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A Micromechanics-Based Processing Model for Predicting Residual Stress in Fiber-Reinforced Polymer Matrix Composites

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Abstract

An experimentally validated, multi-physics and multi-scale processing model was developed to predict the residual stress buildup in a polymer matrix composite during manufacturing. At the macroscale, the composite was modeled as discrete layers of homogeneous, transversely isotropic laminae, while micromechanics was implemented at the subscale to compute the effective lamina responses based on the fiber and matrix properties through an Extended Concentric Cylinder Assemblage (ECCA) model. The composite temperature and Degree of Cure (DOC) distributions were solved by incorporating resin cure kinetics into heat transfer analysis, which were used in the subsequent stress analysis to determine the cure-dependent composite responses, including cure-dependent modulus, thermal strain, and chemical shrinkage. This integrated processing model was applied to predict the cure-induced warpage of a non-symmetric laminate. The proposed model, which incorporates resin cure kinetics, cure-dependent constitutive law, and tool–

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