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A Review on Thermoelasticity Theory with Voids

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Abstract

The present investigation is the review on progress in theory of thermoelasticity with voids. The governing equations of thermoelasticity theory with voids are reviewed. Appropriate literature on theory of thermoelasticity with voids is also reviewed.

Keywords: Thermoelasticity; Voids; Governing Equations

Introduction

Theory of linear elastic materials with voids is an important generalization of the classical theory of elasticity. Materials having small distributed pores may be called porous materials or materials with voids. The intended application of this theory may be found in geological and biological materials like rocks and soils and in manufacturing porous materials for which classical theory of elasticity is not adequate. Nunziato JW, et al. [1] and Cowin SC, et al. [2] developed nonlinear and linear theory of elastic material with voids by using the concept of distributed body introduced by Goodman MA, et al. [3]. This linearized theory of elastic materials with voids is a generalization of classical theory of elasticity and reduces to it when the dependence on change in volume fraction and its gradient are suppressed. In the linear theory of elastic material with voids, the change in void volume fraction and strain are taken as independent kinematic variables. Iesan D [4] established a linear theory of thermoelastic materials with voids. He presented the basic field equations and discussed the conditions of propagation of acceleration waves in a homogeneous isotropic thermoelastic material with voids. He showed that transverse wave propagates without affecting the temperature and the porosity of the material. Iesan D [5] extended the thermoelastic theory of elastic material with voids to include initial stress and the initial heat-flux effects.

Governing Equations

Following Iesan D [4] the constitutive relations, equations of motion and heat conduction equation for a homogeneous, isotropic thermoelastic solid with voids are:

$$\acute{o}_{ij} = 2\grave{\imath}\, e_{ij} + (\ddot{e}\, e_{kk} + b\,\phi - \hat{a}\,\theta)\ddot{a}_{ij}, \quad (1)$$

$$\check{h}_i =, \ \phi_{,i} \quad \hat{g} = -mb\, e_{kk} - \ \phi + \ \theta \quad (2)$$

$$\tilde{n}\c{c} = \hat{a} e_{kk} + a\,\theta + m\phi, \ \rho T_0 \dot{\eta} = q_{i,i}, \quad (3)$$

$$q_i = K\theta_{,i}, \ \rho\psi\phi_{,tt} = h_{i,i} + g \quad (4)$$

$$\mu u_{i,jj} + (\lambda + \mu) u_{j,ij} - \beta\theta_{,i} + b\phi_{,i} = \rho \ddot{u}_i, \quad (5)$$

$$\rho C_E \dot{\theta} + \beta T_0\, \dot{u}_{k,k} + m T_0 \dot{\phi} = K\theta_{,ii}, \quad (6)$$

$$\alpha\phi_{,ii} - b u_{k,k} - \zeta\phi + m\theta = \rho\chi\ddot{\phi}, \quad (7)$$

$$e_{ij} = \frac{1}{2}(u_{i,j} + u_{j,i}), \quad (8)$$

where are the components of the stresses, is the density, are the material constants due to presence of voids, is the change in volume fraction field, is the thermal conductivity, is the heat flux, is the specific entropy, is the equilibrated stress vector, Equilibrated inertia, is the intrinsic equilibrated body force, is thermal constant, is the specific heat, is the displacement vector, is the absolute temperature, is the reference temperature chosen so that is the Kronecker delta, are the Lame's constants, such that is the coefficient of thermal expansion, and superposed dot denotes the derivative with respect to time.

Literature Survey

In the last years, the thermoelasticity theories, which suppose finite velocity for thermal signals, have received many attentions. These theories are called generalized thermoelasticity theories. Lord HW, et al. [6] established the generalized thermoelasticity theory with one delay time while Green A, et al. [7] established the generalized thermoelasticity theory with two thermal relaxation times. Green A, et al. [8-10] presented three types of models (G-N I, G-N II, and G-N III). The constitutive formulations of G-N models are linearized, G-N I is similar to classical coupled thermo-elastic theory, type II shows the propagation of thermal signals with finite speed without energy dissipation, and type III suggests the finite velocity of propagation with energy dissipation. Tzou DY [11] reconstructed the Fourier law by introducing a couple of delay time translations well known as phase-lags and gave rise to the dual-phase-lag model of heat conduction. In order to secure the effects of small scale heat interactions within the solid particles without the loss of energy. Choudhuri SKR [12] has introduced the three-phase-lag heat conduction equation in which the Fourier law of heat conduction is replaced by an approximation to a modification of the Fourier law with the introduction of three different phase-lags for the heat flux vector, the temperature gradient and the thermal displacement gradient.

Dhaliwal RS, et al. [13] formulated the heat-flux dependent thermoelasticity theory for an elastic material with voids. This theory includes the heat-flux among the constitutive variables and assumes an evolution equation for the heat-flux. Ciarletta M, et al. [14] developed a nonlinear theory of non-simple thermoelastic materials with voids. Ciarletta M, et al. [15] studied some results on thermoelasticity for dielectric materials with voids. Marin M [16] studied uniqueness and domain of influ- ence results in thermoelastic bodies with voids. Pompei A, et al. [17] studied the asymptotic spatial behaviour in linear thermoelasticity of materials with voids. A theory of thermoelastic materials with voids and without energy dissipation is developed by Cicco SD, et al. [18], Ciarletta M, et al. [19] presented a model for acoustic wave propagation in a porous material which also allows for propagation of a thermal displacement wave. Singh B [20] studied the wave propagation in a homogeneous, isotropic generalized thermoelastic half space with voids in context of Lord and Shulman theory. Recently, Aoudai M [21] derived the equations of the linear theory of thermoelastic diffusion in porous media based on the concept of volume fraction. Othman and Abd-Elaziz EM, et al. [22] studied the effect of thermal loading due to laser pulse on generalized thermoelastic medium with voids in dual phase lag model. Othman and Abd-Elaziz EM, et al. [23] studied problem of plane waves in a magneto-thermoelastic solids with voids and microtemperatures due to hall current and rotation. The influence of Seebeck effect on a magneto-poro-thermoelastic medium is investigated by Abd-Elaziz EM, et al. [24]. Various researchers studied the effects of voids on plane and surface waves in thermoelastic solids [25-32].

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