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PROCEEDINGS

High-Temperature Fracture Behavior and Toughening Mechanisms of PIP-C/SiC Composites: An Integrated Experimental and Phase-Field Study

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ABSTRACT

Considering the high-temperature application environment and quasi-brittle characteristics, the high-temperature fracture toughness of C/SiC composites is of great significance for the safety application of components in service.

In this work, the fracture toughness of PIP-C/SiC composites at 25 – 1600 ℃ in inert atmosphere was tested. The test results show that the fracture toughness and modes of C/SiC composites have significant temperature dependence and difference in in-plane and out-of-plane orientations. With the rising of temperature, the carrying capacity and KIC of C/SiC composites increase first and then decrease, and an inflection point occurs near the fabrication temperature. The fracture mode of specimens in the in-plane orientation is mode-I cracks and fiber bundles fracture, while in the out-of-plane orientation is mixed-mode cracks. The temperature changes the length of fiber pull out for the specimens in the in-plane orientation, and affect the paths of crack propagation for specimens in the out-of-plane orientation. In particular, the specimens in out-of-plane orientation show bending failure rather than crack propagation at 1600 ℃.

Based on the phase field method, a high-temperature fracture model considering the effects of residual stress, temperature-dependent properties, and interfacial graphitization was established, in order to simulate the microcrack propagation at different temperatures. From the numerical results, the cracks deflect at the PyC interphase below the fabrication temperature, and it gradually decreases with increasing temperature. Near the fabrication temperature, the cracks penetrate straight through the interphase and cut off fibers, and C/SiC composites exhibit brittle fracture. In particular, the interphase graphitization leads to long-debonding of the fiber/matrix interphase at 1600 ℃. Crack deflection and interphase debonding are important toughening mechanisms of C/SiC composites. Overall, these findings contribute to deeper understanding of the fracture mechanism of ceramic matrix composites in high-temperature environments.

KEYWORDS

Ceramic matrix composites; high temperature; fracture toughness; phase field method; crack propagation

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