Interaction Between a Screw Dislocation and a Piezoelectric Circular Inhomogeneity with Interfacial Cracks in Viscoelastic Matrix

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Abstract:
This paper attempts to investigate the problem for the interaction between a screw dislocation and a piezoelectric circular inhomogeneity with interface cracks in viscoelastic matrix. Utilizing the Laplace transform method, we find that the viscoelastic problem is first reduced to an associated elastic one. After solving the associated elastic problem through complex function method, the solution of viscoelastic problem is obtained by using the inverse Laplace transformation. The viscoelasticity of material is modeled by the combination of spring and dashpot. Particularly, the boundary value problem for standard linear solid model is solved analytically. The analytical results show that the force acting on the dislocation depends on the piezoelectric properties of inhomogeneity and interfacial crack, and the magnitude of the force evolves toward a constant value as time elapses. However, the viscoelasticity of material cannot alter the equilibrium position of the dislocation. Results presented in this paper are in agreement with the previous solution as special cases.

Zusammenfassung:
Dieser Artikel untersucht das Problem der Wechselwirkung einer Schraubenversetzung und einer piezoelektrischen, zirkularen Inhomogenität mit den Rissen an der Grenzfläche in einer viskoelastischen Matrix. Mit Hilfe der Laplace-Transformation finden wir, dass das viskoelastische Problem zuerst auf ein entsprechendes elastisches Problem reduziert werden kann. Nach der Lösung des entsprechenden elastischen Problems mit Hilfe der Methode der komplexen Funktion wird die Lösung des viskoelastischen Problems durch eine inverse Laplace-Transformation erhalten. Die Viskoelastizität des Materials wird durch eine Kombination aus Federn und Dämpfern modelliert. Insbesondere wird die Randwertaufgabe des linearen Standard-Festkörpermodells analytisch gelöst. Die analytischen Ergebnisse zeigen, dass die Kraft, die auf die Versetzung wirkt, von den piezoelektrischen Eigenschaften der Inhomogenität und des Risses an der Grenzfläche abhängen, und dass der Betrag der Kraft mit zunehmender Zeit einem konstanten Wert zustrebt. Jedoch kann die Viskoelastizität nicht die Gleichgewichtsposition der Versetzung verändern. Die Ergebnisse, die in diesem Artikel präsentiert werden, stimmen mit früheren Resultaten von Spezialfällen überein.

Résumé:
Cet article tente d'investiguer le problème de l'interaction entre une dislocation vis et une inhomogénéité circulaire piézoélectrique avec des fractures d'interface dans une matrice viscoélastique. En utilisant la méthode de la transformée de Laplace, on trouve que le problème viscoélastique est d'abord réduit à un problème élastique qui lui est associé. Après avoir résolu le problème élastique associé au moyen d'une méthode de fonction complexe, la solution du problème viscoélastique est obtenue en utilisant la transformée de Laplace inverse. La viscoélasticité du matériau est modélisée par la combinaison de ressorts et d'amortisseurs. En particulier, le problème de la valeur frontière pour un modèle de solide linéaire standard est résolu analytiquement. Les résultats analytiques montrent que la force agissant sur la dislocation dépend des propriétés piézoélectriques de l'inhomogénéité et de la fracture interfaciale. L'amplitude de la force évolue vers une valeur constante au cours du temps. Cependant la viscoélasticité du matériau ne peut altérer la position d'équilibre de la dislocation. Les résultats présentés dans cet article sont en accord avec la solution antérieure dans des cas particuliers.

Key words: Dislocation, piezoelectricity, viscoelasticity, circular inhomogeneity, interfacial crack, dislocation force

