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THE STUDY OF LOCAL AND NON-LOCAL EFFECTS IN PIEZOTHERMOELASTIC LAYERED COMPOSITE LEMV CYLINDER WITH STIMULUS OF ROTATION AND GRAVITY.

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Abstract

In this Model, we study local and non-local effects in Piezothermoelastic layered Composite Linear elastic materials with void cylinder with stimulus of rotation and gravity. The mathematical expressions of mechanical and electrical equations are obtained using linear theory of elasticity in the influence of rotation and gravity. The displacement, thermal and electrical expressions are solved mathematically and solution attained by using Bessel's function. The dispersion equations are built on grip free boundary conditions and are numerically inspected for CdSe material. The computed frequency, mechanical and electrical nature against wave number is represented graphically and compared for local and non-local effects.

***Keywords*—** Layered cylinder, LEMV, Non-Local effects, Rotation, Gravity.

Introduction

The novel generalized nonlocal thermoelasticity model predicts fresh characteristics for mechanical parameters. The deliveries of the physical fields are considerably inclined by the gravity field, Rotation and non-local effect. Eringen [1-6] builds the concepts of nonlocal thermoelascity concepts in various fields. Edelen [7] studied another approach in nonlocal effects in thermodynamics of systems. Said [8, 9] initiated the effect of phase-lags, gravity and hydrostatic initial stress in thermoelastic medium. Shakeriaski and Ghodrat [10] discussed the nonlinear response of Cattaneo-type thermal loading of a laser pulse on a medium using the generalized thermoelastic model. Sharma et.al [11] studied Effect of dual phase lag model on the vibration analysis of non-local generalized thermoelastic diffusive hollow sphere. Othman. et.al [12] deliberated effect of initial stress on a microstretch thermoelastic medium immersed in an infinite inviscid fluid with two models. Abouelregal et.al [13] deliberated the influence of a non-local Moore–Gibson–Thompson heat transfer model on an underlying thermoelastic material under the model of memory-dependent derivatives. Zhang and Ma [14] investigated on the microscale memory dependence effect of thermo-viscoelastic rod based on fractional strain theory. Moradi et.al [15] discussed on the vibration and energy harvesting of the piezoelectric MEMS/NEMS via nonlocal strain gradient theory. Selvamani and Mahesh [16, 17, & 18] discussed the effects of nonlocal the effect of nonlocal scale value and phase lags on thermoelastic waves in a multilayered LEMV/CFRP composite cylinder with and without hall current. Selvamani and Mahesh [19] discussed rotation and gravity effects in a piezoelectric viscothermoelastic multilayered composite LEMV/CFRP cylinder. He [20] discussed transient response of a hollow cylinder with nonlocal effect and fractional thermoelasticity. Abouelregal et.al [21, 22] discussed about space-time non-local analysis of a porous thermoelastic hollow cylinder using a heat conduction model featuring a Goufo-Caputo two-parameter fractional derivative with phase lags and analysis of thermoelastic behavior of porous cylinders with voids via a nonlocal space-time elastic approach and Caputo-tempered fractional heat conduction. Cao et.al [23] analysed nonlocal fracture analysis of fiber reinforced composites under heat flux loading. Zhang et.al [24] deliberated deformation and failure mechanism of deep-buried tunnel under the action of fault dislocation and application of nonlocal model in numerical simulation research. He et.al [25] deliberated dynamic response of a half-space with time-fractional heat conduction and nonlocal strain theory. Abouelregal [26] observed Influence of moving heat sources on thermoviscoelastic behavior of rotating nanorods: a nonlocal Klein–Gordon perspective with fractional heat conduction

Based on the above studies, non-local effects in piezoelectric viscothermoelastic multilayered cylinders together with rotation and gravity are not taken into account. So in this model, form a mathematical relation for displacement, temperature, and electrical components; together with rotation and gravity, they are obtained using the linear theory of elasticity. Resolve the mathematical relation with the appropriate method and suitable boundary condition. For making better conclusions, the numerical results consider the material CdSe, and from those results, compared local and non-local effects.

Formation Of Problem

An elastic cylinder with the nature of homogeneous and transversely isotropic is taken to account. The radial radial and axial displacement of equations with rotation is given by

$\sigma^l{}_{rr,r} + \sigma^l{}_{rz,z} + r^{-1}(\sigma^l{}_{rr}) + \rho(\bar{\Omega} \times (\bar{\Omega} \times \bar{u}) + 2(\bar{\Omega} \times \bar{u}_{,t})) = (1 - \epsilon^2\nabla^2)\rho u_{,tt}$
(1a)

$\sigma^l{}_{rz,r} + \sigma^l{}_{zz,z} + r^{-1}\sigma^l{}_{rz} + \rho(\bar{\Omega} \times (\bar{\Omega} \times \bar{w}) + 2(\bar{\Omega} \times \bar{w}_{,t})) = (1 - \epsilon^2\nabla^2)\rho w_{,tt}$
(1b)

The electric displacement equation is given as

$$\frac{1}{r}\frac{\partial}{\partial x}(rD^l_r) + \frac{\partial}{\partial z}(D^l_z) = 0$$

The heat conduction equation

$$K_{11}\left(T^l{}_{,rr} + r^{-1}T^l{}_{,r}\right) + \tau_t\left(K_{11}T^l_{,rr} + K_{33}T^l{}_{,zz}\right)_{,t}$$
$$= \left(\delta + \tau_q\frac{\partial}{\partial t}\right)[T_0 dT^l{}_{,t} + T_0(\beta_1(e^l{}_{rr} + e^l{}_{\theta\theta}) + \beta_3 e^l{}_{,zz} - p_3 E_{,z})]\,)]$$

(1c)

K_{ij} denote heat conduction coefficient. In the above equations make few submissions of τ_θ, τ_q and δ. we get following cases.(i) The Dual phase lags thermoelasticity theory (DPL) when $\tau_\theta = \tau_q = 0$ and $\delta = 1$.

(ii) The Lord–Shulman (LS) generalized thermoelasticity theory when $\tau_\theta, \tau_q \to 0$, $\delta = 1$.

