

The Effect of Magnetic Field on an Infinite Conducting Thermoelastic Rotating Medium under G-N theory

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ABSTRACT: The effect of magnetic field on the thermoelastic rotating medium is investigated under Green-Naghdi theory of types II, III. The medium is considered to be an infinite conducting homogeneous isotropic medium. The normal mode analysis is used to obtain the exact expressions for the considered variables. Numerical results for the considered variables are obtained and illustrated graphically. Comparisons are also made with the results predicted by Green-Naghdi theory of types II, III in the absence and presence of rotation and magnetic field.

KEYWORDS: Thermoelasticity, Magnetic field, Rotation, Normal mode, Green-Naghdi theory.

I. INTRODUCTION

Green and Naghdi (G-N) have formulated three models (I, II, III) of thermoelasticity for homogeneous and an isotropic materials [1, 2]. Model I of G-N theory after linearization reduced to the classical thermoelasticity theory. Model II of G-N theory [3] does not suction dissipation of the thermoelastic energy. In this model, the constitutive equations are derived by starting with the reduced energy equation and by including the thermal displacement gradient among the constitutive variables. Chandrasekharaiah [4] used Laplace method to study the one-dimensional thermal wave propagation in a half space based on G-N theory of type II due to a sudden application of the temperature to the boundary. The disturbances produced in a half space by the application of a mechanical point load and thermal source acting on a boundary of the half space is investigated in ref. [5]. Model III of G-N theory confesses a dissipation of energy, where the constitutive equations are derived starting with a reduced energy equation. It includes the thermal displacement gradient, in addition to the temperature gradient among its independent constitutive variables.

Since most large bodies like the earth, the moon, and other planets have an angular velocity (i.e. rotated bodies), it appears more realistic to study the propagation of plane thermoelastic waves in a rotating medium. The effect of rotation on elastic waves is previously studied many authors [6-8]. The magnetic field effect on a thermoelastic medium investigated by many authors [9-16]. Othman et al. [17] discussed the effect of the magnetic field on a rotating thermoelastic medium with voids under thermal loading due to laser pulse with energy dissipation. Some problems in thermoelastic rotating media are due to Schoenberg and Censor [18], Puri [19], and Roy Choudhuri and Debnath [20, 21]. They reported that, the rotation and the magnetic field play a significant role on all of the physical quantities and the deformation of a body depends on the nature of the applied forces and thermal loading due to laser pulse as well as the types of boundary conditions.

In the present work, we aim to study the effect of the magnetic field on a rotating medium under G-N theory of types II and III, making a comparison between the cases of the presence and the absence of the magnetic field as well as an angular velocity (rotation).

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II. FORMULATION OF THE PROBLEM AND THE BASIC EQUATIONS

Consider a uniform magnetic field vector $\mathbf{H} = (0, 0, H_0)$, a rotation vector $\boldsymbol{\Omega} = (0, 0, \Omega)$, and a displacement vector $\mathbf{u} = (u, v, 0)$.

The Maxwell's equations are

$$\text{curl } \mathbf{h} = \mathbf{J} + \varepsilon_0 \dot{\mathbf{E}}, \quad (1)$$

$$\text{curl } \mathbf{E} = \mu_0 \dot{\mathbf{h}}, \quad (2)$$

$$\mathbf{E} = -\mu_0 (\dot{\mathbf{u}} \wedge \mathbf{H}), \quad (3)$$

$$\text{div } \mathbf{h} = 0. \quad (4)$$

From Eqs. (1)-(4), we obtain

$$\mathbf{J} = (\varepsilon_0 \mu_0 H_0 \ddot{v} - H_0 e_{,y}, -\varepsilon_0 \mu_0 H_0 \ddot{u} + H_0 e_{,x}, 0). \quad (5)$$

The Lorentz force will be

$$\mathbf{F} = \mu_0 (\mathbf{J} \wedge \mathbf{H}). \quad (6)$$

Equation of motion [1]

$$\rho \{\ddot{\mathbf{u}} + [\boldsymbol{\Omega} \wedge (\boldsymbol{\Omega} \wedge \mathbf{u})] + 2(\boldsymbol{\Omega} \wedge \dot{\mathbf{u}})\}_i = \mu u_{i,jj} + (\lambda + \mu) u_{j,ij} - \gamma T_{,i} F_i, \quad i, j = 1, 2, \quad (7)$$

