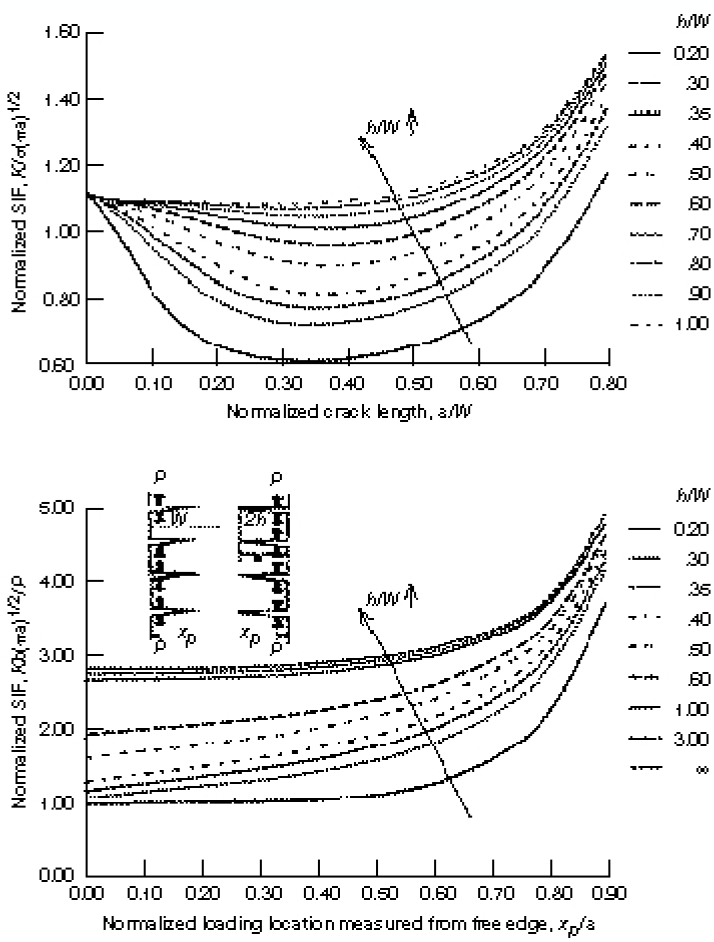
Stress Intensity Factor Solutions for Multiple Edge Cracks in Ceramic Matrix Composites

Ceramic matrix composites (CMC's) are candidate materials for high-temperature aerospace applications where high-strength and low-weight are essential for more efficient engines. One advantage of fiber-reinforced ceramics over monolithic ceramics is an increase in fracture toughness because of the presence of unbroken fibers in the wake of advancing cracks. The unbroken fibers restrict the crack opening displacements, shield the crack tip, and reduce the crack driving forces. Extensive experimental studies of various CMC's have also shown the development of a periodic array of matrix cracks bridged by unbroken fibers in unidirectional and two-dimensional woven systems.



Normalized stress intensity factor (SIF), K, for multiple double-edge notch specimens. Uniform stress, s ; point load, P; crack length, a; half specimen width, W; point loading location, x_p; half crack spacing, h; and specimen thickness, b. Top: Uniform remote load with no bridging. Bottom: Point load along the crack faces for a/W = 0.5.

Before these ceramic matrix composite systems can be used in actual engine applications, life-prediction methodologies have to be established on the basis of these observed failure mechanisms. Consequently, the NASA Lewis Research Center conducted a study to determine the stress intensity factor solutions for periodic arrays of bridged cracks for various crack spacings and crack lengths. Initially, the stress intensity factor of an array of unbridged multiple edge cracks was determined under constant global displacement as well as at a point load along the crack wake. These solutions are expected to contribute toward the development of a damage-based life-prediction methodology for CMC engine components.

Bibliography

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