Stress strain relations are given as follows with the non-local effects

$(1 - \epsilon^2\nabla^2)\sigma^l{}_{rr} = c_{11}e^l{}_{rr} + c_{12}e^l{}_{\theta\theta} + c_{13}e^l{}_{zz} - \beta_1 T^l - e_{31}E^l_z$ (2a)

$(1 - \epsilon^2\nabla^2)\sigma^l{}_{zz} = c_{13}e^l{}_{rr} + c_{13}e^l{}_{\theta\theta} + c_{33}e^l{}_{zz} - \beta_3 T^l - e_{33}E^l_z$ (2b)

$(1 - \epsilon^2\nabla^2)\sigma^l{}_{rz} = c_{44}e^l{}_{rz}$ (2c)

$D_r = e_{15}e^l_{rz} + \varepsilon_{11}E^l_r$ (2d)

$D_z = e_{31}\left(e^l_{rr} + e^l_{\theta\theta}\right) + e_{33}e^l_{zz} + \varepsilon_{33}E^l_z + p_3 T$ (2e)

Where σ^l_{ij} denotes stress, e^l_{ij} denotes strain C_{ij} denotes elastic moduli, β_1, β_3 denotes thermal expansion, ρ denotes density, c_v denotes specific heat capacity, p_3 denotes pyro electric effect, $\tau_\theta$and τ_q are phase lags. Here $\epsilon(= e_0 a_0)$ denotes the elastic nonlocal parameter, a_0 - internal characteristic length and e_0- material constant.

The strains fields of the cylinder are taken as

$$e^l{}_{rr} = u^l{}_{,r} e^l{}_{\theta\theta} = r^{-1}\left(u^l + v^l{}_{,\theta}\right), \quad e^l{}_{zz} = w^l{}_{,z}$$

$e^l{}_{r\theta} = v^l{}_r - r^{-1}\left(v^l - u^l{}_{,\theta}\right), \qquad e^l{}_{z\theta} = v^l{}_{,z} + r^{-1}w^l{}_{,\theta}, \qquad e^l{}_{rz} = w^l{}_{,r} + u^l{}_{,z}$ (3)

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Equation (3) and (2) into Equation (1) gives the following equation of motion addition with rotation and gravity.

$$\frac{c_{11}}{1-\epsilon^2\nabla^2}\left(u^l{}_{,rr}+r^{-1}u^l{}_{,r}+r^{-2}u^l\right)+\frac{c_{13}}{1-\epsilon^2\nabla^2}w^l{}_{,rz}+\frac{c_{44}}{1-\epsilon^2\nabla^2}\left(u^l{}_{,zz}+w^l{}_{,rz}\right)$$

$\frac{(e_{15}+e_{31})}{1-\epsilon^2\nabla^2}E^l_{,rz}-\frac{\beta_1^l}{(1-\epsilon^2\nabla^2)}T^l{}_{,r}+\frac{\rho(\Omega^2u+2\Omega w_{,t})}{1-\epsilon^2\nabla^2}+\frac{\rho g w_{,r}}{1-\epsilon^2\nabla^2}=(1-\epsilon^2\nabla^2)\rho^l u_{,tt}$

(4a)

$$\frac{(c_{44}+c_{13})}{1-\epsilon^2\nabla^2}\left(u^l{}_{,rz}+r^{-1}u^l{}_{,z}\right)+\frac{c_{33}}{1-\epsilon^2\nabla^2}\left(w^l{}_{,zz}\right)+\frac{c_{44}}{1-\epsilon^2\nabla^2}\left(w^l{}_{,rr}+r^{-1}w^l{}_{,r}\right)+e_{15}\left(E^l_{,rr}+r^{-1}E_{,r}\right)$$

$-\frac{\beta_3^l}{1-\epsilon^2\nabla^2}T^l{}_{,r}+\frac{\rho(\Omega^2w+2\Omega u_{,t})}{1-\epsilon^2\nabla^2}+\frac{\rho g u_{,r}}{1-\epsilon^2\nabla^2}=(1-\epsilon^2\nabla^2)\rho^l w_{,tt}$ (4b)

$r^{-1}e_{15}\left(w^l_{,rr}+u^l_{,rz}\right)+\varepsilon_{11}E^l_{,r}+e_{13}u^l_{,rz}+r^{-1}\left(u^l_{,r}\right)+e_{33}w^l_{,zz}+\varepsilon_{33}E^l_{,z}+p_3T=0$ (4c)

$K_{11}\left(T^l{}_{,rr}+r^{-1}T^l{}_{,r}\right)+\tau_\theta\left(K_{11}T^l_{,rr}+K_{33}T^l{}_{,zz}\right)_{,t}=\left(\delta+\tau_q\frac{\partial}{\partial t}\right)[T_0dT^l{}_{,t}+T_0(\beta_1(u^l{}_{,rt}+r^{-1}u^l{}_{,t})+\beta_3w^l{}_{,z}-p_3\phi_{,z})]$ (4d)

The solutions of Equations (1) is considered in the form

$$u^l=U^l\exp\{i(kz+\omega t)\}$$

$$w^l=\left(\frac{i}{h}\right)W^l\exp\{i(kz+\omega t)\}$$

$$E^l=\left(\frac{ic_{44}}{he_{33}}\right)E^l\exp\{i\left(i(kz+\omega t)\right)\}$$

$T^l=\left(\frac{c_{44}}{\beta_3}\right)\left(\frac{T^l}{h^2}\right)\exp\{i(kz+\omega t)$ (2)

k - wave number parameter, ω -angular frequency .Introducing the following non-dimensional values $x=\frac{r}{a},\varepsilon=ka,c=\rho p,\mathrm{R}_1=\frac{\rho p^2a^2(1-\epsilon^2\nabla^2)^2}{c_{44}}$, $\bar{c}_{11}=c_{11}(1-\epsilon^2\nabla^2)/c_{44}$, $\bar{c}_{13}=c_{13}(1-\epsilon^2\nabla^2)/c_{44}$, $\bar{c}_{33}=c_{33}(1-\epsilon^2\nabla^2)/c_{44}$, $\bar{c}_{66}=c_{66}(1-\epsilon^2\nabla^2)/c_{44}$, $\bar{\beta}=\beta_1(1-\epsilon^2\nabla^2)/\beta_3$, $\bar{K}_{33}=\frac{(\rho c_{44})^{\frac{1}{2}}}{\beta_3^2T_0a\Omega}$, $R_2=\varepsilon\left(\bar{e}^l_{15}+\bar{e}^l_{31}\right)(1-\epsilon^2\nabla^2)$,
$R_3=(1-\epsilon^2\nabla^2)(\bar{e}_{15}\nabla^2+\varepsilon^2)\bar{c}_{44}$,
$R_4=-\frac{ip_3\beta^*T_0zk\omega}{e_{33}a^2}$,

