A new topological model for the prediction of dynamic recrystallization

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During hot deformation of metal alloys, the mechanisms of strain hardening and recovery tend to increase and reduce the energy stored in the material, respectively. When a high enough stored energy level is locally reached, new grains nucleate. In parallel, grain boundaries migrate as a result of stored energy gradients across interfaces and capillary effects. The combination of those mechanisms leads to the so-called dynamic recrystallization (DRX) mechanism.

Several mean field models have been proposed in the literature to model DRX [1,2,3]. Mean field models are based on an implicit description of the microstructure by considering grains as spherical entities with a grain radius and a dislocation density. Then, the evolution of each grain is governed by its interaction with the average microstructure, constituted of all other grains.

A common advantage to all these mean field models is their computational cost that is considerably low. Furthermore mean field models generally provide acceptable predictions in terms of recrystallized kinetics and mean grain size evolution. However, grain size distributions issued from mean field simulations are not correctly predicted. This limitation is very likely to arise from the fact that no explicit topology is considered in the mean field models.

In this work, a new topological approach for the mean field modeling of DRX has been developed [4]. This new model is based on the same constitutive equations used in the mean field model of Beltran et al. [3] for modelling strain hardening, recovery and nucleation. The major novelty is based on the consideration of a particular neighbourhood for each grain instead of considering the whole average microstructure. In addition, the grain shape evolution during deformation is also considered in this model. The results of this new model will be compared to those of full field simulations already published [5] and to experimental data related to hot forging of 304L steel. The new mean field formulation leads to significant improvements as compared to former ones.

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