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Sound Wave Propagation in a Multiferroic Thermo Elastic Nano Fiber Under the Influence of Surface Effect and Parametric Excitation

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ABSTRACT
This study investigates that the sound wave propagation of multiferroic thermo elastic Nanofibers under the influence of surface effect and parametric excitation via Timoshenko form of beam equations. The equation of analytical model is obtained for Nanofiber through shear and rotation effect. The solution of the problem is reached through the coupled time harmonic equations in flexural direction. Graphs are drawn for frequency, phase velocity, piezoelectric strain, magnetic field and dynamic displacement at different vibration modes of Nanofibers. From the result obtained, it is seen that the surface effect and excitation frequency gives significant contribution to the physical variables of the Nanofiber. The frequency grows in the presence of surface effect and decay as length increases both in Euler's and Timoshenko beam theory. Also, a comparison of numerical results is made with existing literature and good agreement is arrived. The present study is expected to be more helpful for the design of piezo-thermo-magneto-mechanical Nanofiber-based devices.

Keywords: Sound waves; Nano fiber; Parametric excitation; Surface effect; NEMMS.

1 INTRODUCTION

SMART composite like magneto-thermo-piezo electric Nano materials are used for smart applications as fiber sensors and actuators, structural components of self-monitoring structures. Nowadays, Nano structures such as Nanofibers, Nano beams and Nano membranes are very attractive field for many researchers due to their improvement of the quality properties. The invention of Nanotubes (CNTs) in the early periods gave much attraction in many areas of industrial engineering and Nano sciences. Many applications of CNTs have been reported in the area like biomedical engineering, water and air purification field and electronic devices in Nano electro mechanical systems. Xiang-Fa Wu and Dzenis [1] developed a method to find the wave propagation in Nanofibers in the context

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of continuum mechanics. Xiang-Fa Wu et al. [2] investigated rippling of polymer Nanofibers and they adopted pure nonlinear numerical methods to capture the entire evolution process of surface rippling and relevant effects of the control parameters. The wave propagation in pre stretched polymer Nanofibers is read from Xiang-Fa Wu [3], they obtained result that the size effect of polymer Nanofibers have more influence with either decreasing fiber radius or increasing wave number. Guang et al. [4] reported the microwave absorption enhancement of porous carbon fibers compared with carbon Nanofibers and they concluded that the content of the absorbents influence the microwave absorption properties of the composites. Mohammad Arefi and Ashraf Zenkour [5] studied the analysis of wave propagation in a functionally graded nanobeam resting on visco-Pasternak's foundation; they found that increase of damping parameter of foundation leads to decrease of real and imaginary parts of transverse phase velocity. The multiferroic composite material such as piezomagnetic and piezoelectric materials are able to develop the magnetic and electrical effect by applying mechanical stress. Piezo-materials are the typical types of materials that are known as multiferroic composites or magneto-electro-elastic (MEE) material that together welded on each other to convert the energies in magnetic and electric fields. Therefore, Piezo-materials possess the magneto-electric effect (ME effect). Multiferroic material composites are used to manufacture the actuators, rotating sensors, acoustic devices, control sensors, and transducers, etc. Further, magnetization property and the charged electrical elements will create the magnetic fields. Karlicic et al. [6] studied the dynamics of multiple viscoelastic carbon Nanotube based Nanocomposites with axial magnetic field. Ahmadi and Shokri [7] investigated the optoelectronic properties of silicon hexagonal Nanotubes under an axial magnetic field; they examined the contribution of every transition to the peaks in the linear absorption spectra. Ceballos et al. [8] analyzed the prevalence of information stored in arrays of magnetic Nanowires against external fields. Electromagnetic Nanofiber wires by using magnetic field assisted electro spinning was developed by Guarino et al. [9]. Jiabin Xu et al. [10] reported the controllable generation of Nanofibers through a magnetic-field-assisted electro spinning design. They adopted the concept that the thermal energy is used to convert the mechanical energy of the turbine into electrical energy. Mohammad Arefi and Ashraf Zenkour [11] investigated the wave propagation analysis of a functionally graded magneto-electro-elastic nanobeam rest on Visco-Pasternak foundation; they found that increasing the nonlocal parameter decreases velocity of longitudinal, shear and transverse wave propagation. This decreasing is due to decreasing the stiffness of material with increasing the nonlocal parameter. Mohammad Arefi [12] studied the analysis of wave in a functionally graded magneto-electro-elastic nano-rod using nonlocal elasticity model subjected to electric and magnetic potentials, they concluded that the phase velocity is decreased with increasing the nonlocal parameters of the nano-rod. Yong Li et al. [13] analyzed the electrical conductivity and electromagnetic interference shielding characteristics of multiwalled carbon nanotube filled polyacrylate composite films. Mohammad Arefi and Ashraf Zenkour [14] developed a simplified shear and normal deformations nonlocal theory for bending of functionally graded piezomagnetic sandwich nanobeams in magneto-thermo-electric environment, they concluded that the maximum deflection of the nanobeam increases with increasing the nonlocal parameter of the nanobeam. For the energy conversion in a smart way, piezoelectric materials are commonly used. Piezo electric nano fibers are playing an important role in butane lighters and improvised potato cannons. Jiyoung Chang et al. [15] analyzed the piezoelectric Nanofibers for energy scavenging applications. Arash Tourki Samaei et al. [16] investigated the frequency analysis of piezoelectric Nanowires with surface effects and they found that the surface effects tend to increase the natural frequency in lower modes. Xu Liang et al. [17] developed the surface effects on the post-buckling of piezoelectric Nanowires, they found that surface effects becomes prominent when the thickness of piezoelectric Nanowire at a few Nanometers. Mohammad Arefi and Ashraf Zenkour [18] studied the free vibration, wave propagation and tension analyses of a sandwich micro/nano rod subjected to electric potential using strain gradient theory, they found that the increase in applied electric potential leads to increase in axial displacement of sandwich microrod. Mohammad Arefi [19] reported the surface effect and non-local elasticity in wave propagation of functionally graded piezoelectric nano-rod excited to applied voltage. Mohammad Arefi et al. [20] analyzed the size-dependent free vibration analysis of three-layered exponentially graded nanoplate with piezomagnetic face-sheets resting on Pasternak's foundation; they concluded that increase in inhomogeneous index of exponentially graded core leads to a stiffer core and consequently increase the natural frequencies of nanoplate. Mohammad Arefi and Ashraf Zenkour [21] developed the influence of micro-length-scale parameters and inhomogeneities on the bending, free vibration and wave propagation analyses of a FG Timoshenko's sandwich piezoelectric microbeam, Mohammad Arefi and Ashraf Zenkour [22] later,investigated the size-dependent vibration and bending analyses of the piezomagnetic three-layer nanobeams, they exposed the truth that increase of the applied electric potential, deflection and rotation are increased unlike to axial deformation, maximum electric and magnetic potentials that are decreased. Mohammad Arefi and Ashraf Zenkour [23] reported the iinfluence of magneto-electric environments on size-dependent bending results of three-layer piezomagnetic curved nanobeam based on sinusoidal shear deformation theory, they revealed that increase of nonlocal parameter will reduce the magnitude of all displacement components and rotation.