Heat conduction equation:

$$k^* T_{,ii} + k \dot{T}_{,ii} = \rho C_E \ddot{T} + \gamma T_0 \ddot{e}, \quad (8)$$

Stress tensor and strain tensor relations:

$$\sigma_{ij} = 2\mu \varepsilon_{ij} + (\lambda e - \gamma T) \delta_{ij}, \quad (9)$$

$$\varepsilon_{ij} = \frac{1}{2} (u_{i,j} + u_{j,i}). \quad (10)$$

From Eqs. (7)-(10), we get

$$\alpha \ddot{u} - \Omega^2 u - 2\Omega \dot{v} = (C_0^2 + \frac{\mu_0^2 H_0^2}{\rho}) u_{,xx} + (\frac{\lambda + \mu + \mu_0 H_0^2}{\rho}) v_{,xy} - \frac{\gamma}{\rho} T_{,x} + \frac{\mu}{\rho} u_{,yy}, \quad (11)$$

$$\alpha \ddot{v} - \Omega^2 v + 2\Omega \dot{u} = (C_0^2 + \frac{\mu_0^2 H_0^2}{\rho}) v_{,xx} + (\frac{\lambda + \mu + \mu_0 H_0^2}{\rho}) u_{,xy} - \frac{\gamma}{\rho} T_{,y} + \frac{\mu}{\rho} v_{,xx}, \quad (12)$$

$$\sigma_{xx} = 2\mu \varepsilon_{xx} + \lambda e - \gamma T = (\lambda + 2\mu) u_{,x} + \lambda v_{,y} - \gamma T, \quad (13)$$

$$\sigma_{yy} = (\lambda + 2\mu) v_{,y} + \lambda u_{,x} - \gamma T, \quad (14)$$

$$\sigma_{zz} = \lambda e - \gamma T, \quad (15)$$

$$\sigma_{xy} = \mu (u_{,y} + v_{,x}), \quad (16)$$

$$\sigma_{xz} = \sigma_{yz} = 0. \quad (17)$$

Where, $\alpha = 1 + \frac{\varepsilon_0 \mu_0^2 H_0^2}{\rho}$ and $C_0^2 = \frac{\lambda + 2\mu}{\rho}$.

Using the dimensionless variables

$$x_i' = \frac{x_i}{l}, \quad t' = \frac{C_0}{l} t, \quad u_i' = \frac{\lambda + 2\mu}{l} u_i, \quad T' = \frac{T}{T_0}, \quad \Omega' = \frac{l}{C_0} \Omega, \quad \varepsilon_{ij}' = \frac{\lambda + 2\mu}{\gamma T_0} \varepsilon_{ij}, \quad \sigma_{ij}' = \frac{1}{\gamma T_0} \sigma_{ij}, \quad l = \frac{k^*}{\rho C_E C_0}.$$

Applying the dimensionless variables to Eqs. (8)-(17) yields

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$$\alpha \ddot{u} - \Omega^2 u - 2\Omega v = \left(1 + \frac{\mu_0^2 H_0^2}{\rho C_0^2}\right) u_{,xx} + \left(\beta^2 + \frac{\mu_0 H_0^2}{\rho C_0^2}\right) v_{,xy} - T_{,x} + (1 - \beta^2) u_{,yy}, \quad (18)$$

$$\alpha \ddot{v} - \Omega^2 v + 2\Omega u = \left(1 + \frac{\mu_0^2 H_0^2}{\rho C_0^2}\right) v_{,xx} + \left(\beta^2 + \frac{\mu_0 H_0^2}{\rho C_0^2}\right) u_{,xy} - T_{,y} + (1 - \beta^2) v_{,xx}, \quad (19)$$

$$\ddot{T} + \varepsilon_1 \ddot{e} = \varepsilon_2 \nabla^2 T + \varepsilon_3 \nabla^2 \dot{T}, \quad (20)$$