Equation (5) in Equation (4) we get:

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$$[\bar{c}_{11}\nabla^2-(\mathrm{R}_1^2-\varepsilon^2)]U^l-[\varepsilon(1+\bar{c}_{13})]W^l+R_2E^l-\bar{\beta}T^l=0$$
$$[\varepsilon(1+\bar{c}_{13})\nabla^2]U^l+[\nabla^2+(\mathrm{R}_1^2-\bar{c}_{33}\varepsilon^2)]W^l+R_3E^l-\varepsilon T^l=0$$
$$\varepsilon(1+\bar{c}_{13}^l)\nabla^2U^l+[\bar{e}_{15}\nabla^2+\varepsilon^2]W^l+\left[-\frac{K_{33}}{K}\nabla^2+\bar{K}_{33}^{2}{}^l\varepsilon^2\right]E^l-p^l\varepsilon T^l=0$$
$$\frac{\bar{\beta}T_0z}{c_{44}}\nabla^2U^l+\frac{\tau_qp^2ia}{c_{44}}W^l+R_4E^l+\left(\frac{i\bar{K}_{11}}{\bar{\beta}a^2}\nabla^2(1+\tau_t)+\frac{i\bar{K}_{33}}{\bar{\beta}}(1+ip\tau_t)\varepsilon^2-\frac{\rho\bar{d}ip}{\bar{\beta}}(1-\tau_q)\right)T^l=0$$

Equation (3), reduced as follows

$$(A\nabla^8+B\nabla^6+C\nabla^4+D\nabla^2+E)(U^l\,W^l\,E^l\,T^l)^T=0 \tag{4}$$

The following solutions consider for Equation (4)

$$U^l=\sum_{j=1}^{4}\left[A_jJ_n(\alpha_jx)+B_jy_n(\alpha_jx)\right],$$
$$W^l=\sum_{j=1}^{4}a^l{}_j\left[A_jJ_n(\alpha_jx)+B_jy_n(\alpha_jx)\right],$$
$$E^l=\sum_{j=1}^{4}b^l{}_j\left[A_jJ_n(\alpha_jx)+B_jy_n(\alpha_jx)\right],$$
$$T^l=\textstyle\sum_{j=1}^{4}c^l{}_j\left[A_jJ_n(\alpha_jx)+B_jy_n(\alpha_jx)\right], \tag{5}$$

Here $(\alpha_i^l ax)$, is strictly positive for all i values 1 to 4 and solutions of above equations.

$$(A(\alpha^l{}_ja)^8+B(\alpha^l{}_ja)^6+C(\alpha^l{}_ja)^4+D(\alpha^l{}_ja)^2+E)\,(U^l,W^l,E^l,T^l)=0$$

a_j^l , b_j^l and c_j^l attained form the following equation.

$$[\bar{c}_{11}\nabla^2-(\mathrm{R}_1^2-\varepsilon^2)]-[\varepsilon(1+\bar{c}_{13})]+R_2-\bar{\beta}=0$$
$$[\varepsilon(1+\bar{c}_{13})\nabla^2]+[\nabla^2+(\mathrm{R}_1^2-\bar{c}_{33}\varepsilon^2)]+R_3-\varepsilon=0$$
$$\varepsilon(1+\bar{c}_{13}^l)\nabla^2+[\bar{e}_{15}\nabla^2+\varepsilon^2]+\left[-\frac{K_{33}}{K}\nabla^2+\bar{K}_{33}^{2}{}^l\varepsilon^2\right]-p^l\varepsilon=0$$

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I. MATHEMATICAL EXPRESSION FOR LINEAR ELASTIC MATERIALS WITH VOIDS

The equations of motion for isotropic LEMV materials are given as

$$(\lambda + 2\mu)\left(u_{,rr} + r^{-1}u_{,r} - r^{-2}u\right) + \mu u_{,zz} + (\lambda + \mu)w_{,zz} + \beta E_{,r} = \rho u_{tt}$$

$$(\lambda + \mu)\left(u_{,rz} + r^{-1}u_{,z}\right) + \mu\left(w_{,rr} + r^{-1}w_{,r}\right) + (\lambda + 2\mu)w_{,zz} + \beta E_{,z} = \rho w_{,tt}$$

$$-\beta\left(u_{,r} + r^{-1}u\right) - \beta w_{,z} + \alpha\left(E_{,rr} + r^{-1}E_{,r} + \phi_{,zz}\right) - \delta k E_{,tt} - \omega E_{,t} - \xi E = 0 \tag{7}$$

Stress relation for adhesive material are

$$\sigma_{,rr} = (\lambda + 2\mu)u_{,r} + \lambda r^{-1}u + \lambda w_{,z} + \beta\phi$$

$$\sigma_{rz} = \mu\left(u_{,t} + w_{,r}\right)$$

For Equation (7) the following solution is consider

$$u = \mathbb{u}_{,r} expi(kz + pt)$$

$$w = (\frac{i}{h})\mathbb{W} expi(kz + pt)$$

$$E = \left(\frac{1}{h^2}\right)\mathbb{E}\ expi(kz + pt) \tag{8}$$

The above solution in (7) and nondimensionl variables x and ε, equation can be reduced as

$$\begin{vmatrix} (\lambda + 2\mu)\nabla^2 + M_1 & -M_2 & M_3 \\ M_2\nabla^2 & \bar{\mu}\nabla^2 + M_4 & M_5 \\ -M_3\nabla^2 & M_5 & \alpha\nabla^2 + M_6 \end{vmatrix}(\mathbb{U}, \mathbb{W}, \mathbb{E}) = 0 \tag{9}$$

