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Analysis of wave motion in micropolar transversely isotropic thermoelastic half space without energy dissipation

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Abstract. The propagation of waves in a micropolar transversely isotropic half space in the theory of thermoelasticity without energy dissipation are discussed. After developing the solution, the phase velocities and attenuation quality factor has been obtained. The expressions for amplitudes of stresses, displacements, microrotation and temperature distribution have been derived and computed numerically. The numerical results have been plotted graphically.

Keywords: micropolar; transversely isotropic; amplitude ratios; without energy dissipation.

1. Introduction

Micropolar elasticity theory introduced by Eringen (1968) incorporates the local deformations and rotations of the material points of a body. The theory provides a model that can support body and surface couples and display a high frequency optical branch of the wave spectrum. For engineering applications, it can model composites with rigid chopped fibres, elastic solids with rigid granular inclusions, and other industrial materials such as liquid crystals (Eringen 1968, 1992, Maugin and Mild 1986). Several investigations revealing interesting phenomenon that characterize the micropolar theory and some of its generalizations are contained in (Eringen 1999, 2001, Janusz 2003).

The classical theory of heat conduction predicts that if a material conducting heat is subjected to a thermal disturbance, the effects of the disturbance will be felt instantaneously at distances infinitely far from its source. This prediction is unrealistic from a physical point of view, particularly in problems like those concerned with sudden heat inputs. This shortcoming of the theory stems from the fact that the equation governing the temperature distribution (heat transport equation), on which the theory is based, is a parabolic-type partial differential equation that allows an infinite speed for thermal signals. During last three decades, nonclassical theories free from this drawback by using modified version of classical Fourier's law of heat conduction have been formulated which involve hyperbolic-type heat transport equation and admit finite speed for thermal signals.

The linear theory of micropolar thermoelasticity was developed by extending the theory of micropolar continua to include thermal effects by Nowacki (1966) and Eringen (1970). Tauchert *et al.* (1968) also derived the basic equations of linear theory of micropolar thermoelasticity. Dost and

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Tabarrok (1978) presented the micropolar generalized thermoelasticity by using Green -Lindsay theory. One can refer to Dhaliwal and Singh (1987) for a review on the micropolar thermoelasticity. Chandrasekhariah (1986) formulated a theory of micropolar thermoelasticity which includes heat-flux among the constitutive variables.

Recently, the theory of thermoelasticity without energy dissipation, which provides sufficient basic modifications to the constitutive equation to permit the treatment of a much wider class of flow problems, has been proposed by Green and Naghdi (1993) (called the GN theory). The discussion presented in the above reference includes the derivation of a complete set of governing equations of the linearized version of the theory for homogeneous and isotropic materials in terms of displacement and temperature fields and a proof of the uniqueness of the solution of the corresponding initial mixed boundary value problem. Chandrasekharaiah and Srinath (1996) investigated one-dimensional wave propagation in the context of the GN theory.

The aim of the present paper is to discuss the propagation of waves in the theory of thermoelasticity without energy dissipation for micropolar transversely isotropic half space. The importance of thermal stresses in causing structural damages and changes in functioning of the structure is well recognized whenever thermal stress environments are involved. The phase velocities and attenuation quality factors are obtained and plotted numerically. The expressions for amplitude ratios of components of displacements, microrotation, stresses and temperature distribution are also obtained. A particular case of interest is also deduced.

2. Basic equations

The basic equations in dynamic theory of the plain strain of a homogeneous and micropolar transversely isotropic medium following Eringen (1999) and Green and Naghdi (1993) in the theory of thermoelasticity of without energy dissipation in absence of body forces, body couples and heat sources are given by

$$t_{ji,j} = \rho \ddot{u}_i \tag{1}$$

$$m_{ik,i} + \epsilon_{ijk} t_{ij} = \rho \jmath \ddot{\phi}_k \quad i, j, k = 1, 2, 3 \tag{2}$$

and heat conduction equation is given by

$$\kappa_{ij} T_{,ij} = \rho C^* \frac{\partial^2 T}{\partial t^2} + T_o \frac{\partial^2}{\partial t^2} \beta_{ij} u_{i,j} \tag{3}$$

The constitutive relations can be given as

$$t_{ij} = A_{ijkl}\varepsilon_{kl} + G_{ijkl}\Psi_{kl} - \beta_{ij}T, \; m_{ij} = G_{ijkl}\varepsilon_{kl} + \Psi_{kl} \tag{4}$$

where

$$\varepsilon_{ij} = u_{j,i} + \epsilon_{jik} \phi_k, \Psi_{ij} = \phi_{i,j} \tag{5}$$

In these relations,we have used the following notations

ρ is the density,

$\in_{jik}$ permutation symbol,
u_i components of displacement vector,
ϕ_k component of microrotation vector,
t_{ij} components of the stress tensor,
m_{ij} components of the couple stress tensor,
ε_{ij} components of micropolar strain tensor,
$\kappa_{ij} = \kappa_i\delta_{ij}$ (i not summed) $= (\lambda + 2\mu)C^*$ are the characterstic constants of the theory,
C^* is specific heat at constant strain,
$\beta_{ij} = \beta_i\delta_{ij}$ (i not summed) are the thermal elastic coupling tensor.

