

Predicting grain size distributions in Inconel 718 forgings by mean field modeling

B. Flipon^{1*}, M. Roth¹, M. Bernacki¹, N. Bozzolo¹

¹ Mines ParisTech, PSL - Research University, CNRS, CEMEF, UMR 7635, 06904 Sophia Antipolis, France

*baptiste.flipon@minesparis.psl.eu

Studying and predicting microstructure evolutions by recrystallization of polycrystalline superalloys may be a key aspect in the optimization of industrial processing routes. Forging steps must end up with a defined mean grain size to ensure the targeted mechanical properties, but the grain size distribution also matters. Models which would correctly describe the grain size distribution evolution throughout various thermomechanical conditions are thus of prime interest. In addition, such model should not only be able to predict the grain size distribution within the relevant range of thermomechanical conditions, but it should also be able to do it at many points of a real large scale industrial part with a limited computation time, which remains challenging.

Full field simulations have proven to be predictive of microstructure evolutions [1] but both computation time and the investigated number of points is actually a limit to study microstructure evolutions at the scale of an industrial part. Recent developments in mean field modeling of grain growth and recrystallization are promising in order to reach the aim of accurately predicting the microstructure evolution of a whole industrial part.

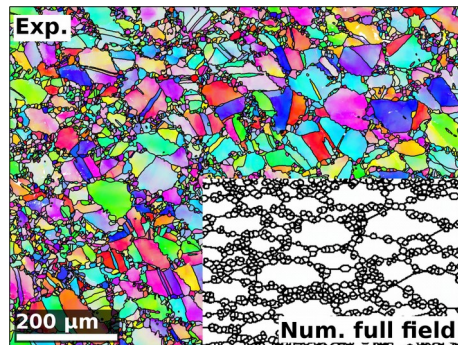


Figure 1. Illustration of discontinuous dynamic recrystallization in Inconel 718 after $\epsilon=0.5$ strain at $T=1050^{\circ}\text{C}$ and $d\epsilon/dt=0.1\text{ s}^{-1}$. Experimental EBSD IPF-Z map is compared to full field numerical predictions.

The mean field model used in this work aims at improving the predicted grain size distribution evolutions by introducing topological aspects through the consideration of a neighborhood for each grain class of the distribution [2]. This semi-topological mean field model will be applied to the prediction of grain size distributions after supersolvus hot deformation of the Inconel 718 alloy, for which recrystallization mechanisms have been and still are widely studied both experimentally and by simulation.

After material parameters identification a set of thermomechanical tests mimicking industrial processing conditions (and including both dynamic and post-dynamic evolutions) will be simulated. Mean field model predictions will be compared to experimental data as well as to full field simulation results.

References

- [1] M. Bernacki, H. Resk, T. Coupez, and R.E. Logé. *Modelling Simul. Mater. Sci. Eng.*, 17(6):064006, 2009.
- [2] L. Maire, J. Fausty, M. Bernacki, N. Bozzolo, P. De Micheli, and C. Moussa. *Mater. Des.*, 146:194 - 207, 2018.