The Effect of Different Roughing Schedules on the Mean-field Static Recrystallisation of Microalloyed Plate Steels

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ABSTRACT

Apart from the alloying elements, the through thickness properties and microstructure of hot rolled metal slabs are largely influenced by the strain sequence or roughing schedule employed during production. Using advanced material models within a finite element analysis environment, roll pass reduction schedules can be designed with a desired through thickness homogeneity or functional grading in mind. To do this effectively, the material model used during simulation should capture all of the relevant deformation mechanisms and physics.

In this study, the formulation and implementation of a dislocation density based material model with recrystallisation [1] is presented. The model kinetic equation is based on that of the Mechanical Threshold Stress model [2] with extensions for large strain deformation [3], thermal recovery and the mean-field treatment of recrystallisation [4]. Multiple cycles of recrystallisation are accommodated with grain boundary mobility modelled as a function of temperature and average slip plane lattice incompatibility. The recrystallisation driving pressure on the other hand is provided by the dislocation build-up in the unrecrystallised material volume fraction.

The model is characterised to simulate the response and static recrystallisation of a low alloy steel. The characterisation is done using a subset of experimental data [5] on the response and static recrystallisation of cylindrical test specimens. The specimens are subjected to different strain sequences. Comparison between the subset of unused experimental data and corresponding simulations is used to cross-validate the model. Here the model is seen to have the ability to replicate as well as predict material response to a fair degree due to the physically motivated mechanisms from which it is derived. A finite element study is finally presented to illustrate the possible effect different reduction schedules could have on the through thickness material state and the ability to asses these effects based on finite element simulations.

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