Where $\nabla^2 = \frac{\partial^2}{\partial x^2} + \frac{1}{x}\frac{\partial}{\partial x}$

$M_1 = \frac{\rho}{\rho^1}(ch)^2 - \bar{\mu}\varepsilon^2$, $M_2 = (\bar{\lambda} + \bar{\mu})\varepsilon$, $M_3 = \bar{\beta}$, $M_4 = \frac{\rho}{\rho^1}(ch)^2 - (\bar{\lambda} + \bar{\mu})\varepsilon^2$,$M_5 = \bar{\beta}\varepsilon$

$M_6 = \dfrac{\rho}{\rho^1}(ch)^2\bar{k} - \bar{\alpha}\varepsilon^2 - i\bar{\omega}(ch) - \bar{\xi}$

Equation (9) expressed as follows ,

$$(\nabla^6 + P\nabla^4 + Q\nabla^2 + R)(\mathbb{U}, \mathbb{W}, \mathbb{E}) = 0 \tag{10}$$

The following solution consider for equation (10)

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$$\mathbb{U} = \sum_{j=1}^{3} \left[A_j J_0(\alpha_j x) + B_j y_0(\alpha_j x)\right],$$

$$\mathbb{W} = \sum_{j=1}^{3} a_j \left[A_j J_0(\alpha_j x) + B_j y_0(\alpha_j x)\right],$$

$$\mathbb{E} = \sum_{j=1}^{3} b_j \left[A_j J_0(\alpha_j x) + B_j y_0(\alpha_j x)\right],$$

$(\alpha_j x)^2$ are solution of the equation when replacing $\nabla^2 = -(\alpha_j x)^2$.

a_j and b_j are got from

$$M_2 \nabla^2 + (\bar{\mu}\, \nabla^2 + M_4) a_j + M_5 b_j = 0,$$
$$-M_3 \nabla^2 + M_5 a_j + (\alpha \nabla^2 + M_6) b_j = 0$$

II. BOUNDARY CONDITIONS AND FREQUENCY EQUATIONS

The below mentioned boundary condition are consider to attain frequency equations

- On the grip free internal and external surface $\sigma^l{}_{rr} = \sigma^l_{rz} = E^l = T^l = 0$ with $l = 1,3$
- At the inner surface $\sigma^l_{rr} = \sigma_{rr}; \sigma^l_{rz} = \sigma_{rz}; E^l = 0; T^l = 0; D^l = 0.$

Based on above boundary condition we acquired as a 22 by 22 determinant equation

$\left|(\mathrm{F}_{ij})\right| = 0\,, \qquad (i, j = 1,2,3, \dots .22)$

At $x = x_0$ Where $j = 1,2,3,4$

$\mathrm{F}_{1j} = 2\bar{c}_{66}(\dfrac{\alpha^1_j}{x_0}) J_1(\alpha^1{}_j x_0) - \left[(\alpha^1{}_j a)^2 \bar{c}_{11} + \zeta \bar{c}_{13} a^l{}_j + \bar{e}_{31} \zeta b^l{}_j + \bar{\beta} c^l{}_j\right] J_0(\alpha^1{}_j a x_0)$

$\mathrm{F}_{2j} = (\zeta + a^1_j + \bar{e}_{15} b^1_j)(\alpha^1_j)\, J_1(\alpha^1{}_j x_0)$

$\mathrm{F}_{3j} = b^1_j J_0(\alpha^1{}_j x_0)$

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$$\mathrm{F}_{4j} = \frac{h_j^1}{x_0} J_0\left(\alpha^1{}_j x_0\right) - (\alpha_j^1)\, J_1\left(\alpha^1{}_j x_0\right)$$

And the other nonzero elements $\mathrm{F}_{1,j+4}, \mathrm{F}_{2,j+4}, \mathrm{F}_{3,j+4}$ and $\mathrm{F}_{4,j+4}$are acquired by substituting J_0 by $J_1$and Y_0 by Y_1.

At $x = x_1$

$$\mathrm{F}_{5j} = 2\bar{c}_{66}(\frac{\alpha_j^1}{x_1}) J_1\left(\alpha^1{}_j x_1\right) - \left[\left(\alpha^1{}_j a\right)^2 \bar{c}_{11} + \zeta \bar{c}_{13} a^l{}_j + \bar{e}_{31} \zeta b^l{}_j + \bar{\beta} c^l{}_j\right] J_0\left(\alpha^1{}_j a x_1\right)$$

$$\mathrm{F}_{5,j+8} = -[2\bar{\mu}\left(\frac{\alpha_j}{x_1}\right) J_1(\alpha x_1) + \left\{-(\bar{\lambda} + \bar{\mu})(\alpha_j)^2 + \bar{\beta} b_j - \bar{\lambda}\zeta a_j\right\} J_0(\alpha_j x_1)$$

$$\mathrm{F}_{6j} = \left(\zeta + a_j^1 + \bar{e}_{15} b_j^1\right)(\alpha_j^1)\, J_1\left(\alpha^1{}_j a x_1\right)$$

$$\mathrm{F}_{6,j+8} = -\bar{\mu}(\zeta + a_j)(\alpha_j) J_1(\alpha_j x_1)$$

$$\mathrm{F}_{7j} = (\alpha_j^l) J_1\left(\alpha_j^l x_1\right)$$

$$\mathrm{F}_{7,j+8} = -(\alpha_j) J_1(\alpha^l{}_j x_1)$$

$$\mathrm{F}_{8j} = a_j^l J_0\left(\alpha_j^l x_1\right)$$

$$\mathrm{F}_{8,j+8} = -a_j^l J_0\left(\alpha_j^l x_1\right)$$

$$\mathrm{F}_{9j} = b_j^l J_0(\alpha_j^l x_0)$$

$$\mathrm{F}_{10j} = e_j(\alpha_j) J_1(\alpha_j^1 x_1)$$

$$\mathrm{F}_{11j} = \frac{c_j^l}{x_1} J_0\left(\alpha_j^l x_1\right) - (\alpha_j^l) J_1\left(\alpha_j^l x_1\right)$$

and the continuing nonzero element at the inner surfaces $x = x_1$ can be acquired on swapping J_0 by J_1 and Y_0 by Y_1 in the above elements. They are $\mathrm{F}_{i,j+4,}\mathrm{F}_{i,j+8,}\mathrm{F}_{i,j+11,}\mathrm{F}_{i,j+14,}(ir = 5,6,7,8)$ and $\mathrm{F}_{9,j+4,}\mathrm{F}_{10,j+4,}\mathrm{F}_{11,j+4,}$ .At the inner surface $x = x_2$, the nonzero elements along the following rows F_{ij} , $(i = 12\ to\ 18$ and $j = 8\ to\ 20)$ are acquired on swapping x_1 by x_2 and superscript 1 by 2 in order. Likewise, at the outer surface $x = x_3$, the nonzero elements F_{ij} , $(i = 19\ to\ 22$ and $j = 14\ to\ 22)$.

