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Modeling of dynamic recrystallization in austenitic stainless steel 304L by coupling a full field approach in a finite element framework with mean field laws

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Mean field (MF) models of dynamic recrystallization (DRX) emerged in the last decades with the intention to implicitly describe the microstructure by considering grains sets as spherical classes. These models have the advantage to provide accurate results in terms of macroscopic results such as recrystallized fraction or grain size but also to provide additional information in terms of grain size distribution and dislocation density distribution [1,2,3,4].

In parallel, finer approaches called full field (FF) models have emerged in the last decades. These approaches consider a complete description of the microstructure topology at the polycrystal scale [5]. A review of the most significant numerical methods can be found in [6].

Several DRX models based on a full field approach can already be found in the literature [7,8,9]. Although literature already provides a large number of papers on full-field DRX models, major drawbacks are either they are developed in 2D and/or they only consider small deformations (< 20%).

In the present work, a 3D model based on the level-set method in a FE framework is employed to model the DRX and PDRX phenomena in austenitic stainless steel 304L at large deformations. The level-set approach coupled to a remesher provides an accurate tracking of interfaces (i.e. grain boundaries) all along the simulation while mean field laws are used for the nucleation, work hardening and recovery mechanisms.

The figure 1 presents four instants of a full field simulation using this model. The 304L steel is firstly deformed under a temperature of 1000°C and a strain rate of 0.01s⁻¹ during 100s (DRX). This process is followed by a hold at 1000°C during 30min (PDRX). The initial number of grains is around 1000 grains while the final number of grains after DRX and PDRX mechanisms are respectively around 50.000 and 10.000 grains.

A first part of this work is dedicated to a presentation of the level-set approach and the constitutive equations of this model. That part is followed by a sensibility study concerning the choice of the initial number of grains and elements so that the model correctly describes experimental results on 304L. The subsequent part presents a comparison between this model and an enriched DRX/PDRX mean field models [2]. Some remarks about the choice of use either a mean field or full field model will conclude this work.

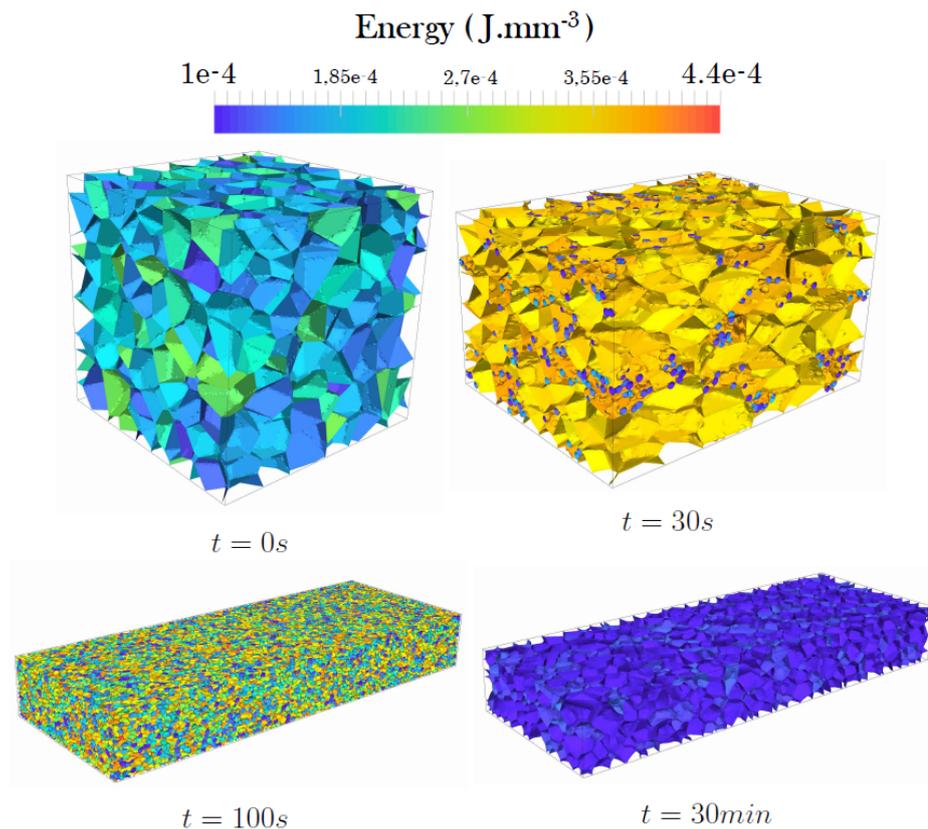


Figure 4 : A DRX + PDRX simulation at large deformation for a 304L austenitic stainless steel. The REV is firstly deformed at 1000°C during 100s following by a 1000°C hold during 30min.

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