Developments in the Reflection of plane waves

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Abstract

The present paper deals with the reflection of plane wave from the free surface. In this paper, we discuss the relatable background of reflection of plane waves. The basic equations for isotropic and homogeneous generalized thermo-elastic media under hydrostatic initial stress are discussed in context of thermo-elasticity.

Keywords:*Plane wave, Thermo-elasticity, Reflection, Relaxation time, Initial stress.*

Introduction

Plane waves are the simplest solution to Maxwell's equations in a homogeneous region of space. From the earliest radio transmissions to the development of modern communications systems, plane waves have played a vital role in the development of electromagnetics. First, every transmitting antenna's far-field radiation has the characteristics of a plane wave when viewed from a reasonable distance away from the antenna. As a result, the incoming wave field coming on a receiving antenna is also measured as a plane wave. Second, the Fourier transform can be used to create the exact field emitted by any source in a given region of space in terms of extended-spectrum of plane waves.

The theory of reflection of plane waves from layered media is also a well-developed area, and relatively simple expressions are sufficient to understand the effects of reflection and transmission when layers are present.Plane waves are a good approximation for certain real-world conditions, such as radio waves at long distances from the transmitter or scattering obstacles with minimal curvature. The classical theory thermal coupled theory of thermoelasticity was given by Biot(bracket). The topic of thermo-elastic plane waves was studied by several authors, including Deresiewicz, Lessen, Chadwick and Sneddon and Puri. Deresiewicz studied the properties of two dilatational motions for the variation in each phase velocity, amplitude attenuation and specific loss. Lesson set down the equation of thermoelasticity within the approximation of theory of elasticity of infinitesimal displacements and displacement derivative. Chadwick and Sneddon studied the propagation of plane waves in an isotropic thermo-elastic solid. Puri proposed the plane wave, in which he investigates the property of two dilatation motions in generalized thermo-elasticity.

A.E. Green stated a uniqueness theorem which shows that the linear heat conduction tensor is symmetrical. In Green and Lindsay's generalized thermo-elasticity theory, V.K. Agarwal [6] studied the propagation and stability of harmonically time-dependent thermo-elastic plane waves of assigned frequency. S.K Roy Choudhuri [7] investigated the effect of rotation, relaxation parameters, and thermo-elastic coupling on wave speed and attenuation coefficient. The reflection of a plane sound wave in a micropolar generalized thermo-elastic solid half-space, comparing the Lord & Shulman and Green & Lindsay theories calculated by B. Singh [8]. In generalized thermo-visco-elasticity, Roychoudhuri and Mukhopadhyay [9] investigated the influence of relaxation time and rotation on plane waves. In the context of L-S, G-L, G-N, coupled and uncoupled thermo-elasticity, J.N. Sharma et al. [10] studied the problem of thermo-elastic wave reflection from the isothermal and insulated stress-free as well as rigidly fixed boundaries of homogeneous isotropic solid half-spaces. B. Singh [11] investigated the plane wave in a viscous-liquid half-space thermal relaxation and thermal conductor. The reflection of the generalized thermo-elastic waves from the solid half-space under hydrostatic initial stress was studied by B. Singh et al. [12] and observed the effect of the hydrostatic initial stress on the reflected waves. The plane wave reflection from an elastic solid half-space under hydrostatic initial stress without energy dissipation was determined by Othman and Song [13], who obtain the reflection amplitude ratio of reflected waves for incidence of P and SV- waves.

Abo-Dahab [14] investigated the propagation of P waves from a stress-free surface, under the magnetic field and thermal relaxation. In a transversely isotropic rotating magneto-thermo-elastic medium, B. Singh and A.K. Yadav [15] discussed the plane wave, which revealed the existence of three waves: qP, qT, and qSV waves. K. Sharma and R. R. Bhargava [16] investigated the propagation of thermo-elastic plane waves at an imperfect boundary of thermal conductive viscous-liquid and generalized thermo-elastic solids where the amplitude ratio of the various reflected and transmitted waves is obtained for an imperfect boundary. R. Kumar and T. Kansal [17] studied the refraction and reflection of plane waves at the boundary between elastic and a thermo-elastic diffusive solid half-space. B. Singh [18] used the G- N theory of thermo-elasticity to investigate the propagation of plane waves in an elastic solid with thermo-diffusion. Abo-Dahab and M. Salama [19] discussed the refraction and reflection of magneto-thermo-elastic plane waves between two solid mediums with external initial stress and heat sources. Under the influence of initial stress and electromagnetic field, the Green and Lindsay model of P and SV wave from the free surface of thermo-elastic diffusion solid was studied by M. Allam et al. [20]. R. Kumar and V. Gupta [21] studied the wave propagation with fractional order derivative at the boundary surface of an elastic and thermo-elastic diffusion medium. At the interface between elastic and thermo-elastic diffusion media, a dual-phase-lag model of wave propagation was studied by R. Kumar and V. Gupta [22].