III. NUMERICAL ANALYSIS

The following material constants of CdSe consider for numerical discussions

$C_{11} = 7.41 \times 10^{10} Nm^{-2}$, $C_{12} = 4.52 \times 10^{10} Nm^{-2}$,; $C_{13} = 3.93 \times 10^{10} Nm^{-2}$,
$C_{33} = 8.36 \times 10^{10} Nm^{-2}$, $C_{44} = 1.32 \times 10^{10} Nm^{-2}$, $T_0 = 298\ K$,$\rho = 5504\ kg\ m^{-3}$,

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$C_T = 260\, J\, Kg^{-1}\, K^{-1}$, $e_{13} = -0.160\, Cm^{-2}$, $e_{33} = 0.347\, Cm^{-2}$, $e_{15} = -0.138Cm^{-2}$,

$\beta_1 = 0.621 \times 10^6\, Nk^{-1}m^{-2}$, $\beta_3 = 0.621 \times 10\, Nk^{-1}m^{-2}$, $P_3 = -2.94 \times 10^6\, Ck^{-1}m^{-2}$,

$K_1 = K_3 = 9\, Wm^{-1}K^{-1}$, $\epsilon_{11} = 8.26 \times 10^{-11}C^2N^{-1}m^{-2}$

$\epsilon_{11} = 8.26 \times 10^{-11}C^2N^{-1}m^{-2}$,$\tau_q = 0.9342 \times 10^{-12}s$, $\tau_q = 0.9342 \times 10^{-12}s$,

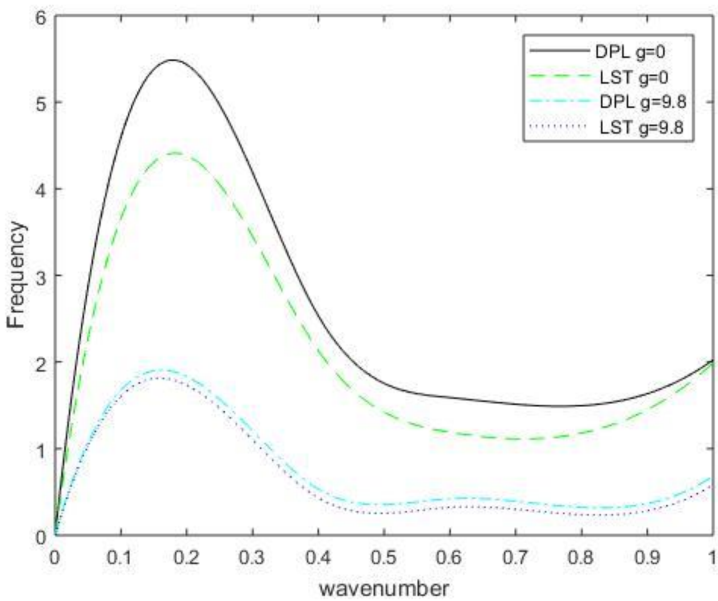

Fig 1. Dimensionless frequency versus wave number in presence and absences of gravity in local elastic cylinder.

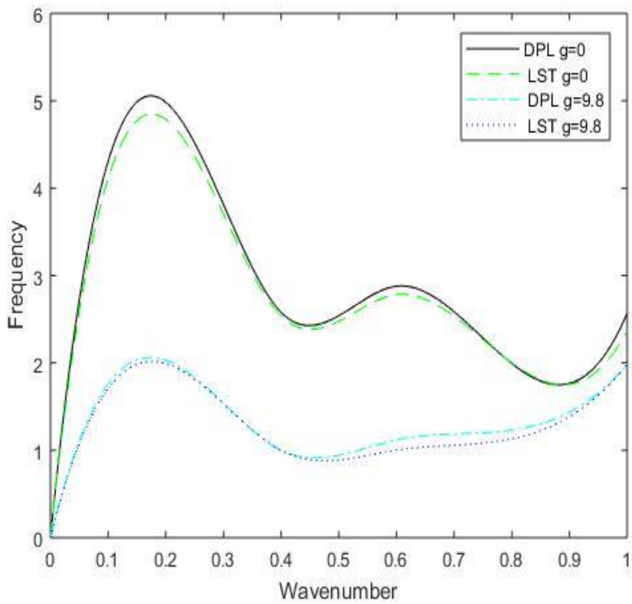

Fig 2 Dimensionless frequency versus wave number in presence and absences of gravity in non-local Elastic cylinder.

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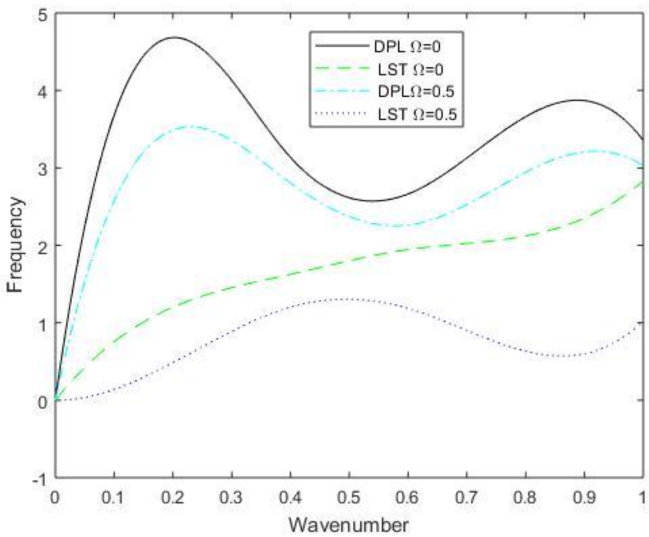

Fig 3. Dimensionless frequency versus wave number in presence and absences of rotation in local Elastic cylinder.

