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Effects of fractional and two-temperature parameters on stress distributions for an unbounded generalized thermoelastic medium with spherical cavity

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ABSTRACT

Effects of fractional and two-temperature parameters on the distribution of stresses of an unbounded isotropic thermoelastic medium with spherical cavity are studied in the context of the theory of two-temperature generalized thermoelasticity based on the Green-Naghdi model III using fractional order heat conduction equation. The surface of the cavity is considered to be free from traction and is subjected to a smooth and time-dependent-heating effect. A spherical polar coordinate system has been used to describe the problem and the resulting governing equations are solved in Laplace transform domain. Numerical Laplace transform inversion method has been then applied to get the stresses in time domain. The numerical estimates of the distributions of stresses are obtained and are presented graphically to study the effects of fractional and two-temperature parameters.

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1. Introduction

Because of two major imperfections of the classical uncoupled theory of thermoelasticity, it became essential to make them modified. The first imperfection was the absence of elastic term in the heat conduction equation for which the theory failed to explain the phenomenon of heat generation due to elastic changes and conversely, elastic changes due to heat supply in thermoelastic solids. The parabolic nature of the heat conduction equation was the second imperfection recommending the infinite speed of propagation of thermal waves throughout the body (Peshkov, 1944). This means that, at any point of the body, thermal effect is realised instantaneously after the heat supply, which is not practically tenable. The elimination of the first imperfection was due to Biot (1955), who introduced an elastic term in the heat conduction equation. This theory is known as classical coupled theory of thermoelasticity. Still this theory was suffering from a second imperfection. To remove the second imperfection several developments and modifications were carried out by several researcher in different times. These modified theories are known as the generalized theory of thermoelasticity. The major contributions towards the formulation and development of generalized theory of thermoelasticity was due to Lord and Shulman (1967); Green and Lindsay (1972); Green and Naghdi (1991, 1992, 1993); Tzou (1995); Choudhuri (2007). For details one can refer to Ignaczak and Ostoja-Starzewski (2010) and Chandrasekharaiah (1986, 1998). It is to be noted that generalized theory of thermoelasticity can be applied to deal with practical problems where high heat fluxes appear for very short time-intervals, which generally occur in laser units, energy channels and nuclear reactors, etc. Many works have been carried out using these theories in the recent past, a few of which are mentioned hereunder. Abd-alla and Abbas (2002) have solved a magneto-thermoelastic problem for an infinitely long, perfectly conducting transversely isotropic cylinder using the theory of generalized thermoelasticity. Abbas and Youssef (2012) have established a generalized thermoelasticity model of temperature dependent materials and used it to solve a thermal shock problem of a generalized thermoelastic half-space by employing the finite element method. Abbas and Abo-Dahab (2014) have solved a thermal shock problem in generalized

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