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Abstract

A continuum mechanics approach is utilized herein to develop a model for predicting the thermomechanical constitution of elastic composites subjected to both monotonic and cyclic fatigue loading. In this model the damage is characterized by a set of second-order tensor valued internal state variables representing locally averaged measures of specific damage states such as matrix cracks, fiber-matrix debonding, interlaminar cracking, or any other damage state. Locally averaged history dependent constitutive equations are posed utilizing constraints imposed from thermodynamics with internal state variables. In Part I the thermodynamics with internal state variables is constructed and it is shown that suitable definitions of the locally averaged field variables will lead to useful thermodynamic constraints on a local scale containing statistically homogeneous damage. Based on this result the Helmholtz free energy is then expanded in a Taylor

series in terms of strain, temperature, and the internal state variables to obtain the stress-strain relation for composites with damage. In Part II the three-dimensional tensor equations developed in Part I are simplified using material symmetry constraints and are written in engineering notation. The resulting constitutive model is then cast into laminate equations and an example problem is solved and compared to experimental results. It is concluded that although the model requires further development and extensive experimental verification it may be a useful tool in characterizing the thermomechanical constitutive behavior of continuous fiber composites with damage.

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