Mohammad Arefi and Ashraf Zenkour [24] studied the transient analysis of a three-layer microbeam subjected to electric potential. Yue et al. [25] investigated the micro scale Timoshenko beam model for piezoelectricity with flexoelectricity and surface effects, they revealed that the deflection and electric field predicted by this new Timoshenko beam model are larger than that predicted by Euler–Bernoulli beam model. Karnovsky Ia and Lebed Oi [26] studied the formulas for structural dynamics-tables, graphs, and solutions. Mohammad Rafiee et al. [27] developed the large amplitude vibration of carbon nanotube reinforced functionally graded composite beams with piezoelectric layers. Liew et al. [28] reported the postbuckling of piezoelectric FGM plates subject to thermo-electro-mechanical loading. Thermo elastic Nanofibers are more important structural components in thermo sensors and their modified engineering components. Ahmed Elgafy and Khalid Lafdi [29] studied the effect of carbon Nanofiber additives on thermal behavior of phase change materials and they found that the heat transfer phenomenon at Nanoscale seems to be more sensitive in surface area. Xinpeng Zhao et al. [30] studied the thermal conductivity model for Nanofiber networks. They constructed the thermal conductivity of the network by both the inter-fiber contact resistance and intrinsic thermal resistance of the Nanofibers. The influence factors of the inter-Nanowire thermal contact resistance in the stacked Nanowires have been imitated by Dongxu Wu et al. [31] and they concluded that the pressure rise and a sintering-treatment are useful to tune the inter-Nanowire thermal contact resistance. Abhinav Malhotra and Martin Maldovan [32] developed the thermal transport in semiconductor Nanotubes. Also, they concluded that the thermal conductivity of the Nanotube depends on the outer diameter even for the same shell thickness. Zahra Musavi et al. [33] developed the effect of thermal magnonic excitations on the electronic conductance of a magnetic Nanowire, they found that the electron tunnelling conductance is improved in the presence of magnonic excitations. Mohammad Arefi and Amir Hossein Soltan Arani [34] investigated the higher order shear deformation bending results of a magneto electro thermo elastic functionally graded nanobeam in thermal, mechanical, electrical, and magnetic environments. Chang [35] developed the thermal–mechanical vibration and instability of a fluid-conveying single-walled carbon nanotube embedded in an elastic medium based on nonlocal elasticity theory. Sound waves with higher frequency have been used in modern engineering and bio mechanics research field. Heireche et al. [36] discussed the sound wave propagation in single-walled carbon Nanotubes with initial axial stress and they showed that the phase velocities decrease with increasing compressive initial stresses. Berrabah et al. [37] investigated the comparative study of sound wave propagation in single-walled carbon Nanotubes using nonlocal elasticity for Aluminium and Nickel. The nonlinear vibration of carbon Nanotube embedded in viscous elastic matrix under parametric excitation by nonlocal continuum theory has been reported by Yi-Ze Wang et al. [38]. They showed that for the mode number being one, the gap between the negative and positive bifurcation points can be enlarged by the parametric load. Yi-Ze Wang and Feng-Ming [39] investigated the dynamical parametric instability of carbon Nanotubes under axial harmonic excitation by nonlocal continuum theory; they reported that the parametric vibration of double-walled carbon Nanotubes has more stable properties than the single-walled carbon Nanotubes. Amir Ahmad and Tripathi [40] studied the parametric excitation of higher-order electromechanical vibrations of carbon Nanotubes.

