PATH-INDEPENDENT H-INTEGRAL FOR INTERFACE CORNERS UNDER THERMAL LOADINGS
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It is well known that the path-independent H-integral is an appropriate tool for calculating the mixed mode stress intensity factors for the interface corners between dissimilar elastic materials. To extend the applicability of the H-integral from the mechanical loading condition to the thermal loading condition, a modified H-integral is proposed in this paper. This modified H-integral possesses an extra domain integral which needs the input of temperature field. Moreover, this domain integral contains singular functions that come from the strain components of the auxiliary system, and a special treatment should be made for the accurate computation of stress intensity factors. The near-tip solutions and auxiliary solutions of displacements, stresses, and temperature required in the calculation of H-integral are all provided in this paper. The validity and versatility of the proposed approach are then shown by carrying out several numerical examples such as cracks under mixed-mode thermal loadings, interface cracks/corners under uniform heat flow or uniform temperature change, and an electronic package, in which the chip has a heat generation rate, placed at a constant temperature ambiance.

1. Introduction

Many engineering objects, for example electronic packages, engines of power vehicles, solar panels, and so on, are operated in thermal environments. Temperature changes, heat flux on the object surface, and heat generation in the interior can deform the object and induce stress when restrictions on deformation are imposed, such as a clamped boundary condition or a perfect-bonded condition along an interface between dissimilar materials. Interface corners commonly appear in these engineering objects and failures initiate from these critical regions due to discontinuities of geometry and material properties. Hence, methods of fracture analysis for estimating the potential of failure and the mode of fracture of interface corners in elastic materials subjected to thermal loading are of great importance. Orders of stress singularity and stress intensity factors are two commonly used parameters when we perform fracture analyses within the category of linear elastic fracture mechanics.

This paper provides an accurate, efficient, and systematic solution technique to calculate these two parameters for interface corners between dissimilar elastic materials subjected to thermal loading.

Studies of fracture analysis of interface cracks subjected to thermal loadings include [Erdogan 1965; Brown and Erdogan 1968; Hwu 1990; 1992; Ikeda and Sun 2001; Banks-Sills and Dolev 2004; Nagai et al. 2007]. Relatively few studies have dealt with interface corners; they include [Munz and Yang 1992; 1993; Banks-Sills and Ishbir 2004; Hwu and Lee 2004; Nomura et al. 2009]. To understand the

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