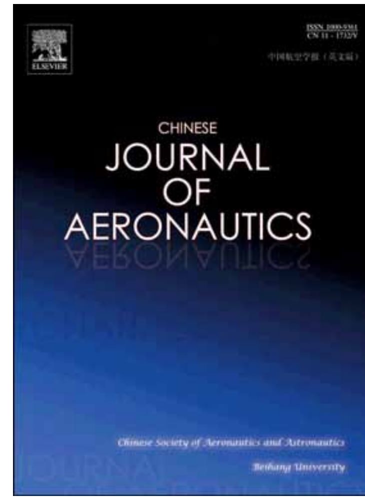

Anti-plane problem of four edge cracks emanating from a square hole in piezoelectric solids

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Anti-plane problem of four edge cracks emanating from a square hole in piezoelectric solids

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Abstract

By constructing a new numerical conformal mapping and using the Stroh-type formulism, an anti-plane problem of four edge cracks emanating from a square hole in piezoelectric solids is investigated. The explicit expressions of the complex potential function, field intensity factors, energy release rates and mechanical strain energy release rate near the crack tip are obtained under the assumptions that the surfaces of the cracks and hole are electrically permeable and electrically impermeable. Numerical examples were presented to show the influences of the geometrical parameters of defects and applied mechanical/electrical loads on the energy release rate and mechanical strain energy release rate under two electrical boundary conditions.

Keywords: Piezoelectric material; Hole; Cracks; Conformal mapping; Stroh-type formulism

1. Introduction

Due to the excellent coupling between mechanical and electrical fields, the piezoelectric devices have been used in aviation and aerospace industry, such as structural health monitoring, precision positioning and vibration control. The actuators and sensor in smart structures, which scale down favorably in terms of power output and efficiency, have yielded the novel compact piezoelectric hydraulic pumps in the aerospace industry [1]. However, the brittleness of piezoelectric materials inevitably leads to many kinds of defects (e.g., cracks and holes) during the processing, manufacturing and in-service periods. Therefore, it is of great significance to understand the fracture behavior of the complicated defects in piezoelectric materials, especially for cracks emanating from holes.

In past decades, many crack problems was considered by researchers. For example, Gao and Yu [2] addressed the generalized two-dimensional plane problems of a semi-infinite crack in a piezoelectric medium subjected to a line force and a line charge based on the Stroh formalism, and obtained the explicit expressions of the field intensity factors and the Green's functions. By comparing the electrically impermeable and permeable boundary assumptions, Wang and Mai [3] pointed out that the electrically impermeable boundary was a reasonable one in engineering applications. Li and Lee [4-5] analyzed the electroelastic behavior of a piezoelectric ceramic strip containing an anti-plane shear crack. By utilizing the integral transform, Li and his coauthors [6-8] considered the anti-plane interface cracks in two bonded dissimilar piezoelectric layers under the electrically permeable and impermeable assumptions. Guo et al. [9] studied the anti-plane problem of a semi-infinite crack in a piezoelectric strip by using the complex variable function method and the technique of the conformal mapping. For the hole problems, Gao and Fan [10] investigated the two-dimensional problems of an elliptical hole in a piezoelectric material based on the complex potential approach and obtained the explicit solutions in closed form under remotely uniform mechanical and electrical loads. Dai et al. [11] performed the stress concentration around an elliptic hole in transversely isotropic piezoelectric solids subjected

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