From the above studies here, we concentrated the sound wave propagation of Nanofibers under the effect of surface related force and parametric excitation in the presence of magneto thermo piezoelectric forces using Timoshenko form of beam equation. Analytical derivation of motion of Nanofiber is derived via Lorentz's force, thermal and piezo electric terms in the presence of surface effect and parametric excitation. The graphs and tables are presented for the physical quantities.

2 MAGNETO THERMO ELECTRO ELASTIC MODEL OF NANOFIBER

The geometry of Nanofiber in the basic form is displayed in Fig.1 via shear force and rotation effect.

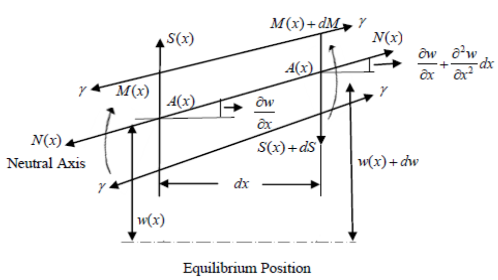

Fig.1
Geometry of Nanofiber in transverse direction.

The dynamic equation of fiber in vertical direction is given as:

$$S-\left(S+\frac{\partial S}{\partial x}dx\right)+\left(E\varepsilon_0 A+2\pi\gamma R+T_l\right)\frac{\partial^2 w}{\partial x^2}dx+qdx=\rho A\frac{\partial^2 w}{\partial t^2}dx+\Delta(t)\frac{\partial^2 w}{\partial x^2}dx \tag{1}$$

where E is Young's modulus, S is the shear force, A is cross-sectional area, ε_0 represent prestrain, R is radius of Nanofiber, γ is surface tension or stress, ρ is mass density and w is deflection of the Nanofiber and $\Delta(t)$ is the periodic load which can be expressed as $\Delta(t)=\Delta_t\cos\theta t$ where Δ_t and θ are the amplitude and frequency of the periodic part. The thermal force T_l is defined as:

$$T_l=-\alpha_x EAT \tag{2}$$

where α_x is coefficient of thermal expansion. T is temperature variation. Processing the moments at centre about an axis to perpendicular to x, y plane, we get

$$-M+\left(M+\frac{\partial M}{\partial x}dx\right)-\frac{S}{2}dx-\left(\frac{S}{2}+\frac{1}{2}\frac{\partial S}{\partial x}dx\right)dx+E\varepsilon_0 A\frac{\partial w}{\partial x}+2\pi\gamma R\frac{\partial w}{\partial x}=J\frac{\partial^2\phi}{\partial t^2} \tag{3}$$

where M is the bending of Nanofiber and ϕ is the angle produced only by bending moment, $J=\rho Idx$. The following basic equation of flexural mode of the Nanofiber is derived from Eqs. (1) - (3) in the presence of magnetic and thermal force

$$\rho A\frac{\partial^2 w}{\partial t^2}+\Delta(t)\frac{\partial^2 w}{\partial x^2}+\frac{\partial S}{\partial x}-\left(E\varepsilon_0 A+2\pi\gamma R+T_l\right)\frac{\partial^2 w}{\partial x^2}-q=0 \tag{4}$$

$$\rho I\frac{\partial^2\phi}{\partial t^2}+S-\left(E\varepsilon_0 A+2\pi\gamma R\right)\frac{\partial w}{\partial x}-\frac{\partial M}{dx}=0 \tag{5}$$