$$\sigma_{xx} = u_{,x} + (2\beta^2 - 1)v_{,y} - T, \quad (21)$$

$$\sigma_{yy} = v_{,y} + (2\beta^2 - 1)u_{,x} - T, \quad (22)$$

$$\sigma_{zz} = (2\beta^2 - 1)e - T, \quad (23)$$

$$\sigma_{xy} = (1 - \beta^2)(u_{,y} + v_{,x}), \quad (24)$$

$$\sigma_{xz} = \sigma_{yz} = 0. \quad (25)$$

Where, $\varepsilon_1 = \frac{\gamma^2 T_0}{\rho^2 C_E C_0^2}$, $\varepsilon_2 = \frac{k^*}{\rho C_E C_0^2}$, $\varepsilon_3 = \frac{k}{\rho l C_E C_0}$ and $\varepsilon_{11} = 1 + \frac{\mu_0^2 H_0^2}{\rho C_0^2}$.

We take a scalar potential Φ and vector potential Ψ related to the displacement components u and v as $u = \Phi_{,x} + \Psi_{,y}$ and $v = \Phi_{,y} - \Psi_{,x}$. (26)

Using Eq. (26) in the Eqs. (18)-(20), we get

$$\left[\alpha \frac{\partial^2}{\partial t^2} - \Omega^2 - \varepsilon_{11} \nabla^2\right] \Phi + 2\Omega \dot{\Psi} + T = 0, \quad (27)$$

$$\left[\alpha \frac{\partial^2}{\partial t^2} - \Omega^2 - (1 - \beta^2) \nabla^2\right] \Psi - 2\Omega \dot{\Phi} = 0, \quad (28)$$

$$\left[\frac{\partial^2}{\partial t^2} - (\varepsilon_2 + \varepsilon_3 \frac{\partial}{\partial t}) \nabla^2\right] T + \varepsilon_1 \nabla^2 \dot{\Phi} = 0. \quad (29)$$

II. NORMAL MODE ANALYSIS

The considered physical variables can be decomposed in terms of the normal modes in the form:

$$\{\Phi, \Psi, T, \sigma_{ij}\} = \{\Phi^*, \Psi^*, T^*, \sigma_{ij}^*\}(y) e^{i(\omega t + bx)}, \quad (30)$$

Applying (30) into Eqs. (27)-(29) gives

$$[D^2 - b_1] \Phi^* + \delta_2 \Psi^* - T^* = 0, \quad (31)$$

$$\delta_3 \Phi^* + [D^2 - b_2] \Psi^* = 0, \quad (32)$$

$$\delta_5 (D^2 - b^2) \Phi^* + [D^2 - b_3] T^* = 0. \quad (33)$$

Where, $\delta_1 = \frac{\alpha \omega^2 + \Omega^2}{\varepsilon_{11}}$, $\delta_2 = \frac{-2i\omega\Omega}{\varepsilon_{11}}$, $\delta_3 = \frac{2i\omega\Omega}{1 - \beta^2}$, $\delta_4 = \frac{\alpha \omega^2 + \Omega^2}{1 - \beta^2}$, $\delta_5 = \frac{\varepsilon_1 \omega^2}{\varepsilon_2 + i\omega \varepsilon_3}$, $\delta_6 = \frac{w^2}{\varepsilon_2 + i\omega \varepsilon_3}$,

$$b_1 = \delta_1 - b^2, \quad b_2 = \delta_4 - b^2 \text{ and } b_3 = \delta_6 - b^2.$$

From Eqs. (31)-(33), we can obtain

$$[D^6 - A D^4 + B D^2 - C] \{\Phi^*, \Psi^*, T^*\} = 0. \quad (34)$$

Where,

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$$A = b_1 + b_2 + b_3 - \delta_5, \quad B = b_1(b_2 + b_3) + b_2 b_3 - \delta_5(b^2 + b_2) - \delta_2 \delta_3, \quad C = b_3(b_1 b_2 - \delta_2 \delta_3) + b_2 b_3 - \delta_5(b^2 b_2).$$

Eq. (34) can be factored as:

$$(D^2 - k_1^2)(D^2 - k_2^2)(D^2 - k_3^2)\{\Phi^*, \Psi^*, T^*\} = 0. \tag{35}$$

Where k_1^2, k_2^2 and k_3^2 are the roots of the characteristic equation of Eq. (35).