B. Singh and A.K. Yadav [23] studied a plane wave in a rotating monocyclic magneto-thermo-elastic medium. Under three generalized thermo-elasticity models, Abo-Dahab [24] et al. investigated the effect of rotation, initial stress, gravity field, thermal field, electromagnetic field, and voids on P wave reflection. K. Kumar et al. [25] studied the reflection of plane waves under the properties of temperature-dependent in an anisotropic magneto-thermo-elastic diffusive medium. N. Dass et al. [26] investigated the plane wave reflection in a nonlocal thermo-elastic medium from the stress-free insulated and isothermal boundaries. In a generalized thermo-elastic half-space with an electromagnetic field, gravity field, and rotation, Abo-Dahab [27] studied the effect of diffusion with voids. A. K. Yadav [28] discussed the effect of impedance boundary conditions on the plane wave reflection in a rotating magneto-thermo-elastic solid half-space with diffusion. The reflection of plane waves from a micro-polar thermo-elastic solid half-space with an impedance boundary condition was discussed by B. Singh et al. [29]. N. Sarkar et al. [30] examined the magneto thermo-elastic waves reflection from thermally insulated and stress-free surfaces. With the two temperatures, the modified Green-Lindsay (G-L) theory of generalized thermo-elasticity was used (2T). On the surface of a homogeneous piezo-thermo-elastic fiber-reinforced composite half-space, the incidence of plane waves was investigated by B. Singh and S. Guha [31]. A. K. Yadav [32] investigated the plane wave propagation in an initially stressed rotating magneto-thermo-elastic solid half-space. The reflection phenomenon of a coupled plane wave incident on a thermally isothermal and insulated surface is investigated. In the presence of thermal loading bounded by a three-phase-lag (3PHL) thermo-elastic model, the reflection coefficient of thermo-elastic plane waves at the free surface of an elastic half-space investigated by S. M. Abo-Dahab et al. [33], which was affected by the properties of temperature-dependent and initial stress.

Basic Equations:

Green and Lindsay's proposed thermo-elasticity equation is

i. $e_{ij} = \frac{1}{2}\left(\frac{\partial u_i}{\partial x_j} + \frac{\partial u_j}{\partial x_i}\right)$ (1)

ii. $-\frac{\partial q_i}{\partial x_i} = \rho C_v \left(\frac{\partial \theta}{\partial t} + \alpha^* \frac{\partial^2 \theta}{\partial t^2}\right) + \gamma \theta_\circ \frac{\partial \Delta}{\partial t}$(2)

iii. $\tau_{ij} = \lambda \Delta \delta_{ij} + 2\,\mu e_{ij} - \gamma\,(\theta + \alpha \frac{\partial \theta}{\partial t})\delta_{ij}$ (3)

iv. $q_i = -K \frac{\partial \theta}{\partial x_i}$ (4)

Where $\Delta = \frac{\partial u_i}{\partial x_i}$, $\gamma = (3\lambda + 2\mu)\alpha_t$

v. $\frac{\partial \tau_{ij}}{\partial x_j} = \rho[\frac{\partial^2 u_i}{\partial t^2} + \{\Omega \times (\Omega \times u)\}_i + \left(2\Omega \times \frac{\partial u}{\partial t}\right)_i]$ (5)

vi. $k \frac{\partial^2 \theta}{\partial {x_i}^2} = \rho\, C_v \left(\frac{\partial \theta}{\partial t} + \alpha^* \frac{\partial^2 \theta}{\partial t^2}\right) + \gamma \theta_\circ \frac{\partial \Delta}{\partial t}$ (6)

where e_{ij} is strain tensor, q_i is component of heat flux, $\rho$is density and A, μ are lame constant, δ_{ij} is kronecker delta, k is thermal conductivity, u_i is component of displacement vector, $2\Omega \times \frac{\partial u}{\partial t}$ is Carioles acceleration, $\Omega \times (\Omega \times u)$is Central acceleration, α is Volume coefficient of thermal expansion.

Conclusion

The number of theories in Reflection of Plane waves has been evolved over the past years and these results are useful to find the effect of different parameters with different combinations of mediums. This paper will give an overview of the work done so far in Reflection of Plane waves, which will help the researchers to explore this field that can enrich the topic. Also, the background of Reflection of Plane waves has discussed.

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