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Two complementary high-cycle fatigue models for the multiscale simulation of fiber reinforced polymers

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Fiber reinforced polymers are of central importance in many industrial applications such as lightweight constructions. Due to the complex microscopic structure of fiber reinforced polymers, their experimental characterization is tedious and time consuming, especially for the mechanical experiments required for high-cycle fatigue tests. Multiscale high-cycle fatigue-damage models offer to reduce this experimental effort on the material scale significantly and to replace high-cycle fatigue component measurements.

The choice of the high-cycle fatigue model is essential to match experimental results and their feasibility in multiscale simulation frameworks. We compare the recently developed isotropic non-local high-cycle fatigue-damage model of Köbler et. al. [1] with the fatigue-damage model of Magino et. al. [2], which precludes localization due its convex nature.

Both models describe the stiffness degradation of the polymer matrix under fatigue loading in the (logarithmic) cycle space. The resulting stiffness degradation of the fiber reinforced composite will be computed by using FFT-based homogenization [3]. By applying model-order reduction techniques, effective models for the anisotropic fatigue-damage behavior of the fiber reinforced microstructure are generated. We investigate the efficiency of these effective models, having the computational complexity of heuristic macroscopic material models, in simulations of a three dimensional benchmark part of industrial size.

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