VIII International Conference on Computational Plasticity
COMPLAS VIII
E. Oñate and D.R.J. Owen (Eds)

CALIBRATION OF A MULTISCALE MATERIAL MODEL BASED ON MACROSCALE TEST DATA

Robert Lillbacka*† and Magnus Ekh†

* Building Technology and Mechanics
SP Swedish National Testing and Research Institute
Box 857, SE-501 15 Borås, Sweden
e-mail: lilrob@am.chalmers.se, web page: http://www.sp.se

†Department of Applied Mechanics
Chalmers University of Technology
SE-412 96 Gothenburg, Sweden
Web page: http://www.am.chalmers.se

Key words: Calibration, Crystal plasticity.

1 INTRODUCTION

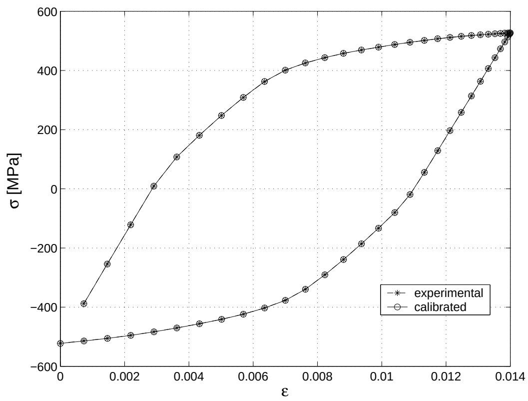
In recent years, the interest for multiscale material modeling (MMM) has increased, e.g., references[1,2,3]. The main motivation for using MMM is to account for the coupling between different geometrical scales, i.e., for polycrystalline materials, the macroscale (structural problem), mesoscale (grain structure) and microscale (individual grains). When the scales are sufficiently separated, the basic strategy is to apply the chosen macroscopic control variables, in terms of stresses and strains, as boundary conditions on the representative volume element (RVE). The RVE, which should mimic the grain structure of the material, is discretized using finite elements and the equilibrium equation is solved. The macroscopic response variables are then obtained via numerical homogenization of the constitutive behavior on the microscale by volume averaging on the RVE. Thereby, the constitutive modeling is shifted from the macroscale to the microscale. In order to predict real material behavior it is of utmost importance that the material parameters in the microscale constitutive model are determined from experimental data. However, experimental data usually relate the macroscopic stresses and strains leading to the need to use MMM in order to determine the material parameters.

In this contribution MMM is used to determine the material parameters in a crystal plasticity model with crystallographic damage[4]. The determination of the material parameters is done through numerical optimization, whereby, a least square measure of the discrepancy between simulated response and experimental data is minimized with respect to a certain norm. Since the simulated response requires the solution of a finite element problem on the RVE it is computationally demanding. Therefore, a strategy based on different assumptions for the boundary conditions on the RVE, as well as different optimization algorithms, is considered in order to reduce the computational effort. Furthermore, a parameter sensitivity analysis is performed to find the correlation between the material parameters.

The studied material is a two-phase stainless steel with both ferritic and austenitic phases. Hence, the material parameters for both the ferrite and the austenite need to be determined. This is a tedious task since experiments show that the properties of the pure ferritic and austenitic phases are changed when they are combined in a two-phase steel. Therefore, two materials with different volume fractions of the two phases have been manufactured and tensile and LCF tests have been performed on these in order to be able to determine the material parameters. Furthermore, a third material is used for predicting the behavior of the multiscale material model.

2 PRELIMINARY RESULTS

In order to be able to identify the material parameters in the crystal plasticity model, RVE:s that mimic the real duplex stainless steel have been generated using a Voronoi algorithm. Preliminary calibrations have been performed using two RVE:s with 30% and 70% ferrite, respectively. In order to judge whether macroscopic data of LCF type for two different volume fractions are sufficient, fictive experimental data (similar to real experimental data) were used in the calibrations. The calibration was performed using the gradient based Han-Powell optimization algorithm combined with a sensitivity analysis. In Fig. 1 the agreement between fictive experimental and calibrated results is shown.



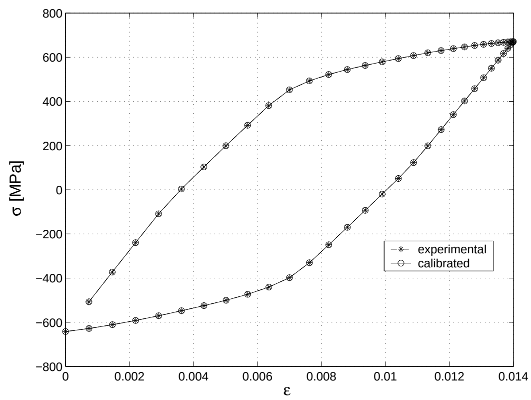


Figure 1: Fictive experimental and simulated results (cycle 50) for 30% ferrite (left) and 70% ferrite (right).

REFERENCES

[1] V.G. Kouznetsova. Computational homogenization for the multi-scale analysis of multi-phase materials.*PhD thesis, Technische Universiteit Eindhoven.*, 2002.

[2] C. Miehe, J. Schröder, and J. Schotte. Computational homogenization analysis in finite strain plasticity. Simulation of texture development in polycrystalline materials. *Comput. Methods Appl. Mech. Engng.*, **171**, 387–418, 1999.

[3] T.I. Zohdi. Computational modeling and design of new random microheterogeneous materials. *CISM Course Notes.*, 2002.

[4] M. Ekh, R. Lillbacka and K. Runesson. A model framework for anisotropic damage coupled to crystal (visco)plasticity. *Int. J. Plast.* **20**, 2143–2159, 2004.