The solution of Eq. (35) can be given as:

$$\Phi^* = \sum_{n=1}^3 M_n e^{-k_n y}, \tag{36}$$

$$\Psi^* = \sum_{n=1}^3 M_n H_{1n} e^{-k_n y}, \tag{37}$$

$$T^* = \sum_{n=1}^3 M_n H_{2n} e^{-k_n y}. \tag{38}$$

With $H_{1n} = \frac{-\delta_3}{k_n^2 - b_2}$, $H_{2n} = \frac{-\delta_5(k_n^2 - b^2)}{k_n^2 - b_3}$ and M_n ($n = 1, 2, 3$) are some constants.

Using the previous form of Φ^* , Ψ^* and T^* in Eq. (26) we get

$$u^* = \sum_{n=1}^3 (ib - k_n H_{1n}) M_n e^{-k_n y}, \tag{39}$$

$$v^* = \sum_{n=1}^3 (-k_n - ib H_{1n}) M_n e^{-k_n y}, \tag{40}$$

$$\sigma_{xx}^* = \sum_{n=1}^3 [-b^2 - ibk_n H_{1n} + (2\beta^2 - 1)(k_n^2 + ibk_n H_{1n}) - H_{2n}] M_n e^{-k_n y}, \tag{41}$$

$$\sigma_{yy}^* = \sum_{n=1}^3 [k_n^2 - ibk_n H_{1n} - (2\beta^2 - 1)(b^2 + ibk_n H_{1n}) - H_{2n}] M_n e^{-k_n y}, \tag{42}$$

$$\sigma_{zz}^* = \sum_{n=1}^3 [(2\beta^2 - 1)(k_n^2 - b^2) - H_{2n}] M_n e^{-k_n y}, \tag{43}$$

$$\sigma_{xy}^* = \sum_{n=1}^3 (1 - \beta^2)[(k_n^2 + b^2)H_{1n} - 2ibk_n] M_n e^{-k_n y}. \tag{44}$$

IV. PARTICULAR CASES

We will discuss the following cases under the G-N theory of types II and III:

Case1: In the presence and the absence of the magnetic field, while the rotation is present.

Case2: In the presence and the absence of the rotation effect, while the magnetic field is present.

V. BOUNDARY CONDITIONS

To determine M_n ($n = 1, 2, 3$) we can take these boundary conditions on the surface $y = 0$ as:

$$T(x, 0, t) = p e^{i(\alpha x + \beta t)} \quad \text{and} \quad \sigma_{xx}(x, 0, t) = \sigma_{xy}(x, 0, t) = 0. \tag{45}$$

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Where p is the constant temperature applied to the surface.

Substituting the expressions of the considered physical quantities in these boundary conditions, we can obtain the three equations satisfied by the parameters. After applying the inverse of matrix method on the obtained equations, we get the values of the constants M_n ($n = 1, 2, 3$).

$$\begin{pmatrix} M_1 \\ M_2 \\ M_3 \end{pmatrix} = \begin{pmatrix} H_{21} & H_{22} & H_{23} \\ L_{11} & L_{12} & L_{13} \\ L_{21} & L_{22} & L_{23} \end{pmatrix}^{-1} \begin{pmatrix} p \\ 0 \\ 0 \end{pmatrix}. \tag{46}$$

Where, $L_{1n} = [-b^2 - ibk_n H_{1n} + (2\beta^2 - 1)(k_n^2 + ibk_n H_{1n}) - H_{2n}]$,
 $L_{2n} = (1 - \beta^2)[(k_n^2 + b^2)H_{1n} - 2ibk_n]$, $n = 1, 2, 3$.

