New Phenomenological Constitutive Models for the Description of Material Behavior under Static and Dynamic Loads: Application to High-Speed Machining and Use of Inverse Methods

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Abstract. Machining process of titanium alloys requires challenging task especially regarding the reached high gradients of plastic deformations, plastic strain rates and temperatures during the material forming. Both static and rapid (dynamic) loadings conditions occur during the material chip formation during machining processes. On the other hand, despite the wide spread adoption of titanium alloys in a wide range of industrial applications, several problems are encounter during their machining: high plastic strain localization, segmented chips, accelerated local tool wear. Although the recent advances concerning the experimental devices, it is still difficult experimentally to investigate on a mesoscopic scale all these instantaneous phenomena. Therefore, to obtain a reliable numerical analysis in addition with some experimental tests is still an efficient alternative for a better understanding of cutting processes. The modeling reliability is dependent on the definition of an adequate work-piece material behavior based on physical phenomena. This research study is start from the general physically based material constitutive models proposed by Gavrus [1-3] adopted to reproduce isotropic plastic behavior of the Ti6Al4V titanium alloy for large plastic deformations. Based on the literature review [4–9], rheological models of Ti6Al4V alloy [10-11] are improved and identified starting from on iterative non-linear regression methods. The main goal is to allow a well description of both static & dynamic loading conditions for a wide range of plastic strains, plastic strain rates and temperatures together with use of a transition state identification. The adequacy of the proposed rheological models is discussed and comparisons with experimental results of literature [4-8] are presented. A general user material subroutine VUHARD© is implemented in the commercial code Abaqus®/Explicit. Numerical simulations of tensile/compression tests are performed. A 2D FE modeling of Ti6Al4V machining is carried out and adequacy of proposed constitutive models to predict local variables for both moderate and high kinematic speeds is examined.

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