The bending and shear forces are given in terms of cross sectional area by

$$M=\int_A w\prod{}^P dA \tag{6}$$

$$S=\int_A \tau dA \tag{7}$$

In which $\prod^P$ and τ indicates the normal and shear stress of the fiber. Lorentz force is created on Nano fiber by using the magnetic field $\overline{H}(H_x,0,0)$ in longitudinal direction along with magnetic permeability. From Karilicic et al. [6], the pressure by the Lorentz force on Nanofiber can be expressed as:

$$q=\int_A f_z dA=\eta AH_x^2\frac{\partial^2 w}{\partial x^2} \tag{8}$$

where f_z is the Lorentz force in z axis. η and H_x denotes the magnetic field and magnetic permeability. Then the stress –strain relation in the piezoelectric materials are given by

$$\prod{}^P=E\varepsilon-d_{31}E_z \tag{9}$$

$$\tau=G\gamma_0 \tag{10}$$

where E_z is the electric field, $G = E/2(1+v)$ denotes shear modulus, d_{31} denote the piezoelectric strain constant. The normal and shear strain component ε and γ_0 can be expressed by

$$\varepsilon = w\frac{\partial \phi}{\partial x} \tag{11}$$

$$\gamma_0 = \phi - \frac{\partial w}{\partial x} \tag{12}$$

In one dimensional case, the expression connecting between the applied voltage $V(t)$ and electric field intensity Liew et al. [28] within a piezoelectric actuator is given by

$$E_z = \frac{V(t)}{h_p} \tag{13}$$

Using Eqs. (11)-(13) upon Eqs. (9) - (10) and employing Eqs. (6) and (7) in the remaining relations, we can obtain the bending force as follows:

$$M = EI\frac{\partial \phi}{\partial x} - d_{31}A\frac{V(t)}{h_p}w \tag{14}$$

where $I = \int_A w^2 dA$ is the inertial force through area of the cross section of the Nanofiber and shear force is given as:

$$S = G\left(\phi - \frac{\partial w}{\partial x}\right)A\Im \tag{15}$$

where $\Im = \left(6+12v+6v^2\right)/\left(7+12v+4v^2\right)$ is the coefficient of shear. Applying the Eqs. (14) - (15) upon Eqs. (4) – (5), we get

$$\rho\frac{\partial^2 w}{\partial t^2} + \frac{\Delta(t)}{A}\frac{\partial^2 w}{\partial x^2} + \Im G\left(\frac{\partial \phi}{\partial x} - \frac{\partial^2 w}{\partial x^2}\right) - \left(E\varepsilon_0 + \frac{2\gamma}{R} - \alpha_x ET - \eta H_x^2\right)\frac{\partial^2 w}{\partial x^2} = 0 \tag{16}$$

$$\rho I\frac{\partial^2 \phi}{\partial t^2} + \Im GA\left(\phi - \frac{\partial w}{\partial x}\right) - \left(EA\varepsilon_0 + 2\pi R\gamma\right)\frac{\partial w}{\partial x} - EI\frac{\partial^2 \phi}{\partial x^2} + d_{31}A\frac{V(t)}{h_p}\frac{\partial w}{\partial x} = 0 \tag{17}$$

3 ANALYTICAL SOLUTION OF THE PROBLEM

To analyze the effect of magneto thermo electro elastic effects and other forces on the vibration of the Nanofibers, we solve the coupled Eqs. (16) and (17) for the time harmonic case of vibrations. We seek for the flexural wave motion as:

$$\begin{aligned} w(x,t) &= \overline{W}e^{i\varpi t}\sin\left(\frac{n\pi x}{L}\right) \\ \phi(x,t) &= \bar{\phi}e^{i\varpi t}\cos\left(\frac{n\pi x}{L}\right) \end{aligned} \tag{18}$$

where $\overline{W}$ is the amplitude of deflections, $\bar{\phi}$ is the amplitude of the slope due to bending deformation of the fiber, L is the length of the Nanofiber. Also, the frequency of the vibration of Nanofiber is denoted by ϖ. Substituting Eqs. (18) in Eqs. (16) – (17), We get

