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A MODE-III CRACK WITH SURFACE EFFECT IN A MAGNETOELECTROELASTIC MEDIUM

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Abstract
In this paper, the contribution of surface effect to the anti-plane deformation of a magnetoelectroelastic medium weakened by a crack is investigated. The surface magnetoelectroelasticity is incorporated by using the extended surface/interface model of Gurtin and Murdoch. The mixed boundary value problem of the mode-III crack is formulated by using a continuous distribution of screw dislocations and the dislocations of electric potential and magnetic potential on the crack, and the problem is finally reduced to solving a system of coupled Cauchy singular integro-differential equations, which can be numerically solved by the decoupling and collocation methods. The results show that the stresses, eldctric displacements and magnetic induction near the crack tips exhibit the logarithmic singularity when the surface effect is considered. When there is no surface effect on the crack face, the classical square-root singularity of the near crack-tip fields can be observed.

1. Introduction

Because of the intrinsic magneto-electric coupling effect, magnetoelectroelastic materials have been used in smart structures for a variety of applications. Some defects (such as cracks and dislocations) could be induced during the manufacturing processes or during service by the mechanical, electric or magnetic loadings, which can adversely influence the performance of the structures. There has been a growing interest among researchers in solving fracture mechanics problems in magnetoelectroelastic media to study the coupling effect and multi-physical fields on the crack behavior. The classical theory of linear elastic fracture mechanics (LEFM) leads to the near crack-tip stress fields with the square-root singularity. Recently, some interesting research works have been reported on refining the LEFM by considnering the surface effect on crack faces. In this work, the surface effect of a mode-III crack in a magnetoelectroelastic medium is investigated by using an extended version of the Gurtin-Murdoch model. In order to simplify the analysis involved, the anti-plane shear deformation of a cracked hexagonal magnetoelectroelastic medium is considered. By applying the Green's function method, the crack problem is reduced to a system of coupled Cauchy singular integro-differential equations, which can be numerically solved by the decoupling and collocation methods. The result indicates that the surface effect on the crack surface leads to the crack-tip stress fields to have a logarithmic singularity, and the classical square-root singularity near the crack-tip can be recovered when there is no surface effect considered on the crack faces.

2. Results

The crack problem is formulated by considering a distribution of line dislocations, electric potential dislocations and magnetic potential dislocations on the crack with surface magnetoelectroelasticity. The mixed boundary value problem of the crack is reduced to solving a system of coupled singular integro-differential equations, which is numerically solved by the decoupling and collocation methods. The magnetoelectroelastic field of stresses, strains, electric displacements, electric fields, magnetic induction and magnetic fields near the crack tips can be obtained in an explicit form. The obtained results are:

a. The asymptotic expressions of stresses, strains, electric displacements, electric fields, magnetic induction and magnetic fields near the crack tips are obtained. The corresponding quantities normal to the crack face direction (y-direction) exhibit the logarithmic singularity, while the

corresponding quantities along the crack face direction (x-direction) are linearly related to the values of the local crack-tip coordinate angle.

b. In the case when there is no surface effect on the crack surfaces, the crack-tip fields of the stresses, electric displacements and magnetic induction normal to the crack face direction (y-direction) exhibit the classical square-root singularity, while the corresponding quantities along the crack face direction (x-direction) are of constant values when the uniform loadings are applied at infinity.

3. Conclusions

A theoretical analysis has been carried out for the mode-III crack with surface effect on crack faces in a hexagonal magnetoelectroelastic material subjected to remote anti-plane mechanical and in-plane electrical and magnetical loadings. The crack problem is formulated by using a continuous distribution of screw dislocations and electric potential dislocations and magnetic potential dislocations on the crack. The mixed boundary value problem of the crack with surface effect is reduced to solving a system of coupled singular integro-differential equations, which is further decoupled and numerically solved by using the collocation method. It is found that the surface effect on the crack surfaces leads to the logarithmic singularity of the near crack-tip fields.

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