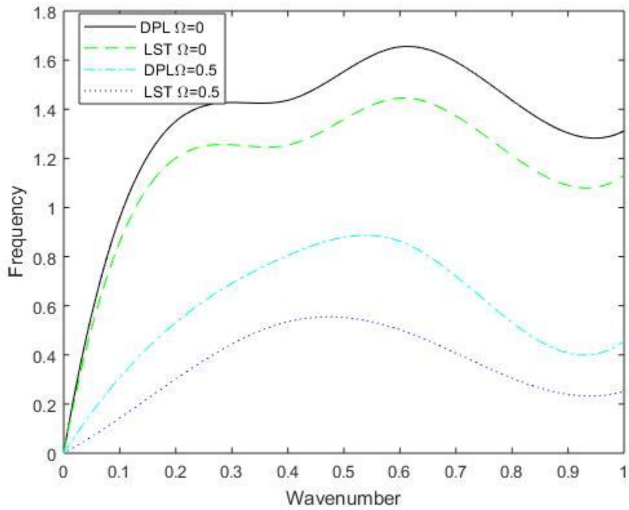

Fig 4. Dimensionless frequency versus wave number in presence and absences of rotation in non-local Elastic cylinder.

Fig. 1 represents the variation of wave number versus non-dimensional frequency against DPL and LST theory with and without gravity for a local thermoelastic multilayered cylinder. In the above formation the absence of non-local parameter $(1-\epsilon^2\nabla^2)$, attain local thermoelastic multilayered cylinder results. Fig. 2 represents the variation of wave number versus non-dimensional frequency against DPL and LST theory with and without gravity for a nonlocal thermoelastic multilayered cylinder. From this, we observed similar changes in local and nonlocal elastic cylinders in the presence and absence of gravity for DPL and LST theory.

Fig. 3 represents the variation of wave number versus non-dimensional frequency against DPL and LST theory with and without rotation for a local thermoelastic multilayered

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cylinder. Fig. 4 represents the variation of wave number versus non-dimensional frequency against DPL and LST theory with and without rotation for a nonlocal thermoelastic multilayered cylinder. From this, we observed similar changes in local and nonlocal elastic cylinders, in the presence and absence of rotation for DPL and LST theory. Further rotation parameter creates impact in Non-dimensional frequency against wave number in both cases.

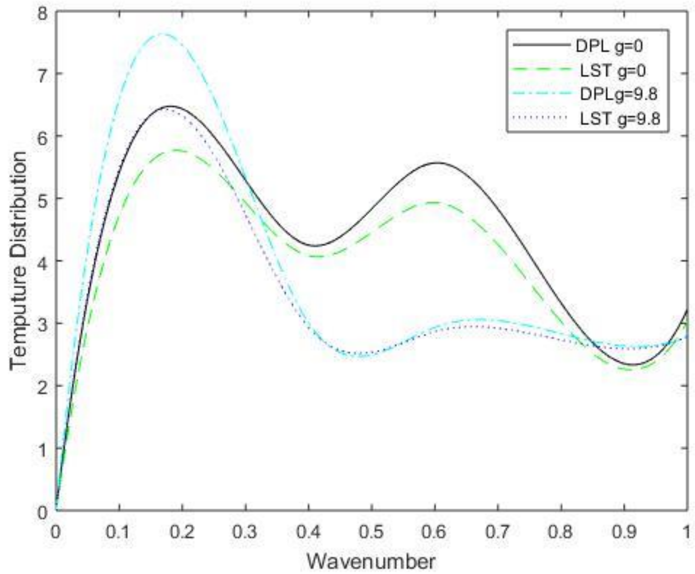

Fig 5. Distribution of temperature versus wave number in presence and absences of gravity in local Elastic cylinder.

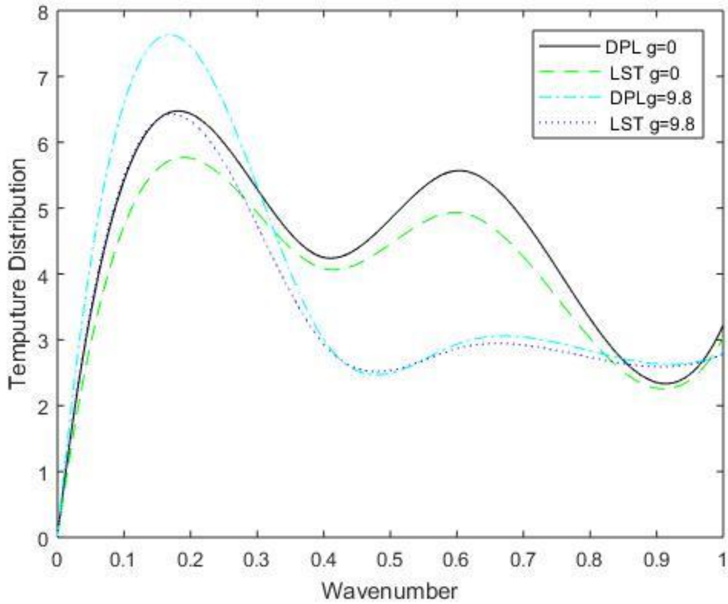

Fig 6. Distribution of temperature versus wave number in presence and absences of gravity in nonlocal Elastic cylinder.

