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A two-dimensional generalized electro-magneto-thermoviscoelastic problem for a half-space with diffusion

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ABSTRACT

The present paper is aimed at studying the effects of viscosity and diffusion on thermoelastic interactions in an isotropic, thermally and electrically conducting half-space solid whose surface is subjected to mechanical and thermal loads. The formulation is applied to the generalized thermoelasticity based on the Green and Lindsay (G–L) theory, where there is an initial magnetic field parallel to the bounding plane. The normal mode analysis is used to obtain the expressions for the variables considered. Numerical computations are performed for a specific material and the results obtained are represented graphically. Comparisons are made within the theory in the presence and absence of viscosity and diffusion.

1. Introduction

The classical theory of thermoelasticity has been generalized and modified into various thermoelastic models that run under the label of "hyperbolic thermoelasticity". The notation hyperbolic reflects the fact that thermal waves are modelled, avoiding the physical paradox of the infinite propagation speed of the classical model. At present, there are several theories of the hyperbolic thermoelasticity. The first was developed by Lord and Shulman [1] who obtained a wave-type heat equation by postulating a new law of heat conduction to replace the classical Fourier's law. This new law contains the heat flux vector as well as its time derivative. It also contains a new constant that acts as a relaxation time. The second was developed by Green and Lindsay [2]. This theory contains two constants that act as relaxation times and modifies all the equations of the coupled theory, not the heat conduction equation only. Both of these theories ensure finite speeds of propagation for heat wave.

Investigation of the dynamic problem concerning the interactions among electromagnetic field, temperature, stress and strain in a thermoelastic solid is immensely important because of its extensive uses in diverse fields, such as geophysics for understanding the effect of the earth magnetic field on seismic waves, damping of acoustic waves in a magnetic field, emission of electromagnetic radiations from nuclear devices, electrical power engineering, optics etc. Many authors have considered the propagation of electromagneto-thermoelastic waves in an electrically and thermally conducting solid. Nayfeh and Nemat-Nasser [3] studied the propagation of plane waves in a solid under the influence of an electromagnetic field. Sherief and Helmy in [4] examined a two-dimensional problem for a half-space in a magneto-thermoelastic medium. Tianhu et al. [5] considered the electromagnetic-thermoelastic interactions in a semi-infinite perfectly conducting solid subjected to a thermal shock on its surface when the solid and its adjoining vacuum is subjected to a uniform axial magnetic field. Youssef [6] has solved the problem of magneto generalized thermoelasticity by taking the electrical conductivity, thermal conductivity and modulus of elasticity to be variable. Reflection of magneto-thermoelastic waves in a rotating medium has been investigated by Othman and Song [7]. Recently, He and Cao [8] studied the magneto-thermoelastic problem of a thin slim strip placed in a magnetic field and subjected to a moving plane of heat source.

Diffusion can be defined as the spontaneous migration of substances from regions of high concentration to regions of low concentration. There is now a great deal of interest in the study of this phenomenon, due to its many applications in geophysics and industrial applications. Thermodiffusion in the solids is one of the transport processes that has great practical importance. Thermodiffusion in an elastic solid is due to the coupling of the fields of temperature, mass diffusion and that of strain. Nowacki [9–11] developed the theory of thermoelastic diffusion. In this theory, the coupled thermoelastic model is used which implies infinite speeds of propagation of thermoelastic waves. Sherief et al. [12] developed the theory of

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