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Multiscale Cohesive Zone Modeling of Composite Microstructure

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Abstract : A finite element cohesive zone model is used to predict the temperature dependent material properties of a polyimide matrix composite with unidirectional carbon fiber arrangement. The cohesive zone parameters have been obtained from previous research involving an atomistic-to-continuum multiscale simulation of the fiber-matrix interface using the bridging cell multiscale method. The goal of the research was to both investigate the effect of temperature change on the composite behavior with respect to transverse loading as well as the validate the use of cohesive parameters obtained from atomistic-to-continuum multiscale modeling to predict fiber-matrix interfacial cracking. From the multiscale model cohesive zone parameters (i.e. maximum traction and energy of separation) were obtained by modeling the interface between the coarse-grained polyimide matrix and graphite based carbon fiber. The cohesive parameters from this simulation were used in a cohesive zone model of the composite microstructure in order to predict the properties of the macroscale composite with respect to changes in temperature ranging from 21 ˚C to 316 ˚C. Good agreement was found between the microscale RUC model and experimental results for stress-strain response, stiffness, and material strength at low and high temperatures. Examination of the deformation of the composite through localized crack initiation at the fiber-matrix interface also agreed with experimental observations of similar phenomena. Overall, the cohesive zone model was shown to be both effective at modeling the composite properties with respect to transverse loading as well as validated the use of cohesive zone parameters obtained from the multiscale simulation.

Keywords : cohesive zone model, fiber-matrix interface, microscale damage, multiscale modeling
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