Electromechanical fracture analysis for corners and cracks in piezoelectric materials

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A B S T R A C T

Corners and cracks are usually studied separately in the literature. To build a bridge connecting these two different but similar topics, in this paper the solutions for piezoelectric multi-wedges, which cover corners and interface corners, are used to study the cracks and interface cracks in piezoelectric materials. Moreover, the stress/electric intensity factors defined for cracks, interface cracks and interface corners are also extended to the general corners. By taking the special feature of Stroh formalism for anisotropic elasticity, all the solutions presented in this paper for piezoelectric materials preserve the same matrix form as those of the corresponding anisotropic problems. To see more clearly about the piezoeffects on the corners and cracks, most of the complex matrix form solutions are expanded in real component form for two typical piezoelectric ceramics with different poling directions.

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1. Introduction

Due to the widely applications of piezoelectric materials and their possible failure induced by cracks, several different kinds of crack problems for piezoelectric materials have been discussed in the literature such as (Pak, 1990; Sosa, 1991; Kuo and Barnett, 1991; Suo et al., 1992; Park and Sun, 1995; Liang and Hwu, 1996). However, relatively few discussions have been devoted into corners in piezoelectric materials (Chung and Ting, 1995; Xu and Rajapakse, 2000; Weng and Chue, 2004) and the connections between cracks and corners. Recently, a unified definition of stress intensity factor was proposed (Hwu and Kuo, 2007) to build a bridge connecting the failure prediction among the interface corners, interface cracks and cracks in homogeneous materials. Here, we like to extend this discussion to corners and cracks in piezoelectric materials. By taking the advantages of Stroh formalism (Stroh, 1958; Ting, 1996) which preserves most essential features of anisotropic elasticity when extending to include the piezoeffects, several explicit closed form solutions for corners and cracks in piezoelectric materials are presented in this paper. Thus, in Section 2, the electromechanical analysis is briefly stated based upon the extended Stroh formalism for piezoelectric anisotropic elasticity.

In Section 3, the orders of stress/electric intensity factors for piezoelectric multi-wedges are presented by the same matrix form solutions as those shown for anisotropic multi-wedges (Hwu and Lee, 2004), and resemblance