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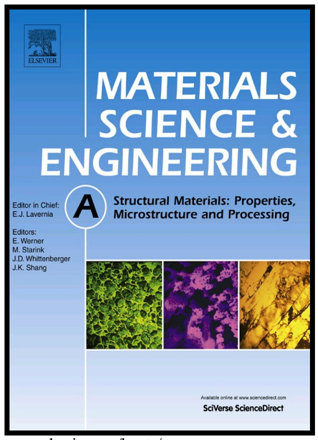

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Cohesive zone modeling of crack propagation influenced by martensitic phase transformation

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Abstract

A numerical model that can predict the influence of martensitic phase transformation on crack propagation, is proposed. The model is comprised of a large strain plasticity model that accounts for martensitic phase transformation and a cohesive zone model to simulate the interface behavior. Different dependencies of the traction-separation law on the local volume fraction of martensite are investigated. Furthermore, as martensitic phase transformation is strongly temperature dependent, different isothermal settings are considered. It is, for example, verified that at lower temperatures, martensitic phase transformation retards crack propagation to a greater extent. It is also shown that the retarding effect depends on how the martensite dependent cohesive zone model is formulated.

Keywords: Martensite, Phase transformation, Crack propagation, Cohesive zone

1. Introduction

Austenitic stainless steel is a widely used engineering material due to its fatigue and corrosion resistance. At low temperatures, diffusionless phase transformation from ductile austenite to relatively more brittle martensite is likely to occur depending on the temperature and the deformation conditions, cf. [1]. Such phase transformation has a significant impact on the material behavior, not least related to fracture properties. Modeling the diffusionless phase transformation from austenite to martensite has been extensively studied in the literature, for example in [2, 3, 4, 5, 6, 7]. The evolution of the transformation plastic strain rate is obtained for a steel undergoing a transformation under a small applied stress in [2, 3]. In [4], the macroscopic strain is obtained following a homogenization of the microscopic transformation strain in a micro-region. A transformation potential based on the assumption that phase transformation occurs only if it leads to decrease in Gibbs free energy, is considered in [5]. In [6], a thermodynamically consistent constitutive model which accounts for phase transformation in elastoplastic materials undergoing large deformation, is presented. Modeling phase transformation in shape memory alloys is considered in [7], where evolution of plastic deformation in each phase is considered.