticity, the determination of the active set is not always unique [1]. In case of plastic slip in more than one slip system the active set cannot be determined solely by the predictor criterion. Additional selection criteria are necessary. However, these criteria often fail to find an admissible set of active slip systems resulting in an unstable algorithm [1]. In order to achieve a more robust implementation, the KKT conditions can be replaced by an equivalent system of semi-smooth Fischer-Burmeister (FB) complementary functions. If the predictor criterion is violated for any slip system, the system of FB-functions is solved for all slip systems and the active set is determined implicitly by solving the system [3]. Simulations demonstrate that the FB-formulation delivers a more robust algorithm compared to the standard formulation with active set search.

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