3. Formulation of the problem

We consider homogeneous, micropolar transversely isotropic medium under the theory of thermoelasticity without energy dissipation, initially in an undeformed state and at uniform temperature T_o. We take the origin of coordinate system on the top plane surface and x_3 axis pointing normally into the half-space, which is thus represented by $x_3 \geq 0$ (Fig. (a)). We consider plane waves in plane such that all particles on a line parallel to x_2-axis are equally displaced. Therefore, all the field quantities will be independent of x_2 coordinate. So, we assume the components of the displacement and microrotation vector for two dimensional problem of the form

$$\vec{U} = (u_1, 0, u_3),\ \vec{\phi} = (0, \phi_2, 0) \tag{6}$$

With the aid of Eq. (6), Eqs. (1)-(4) reduced to

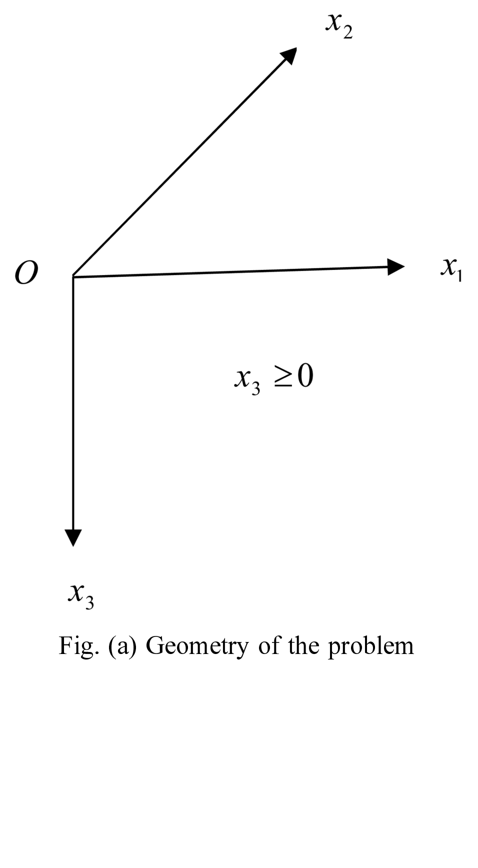

Fig. (a) Geometry of the problem

$$A_{11}\frac{\partial^2 u_1}{\partial x_1^2} + (A_{13} + A_{56})\frac{\partial^2 u_3}{\partial x_1 x_3} + A_{55}\frac{\partial^2 u_1}{\partial x_3^2} + K_1\frac{\partial \phi_2}{\partial x_3} - \beta_1\frac{\partial T}{\partial x_1} = \rho\frac{\partial^2 u_1}{\partial t^2} \tag{7}$$

$$A_{66}\frac{\partial^2 u_3}{\partial x_1^2} + (A_{13} + A_{56})\frac{\partial^2 u_1}{\partial x_1 x_3} + A_{33}\frac{\partial^2 u_3}{\partial x_3^2} + K_2\frac{\partial \phi_2}{\partial x_1} - \beta_3\frac{\partial T}{\partial x_3} = \rho\frac{\partial^2 u_3}{\partial t^2} \tag{8}$$

$$B_{77}\frac{\partial^2 \phi_2}{\partial x_1^2} + B_{66}\frac{\partial^2 \phi_2}{\partial x_3^2} - X\phi_2 + K_1\frac{\partial u_1}{\partial x_3} + K_2\frac{\partial u_3}{\partial x_1} = \rho \jmath\frac{\partial^2 \phi_2}{\partial t^2} \tag{9}$$

$$\kappa_1\frac{\partial^2 T}{\partial x_1^2} + \kappa_3\frac{\partial^2 T}{\partial x_3^2} = \rho C^*\frac{\partial^2 T}{\partial t^2} + T_o\frac{\partial^2}{\partial t^2}\left(\beta_1\frac{\partial u_1}{\partial x_1} + \beta_3\frac{\partial u_3}{\partial x_3}\right) \tag{10}$$

where

$$K_1 = A_{56} - A_{55}, K_2 = A_{66} - A_{56}, X = K_2 - K_1$$

For simplification we use the following non-dimensional variables

$$x_i' = \frac{x_i}{L},\ u_i' = \frac{u_i}{L},\ m_{ij}' = \frac{m_{ij}}{L\beta_1 T_o},\ \phi_i' = \frac{\rho c_1^2}{\beta_1 T_o}\phi_i$$

$$t_{ij}' = \frac{t_{ij}}{A_{55}},\ t' = \frac{c_1}{L}t, T' = \frac{T}{T_o}, c_1^2 = \frac{A_{55}}{\rho} \tag{11}$$

where L is a parameter having dimensions of length and c_1 is the longitudinal wave velocity of the medium.

