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Thermoelastic homogenization and experimental investigations of a thermoset-based long fiber reinforced composite

L. Kehrer*[1], P. Pinter[2], K. A. Weidenmann[3] and T. Böhlke[4]

[1] Institute of Engineering Mechanics, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany, loredana.kehrer@kit.edu, http://www.itm.kit.edu/cm

[2] Institute of Applied Materials, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany, pascal.pinter@kit.edu, https://www.iam.kit.edu/wk

[3] Institute of Applied Materials, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany, kay.weidenmann@kit.edu, https://www.iam.kit.edu/wk

[4] Institute of Engineering Mechanics, Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany, thomas.boehlke@kit.edu, http://www.itm.kit.edu/cm

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Fiber reinforced polymers are increasingly applied as resource efficient semi-structural materials, especially in the sector of engineering applications. Thermoset-based composites reinforced with continuous and discontinuous glass or carbon fibers provide advantages with respect to their specific material properties, various design possibilities as well as short cycle times during the manufacturing process. The work at hand considers a long discontinuous fiber reinforced composite consisting of a polyester and polyurethane hybrid resin (UPPH) as matrix material. Manufactured by sheet molding compound (SMC), a local fiber orientation distribution of the fibers is induced leading to anisotropic material behavior. By means of dynamic mechanical analysis (DMA) with the GABO Eplexor® 500N, the thermoviscoelastic material behavior is characterized both for fiber reinforced and pure UPPH samples. These tests indicate a distinct temperature-dependent but a less pronounced viscoelastic material behavior of the matrix and composite materials. The material behavior on microscopic scale is, thus, thermodynamically modeled with temperature-dependent elasticities. Based on [1], an extended Hashin-Shtrikman-type (HS) mean field model is used to determine the effective thermoelastic material properties. Accounting for the orientation information on the microscopic scale, the HS-type homogenization method is formulated explicitly in terms of orientation tensors of 2nd and 4th order which are determined based on computed tomography scans (μCT) [2]. Furthermore, the effective thermoelastic behavior calculated by the HS-type method is compared to results obtained by the full field homogenization using the software tool GeoDict®. Herein, by means of fast Fourier transformation, the boundary value problem for a voxel-based volume element is solved. Finally, simulation results by mean and full field methods are compared to experimental data from DMA and discussed.

REFERENCES

[1] J. R. Willis, *Variational and related methods for the overall properties of composites.* Advances in Applied Mechanics, Vol. **21**, pp. 1–78, 1981.

[2] P. Pinter, S. Dietrich, K. A. Weidenmann, *Algorithms for the determination of orientation-tensors from three dimensional μCT images with various microstructures.* Conference Proceedings ICCM20, 2015.