6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

REDUCED ORDER MULTISCALE MODELING OF THE VISCOELASTIC VISCOPLASTIC RESPONSE OF FIBER REINFORCED COMPOSITES

Iuri B. C. M. Rocha[1,2], Frans P. van der Meer[2,*] and Lambertus J. Sluys[2]

[1] Knowledge Centre WMC, Kluisgat 5, 1771 MV Wieringerwerf, The Netherlands
i.barcelos@wmc.eu

[2] Delft University of Technology, PO Box 5048, 2600 GA Delft, The Netherlands
f.p.vandermeer@tudelft.nl, l.j.sluys@tudelft.nl

Keywords: *Reduced order modeling, multiscale, rate-dependency, cyclic loading*

Predicting the long-term mechanical response of fiber reinforced composites requires a microechanical approach. By explicitly modeling fibers, resin and interfaces, the complex response of the composite material due to e.g. cyclic loading can be derived from a detailed model with relatively simple constitutive ingredients. In order to describe the evolution of the macromechanical stress distribution in relation to the local response, a multiscale approach with continuous two-way coupling between the scales can be used [1]. However, such multiscale modeling comes with very high computational costs, because of the high number of micromechanical models that is to be solved. This problem is aggravated when cyclic loading and long-term aging of the material are considered and many steps are needed in order to maintain accuracy in time-dependent models.

In this contribution, the possibilities to speed up the micromechanical analysis with reduced order modeling are explored. A multiscale problem with cyclic loading is analyzed. The micromodel consists of linear elastic fibers, a viscoelastic/viscoplastic resin with damage and cohesive interfaces. A hyper-reduction scheme is employed that combines the Proper Orthogonal Decomposition (POD) with the Empirical Cubature Method (ECM) [2] within the cycles where evolution of state variables is very slow. Between cycles, state variables are updated as well as, if necessary, the POD basis. In order to recover the stresses at all integration points a Gappy Data least-squares reconstruction is used in combination with a k-means clustering algorithm [3]. The speed-up obtained with the different reduced order techniques is analyzed.

REFERENCES

[1] IBCM Rocha, FP van der Meer, RPL Nijssen, and LJ Sluys. A multiscale and multiphysics numerical framework for modelling of hygrothermal ageing in laminated composites. *Int J Numer Method Eng*, 112:360–379, 2017.

[2] JA Hernández, M Caicedo, and A Ferrer. Dimensional hyper-reduction of nonlinear finite element models via empirical cubature. *Comput Method Appl Mech Eng*, 313:687–722, 2017.

[3] Z Liu, MA Bessa, and WK Liu. Self-consistent clustering analysis: An efficient multi-scale scheme for inelastic heterogeneous materials. *Comput Method Appl Mech Eng*, 306:319–341, 2016.