4. Solution of the problem

The solution of the considered physical variables can be decomposed in terms of normal modes as

$$(u_1, u_3, \phi_2, T) = (1, \bar{u}_3, \bar{\phi}_2, \bar{T})u_1 e^{\iota\xi(x_1 + mx_3 - ct)} \tag{12}$$

where ξ is the wave number, $\omega = \xi c$ is the angular frequency and c is phase velocity of the wave, m is the unknown parameter which signifies the penetration depth of the wave, $\bar{u}_3, \bar{\phi}_2, \bar{T}$ are respectively, the amplitude ratios of displacement u_3, microrotation ϕ_2 and temperature T to that of displacement u_1.

Using Eqs. (11) and (12) in Eqs. (7)-(10), we obtain four homogeneous equations in four unknowns, which on solving for the non trivial solution yields a biquadratic equation in $q(= m^2)$ of the form

$$Aq^4 + Bq^3 + Cq^3 + Dq + E = 0 \tag{13}$$

where

$$A = -\xi^8,\ B = \xi^4[d_2d_5\xi^4 - a_4a_7 + \xi^2(a_1 + a_3 + a_5 - a_8 + d_3d_9)]$$

$$C = \xi^4[a_2(d_5a_7 - a_6) - a_3a_5 + d_6(d_{10} + a_4d_2) + a_1a_8 - d_3d_9(a_7 - a_8) - (a_1 - a_8)$$

$$(a_3 + a_5)] - \xi^6(d_2d_5a_5 + d_2d_6d_9 + d_3d_5d_{10}) + \xi^2a_7(a_5 + a_1a_4 - d_3d_9)]$$

$$D = \xi^2[a_2a_3a_6 - a_2a_5(d_5a_7 - a_6) + a_7d_6a_2d_9 - a_4a_6(a_5d_2 + d_3d_{10}) + (a_1 - a_8)a_3a_5 - a_1a_8$$

$$(a_3 + a_5) - d_3d_9a_7a_8] - a_4a_1a_5a_7 - \xi^4[d_6d_{10}(a_1 - a_8) + d_2(d_5a_5a_8 + d_6d_9d_8) + d_3d_5d_8d_{10}]$$

$$E = a_2(\xi^2d_6a_6d_{10} - a_3a_5a_6) + a_1a_8(a_3a_5 - \xi^2d_6d_{10}),\ a_1 = \omega^2 - d_1\xi^2,\ a_2 = -\iota\xi d_{13}$$

$$a_3 = \omega^2d_7 - \xi^2d_4,\quad a_4 = -\iota\xi d_{14},\quad a_5 = \omega^2d_{12} - d_{11} - d_8\xi^2,\quad a_6 = -\iota\omega^2\xi\bar{\beta}\varepsilon_2$$

$$a_7 = a_6/\bar{\beta},\quad a_8 = \bar{\kappa}\xi^2 - \omega^2\varepsilon_1,\quad d_1 = \frac{A_{11}}{A_{55}},\quad d_2 = \frac{A_{13} + A_{56}}{A_{55}},\quad d_3 = \frac{\beta_1T_0K_1}{A_{55}A_{11}},\quad d_8 = \frac{B_{77}}{B_{66}}$$

$$d_4 = \frac{A_{66}}{A_{33}},\quad d_5 = \frac{A_{13} + A_{56}}{A_{33}},\quad d_6 = \frac{\beta_1T_0K_2}{A_{33}A_{11}},\quad d_7 = \frac{A_{55}}{A_{33}},\quad d_9 = -\frac{K_1A_{55}L^2}{B_{66}\beta_1T_0}$$

$$d_{10} = \frac{K_2}{K_1}d_9,\quad d_{11} = \frac{XL^2}{B_{66}},\quad d_{12} = \frac{A_{55}J}{B_{66}},\quad d_{13} = \frac{\beta_1T_0}{A_{55}},\quad d_{14} = \frac{\beta_3T_0}{A_{55}}$$

$$d_{16} = \frac{A_{65}}{A_{55}},\quad d_{17} = \frac{B_{66}}{A_{55}L^2},\quad \varepsilon_1 = \frac{\rho C^* c_1^2}{\kappa_3},\quad \varepsilon_2 = \frac{\beta_3c_1^2}{\kappa_3},\quad \bar{\kappa} = \frac{\kappa_1}{\kappa_3},\quad \bar{\beta} = \frac{\beta_1}{\beta_3}$$

The complex coefficients implies that four roots of this equation may be complex. The complex phase velocities of the quasi-waves, given by q_i, will be varying with the direction of phase propagation. The complex velocity of a quasi-wave 'j' i.e., $q_i = q_R + \iota q_I$, defines the phase propagation velocity $V_i = (q_R^2 + q_I^2)/q_R$ and attenuation quality factor $Q_i^{-1} = -2q_I/q_R$ for the corresponding wave. Therefore, the four waves propagating in such a medium are attenuating waves. The same directions of waves propagation and attenuation vectors of these waves make them homogeneous waves. These waves are called quasi-waves because polarizations may not be along the dynamic axes. The waves with velocities q_1, q_2, q_3, q_4 may be named as quasi-longitudinal displacement(qLD)wave, quasi thermal wave (qT), quasi transverse microrotational (qTM)wave and quasi transverse displacement(qTD)wave, that are propagating with the descending phase velocities V_i, (i = 1, 2, 3, 4), respectively.

