Linear viscoelasticity of anisotropic carbon fibers reinforced thermoplastics: from micromechanics to dynamic torsion experiments

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Abstract

Focusing on tanks applications, like H2 tank, the creep behavior of structures is a concern. In order to predict it, one needs to know the composite viscoelastic behavior. In this study, we have tried to answer to two questions: 1) Is it possible to simply characterize the transversely isotropic linear viscoelastic of a unidirectional (UD) composite in the lab? 2) Can we predict it using homogeneization?

For that purpose, dynamic torsion tests were conducted at 1 Hz over a wide temperature range, from the glassy to the rubbery states of the polymeric matrix, on both the pure matrix and the composite, for various cutting angles relative to the fibers. A two-step modeling procedure in the frequency domain is presented to predict and validate the effective behavior of the composite. The first step involves FFT-based homogenization, which maps the microstructure and constituent behaviors to effective transversely isotropic viscoelastic properties. The second step consists of finite element simulations using the effective behavior calculated from homogenization as input to replicate the experiments. A comparison between experimental results and model predictions across the entire temperature range is performed. The modeling predictions show good accuracy at low temperatures, where the matrix is in the glassy state. At high temperatures, where the matrix is in the rubbery state, the predicted behavior becomes too soft. As the phase contrast increases and the ratio of matrix bulk modulus to shear modulus rises significantly, the impact of fiber arrangement on the effective properties becomes more pronounced.

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