The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

Crystal plasticity models for cast irons

Viacheslav Balobanov[1], Matti Lindroos[1], Tom Andersson[1] and Anssi Laukkanen[1]

[1] VTT Technical Research Centre of Finland
P.O. Box 1000, FI-02044, VTT, Finland
e-mail: first.second@vtt.fi

For centuries, cast iron is one of the most widespread material used in industrial applications. Despite this fact, a lack of multi-scale models explaining the global mechanical response of the material on the micro-level can be observed [1]. The reason is in complicated structure and extreme heterogeneity of the material consisting of iron and iron alloy crystals in different phases as well as soft graphite inclusions (nodulars or flakes).

The current contribution is devoted to the development of the methods and numerical tools based on the classical and gradient crystal plasticity models [2, 3, 4]. A reduced micromorphic crystal plasticity model [5, 6] is utilized to address scale dependencies while treating the cast iron as a composite material with full field modeling. The model is coupled to a cohesive zone-like treatment of damage to address the evolution of cracks arising from plastic slip during cyclic loading. The tension-compression asymmetry prevalent in cast irons is included and its sources addressed, including a smeared contact approach for closure of cracks formed under the tensile stages of loading. Altogether, the investigations and implementations are aimed at proper multiscale modeling of the wear, fracture, and fatigue processes in cast irons as well as cast processes. The experimental observations are addressed in order to validate the numerical results.

REFERENCES

[1] V. Norman, M. Calmunger, On the micro- and macroscopic elastoplastic deformation behaviour of cast iron when subjected to cyclic loading, International Journal of Plasticity 115 (2019) 200–215.

[2] F. Roters, P. Eisenlohr, L. Hantcherli, D. Tjahjanto, T. Bieler, D. Raabe, Overview of constitutive laws, kinematics, homogenization and multiscale methods in crystal plasticity finite-element modeling: Theory, experiments, applications, Acta Materialia 58 (4) (2010) 1152–1211.

[3] M. Lindroos, G. Cailletaud, A. Laukkanen, V.-T. Kuokkala, Crystal plasticity modeling and characterization of the deformation twinning and strain hardening in hadfield steels, Materials Science and Engineering: A 720 (2018) 145 – 159.

[4] V. Balobanov, M. Lindroos, T. Andersson, A. Laukkanen, Crystal plasticity modeling of grey cast irons under tension, compression and fatigue loadings, Crystalls (2022) Accepted.

[5] S. Forest, K. Ammar, B. Appolaire, N. Cordero, A. Gaubert, Micromorphic approach to crystal plasticity and phase transformation, Springer Vienna, Vienna, 2014, pp. 131–198.

[6] M. Lindroos, J.-M. Scherer, S. Forest, A. Laukkanen, T. Andersson, J. Vaara, A. Mantyla, T. Frondelius, Micromorphic crystal plasticity approach to damage regularization and size effects in martensitic steels, International Journal of Plasticity (2022) Accepted.