5. Boundary condition

We assume that the boundaries of the half space are stress free thermally insulated. Therefore, we consider following types of boundary conditions:

Mechanical conditions: The mechanical boundary conditions at $x_3 = 0$ for stress free boundaries are given by

$$t_{33} = 0, \quad t_{31} = 0, \quad m_{32} = 0 \tag{14}$$

where

$$t_{33} = A_{11}\frac{\partial u_1}{\partial x_1} + A_{33}\frac{\partial u_3}{\partial x_3} - \beta_3 T \tag{15}$$

$$t_{31} = A_{65}\frac{\partial u_3}{\partial x_1} + A_{55}\frac{\partial u_1}{\partial x_3} + K_1\phi_2 \tag{16}$$

$$m_{32} = B_{66}\frac{\partial \phi_2}{\partial x_3} \tag{17}$$

Thermal conditions: The thermal boundary condition at $x_3 = 0$ is given by

$$\frac{\partial T}{\partial x_3} + hT = 0 \tag{18}$$

where h is the surface heat transfer coefficient;
$h \rightarrow 0$ corresponds to thermally insulated boundaries and
$h \rightarrow \infty$ refers to isothermal boundaries.

For the solution for surface waves, it is essential that motion is confined to free surface $x_3 = 0$ of the half-space, so that the characteristic roots q_i must satisfy the radiation conditions *Real* $(q_i) \geq 0$. So, we take the solution for the displacement, microrotation and temperature distribution of the form

$$(u_1, u_3, \phi_2, T) = \sum_{i=1}^{4} A_i(1, r_i, s_i, t_i)e^{i\xi(x_1 - ct + im_i x_3)}$$

$$r_i = \frac{\Delta_{1i}}{\Delta_i}, \quad s_i = -\frac{\Delta_{2i}}{\Delta_i}, \quad t_i = \frac{\Delta_{3i}}{\Delta_i}, \quad i = 1, 2, 3, 4$$

$$\Delta_i = \begin{vmatrix} a_3 - m_i^2\xi^2 & i\xi d_6 & m_i a_4 \\ -i\xi d_{10} & a_5 - m_i^2\xi^2 & 0 \\ m_i a_7 & 0 & a_8 + m_i^2\xi^2 \end{vmatrix}, \quad \Delta_{1i} = \begin{vmatrix} -d_5 m_i\xi^2 & i\xi d_6 & m_i a_4 \\ -i\xi d_9 & a_5 - m_i^2\xi^2 & 0 \\ a_6 & 0 & a_8 + m_i^2\xi^2 \end{vmatrix}$$

$$\Delta_{2i} = \begin{vmatrix} -d_5 m_i\xi^2 & a_3 - m_i^2\xi^2 & m_i a_4 \\ -i\xi d_9 & -i\xi d_{10} & 0 \\ a_6 & m_i a_7 & a_8 + m_i^2\xi^2 \end{vmatrix}, \quad \Delta_{3i} = \begin{vmatrix} -d_5 m_i\xi^2 & a_3 - m_i^2\xi^2 & i\xi d_6 \\ -i\xi d_9 & -i\xi d_{10} & a_5 - m_i^2\xi^2 \\ a_6 & m_i a_7 & 0 \end{vmatrix} \tag{19}$$

6. Amplitudes of stresses, displacements, microrotation and temperature distribution

In this section the expressions for the amplitudes of the components of displacement, microrotation, stresses and temperature distribution for plane waves can be obtained as

$$t_{33} = \sum_{i=1}^{4}\left[\frac{A_i}{A_1}a_i^* e^{-m_i\xi x_3}\right]A_1 e^{\iota\xi(x_1-ct)}, \quad t_{31} = \sum_{i=1}^{4}\left[\frac{A_i}{A_1}b_i^* e^{-m_i\xi x_3}\right]A_1 e^{\iota\xi(x_1-ct)}$$

$$m_{32} = \sum_{i=1}^{4}-d_{17}\left[\frac{A_i}{A_1}s_i m_i\xi e^{-m_i\xi x_3}\right]A_1 e^{\iota\xi(x_1-ct)}, (u_1, u_3, \phi_2, T) = \sum_{i=1}^{4}\left[\frac{A_i}{A_1}(1, r_i, s_i, t_i)e^{-m_i\xi x_3}\right]A_1 e^{\iota\xi(x_1-ct)}$$

where

$$a_i^* = \iota\xi d_1 - \frac{r_i m_i\xi}{d_7} - d_{14}t_i, \quad b_i^* = \iota\xi d_6 r_i - m_i\xi + s_i d_{13}(d_{16}-1)$$

7. Particular case

Taking

$$A_{11} = A_{33} = \lambda + 2\mu + K, A_{55} = A_{66} = \mu + K, A_{13} = \lambda, A_{56} = \mu$$

$$B_{66} = B_{77} = \gamma, \kappa_1 = \kappa_3 = \kappa, \beta_1 = \beta_3 = \beta$$

with

$$-K_1 = K_2 = X/2 = K$$

we obtain the corresponding expressions for the isotropic micropolar thermoelastic half space without energy dissipation.

