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ABSTRACT:

Failure Prediction of Short Fiber Reinforced Thermoplastics using RVEs

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Short fibre reinforced plastics (SFRP) are widely used in the automotive and aerospace industries due to their good specific mechanical properties and excellent processability. However, their heterogeneous microstructure and fibre orientation distribution lead to anisotropic mechanical behaviour and complex failure mechanisms. Representative volume element (RVE) simulations provide a physically based framework for capturing the microstructure and predicting local stress distributions and failure initiation. Nevertheless, the relationship between microstructural failure events and the resulting macroscopic failure behaviour remains insufficiently understood.

In this work, an RVE modelling approach based on the methodologies proposed by Breuer [1] and Schraa [2] is used to investigate the stress states associated with failure initiation at the microstructural scale. Different fibre orientation distributions are considered in order to generate a representative set of RVEs failure. The local stress tensors corresponding to RVE at failure are extracted and evaluated in the principal stress space. This enables the reconstruction of a failure domain directly derived from the microstructural response of the material. The resulting failure envelope provides insight into the influence of fibre orientation and multiaxial stress states on the macroscopic failure behaviour. Furthermore, the characteristics of the reconstructed failure domain are analysed and compared with classical macroscopic failure criteria to assess their capability to represent the anisotropic failure behaviour of short fibre reinforced polymers.

[1] Kevin Breuer. “Beitrag zur Multiskalensimulation kurzfaserverstärkter Kunststoffe“. PhD thesis, TU Dresden. (2022)

[2] Lucas Schraa. „Charakterisierung und Simulation infrarotgeschweißter kurzglasfaserverstärkter Thermoplaste“. PhD thesis, TU Dresden. (2026)