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MODELLING OF RECRYSTALLIZATION PHENOMENA AT THE PROCESS SCALE AND AT THE MICROSTRUCTURE SCALE

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Abstract. A mean field model describing dynamic and static recrystallization is developed in the general context of multi-pass metal processing. The model considers categories of grains based on two state variables, grain size and total dislocation density. It is computationally cheap and therefore suitable for direct coupling at the scale of forming processes, for industrial applications. The parameters of the model can be identified from inverse analysis, using experimental stress-strain curves, recrystallized volume fractions, and grain sizes. Applications are illustrated based on experimental data from mechanical testing on 304L stainless steel.

Parallel to the mean field method, a finite element approach is developed whereby synthetic mesoscopic microstructures are meshed adaptively and anisotropically, with refinement close to the grain boundaries. Crystal plasticity finite element (CPFEM) simulations are combined with a level set framework to model nucleation and growth processes, following plastic deformation. In the level set method, the kinetic equation describing interface motion uses the calculated stored energy field provided by CPFEM calculations, and works on the same mesh.

Discontinuous dynamic recrystallization can be modelled within the same approach.

Mean field and finite element approaches are compared, and it is shown that the detailed information provided by finite element simulations can be used to calibrate or optimize the mean field method.