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INVESTIGATION OF THE THERMAL FRACTURE OF A NON-HOMOGENEOUS MATERIAL FOR MIXED-MODE CRACK BASED ON THE NON-FOURIER THEORY

Y.Y. Zhang [1,2], Z.T. Chen [1*], Fengnan Guo[3], Zehui Zhang[2], T. Ye [2]
[1] Department of Mechanical Engineering, University of Alberta, Edmonton, AB T6G1H9, Canada
[2] School of Astronautic, Civil Aviation Flight University of China, Guanghan 618307, China
[3] State Key Laboratory of Structural Analysis for Industrial Equipment, School of Aeronautics and Astronautics, Dalian University of Technology, Dalian 116024, China
*zengtao@ualberta.ca

ABSTRACT

Non-homogeneous materials (NMs) are complex structures with extreme working conditions. They are mainly used in thermal protection systems of engines and key components of high-speed aircraft. Fracture failure is a typical failure mode of NMs. Meanwhile, strong transient working conditions may occur in the NMs. The Fourier heat conduction, which assumes heat propagating at an infinite speed, is not suitable for the strong transient working conditions. In order to fully understand the thermal fracture behavior of NMs, it is necessary to investigate the fracture problems of NMs under strong transient thermal loading.

To solve the thermal fracture problems of NMs under transient thermal shock, this paper proposes a method which combined the Newmark method and the transient interaction energy integral method (IEIM). The strong transient temperature and the transient thermal stress intensity factors (TSIFs) of NMs under strong transient thermal load can be obtained using the proposed method. Some examples are proposed to study the influence of the properties on the TSIFs. Firstly, the influences of Young's modulus, thermal relaxation time, thermal expansion coefficient, and density continuity on the mixed-mode TSIFs at the weak interfaces are studied. Then the crack growth laws under thermal shock at the strong and weak interfaces are analyzed. In addition, the influences of the crack angle on the mixed-mode TSIFs are investigated. The present work can be used for the design, evaluation of NMs under transient thermal loading.

KEYWORDS: Newmark method; Transient thermal stress intensity factors; Interaction energy integral method; Non-homogeneous materials; Thermal shock crack growth.