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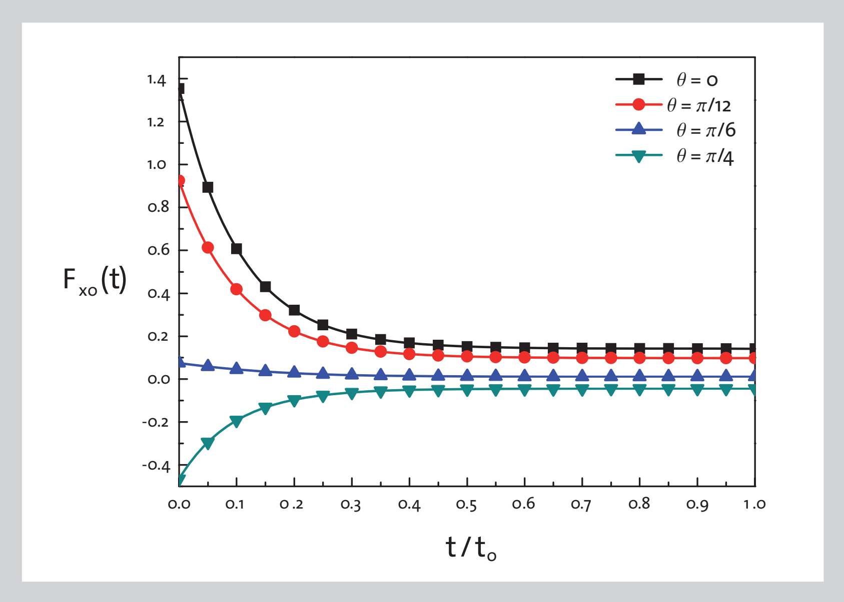

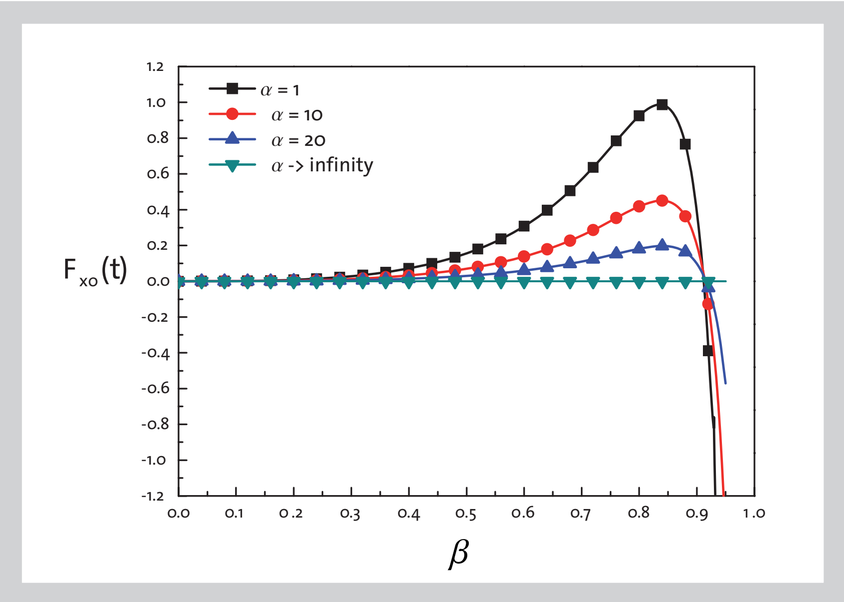

Figure 7: Normalized force $F_{xo}(t)$ versus t/t_o with different θ for $\alpha = 10$, $\xi = 10$, $\beta = 0.8$, and $\lambda = 1$.

Figure 8: Normalized force $F_{xo}(t)$ versus β with different α for $t/t_o = 0.1$, $\xi = 10$, $\lambda = 1$, and $\theta = \pi/12$.

viscous fluid which can not resist the dislocation and the dislocation force vanishes as α tends to infinity.

8 CONCLUSION

This paper makes a detailed investigation to the problem of interaction between a screw dislocation and a piezoelectric circular inhomogeneity with single interfacial crack in viscoelastic matrix, which is subjected to remote longitudinal shear. By using the Laplace transform method, the electro-viscoelastic problem is first reduced to an associated electro-elastic problem. Then it is solved through elastic complex potentials method. The viscoelastic stress intensity of crack tip and the viscoelastic force acting on dislocation are derived analytically by Laplace inverse transformation. Particularly, the explicit solutions of dislocation force are obtained for standard linear solid model. Numerical results obtained demonstrate that the viscoelasticity plays an important role in determining the dislocation force, and the magnitude of the dislocation force will decrease and drive to a constant value at last, however, the viscoelasticity of material has no effect on the changes of the equilibrium of dislocation which is different from the inhomogeneity and interfacial cracks. Based on the discussion we have mentioned above it is suggested that viscoelasticity should be taken into account in the analysis of the interaction between dislocation and piezoelectric inhomogeneity in non-piezoelectric matrix.

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