



Chun Cheng

**A multi-mechanism model for
cutting simulations combining
asymmetric effects and gradient
phase transformations**

A multi-mechanism model for cutting simulations combining asymmetric effects and gradient phase transformations

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Abstract

In order to study the white layer formation and several mechanisms in high speed cutting, we develop a multi-mechanism model (MMM) for cutting simulation taking asymmetric visco-plasticity, phase transformation and transformation induced plasticity (TRIP) into account. To this end, the well-known Johnson-Cook model is extended by the concept of weighting functions for considering the asymmetric effect, which labels different material behaviors under tension, compression and shear. For the special scenario of high speed cutting with martensite as the initial phase, two phase transformations are considered: 1. Transformation of the martensitic initial state into austenite, then 2. retransformation to martensite. The model is formulated within a thermodynamic framework at large strains, and specialized and applied to high speed cutting.

Furthermore, we extend the MMM with a phase gradient based on the concept of generalized stresses proposed by Gurtin and Forest in order to consider different interface energies appearing in phase transformations. To this end, the austenite mass fraction, which represents a chemical variable, is treated as an extra degree of freedom in the modelling part as well as in the finite element formulation. We consider its first gradient and study its influence on the phase transformations. Moreover, hardness dependency and hardness modification due to white layer formation are taken into account.

Zusammenfassung

Um die Weißschichtbildung und verschiedene Mechanismen im Hochgeschwindigkeitszerspanen zu untersuchen, wird ein Mehrmechanismenmodell (MMM) für Zerspansimulation entwickelt, wobei asymmetrische Visko-Plastizität, Phasenumwandlung und Umwandlungsplastizität (TRIP) berücksichtigt werden. Zur Berücksichtigung der asymmetrischen Visko-Plastizität wird das bekannte Johnson-Cook Modell um das Konzept der Wichtungsfunktionen erweitert. Für das spezielle Szenario Hochgeschwindigkeitszerspanen mit Martensit als Anfangsphase werden zwei Phasenumwandlungen berücksichtigt: 1. Umwandlung von der Anfangsphase Martensit in Austenit, dann 2. Rückwandlung in Martensit. Das Modell wird in einem thermodynamischen Rahmen für große Deformation formuliert und anschließend für Hochgeschwindigkeitszerspanen spezialisiert und angewendet.

Des Weiteren wird das MMM zur Berücksichtigung von unterschiedlichen auftretenden Interface-Energien um einen Phasengradienten erweitert, wobei die verallgemeinerte Theorie von Gurtin und Forest zugrunde gelegt wird. Zu diesem Zweck stellt der austenitische Massenanteil eine chemische Variable dar und wird als zusätzlicher Freiheitsgrad sowohl in der Materialmodellierung als auch in der Finite-Element-Formulierung behandelt. Der erste Gradient von dem austenitischen Massenanteil wird berücksichtigt und dessen Einfluss auf die Phasenumwandlungen wird untersucht. Darüber hinaus werden Härteabhängigkeit und Härteänderung infolge Weißschichtbildung berücksichtigt.

Preface

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