Mesoscopic modelling of the RTM process for homogenization

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ABSTRACT

Our work concentrates on the mesoscopic constitutive model for temperature-dependent visco-elastic effects accompanied by curing, which are important phenomena in production processes of intrinsic hybrids. These integral components are hybridized in a modified resin transfer molding process adding e.g. steel as a second semi-finished product to the textile. During hybridization and later mechanical loading, the periodic microstructure defined by resin and fibers is taken into account as a representative unit cell (RVE) subjected to thermo-mechanical loading.

The polymeric resin component is modeled using an approach form [1], where an additive ternary decomposition of the logarithmic Hencky strain tensor into mechanical, thermal and chemical parts is used. Based on the concept of stoichiometric mass fractions for resin, curing agent and solidified material the bulk compression modulus as well as the bulk heat- and shrinking dilatation coefficients are derived and compared with ad hoc assumptions from the literature [2,3]. Moreover, we use the amount of heat generated during differential scanning calorimetry until completion of the chemical reactions, to define the chemical energy. As a major result, the resulting latent heat of curing occurring in the heat-conduction equation derived in our approach reveals an ad hoc approach from [4] as a special case.

Linear thermo-elastic fibers in addition with the resin are used to model an RVE on the mesoscale. Periodic boundary conditions for displacements are applied including a macrostrain from the upper scale, to describe mechanical loading, while thermal loading is handled homogenously on the mesoscale. Homogenization leads to results on the less resolved macroscale.

In the examples we illustrate the characteristic behavior of the model, such as shrinking due to curing and temperature dependence and simulate the hybridization process as well as mechanical loading of the cured part with the finite-element-method. Results from the mesoscale are compared with those of the macroscale.

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