Introduction

Under severe thermal conditions, the failure of heterogeneous materials originates from thermal expansion anisotropy, non-uniformity and/or mismatches between the constituents at the meso or micro level. Therefore a comprehensive understanding of the thermal and mechanical fields and their interaction at all relevant levels of observation is essential for the prediction of failure.

Objective

The goal of this contribution is to construct a multi-scale thermomechanical analysis approach within the framework of computational homogenization, which can be used to investigate the underlying mechanisms and the interaction between mechanical and thermal fields more transparently.

Modeling

The basic idea is the derivation of the macroscopic material response from the solution of a thermomechanical boundary value problem (BVP) defined at the micro level. The mechanical and thermal excitation of the microstructure is prescribed in terms of the macroscopic deformation gradient \( F_M \), the macroscopic temperature \( \theta_M \) and temperature gradient \( \nabla_M \theta_M \) through boundary conditions. Upon solution of the micro level problem, the macroscopic quantities are extracted as simple volume averages of the resulting stress and heat flux distributions.

Through condensation procedures as outlined in [1] and [2]. The implemented operator split nested finite element framework is demonstrated by an example problem. In fig. 1, a long plate made of boron fiber reinforced aluminum with the applied boundary conditions is shown.

The boron fibers are assumed to be elastic and the aluminum matrix is taken to be elasto-plastic with kinematic hardening.

Future Work

Damage mechanisms at the micro level (e.g. interfacial failure) will be introduced to the model.

References

2. Özdemir et al, I.J.N.M.E., online available