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TWO STEP HOMOGENIZATION APPROACH FOR MODELING THE MACROSCOPIC MATERIAL BEHAVIOR OF TEXTILE REINFORCED COMPOSITES

D. Branke[1], M. Kästner[1], M. Pohl[2] and V. Ulbricht[1]

[1] Institute of Solid Mechanics, Technische Universität Dresden, 01062 Germany
{Dominik.Branke; Markus.Kaestner; Volker.Ulbricht}@tu-dresden.de, mfk.mw.tu-dresden.de
[2] Institute of Lightweight Engineering and Polymer Technology, Technische Universität Dresden, 01062 Germany

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The design process of novel hybrid structures made of textile reinforced composites with thermoplastic matrices requires an integrated simulation of the deformation behavior as well as the prediction of effective properties which can be applied in a macroscopic structural analysis. Especially, knowledge on the macroscopically nonlinear material behavior of the composite is needed for consistent lightweight design. In this contribution a par-

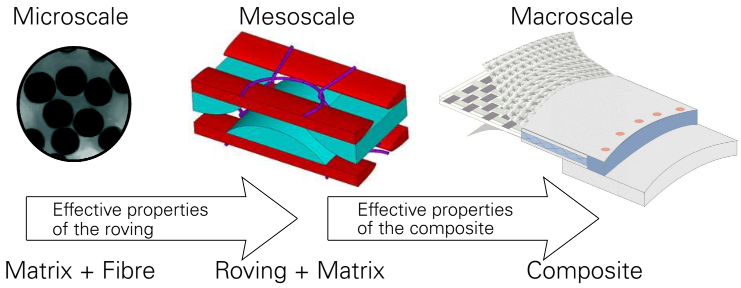

Figure 1: Hierarchical material structure of the considered composite

ticular composite – with a polypropylene (PP) matrix and rovings consisting of PP and glass filaments as textile reinforcement – is analysed experimentally and numerically. For the PP matrix, a viscoplastic material model based on an overstress formulation [1] has to be used to model its short term and long term behavior. However, focussing on time intervals larger than 10^3 seconds, this viscoplastic model can be reduced to a linear viscoelastic material model for which efficient homogenization techniques can be applied.
Due to fact that the reinforcement structure is made of rovings which consist of glass filaments and PP matrix material at the microscopic scale, a viscoelastic homogenization procedure is used to obtain a viscoelastic, homogeneous equivalent medium at the mesoscopic scale (see Figure 1). The approach is based on Hill's principle, the equivalence of

the stored stress power and it takes advantage of the elastic-viscoelastic correspondance principle in combination with a LAPLACE-CARSON transformation [2].
In addition to the material models for the constituents – the PP matrix and the roving – it is necessary to create a proper geometric model of the mesoscopic reinforcement structure. Therefor, individual pictures of a computed tomography scan are used to obtain the dimensions of the rovings and the layers of the composite [3]. An idealized mesoscopic representative volume element is build by means of these values (Figure 2). Based on the mesoscopic RVE model and the previously mentioned viscoelastic homogenization scheme, a second homogenization step provides the effective anisotropic viscoelastic material behavior of the composite. Eventually, different load cases, including out-of-plane compression which is of special interest for joining technologies, are simulated and compared to experimental results.

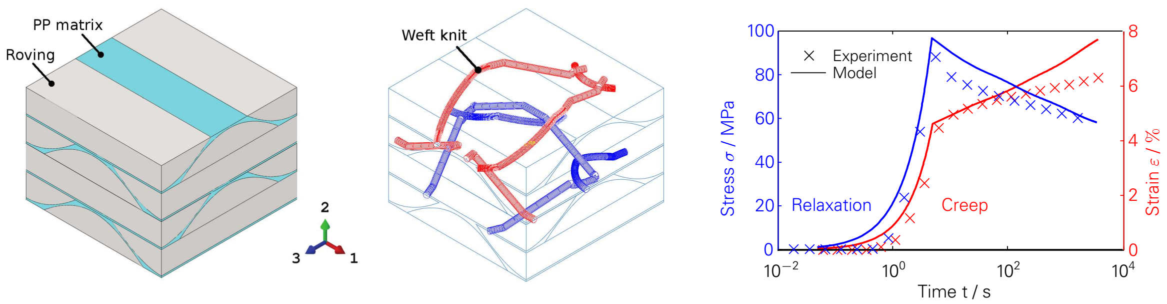

Figure 2: Mesoscale: RVE-Model and numerical simulation

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