Multiaxial Fatigue Life Estimation Using an Improved Lemaitre's Continuous Damage Model

Guilherme V. Ferreira*, Lucival Malcher† and Raniere S. Neves°

*†° Group of Fatigue, Fracture and Materials (GFFM)
University of Brasília
Department of Mechanical Engineering, UnB-FT-ENM, 70910-900, Brasília, DF, Brazil
E-mail*: guilhermedf@gmail.com
E-mail†: malcher@unb.br
E-mail°: raniere_neves@aluno.unb.br

ABSTRACT

Multiaxial fatigue lifes, predicted by traditional approaches, such as Smith-Watson-Topper and Fatemi-Socie, e.g., normally have a reasonable correlation with experimental data, for simple problems. Usually, for the application of these traditional models in complex problems, as in the presence of variable amplitudes, are employed linear damage accumulation rules (Miner's Rule, e.g.) and simplified methods for cycle counting (Rainflow couting, e.g.). Such considerations may lead to significantly different life predictions, regarding the experimental data. Aiming to develop an alternative methodology, it is proposed, in the present contribution, to use an approach based on the Continuum Damage Mechanics to estimate fatigue life, having, as reference, the so called Improved Lemaitre's model (Improved CDM model). The cited model takes into account the function of damage denominator, calibrated according to two different loading conditions, and also the Chaboche approach to introduce the kinematic hardening effect, considering two nonlinear and one linear terms for the backstress. The model is implemented in an academic finite elements tool, which simulates the effect of one Gauss point, through an implicit integration method for the evolution equations. Finally, the model is tested using experimental data from the literature for a S460N steel. Normal and shear uniaxial loading conditions, as well as proportional and non-proportional multiaxial loading conditions are used. The results have shown that the continuum damage approach is able to estimate fatigue life under complex loading conditions and high levels of total deformation.

REFERENCES

[1] A. Fatemi and N. Shamsei, "Multiaxial fatigue: An overview and some approximation models for life estimation", *International Journal of Fatigue*, **33**, 948-958 (2011).

[2] J. Lemaitre, "A continuous damage mechanics model for ductile fracture", *Journal of Engineering Materials and Technology*, **107**, 83-89 (1985).

[3] L. Malcher and E.N. Mamiya, "An improved damage evolution law based on continuum damage mechanics and its dependence on both stress triaxiality and the third invariant", *International Journal of Plasticity*, **56**, 232-261 (2014).

[4] E.A. De Souza Neto, D. Perić and D.R.J. Owen, "A model for elastoplastic damage at finite strains: algorithmic issues and applications", *Engineering Computations*, **11**, 257-281 (1994).

[5] Y. Jiang, O. Hertel and M. Vormwald, "An experimental evaluation of three critical plane multiaxial fatigue criteria", *International Journal of Fatigue*, **29**, 1490-1502 (2007).