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PROCEEDINGS

Thermal Shock Fracture of Functionally Graded Materials Based on the Phase-Field Fracture Method

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ABSTRACT

The thermo-elastic fracture problems of functionally graded materials (FGMs) are thoroughly investigated based on a phase field model. In this model, the material constants and fracture toughness vary with the spatial coordinates, the thermal conductivity and stiffness constants in the damaged regions are degraded by the phase-field variable, and the crack evolution is driven by the variation of elastic energy induced by the thermo-mechanical loading. Therefore, the temperature, mechanical and damage fields are coupled with each other. The finite element discretization of the governing equations and the numerical implementation details are provided. The validation of the present approach has been checked by comparing the present results with the analytical, numerical, and experimental results in literature. The examples of thermo-elastic tensile fracture and thermal cracking of FGMs are performed to investigate the influence of material heterogeneity and external thermal load. For the tensile fracture in a thermal environment, the material gradient index and the applied thermal load have significant effects on the prestress, peak force, and fracture displacement. For thermal shock cracking, the material gradient index significantly influences the locations of crack nucleation, crack number, and crack length. Furthermore, the experimental phenomenon of crack deflection in FGMs has been captured by the present simulations. The present study provides a guidance for understanding the fracture mechanism, designing the FGMs and assessing the safety of FGM structures in engineering practice.

KEYWORDS

Functionally graded materials; phase-field model; thermal shock fracture

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