VI. NUMERICAL CALCULATIONS AND DISCUSSION

We will choose a copper material for purposes of numerical calculations; therefore, the material constants were taken as

$$\lambda = 7.76 \times 10^{10} \text{ N.m}^{-2}, \quad \mu = 3.86 \times 10^{10} \text{ kg.m}^{-1}\text{s}^{-1}, \quad k^* = 386 \text{ w.m}^{-1}\text{s}^{-1}\text{.k}^{-1}, \quad \alpha_t = 1.78 \times 10^{-5} \text{ k}^{-1}, \quad C_E = 293 \text{ k},$$

$$\rho = 8954 \times 10^{10} \text{ kg.m}^{-3}, \quad C_E = 383.1 \text{ J.kg}^{-1}\text{.k}^{-1}.$$

The comparison was carried out for the values: $x = 0.2$, $p = 0.01$, $\omega = 0.7$, $b = 0.3$, $t = 0.7$.

The comparisons were carried out to the displacement component u , the stress tensors σ_{xy} and the temperature T under the G-N theory of both types II and III in the cases: $H_0 = 0, 10^8$ and $\Omega = 0, 0.2$. The case of the presence and the absence of the magnetic field in the context of the G-N theory of both types II and III with $\Omega = 0.2$ was shown in the Figs. 1-3. Fig. 1 explains that the distribution of horizontal displacement u in the presence of a magnetic field is greater than the values in the absence of a magnetic field under the (G-N) of type II, while the values based on the (G-N) of type III in the absence of a magnetic field are greater than that in the presence of a magnetic field. Fig. 2 exhibits that the distribution of the temperature T satisfies the boundary conditions. The magnetic field has no great effect on the distribution. Fig. 3 shows that, the distribution of the stress component σ_{xy} satisfies the boundary conditions. The amplitude of the shear stress σ_{xy} in both types II and III of the (G-N) theory in the presence of a magnetic field is greater than that in the absence of a magnetic field.

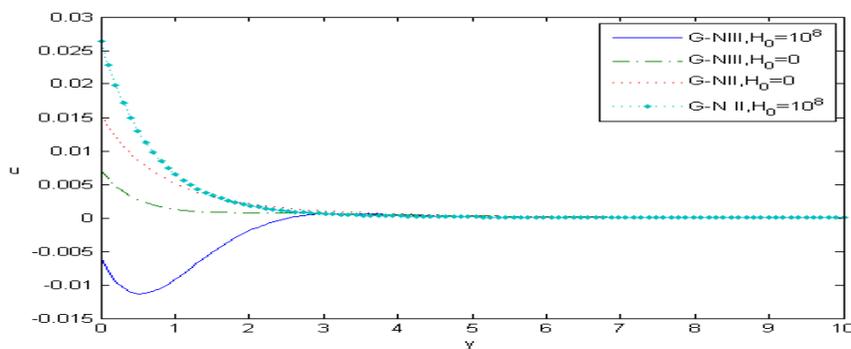


Fig. 1 Horizontal displacement distribution in the presence and absence of magnetic field.

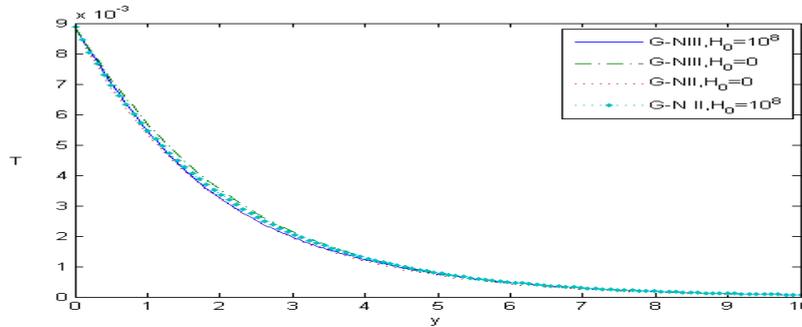


Fig. 2 Temperature distribution in the presence and absence of magnetic field.

