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Dynamic Crack Propagation of Ceramic Materials under High Temperature Thermal Shock

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ABSTRACT

Ceramics has become one of the most promising candidate materials in the aerospace field due to its advantages of high melting point, corrosion resistance, wear resistance, and high-temperature stability [1,2]. However, the inherent brittleness of ceramics makes it prone to thermal shock failure under high-temperature extreme environments, which can lead to sudden catastrophic accidents in the structure [3-6]. This paper takes the high-temperature resistant ceramic materials in the aerospace industry as the research object. And the dynamic crack propagation mechanism is analyzed. Through the computational method based on the extended finite element method (XFEM), the stress, temperature, deformation field, and dynamic crack propagation process of the square specimen under local high-speed thermal shock at different temperatures are simulated. The dynamic crack propagation rules and failure forms of the material under local high-speed thermal shock in extreme environments are explored. On this basis, combined with theoretical and numerical calculation methods, the stress field of ceramic materials in high-temperature complex environments, the thermomechanical coupling mechanism, and the crack path selection are analyzed. The relationship between temperature and the geometric shape of dynamic crack propagation is theoretically constructed. The overall failure criteria under different temperature conditions is proposed. And the evaluation of the thermal shock resistance of the material in extreme environments is achieved. A basic theory for the design and manufacture of related materials is provided for the aerospace industry.

KEYWORDS

Thermal shock; dynamic properties; high-temperature environment; crack propagation; ceramic

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