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Magneto-thermoviscoelastic wave propagation at the interface between two micropolar viscoelastic media

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Abstract

Problems of a plane harmonic wave at the interface between two viscoelastic media are studied under generalized thermoviscoelastic theory when the media permeate into a uniform magnetic field. Using potential function, the governing equations reduced to two four-order differential equations. Amplitude ratios of reflection and refraction of different waves with the angle of incidence are obtained using continuous boundary conditions. Some special cases are considered in the absence of effects of micropolar or viscous. By numerical calculation, the variations of amplitude ratios of reflection and refraction with the angle of incidence are shown graphically for aluminium-epoxy and magnesium crystal micropolar viscoelastic materials. Comparison among CD, LS and GL theories and effects of magnetic field, viscous and micropolar are given by numerical results in this paper.

Keywords: Reflection and refraction; Magneto-thermoviscoelastic wave; Generalized thermoelastic theory; Propagation vector and attenuation vector

1. Introduction

The general theory of linear and nonlinear micropolar continuum mechanics was given by Eringen and Suhubi [1,2] and Eringen [3]. It is used to describe polymer and material possessing microstructures. Metals, polymers, composites, soils, rocks and concrete are typical media with microstructures. The difference between the micropolar theory and the classical theory is the introduction of an independent microrotation vector. Also, there exists not only traditional stress tensor but also couple stress tensor for micropolar theory. In recent years, study of the micropolar theory becomes more important due to large-scale exploitation and application of composite, polymer and large grain materials. At the present time, many researches have studied the micropolar theory under generalized thermoelastic and thermoviscoelastic theory [4–6].

For the classical theory of thermoelasticity, the thermal and mechanical waves propagate with an infinite velocity, which is physically impossible. To eliminate the paradox between infinite speed determined by

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Nomenclature

λ, μ, k, α, β and γ	module of the medium
C_E	specific heat at constant strain
T	absolute temperature
σ_{ij}	components of stress tensor
m_{ij}	components of couple stress
u_i	components of displacement vector
μ_0	magnetic permeability
τ_0 and τ_1	relaxation time
e	dilatation
γ	$(3\lambda + 2\mu + k)\alpha_t$
$\vec{\mathbf{H}}$	initial uniform magnetic intensity vector
$\vec{\mathbf{h}}$	induced magnetic field vector
$\vec{\mathbf{J}}$	current density vector
ε	coupling parameter
A, β and α^*	experiential constants
ρ	density
t	time
T_0	reference temperature
ε_{ij}	components of strain tensor
ω_i	components of microrotation vector
k'	thermal conductivity
ε_0	dielectric constant
J	micro inertia moment
α_t	coefficient of linear thermal expansion
ϕ and ψ	displacement potential
$\vec{\mathbf{E}}$	induced electric field vector
$\vec{\mathbf{u}}$	displacement vector
K	$\lambda + (2/3)\mu$ bulk modulus
$R(t)$	relaxation function
n	non-dimensional constant

conventional theory and finite speed observed in many experiments of the propagation of thermal signals, the theory of generalized thermoelasticity was proposed by Lord and Shulman [7] and Green and Lindsay [8] (here called LS and GL theories, respectively) by introducing one or two relaxation times in the thermoelastic process. The LS model itself is based on a modified Fourier's law, but the GL model admits second sound even without violating the classical Fourier's law. The two theories are structurally different from one another, and one cannot be obtained as a particular case of the other. Various problems characterizing these two theories have been investigated, and reveal some interesting phenomena. Chandrasekharaiah [9,10] gives brief review of this topic.

The problem of reflection and refraction of plane waves at a plane interface of micropolar medium has been discussed by many authors, e.g., Parfitt and Eringen [11] and Ariman [12], etc. Recently, Singh and Kumar [13,14] investigated reflection and refraction of interface wave between viscoelastic solid and micropolar elastic solid. Kumar [15] studied wave propagation in micropolar viscoelastic generalized thermoelastic solid. Kumar and Deswal [16] studied propagation of surface wave in micropolar thermoelastic materials under thermoelasticity without energy dissipation. But few papers concerned with problems of wave propagation at the interface between two micropolar viscoelastic media permeated in magnetic field under generalized thermoviscoelastic theory.

In this paper, we studied reflection and refraction at the interface between two micropolar viscoelastic media permeated in uniform magnetic field under generalized thermoviscoelastic theory. Equations for reflec-