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TOWARD A POLYCRYSTAL MODELING OF MARTENSITIC PHASE TRANSFORMATION BASED ON THE MECHANISM OF MAGEE

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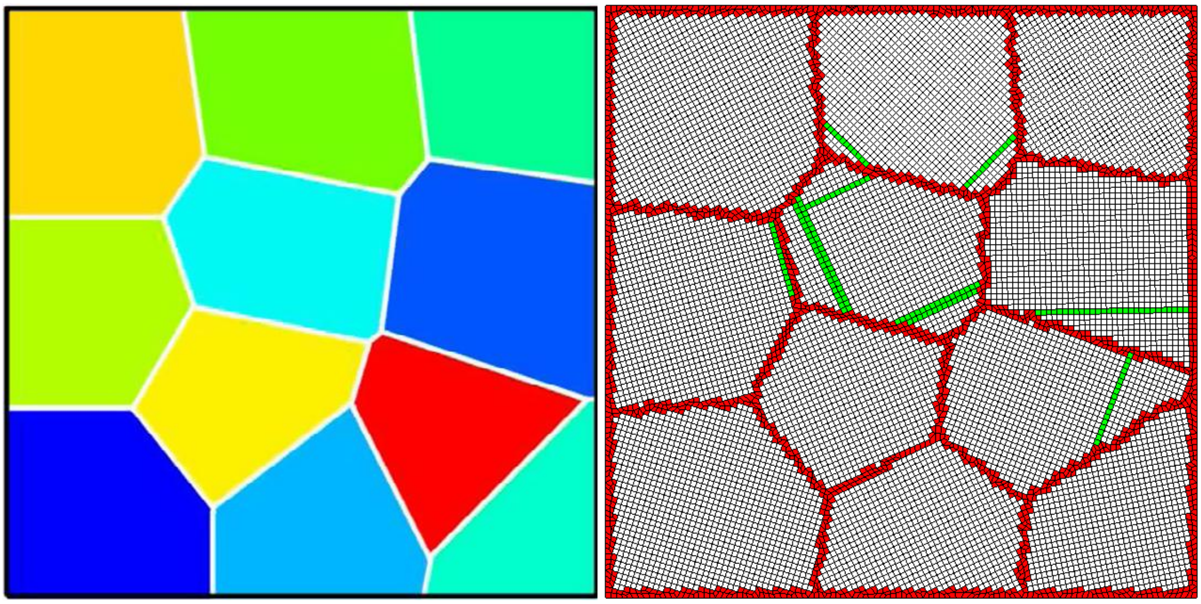
This work presents our recent advances in the modeling of the elastoplastic phenomena related to austenite-martensite phase transformation in steels. The phenomena under consideration are encountered when the phase transformation is combined to a mechanical external loading. It concerns in particular transformation plasticity (TRIP) which is observed when a small load is applied during the transformation or as a consequence of a pre-hardening of austenite [1]. In this latter case, accounting for the Magee mechanism in the modeling have proved to be the most appropriate solution w.r.t. Greenwood-Johnson based modeling [2,3].



(a) (b)

Figure 1: (a) 2D computational domain, created using Voronoi tessellation [4]. (b) The corresponding polycrystal generated with MsbGrid [5]. The elements in each grain are structured and follow a specific tilt which refer to the crystallographic orientation of the grain.

In this modeling, the progress of the transformation is ensured by successive transformation of martensite plates and is prescribed by a thermodynamical criterion (*e.g.* maximal work, or minimization of the free energy), associated to the variant formation. The phases are assumed to be homogeneous and are governed by elastoplastic constitutive laws. Each plate consists of a band of elements and is bounded in each of its two ends, either by the grain boundary or by another plate already transformed. The transformation of a plate is achieved by gradually imposing the transformation strain tensor and associating the mechanical properties of the martensite to all corresponding elements. Each time a martensite plate is formed, the stress-strain fields are computed by the finite element method, then using the thermodynamical criterion a new plate is identified and chosen to be the next plate to transform. This model has been evaluated in [2,3] by comparison to experiments and different modeling predictions (Leblond [6], Taleb & Sidoroff [7], Barbe & Quey [8]) for uniaxial varying loads.

At its origin, the modeling is based on a single grain with an arbitrary set of variant orientations, which leads to large variations of transformation rate and TRIP during the transformation. The present work aims at improving this by taking into consideration a set of randomly oriented grains, as illustrated in fig. 1. These polycrystals are created by the MsbGrid (Multi-structured block Grid) generator (free and open-source) [5]. The crystallographic orientations and the spatial distribution of grains are chosen randomly or given explicitly as input data. Evaluation of this modeling is performed by comparison to experimental measurements of TRIP for the martensitic transformation of 35NiCrMo16 steel. Besides modeling aspects, attention is paid to the conditions under which experimental TRIP tests should be performed in order to guarantee the uniaxiality of loading. Biaxial tests are further considered in order to analyze, in particular, the relevance of a von Mises criterion for predicting transformation plasticity.

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