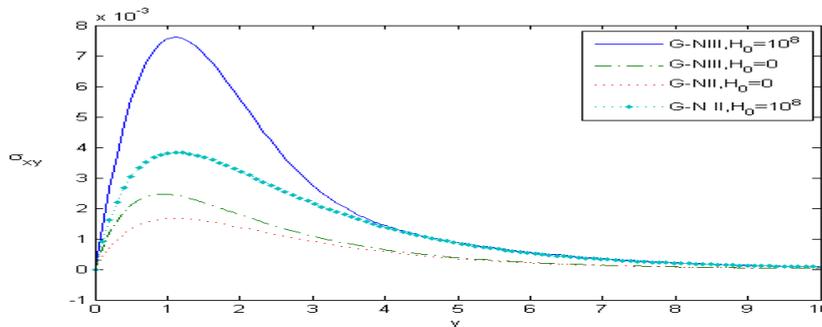


Fig. 3 Distribution of stress component σ_{xy} in the presence and absence of magnetic field.

The case of the presence and the absence of the rotation in the context of the G-N theory of both types II and III with $H_0 = 10^8$ was shown in the Figs. 4-6. Fig. 4 explains that the distribution of horizontal displacement u in the absence of rotation is less than the values in the presence of rotation. The values based on the (G-N) II greater than which based on the (G-N) III in each case (with and without the rotation). Fig. 5 exhibits that the distribution of the temperature T satisfies the boundary conditions. The rotation has the same effects on the temperature distribution for the both types of (G-N) theory. Fig. 6 shows that, the distribution of σ_{xy} has a similar behavior under the (G-N) theory of type II and III. We note that, the amplitude with the effect of the rotation is lesser than that without rotation. The amplitude based on the (G-N) III under the effect of rotation is greater than that based on the (G-N) II. All the physical quantities are continuous and the curves converge to zero.

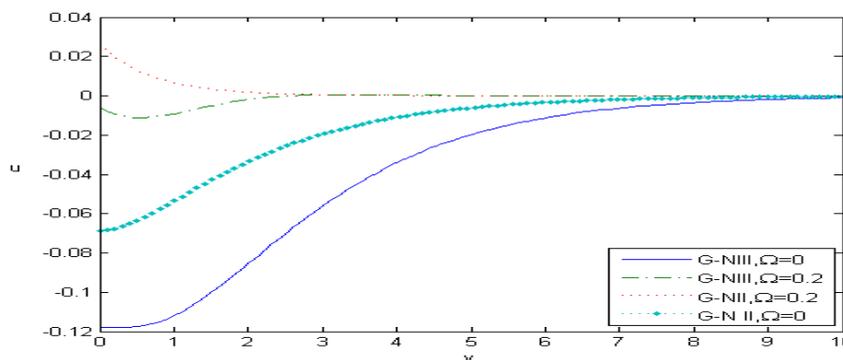


Fig. 4 Horizontal displacement distribution in the presence and absence of rotation.

