
An anisotropic model for the multiscale analysis of short fiber reinforced polymers through Phase Field

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Abstract

Understanding and modeling the fracture mechanical behavior of short glass fiber reinforced polymers (SFRPs) is challenging: the strong heterogeneity induced by the manufacturing process causes a tight coupling of the material microstructure to the effective response on the component scale. Aiming to account for this microstructural complexity, fracture is approached using a multiscale approach.

Typically manufactured via injection moulding, SFRP components exhibit locally varying microstructural configurations e.g., fiber orientations, fiber volume contents, and fiber length distributions, which render fracture modelling a challenging task. To resolve the microstructure induced anisotropy and its relationship with the macroscopic material behavior, the well established isotropic phase field models of brittle fracture is extended towards the anisotropic case making use of the fiber orientation interpolation concept. To create the database, the anisotropic elastic coefficients are obtained from previously executed micromechanical simulations on realistic microstructures using the efficient microscopic solver FeelMath. At the simulation level, the local microstructure must be known in order to access the database: microstructural information stemming from either X-ray micro computed tomography or from injection moulding process simulation is mapped into the Abaqus mesh prior the execution of the macroscopic simulation. The performance of the simulation method is demonstrated by means of several numerical analyses and the prediction quality together with the limitations of the proposed method are demonstrated.

Therefore, an innovative approach is proposed using an offline training of a database plus a fiber interpolation concept to take into account the heterogeneity of the material. The approach is fully integrated into the seamless simulation chain for SFRPs ranging from the manufacturing process to the structure mechanical fracture analysis. The limitations of the approach stemming from the underlying assumptions are quantified and further development needs are identified.

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