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STOCHASTIC VIRTUAL TESTS FOR FIBER COMPOSITES

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We will describe a Virtual Test system for continuous fiber composites. The virtual test draws from a new wave of advanced experiments and theory that address physical, mathematical, and engineering aspects of material definition and failure prediction. The methods go far beyond currently standard tests and conventional FEM analysis to challenge our conception of what can constitute a practicable engineering approach. Emphasis will be given to high temperature ceramic matrix composites with textile reinforcement, which have been the subject material of the National Hypersonic Science Center, Materials and Structures, a joint AFOSR/NASA program. However, thematic topics also address generic fiber composites.

Development has been organized as a "pipeline" that links the separate disciplinary efforts of groups housed in seven institutions spread across the US. The main research steps are: high resolution three-dimensional (3D) imaging of the microstructure, statistical characterization of the microstructure, formulation of a probabilistic generator for creating virtual specimens that replicate the measured statistics, creation of a computational model for a virtual specimen that allows general representation of discrete damage events, calibration of the model using room and high temperature tests, simulation of failure, and model validation. Key new experiments include digital surface image correlation and μm-resolution 3D computed tomography imaging of the microstructure and evolving damage, both executed at temperatures exceeding 1500°C. Conceptual advances include using both geometry and topology to characterize stochastic microstructures. Computational methods include new probabilistic algorithms for generating stochastic virtual specimens and a new Augmented Finite Element Method (A-FEM) that yields extreme efficiency in dealing with arbitrary cracking in heterogeneous materials. The challenge of relating variance in engineering properties to stochastic microstructure in a computationally tractable manner, while retaining necessary physical details in models, is discussed.