Residual Stresses in Duplex Steels: Mean Field Modelling and Characterization

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ABSTRACT

In the talk, the mechanism-based modelling of residual stresses of first, second and third kind in duplex steels is discussed. The modelling is realized by a two-scale approach, which combines a classical mean field homogenization [1] with the principle of maximum entropy [2]. In comparison to full field approaches the computation time is reduced significantly. This allows for an application of the model approach at the integration point level of three-dimensional finite elements.

The mean field theory is used to derive a system of equations for the macroscopic residual stress of first kind and the microscopic residual stresses of second kind, i.e., the phase averages of the residual stresses on the grain level. For this estimate, the macroscopic stress, strain and stiffness data are used. The heterogeneity of the residual stresses within each phase, i.e., the residual stresses of third kind, are estimated based on a maximum entropy estimate. Within this approach the definition of the effective stress and strain and the Hill-Mandel condition are considered as constraints for the microscopic stress and strain distribution. By maximizing the information theoretic entropy, the local stress and strain distributions are estimated by Gauss distributions. By extending this approach, plastic deformations on the grain scale are taken into account.

The mechanical behaviour of the phases is experimentally characterized by X-ray diffraction within a quasi in-situ tensile test. For pre-defined loading steps the tensile test is interrupted and phase specific stresses are determined. Additionally, phase specific residual stresses are analysed after unloading from each loading step. This allows for the determination of material parameters as an input for the simulation as well as the comparison of the simulation results with respect to the residual stresses of first, second and third kind.

The aforementioned methods are applied to the duplex steel X2CrNiN23-4 (1.4362), which consists of a ferritic phase and an austenitic phase of equal volume fraction. Due to the high amount of both phases and the good separability of the diffraction lines the material is excellently suited for the experimental analysis of phase-specific residual stresses.

REFERENCES

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