8. Numerical results and discussion

In order to illustrate the theoretical results obtained in the preceding sections, we now present some numerical results. For numerical computation, we take the values of relevant parameters for transversely isotropic micropolar thermoelastic solid as

$$A_{11} = 15.974 \times 10^{10}\ \mathrm{Nm}^{-2}, A_{33} = 13.843 \times 10^{10}\ \mathrm{Nm}^{-2}, A_{55} = 5.357 \times 10^{10}\ \mathrm{Nm}^{-2}$$

$$A_{66} = 5.42 \times 10^{10}\ \mathrm{Nm}^{-2}, A_{13} = 9.59 \times 10^{10}\ \mathrm{Nm}^{-2}, A_{56} = 5.89 \times 10^{10}\ \mathrm{Nm}^{-2}$$

$$B_{77} = 1.779 \times 10^{9}\ \mathrm{N}, B_{66} = 2.779 \times 10^{9}\ \mathrm{N}, \rho = 1.74\ \mathrm{kg/m^3}, C^* = 1.04\ \mathrm{Cal/K}, \jmath = 0.2\ \mathrm{m^2}$$

For comparison with micropolar isotropic without energy dissipation thermoelastic solid, following (Eringen 1984), we take the following values of relevant parameters of micropolar isotropic solid for the case of Magnesium crystal like material as

$$\rho = 1.74 \times 10^{3}\ \mathrm{Kg/m^3}, \lambda = 9.4 \times 10^{10}\ \mathrm{N/m^2}, \mu = 4.0 \times 10^{10}\ \mathrm{N/m^2}$$

$$\gamma = 0.779 \times 10^{-9}\ \mathrm{N}, \jmath = 0.2 \times 10^{-19}\ \mathrm{m^2}, \beta = 2.58\ \mathrm{N/m^2\ deg}$$

Figs. 1 and 2 shows the variation of phase velocities V_i, $i = 1, .. 4$, and attenuation quality factors Q_i^{-1}, $i = 1, .. 4$. In these figures the solid curve represents the case of micropolar transversely

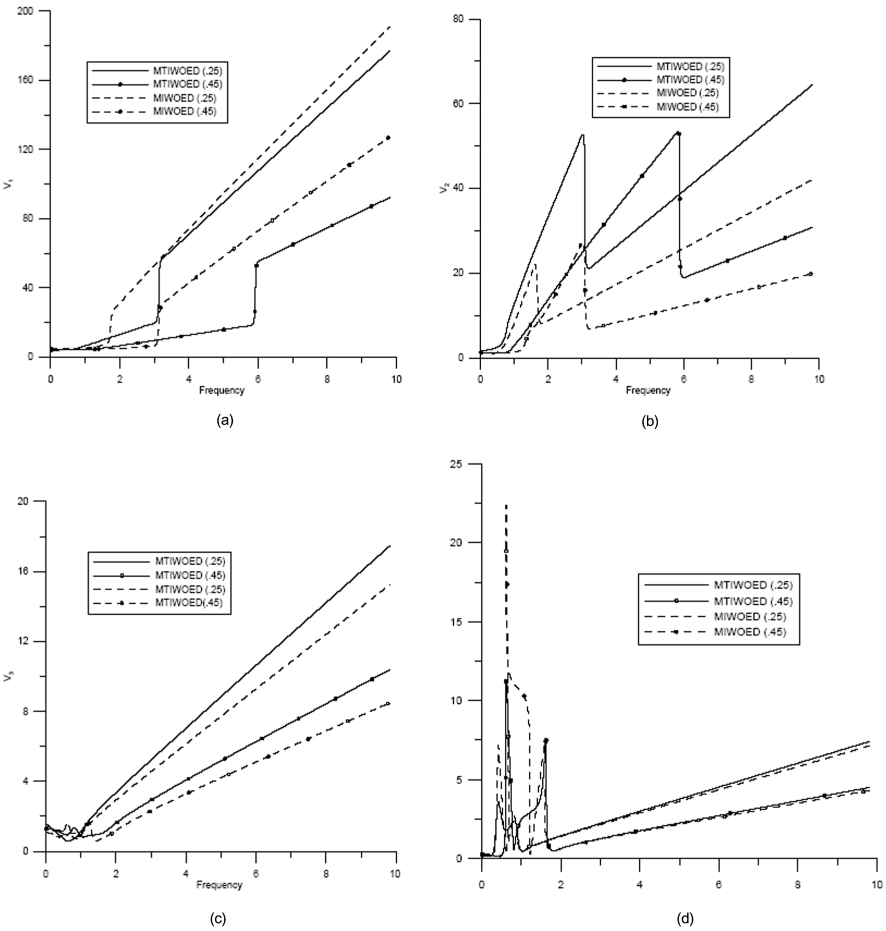

Fig. 1 Variations in the phase velocity (a) V_1 (b) V_2 (c) V_3 (d) V_4 of waves with respect to frequency

