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ORIGINAL PAPER

Evaluation of stress intensity factors in functionally graded plate under mechanical and thermal loadings

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Abstract
The analysis of FGM structures requires the implementation of sophisticated mechanical behavior simulation tools, and the interaction between design and manufacturing and the risks associated with cracks play an important role in understanding the mechanical behavior of crack structures. The effect of cracking on the functional gradient plate was studied in this research. In our study and for damage tolerance insurance, the stress intensity factor was determined for the purpose of predicting the behavior of cracked structures similar to the examples studied i.e. type of combination of FGM materials, type of applied load and type of crack, the numerical evaluation of this factor is determined using the displacement extrapolation technique (DET) and the generalized displacement correlation method (GDC) in an APDL (Ansys Parametric Design Language) numerical code to prove the evolution, the continuous variations of the material properties are incorporated by specified parameters at the centroid of each element. The crack growth paths with different FGM gradient parameters under mechanical and thermal loads are investigated and compared with reference solutions. The current DET, GDC, and reference solution results are in good agreement.

Keywords Stress intensity factor (SIF) · Functionally graded materials (FGM) · Displacement extrapolation technique (DET) · Mode-I · Generalized displacement correlation (GDC)

1 Introduction

Researchers need the materials for the new ideas in order to put them into practice. From the basic material of the periodic table to composite materials, we have now advanced to functionally graded materials. In the modern world, where material change is happening much more quickly than it has in the past, new concepts must overcome a new set of obstacles. A team of Japanese researchers began creating a composite material in 1980 for a space program that required to withstand significant temperature variations. Think of a composite material that has A and B as its two sides. In the event that face A is exposed to a temperature of 2000 K, face B should not be affected. For this project, scientists chose laminated composite material (LCM). Every time (LCM) failed, it was due to delamination, which is the separation of LCM from the point where they were originally bonded. Why did this happen? Because of the high-stress intensity factor caused to sudden changes in materials. Scientists discovered that the material should be gradually added to each other to lessen the high-stress intensity component, and here the concept of FGM is visualized [1–7]. For fracture analysis, the estimation of stress intensity factors (SIF) for such cracks is necessary. The mechanical characteristics of the crack along its whole length, crack direction, property profile, crack-tip position, and specimen geometry all affect the SIF. Because the SIF is a critical failure parameter in graded materials, predicting SIF values for various loading and gradient scenarios has been the focus of computational and experimental work on FGMs thus far. A significant part of the research has been done to determine the orientation and impact of cracks on the component's performance. Many authors have investigated and reported the impact of combining the aforementioned factors. Theoretical research has been done on the fracture

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