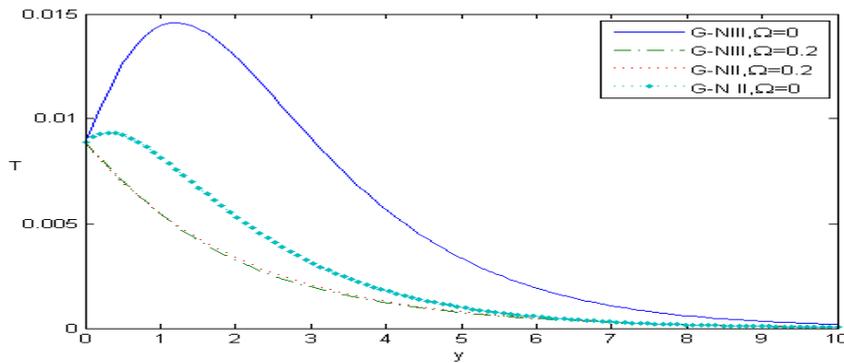


Fig. 5 Temperature distribution in the presence and absence of rotation

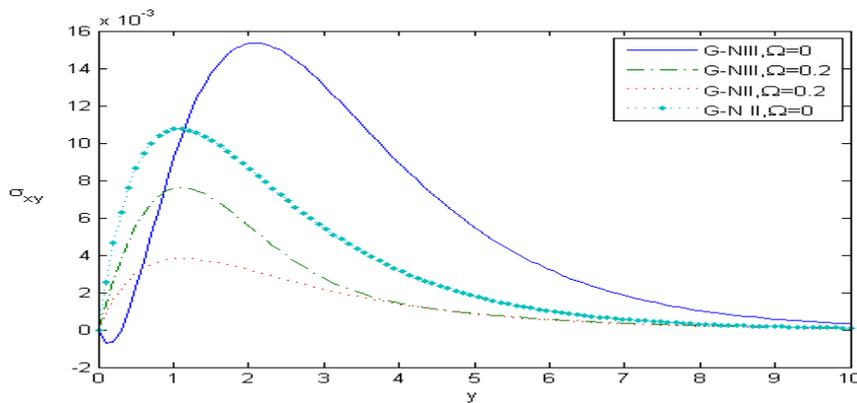


Fig. 6 Distribution of ' component σ_{xy} in the presence and absence of rotation.

Figs. 7 and 8 describe the 3D surface curves for the horizontal displacement u and the stress component σ_{xy} for the rotating conducting thermoelastic medium in the context of the (G-N) theory of type III. These figures are very important to study the dependence of these physical quantities on the vertical component of distance, and show that they move in the wave propagation behavior.

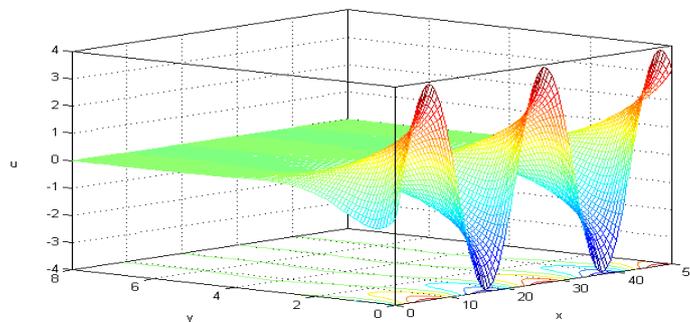


Fig. 7 (3D) Distribution of the displacement component u against both components of distance in the presence of the rotation and the magnetic field for (G-N) of type III.

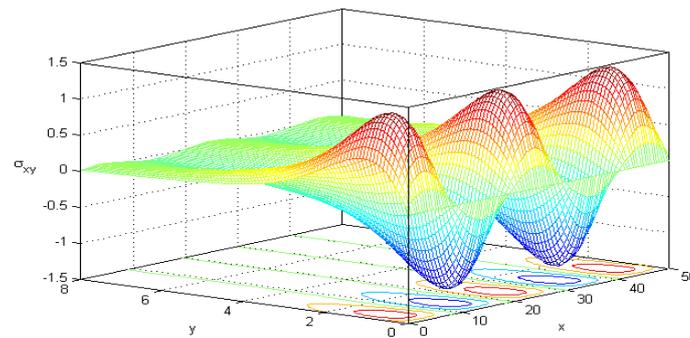


Fig. 8 (3D) Distribution of the stress component σ_{xy} against both components of distance in the presence of the rotation and the magnetic field for (G-N) of type III.

VII. CONCLUSIONS

Comparison between the figures illustrates that:

1. All the discussed physical quantities satisfy the boundary conditions.
2. The rotation and the magnetic field effects appear on the distribution of the quantities except the temperature.
3. The magnetic field has no great effect on the temperature distribution of the rotating medium.
4. The values of all quantities converge to zero.

Nomenclature

$\gamma = (3\lambda + 2\mu)\alpha_t$	α_t	Coefficient of linear thermal expansion.
ρ	K^*	The coefficient of heat conduction.
C_E	K	Material constant characteristic.
λ, μ	σ_{ij}	Stress tensor components.
ε_{ij}	T_0	Reference temperature.
μ_0	ε_0	The electric permeability.
\mathbf{J}	\mathbf{E}	The induced electric field vector.
\mathbf{h}		

