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Analytical solution for axisymmetric thermoelastodynamic problems in a transversely isotropic half-space under a surface loading

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Abstract

In the present study, the theory of coupled thermoelastodynamic is applied to determine the displacement, temperature and stress (DTS) fields of a torsionless axisymmetric transversely isotropic half-space under a surface loading. The basic equations of coupled thermoelasticity consist of the equations of motion and the energy equation, which forms a set of completely coupled partial differential equations for the displacement and temperature fields. Potential method is employed for uncoupling the set of basic equations of coupled thermoelasticity. With the aid of a potential function existed in the literature, the system of equations are uncoupled, where a sixth order partial differential equation is received. Displacement components and temperature are written with respect to the potential function in cylindrical coordinate system. The Laplace and Hankel integral transforms are employed to suppress the time and radial variables, respectively. One may apply the inverse Hankel and Laplace transforms to determine the DTS fields and other quantities of interest in physical (space-time) domain. Eventually, the integrand functions of DTS components are obtained analytically.

Keywords: thermoelasticity, transversely isotropic, axisymmetry, potential function, Laplace and Hankel transforms.

1. INTRODUCTION

So far, many investigations have been made for wave propagation in an elastic medium One of the earliest studies for time harmonic wave propagation in isotropic materials is the work done by Lamb [1] in 1904. As other works, one can mention studies by Achenbach [2], Apsel and Luko [3], Pak [4] and Pak and Guzina [5]. In time domain analysis, Pekeris [6] probed the solution of an axisymmetric isotropic half-space subjected to a suddenly applied point load. Pekeris [7] also determined the displacements in a half-space caused by a buried point load. Anisotropic materials have also been used as engineering material, from which transverse isotropy has most application. One of the earliest researches which have done in transversely isotropic materials is due to Michell [8], in which elastoestatic problem under a specific surface load in a half-space was treated. Eubanks and Sternberg [9] made an investigation of the potential functions in elastostatic transversely isotropic problems. In elastodynamic, Stonely [10] showed that there is some differences between wave propagation in transversely isotropic materials compared with isotropic one. Some other studies in elastodynamic case are by Synge [11], Rajapaks and Wang [12], Wang and Achenbach [13], Rahimian et. al. [14], and Eskandari-Ghadi et al [2007, 2008, 2009 and 2010]. Rahimian et al [14], carried out an investigation to determine the displacements, strains and stresses due to time-harmonic surface load in a three-dimensional transversely isotropic by means of the method of potential. Eskandari-Ghadi and Sattar [15] treated an axisymmetric wave motion in the time domain for a transversely isotropic material and have