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Strength Analysis of SiC/Al Functionally Graded Materials due to Thermal Loading

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Summary

Functionally graded materials are initially designed to release thermal stress concentration in airplane components in a way of combining metals and high temperature ceramics. They are able to solve problems in conventional composite materials by means of varying its material properties gradually and continuously. So the crack property studying of FGM is essential for FGM rating, manufacturing and application.

A transition mapped quadrilateral meshing of finite element is set up in this paper to simulate crack propagation in functionally gradient material specimen according to the Multi-Layer Method. Element deletion method deactivates elements by multiplying their stiffness by a severe reduction factor when element strain reaches the prescribed threshold value. Therefore, element deletion is useful for modeling effects due to phase changes (as in welding process), failure-surface propagation and other analysis-dependent element changes. To achieve a better element deletion calculation, a transition mapped quadrilateral mesh is needed. Solid modeling and element generating technique are used to get the transition mesh which can underline the interested fracture region and at the same time save computing time.

Aided by element deletion method, the model is employed to calculate three FGM specimens and two other homogeneous material specimens under thermal loading in Figure 1.

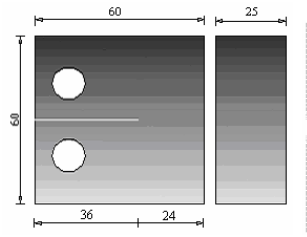

Figure 1: Meshed model of specimen

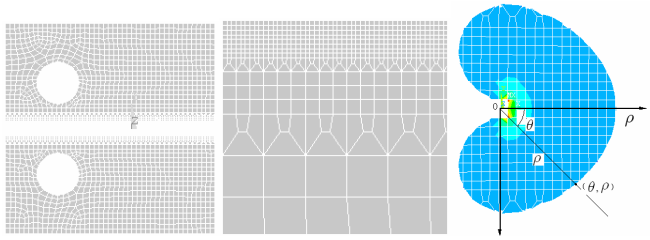

Figure 2: Crack propagation

A conclusion can be drawn from the element strain solutions that the crack propagates in a direction perpendicular to the gradient direction of the 4 layers FGM specimen. In addition, two valuable fracture parameters have been put forward to quantify the crack propagation behavior in a SiC/AL FGM in Figure 2. The results show the propagation due to thermal loading different to the crack due to

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mechanical loading which propagates prone to the material with the lower specific modulus.

keywords: Functionally gradient material; Element deletion; Propagation angle; Transition mapped quadrilateral meshing; No-dimensional propagation radius