REFERENCES

- [1] Hetnarski RB, and Eslami MR, "Thermal stresses advanced theory and applications", Springer Science, 2009.
- [2] Green AE, and Naghdi PM, "Thermoelasticity without energy dissipation", Journal of Elasticity, vol. 31, pp. 189-208, 1993.
- [3] Green AE, and Naghdi PM, "On undamped heat waves in an elastic solid", Journal of Therm Stresses, vol. 15, pp. 253-264, 1992.
- [4] Chandrasekharaiah DS, "One-dimensional wave propagation in the linear theory of thermoelasticity without energy dissipation", Journal of Therm Stresses, vol. 19, pp. 695-710, 1996.
- [5] Sharma JN, and Chauhan RS, "Mechanical and thermal sources in a generalized thermoelastic half space", Journal of Therm Stresses, vol. 24, pp. 651-675, 2001.
- [6] Sinha M, and Bera RK, "Eigenvalue approach to study the effect of rotation and relaxation time in generalized thermoelasticity", Computers and Mathematics with Applications, vol. 46, pp. 783-792, 2003.
- [7] Destrade M, Proceeding of the Royal Society of London. Series A, vol. 463, pp. 495-502, 2004.
- [8] Othman MIA, Zidan MEM, and Hilal MIM, "Effect of magnetic field on a rotating thermoelastic medium with voids under thermal loading due to laser pulse with energy dissipation", Canadian Journal of Physics, vol. 92, no.11, pp. 1359-1371, 2014.
- [9] Othman MIA, and Song YQ, "The effect of rotation on 2-D thermal shock problems for a generalized magneto-thermoelasticity half-space under three theories", Multidisciplinary Modeling in Materials and Structures, vol. 5, no.1, pp. 43-58, 2009.
- [10] Othman MIA, Zidan MEM, and Hilal MIM, "The influence of gravitational field and rotation on thermoelastic solid with voids under Green-

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- Naghdi theory", Journal of Physics, vol. 2, no. 3, pp. 22-34, 2013.
- [11] Abbas IA, Abd-alla AN, and Othman MIA, "Generalized magneto-thermoelasticity in a fibre-reinforced anisotropic half-space", International Journal of Thermophysics, vol. 32, no. 5, pp. 1071-1085, 2011.
- [12] Atwa SY, "Generalized magneto-thermoelasticity with two temperature and initial stress under Green-Naghdi theory", Applied Mathematical Modelling, vol. 38, pp. 5217-5230, 2014.
- [13] Chand D, Sharma JN, Sud SP, "Transient generalized magneto thermoelastic waves in a rotating half-space", International Journal of Engineering Science, vol. 28, pp.547-556, 1990.
- [14] Choudhuri SKR, and Roy GC, "Temperature-rate dependent magneto-thermoelastic waves in a finitely conducting elastic half-space", Computers and Mathematics with Applications, vol. 19, pp. 85-93, 1990.
- [15] Das P, and Kanoria M, "Magneto-thermoelastic waves in an infinite perfectly conducting elastic solid with energy dissipation", Applied Mathematics and Mechanics, vol. 30, pp. 221-228, 2009.
- [16] Agarwal VK, "On electromagneto-thermoelastic plane waves", Acta Mechanica, vol. 10, pp. 181-191, 1967.
- [17] Othman MIA, Zidan MEM, and Hilal MIM, "Effect of magnetic field on a rotating thermoelastic medium with voids under thermal loading due to laser pulse with energy dissipation", Canadian Journal of Physics, vol. 92, pp. 1359-1371, 2014.
- [18] Schoenberg M, and Censor D, "Elastic waves in rotating media", Quarterly of Applied and Mathematics, vol. 31, pp. 115-125, 1973.
- [19] Puri P, "Plane thermoelastic waves in rotating media", Bull DeL'Acad Polon Des Sci Ser Tech, vol. 24, pp. 137-144, 1976.
- [20] Roy Choudhuri SK, and Debnath L, "Magneto-elastic plane waves in infinite rotating media", Journal of Applied Mechanics, vol. 50, pp. 283-287, 1983.
- [21] Roy Choudhuri SK, and Debnath L, "Magneto-thermoelastic plane waves in a rotating media", International Journal of Engineering Science, vol. 21, pp. 155-163, 1983.