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ORIGINAL PAPER

Memory response in a two-dimensional transversely isotropic thick plate with varying heat source

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This present survey deals with a novel mathematical model of generalized thermoelasticity which investigates the transient phenomena in a two-dimensional problem for a transversely isotropic thick plate having a heat source. The upper surface of the plate is stress-free with prescribed surface temperature while the lower surface of the plate rests on a rigid foundation and is thermally insulated. The study is carried out in the context of the three-phase-lag thermoelastic model. The governing equations for displacement and temperature fields are obtained in the Laplace-Fourier transform domain by applying the Laplace and Fourier transform techniques. The inversion of double transform has been done numerically. The numerical inversion of the Laplace transform is done by using a method based on the Fourier series expansion technique. The numerical estimates of the quantities of physical interest are obtained and depicted graphically. The effect of the memory-dependent derivative on the solutions has been studied.

KEYWORDS
Fourier transform, Laplace transform, memory dependent derivative, spatially varying heat source, three-phase-lag thermoelastic model, transversely isotropic material

INTRODUCTION

In order to eliminate the paradox of the infinite velocity of heat propagation in the classical theory of thermoelasticity, different theories of non-classical thermoelasticity have been evolved, see Hetnarski and Ignaczak [1]. Some researchers, namely Lord and Shulman [2], Green and Lindsay [3] and Chandrasekharaiah [4], modified the Fourier law of heat conduction and constitutive relations to obtain a hyperbolic equation for heat conduction. These models include the time needed for the acceleration of heat flow and take into account the coupling between temperature and strain fields. Relevant theoretical developments on the subject were made by Green and Naghdi [5–7]. Islam and Kanoria [8] have studied two-dimensional transversely isotropic thick plate with spatially varying heat sources and body forces. Two-dimensional problems on generalized thermoelasticity have been studied by many authors [9, 10].

Roychoudhuri [11] has established a generalized mathematical model of a coupled thermoelasticity theory that includes three-phase lags in the heat flux vector, the temperature gradient and in the thermal displacement gradient. The more general model established reduces to the previous models as special cases. According to this model $\vec{q}(P, t+\tau_q) = -[K_1\vec{\nabla}T(P, t+\tau_T) + K^\star\vec{\nabla}\nu(P, t+\tau_\nu)]$, where $\vec{\nabla}\nu$ $(\dot{\nu} = T)$ is the thermal displacement gradient and $K^\star$ is the additional material constant. To study some practical relevant problems, particularly in heat transfer problems involving very short time intervals and in the problems of very high heat fluxes, the hyperbolic equation gives significantly different results