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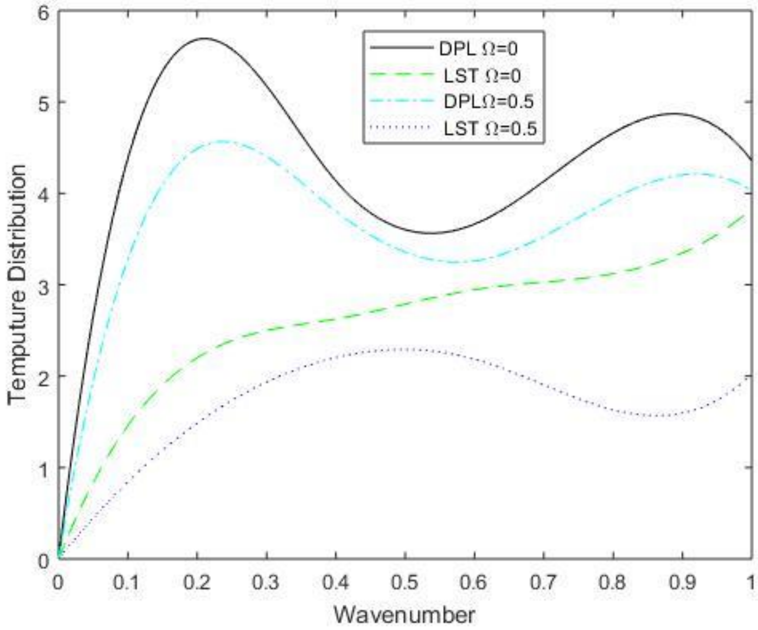

Fig 7. Distribution of temperature versus wave number in presence and absences of rotation in local Elastic cylinder.

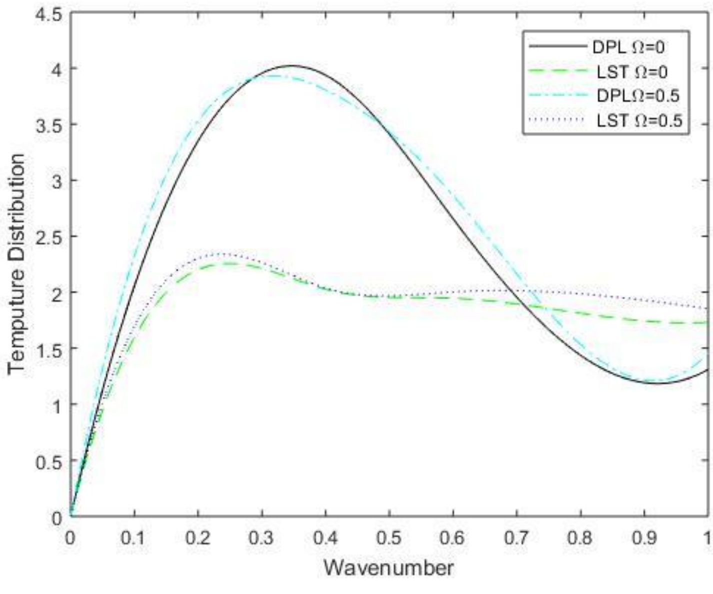

Fig 8. Distribution of temperature versus wave number in presence and absences of rotation in non-local Elastic cylinder.

Fig. 5 represents the variation of wave number versus temperature distribution against DPL and LST theory with and without gravity for a local thermoelastic multilayered cylinder. Fig. 6 represents the variation of wave number versus temperature distribution against DPL and LST theory with and without gravity for a nonlocal thermoelastic multilayered cylinder. In this, we detected similar changes in local and nonlocal elastic cylinders in the presence and absence of gravity for DPL and LST theory.

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Fig. 7 represents the variation of wave number versus temperature distribution against DPL and LST theory with and without rotation for a local thermoelastic multilayered cylinder. Fig. 8 represents the variation of wave number versus temperature distribution against DPL and LST theory with and without rotation for a nonlocal thermoelastic multilayered cylinder. In this, we detected similar changes in local and nonlocal elastic cylinders, in the presence and absence of rotation for DPL and LST theory. Further rotation parameter creates more impact in temperature distribution against wave number in both cases.

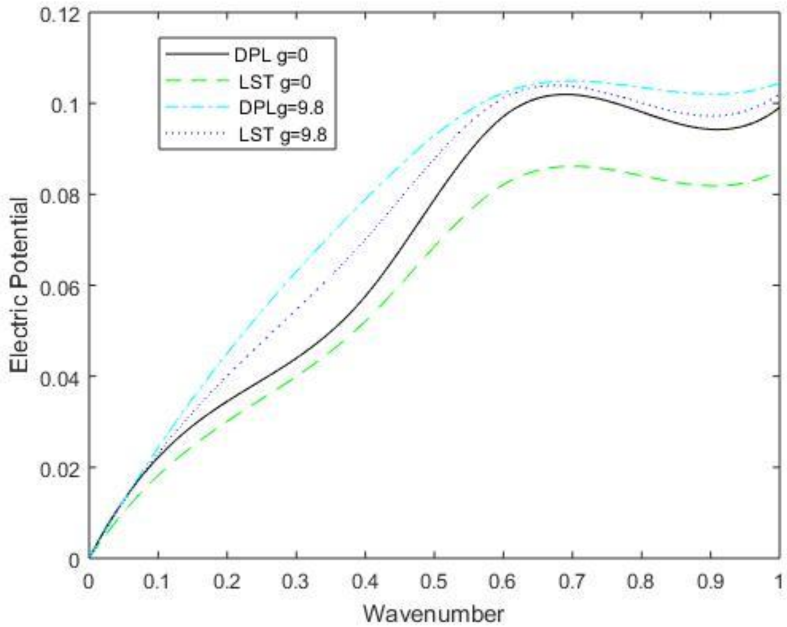

Fig 9. Distribution of electric potential versus wave number in presence and absences of gravity in local Elastic cylinder.

Fig. 9 denotes the variation of wave number versus electric potential against DPL and LST theory with and without gravity for a local thermoelastic multilayered cylinder. Fig. 10 represents the variation of wave number versus electric potential against DPL and LST theory with and without gravity for a nonlocal thermoelastic multilayered cylinder. In this, we observed that the electric potential retains an increasing nature in local elastic cylinders, while it exhibits the same behavior only at lower values of wave number in nonlocal cylinders, both in the presence and absence of gravity for DPL and LST theory.

Fig. 11 denotes the variation of wave number versus electric potential against DPL and LST theory with and without rotation for a local thermoelastic multilayered cylinder. Fig. 12 represents the variation of wave number versus electric potential against DPL and LST theory with and without rotation for a nonlocal thermoelastic multilayered cylinder. In this, we detected slight variation in electric potential for local and nonlocal elastic cylinders, in the presence and absence of rotation for DPL and LST theory.