isotropic half space in theory of thermoelasticity of without energy dissipation (MTIWOED), while dotted curve represents the case of micropolar isotropic half space without energy dissipation (MIWOED). The comparison in the values of MTIWOED and MIWOED, for two value of wave number (ξ = .25, .45) have been shown in all the graphs. The curves without center symbol stand for ξ = .25, while curves with center symbol stands for ξ = .45.

It can be seen from Fig. 1(a) that the value of phase velocity V_1 start with sharp initial increase, then become constant for some time and then again increases with increase in frequency. The variation pattern remains same for all the cases, with slight difference in their amplitude. Also, the value of phase velocity gets decreased due to anisotropy. Fig. 1(b) shows that the value of phase velocity V_2, in the case of MTIWOED and for ξ = .25, start with slow increase, then sharply increases over the interval (1.2,3), then sharply decreases and again start increases with further increase in frequency. While for ξ = .45, the variation pattern remain same except with difference that the interval of sharp increase from (1.2,3) to (1,6). Here the amplitudes get increased due to anisotropy. It is evident form Fig. 1(c) that the value of phase velocity V_3 for the all the cases, initially oscillates with very small amplitude, then increases with increase in frequency. The values

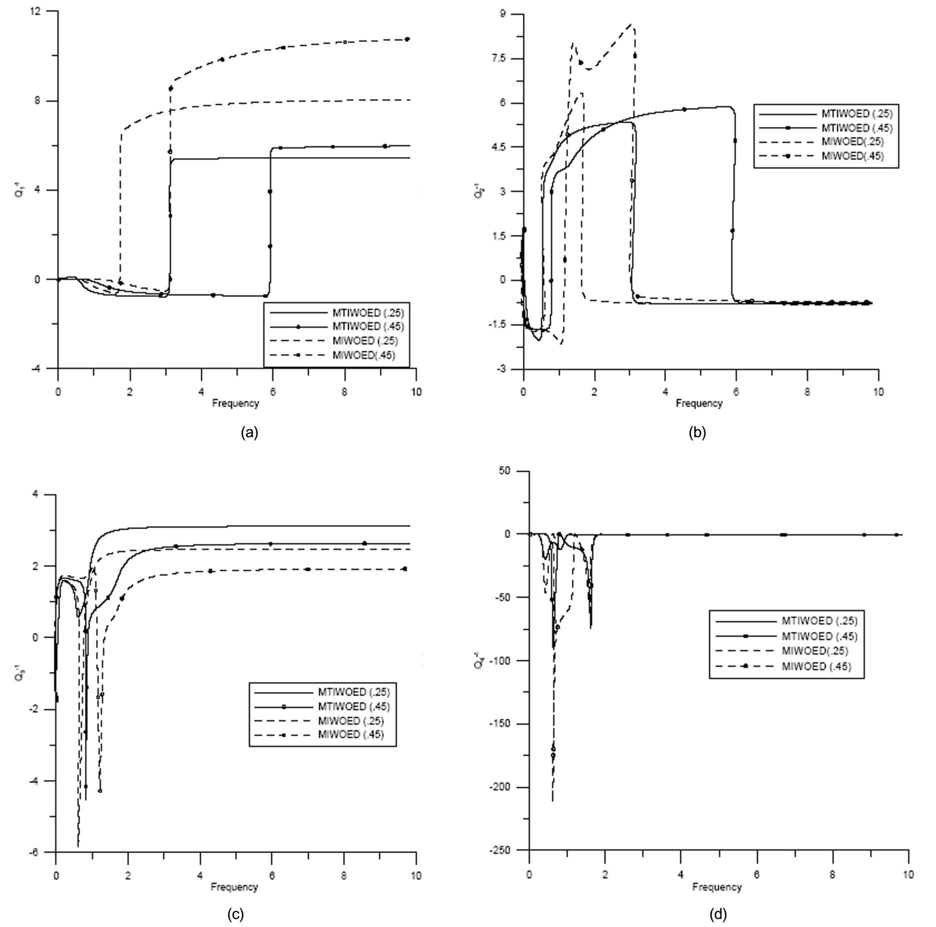

Fig. 2 Variations in the attenuation quality factor (a) Q_1^{-1} (b) Q_2^{-1} (c) Q_3^{-1} (d) Q_4^{-1} of waves with respect to frequency

for the case of MTIWOED are higher in magnitude as compared to those of MIWOED. Fig. 1(d) represents the variation in the value of phase velocity V_4 with frequency. It can be seen form this figure that the variation pattern is similar to the case of Fig. 1(c) except with difference that the initial amplitude of oscillations get very large in the present case.

