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EFFECTS OF STRESS CONCENTRATIONS AT THE SLIPPING FIBER/MATRIX INTERFACE ON TENSILE STRENGTH OF CERAMIC MATRIX COMPOSITES

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ABSTRACT

Ceramic matrix composites can exhibit a transition from strong, tough behavior to brittle behavior as the interfacial sliding resistance τ between the fibers and the matrix increases. The detailed micromechanical reasons for this dangerous transition are not well understood, but are clearly important for optimizing performance in such composite systems. One mechanism of weakening involves a transition, with increasing τ, from "global" to "local" load transfer from broken to unbroken fibers near the slipping interface. These stress concentrations have been nicely investigated previously by Steif and coworkers (1991) for 2d geometries and by Weitsman and coworkers (1993) using shear-lag for an axisymmetric problem, but the precise implications of these stress concentrations on actual tensile composite failure have not been fully investigated. Here, the problem of stress concentrations in the fiber is revised using the very accurate yet efficient Axisymmetric Damage Model of Pagano (1993) to calculate the axial fiber stresses. The geometry is axisymmetric with a transverse matrix crack and a debond crack along the fiber/matrix interface having a constant sliding resistance τ. The stress concentrations obtained are compared to previous results, and generally increase with increasing τ. More importantly, the fiber surface stresses are then used to determine the probability of fiber fails by surface flaws having a Weibull probability distribution, and the overall composite strength is calculated in a manner similar to that originally suggested by Thouless and Evans for a single matrix crack. The results show a decrease in strength with increasing τ, relative to the common approximation of assuming uniform stresses across the fiber cross-section. The nature of the tough to brittle transition will be discussed in light of these results.

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