Applied Mathematics and Computation 254 (2015) 360–369

Contents lists available at ScienceDirect

Applied Mathematics and Computation

journal homepage: www.elsevier.com/locate/amc

Thermoelastic interaction in a thermally conducting cubic crystal subjected to ramp-type heating

Ibrahim A. Abbas [a,b,*], Rajneesh Kumar [c], Leena Rani [d]

[a] Department of Mathematics, Faculty of Science and Arts – Khulais, King Abdulaziz University, Jeddah, Saudi Arabia
[b] Department of Mathematics, Faculty of Science, Sohag University, Sohag, Egypt
[c] Department of Mathematics, Kurukshetra University, Kurukshetra 136119, Haryana, India
[d] Department of Mathematics,GD Goenka World Institute, Sohna Road, Gurgaon, Haryana, India

A R T I C L E   I N F O

Keywords:
Generalized thermoelasticity
Cubic crystal
Relaxation times
Ramp type heating
Finite element method

A B S T R A C T

In this paper, the thermoelastic interactions in a homogeneous, thermally conducting cubic crystal, elastic half-plane has been studied. A linear temperature ramping function is used to more realistically model. The general solution obtained is applied to a specific problem of a half space subjected to ramp-type heating. The components of displacement, stresses, and temperature distribution are obtained by applying a numerical finite element method. Some particular cases are also discussed in the context of the problem. The comparison in Lord and Shulman (LS), Green and Lindsay (GL) and Green and Naghdi (GN) theories have been shown graphically to estimate the effect of ramping parameter of heating for isothermal boundary.

1. Introduction

The generalized theories of thermoelasticity have been developed to overcome the infinite propagation speed of thermal signal predicted by classical theory of thermoelasticity Biot [1]. There are two generalizations of the classical theory of thermoelasticity. The first generalization was proposed by Lord and Shulman [2] and is known as L–S theory, which involve one relaxation time for a thermoelastic process. The second generalization is due to Green and Lindsay [3] and is known as G–L theory that takes into account two parameters in relaxation time. Dhaliwal and Sherief [4] extended the generalized theory of thermoelasticity (LS) to anisotropic media. Banerjee and Pao [5] investigated the propagation of plane harmonic waves in homogenous anisotropic thermoelastic solids. Sharma and Singh [6] investigated the propagation of generalized thermoelastic waves in cubic crystals. Li [7] developed the generalized theory of thermoelasticity for an anisotropic medium.

Green and Naghdi [8–10] proposed three models, which are subsequently referred to as GN-I, II, III models. The linearized version of model-I correspond to classical thermoelastic model. In model-II the internal rate of production of entropy is taken to be identically zero implying no dissipation of thermal energy. This model admits undamped thermoelastic waves in a thermoelastic material and is known as thermoelasticity without energy dissipation. Model –III includes the previous two models as special cases and admits dissipation of energy.

Tzou [11] proposed a dual phase-lag heat conduction model to incorporate the effect of microscopic interactions in the fast transient process of heat transport mechanism in a macroscopic formulation. Two different phase–lags (one for the heat

* Corresponding author at: Department of mathematics, Faculty of Science, Sohag University, Sohag, Egypt.
E-mail addresses: ibrabbas7@yahoo.com (I.A. Abbas), rajneesh_kuk@rediffmail.com (R. Kumar).

http://dx.doi.org/10.1016/j.amc.2014.12.111
0096-3003/