Fig. 2 represents the variation in the value of attenuation quality factors Q_i^{-1}, i = 1, .. 4. It is depicted from Fig. 2(a) that the value of attenuation quality Q_1^{-1} for the case of MTIWOED and for both values of wave number, initially decreases, then shows a high jump in its value, to become constant at the end. For MIWOED the variation pattern is similar with difference in their amplitude (which is increased in this case). Fig. 2(c) and 2(d) represent the variations of attenuation quality factor Q_3^{-1}, Q_4^{-1} with frequency. It can be seen from these figures that, for the case of MTIWOED the value of attenuation quality factors show a hump within the interval (0,2) and then flatten out to become constant at the end. The variation pattern for both Q_3^{-1} and Q_4^{-1} remains similar with difference in the height of hump. It can be seen from Fig. 2(b) that the values of attenuation quality factor Q_2^{-1} oscillate and ultimately become constant, for all the cases.

Figs. 3 and 4 show the variations in amplitude of stresses, temperature distribution and

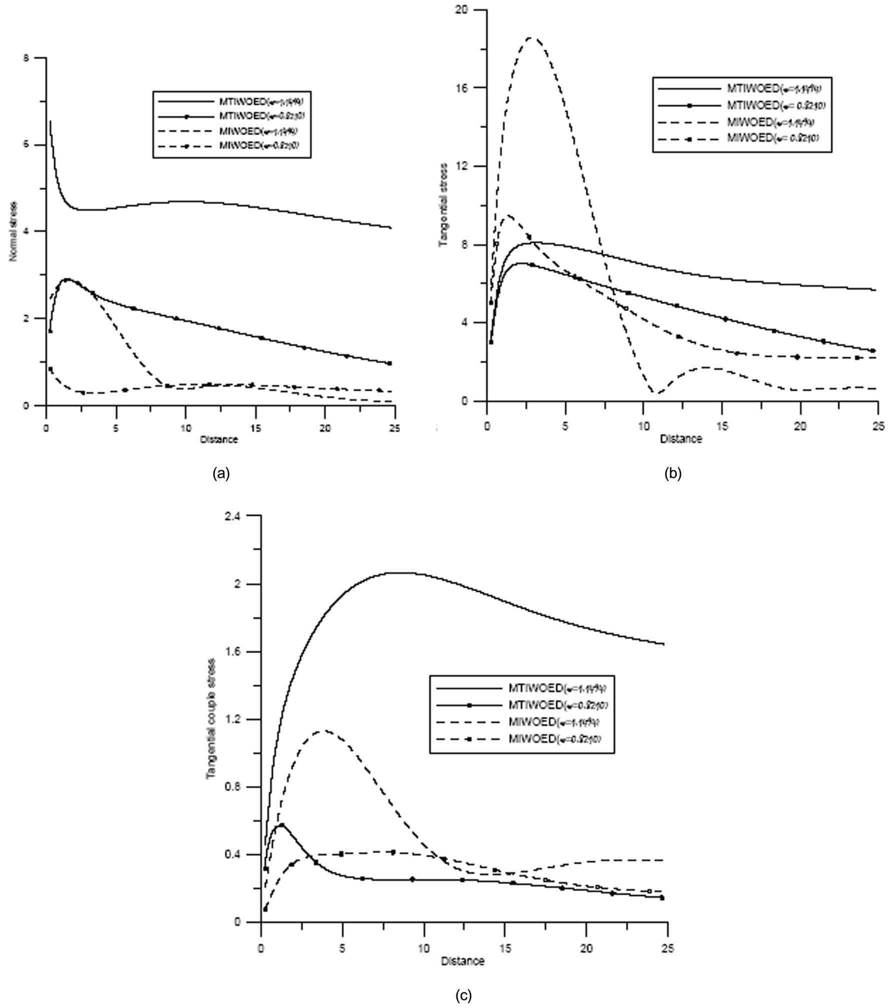

Fig. 3 Variations stresses (a) normal stress (b) tangential stress (c) tangential couple stress with respect to distance.

components of displacement and microrotation with distance. All numerical computations are carried out for single fixed value of wave number and for two given values of frequency 1.1494 and .8210. The computations were carried out within the range $0 \le x_1 \le 25$. It is depicted from Fig. 3(a) that the value of normal stress sharply decreases, then increases and decreases with increase in distance for $\omega = 1.1494$, while for $\omega = .8210$, its value start with sharp increase and then decreases. For MIWOED the variations for $\omega = 1.1494$ is similar to the variations for MTIWOED when $\omega = .8210$ and vice versa, with difference in their amplitudes. Figs. 3(b) and 3(c) shows that the variation of tangential stresses, for both the values of ω start with initial increase within the range $0 \le x_3 \le 2.5$ and then decreases with increase in distance from the surface $x_1 = 0$ in the case of MTIWOED. However for the case of MIWOED, its value oscillate with large and small amplitude and then flatten to become constant, when $\omega = 1.1494$ and $\omega = .8210$, respectively. The variation in amplitude get increased with increase in frequency.