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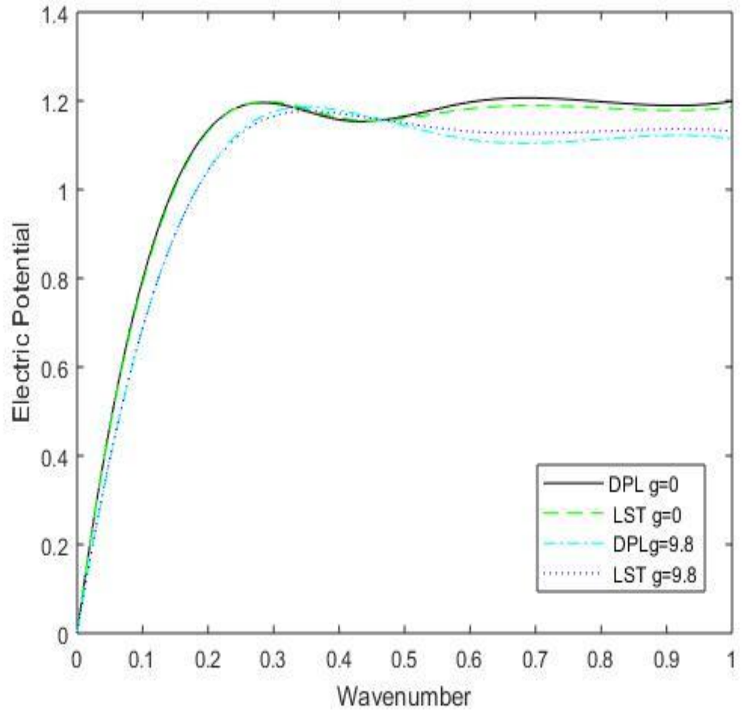

Fig 10. Distribution of electric potential versus wave number in presence and absences of gravity in non-local Elastic cylinder.

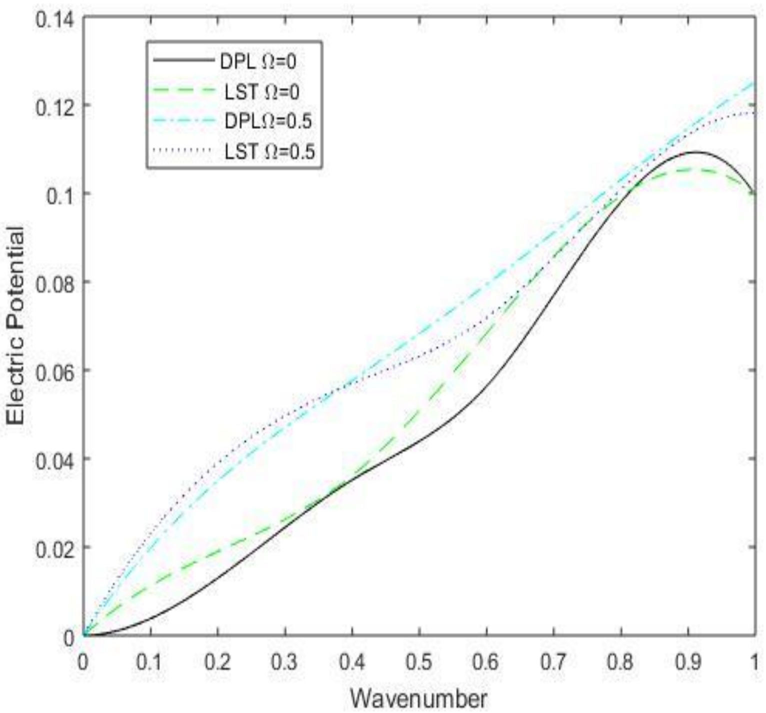

Fig 11. Distribution of electric potential versus wave number in presence and absences of rotation in local Elastic cylinder.

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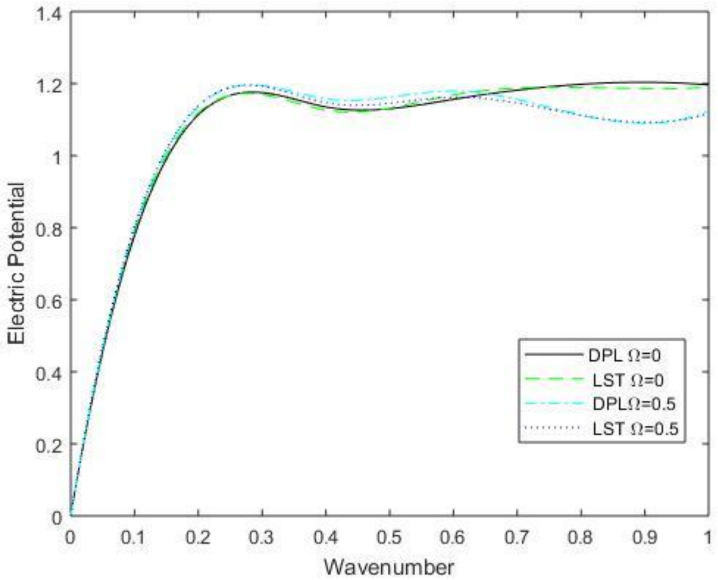

Fig 12. Distribution of electric potential versus wave number in presence and absences of rotation in non-local Elastic cylinder.

Conclusions

This problem is framed by the analysis of the local and non-local effects of Piezothermoelastic layered Composite LEMV Cylinder with stimuli of rotation and gravity. To attain that, the modeling of mechanical, thermal and electric parameters is framed for the above-mentioned case and that modeling is exactly solved by the linear theory of elasticity and appropriate boundary conditions. For performing the numerical results, the material constants of cdSe were considered. The numerical calculation was carried out through MATLAB and their results are expressed in a graphical illustration. Through that, in both cases, gravity creates similar effects in frequency and thermal distribution as well as rotation creates slight variation. The variation in electric potential retains some significant variation in the nonlocal elastic cylinder compared to the local elastic cylinder.

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