On modeling damage and failure in ceramic matrix fiber reinforced composites

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Fiber reinforced ceramic matrix composites (CMC) are targeted for many jet engine applications. These materials exhibit non-linear deformation response due to progressive microcracking of the matrix material. Multiple analytical ply-level models have been developed to predict crack spacing in brittle materials. In this talk, results will be presented for computational models that use the energy-based crack band theory to simulate the post-peak response observed in the macroscale response of notched, cross-play laminates subjected to remote uniaxial loading. Damage and failure that starts at the notch is reproduced in the computational results. The computational framework includes realistic CMC microstructures that are modeled in a two-scale finite element based predictive methodology. The subscale computations are complemented through micromechanics based substructure analysis that show the progressive development of matrix microcracks when cross-ply CMCs are subjected to tension. Microstructural details are captured in the model such as random fiber locations, fiber clustering, eccentric fiber coatings etc. The predicted crack spacing, which is a characteristic length of the physical mechanisms, is seen to agree with experiment. Furthermore, the macroscale model predictions are shown to be able to capture experimentally observed results for the tensile response of cross-ply laminates at room and elevated temperature.

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