Fig. 4 shows the value of amplitude ratios of the components of displacement, microrotation and

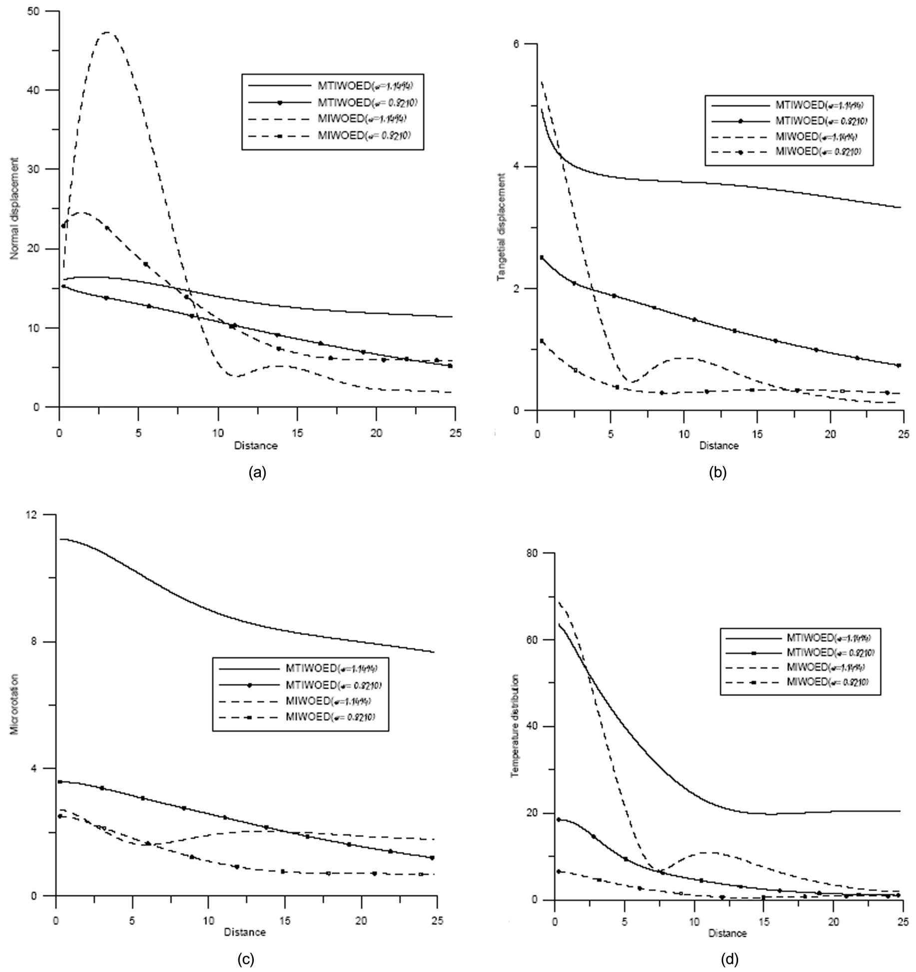

Fig. 4 Variations in the values of (a) normal displacements (b) tangential displacements (c) microrotation (d) temperature distribution of waves with respect to distance

temperature distribution with distance. It is illustrated from Fig. 4(a) that the value of normal displacement in the case of MTIWOED and for both the values of frequency decreases to become constant with distance, while for MIWOED its value oscillates with very large amplitude and then the amplitude of oscillation decrease to become constant ultimately when $\omega = 1.1494$ and for $\omega = .8210$ its value decreases to become constant. Figs. 4(b) and 4(d) depict the variations of amplitude of tangential displacement and temperature distribution with distance. It can be seen from these figures that for the case of MTIWOED, their values goes on decreasing and become constant as the distance from the surface increases. While for MIWOED, their values sharply decreases over the interval (0,7), then oscillates with small amplitude to become constant when $\omega = 1.1494$, while when $\omega = .8210$ its value slowly decreases to become constant. It is observed from Fig. 4(c) that the value of microrotation for both the frequencies, decreases to become constant in the case of MTIWOED, while for the case of MIWOED its value oscillates with very small amplitude to become constant.

9. Conclusions

The propagation of waves in micropolar material has many applications in various field of science and technology, namely, atomic physics, industrial engineering, thermal power plants, submarine structures, pressure vessel, aerospace, chemical pipes and metallurgy. In this view propagation of waves in a micropolar transversely isotropic half space with thermoelasticity of without energy dissipation has been discussed. The phase velocities and attenuation quality factors has been computed and plotted graphically. The expression for amplitudes of stresses, displacements, microrotation and temperature distribution have been derived and computed numerically. The values of phase velocity for the first waves, get decreased due to anisotropy, while for the rest waves, their values get increased. Similarly, the attenuating quality factor of preceding 2 waves get decreased due to anisotropy, which is reversed in the case of remaining waves.

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