$$\left[\rho\varpi^2+\frac{\Delta(t)}{A}\left(\frac{n\pi}{L}\right)^2-\left(\Im G+E\,\varepsilon_0+\frac{2\gamma}{R}-\alpha_x ET-\eta H_x^2\right)\left(\frac{n\pi}{L}\right)^2\right]\overline{W}+\Im G\frac{n\pi}{L}\bar{\phi}=0 \tag{19}$$

$$\left[\left(\Im GA+(EA\,\varepsilon_0+2\pi R\gamma)-d_{31}A\frac{V(t)}{h_p}\right)\frac{n\pi}{L}\right]\overline{W}-\left[-\rho I\varpi^2+\Im GA+EI\left(\frac{n\pi}{L}\right)^2\right]\bar{\phi}=0 \tag{20}$$

The above equations can be written in the matrix form as:

$$\left([K]-\varpi^2[M]\right)\begin{bmatrix}\overline{W}\\ \bar{\phi}\end{bmatrix}=\begin{bmatrix}0\\0\end{bmatrix} \tag{21}$$

where

$$[K]=\begin{bmatrix}\left(\frac{\Delta(t)}{A}-\left(\Im G+E\,\varepsilon_0+\frac{2\gamma}{R}-\alpha_x ET-\eta H_x^2\right)\right)\left(\frac{n\pi}{L}\right)^2 & \Im G\frac{n\pi}{L}\\ \left(\Im GA+(EA\,\varepsilon_0+2\pi R\gamma)-d_{31}A\frac{V(t)}{h_p}\right)\frac{n\pi}{L} & -\left(\Im GA+EI\left(\frac{n\pi}{L}\right)^2\right)\end{bmatrix}$$

$$[M]=\begin{bmatrix}-\rho & 0\\ 0 & -\rho I\end{bmatrix}$$

Eq. (21) expresses the two natural frequencies. Lower frequency represents the flexural wave and higher frequency shows the transverse motion of the fiber.

4 NUMERICAL DISCUSSION

In this section the numerical computation of magneto thermo piezo electric Nanofiber with surface and parametric effect is presented. The mechanical and other interacted material properties are considered from Xiang-Fa Wu and Dzenis [1] as $E=100MPa$, $v=0.5$, $\rho=2000kg/m^3$. The neumerical value of longitudinal magnetic field and magnetic permeability are taken from Yong Li et al. [13] as $H_x=10^7 A/m$ and $\eta=4\pi\times10^{-7}H/m$. The piezoelectric material value is taken from Liew et al. [28] as $d_{31}=2.54\times10^{-10}m/V$. From chang [35] the temperature and coefficient of thermal expansion are considered as $T=40K$, $\alpha_x=-1.6\times10^{-6}K^{-1}$. The prestrain value is taken as zero. The influence of the parametric excitation frequency of the Nanofiber is defined by the relation $\Gamma=\frac{\theta}{\varpi}$ where θ is the frequency of the parametric excitation and ϖ is the fundamental frequency of the Nanofiber.

Figs. 2-3 represent the frequency scale with varying wave number of the magneto thermo electro elastic Nanofiber with fixed surface and excitation frequency effect $\gamma=0.05,\Gamma=0.5$ and $\gamma=0.1,\Gamma=1.0$ for different vibration modes. From Figs. 2-3, it is observed that the wave frequency increases with respect to its wave number for the different values of surface effect and frequency parameters. Fig.3 indicates the high in magnitude of frequency due to the increase in surface effect value and excitation frequency. A comparative plot is given in Figs.4 and 5 between the phase velocity and wave number of the magneto thermo electro elastic Nanofiber for the values mode number. It seen from Figs. 4 and 5 that with the effect of surface force and excitation frequency the phase velocity values decreases in the negative direction with an increasing wave number. This may happen due to the effect of surface effect and other interacted forces.

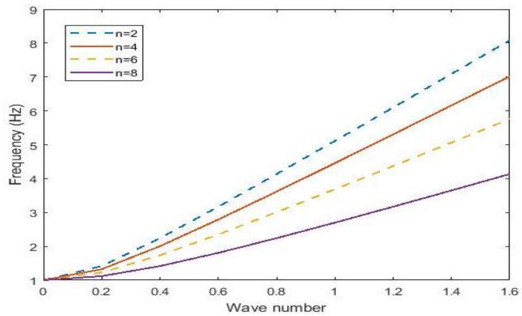

Fig.2
Frequency distribution with wave number via $\gamma = 0.05, \Gamma = 0.5$.

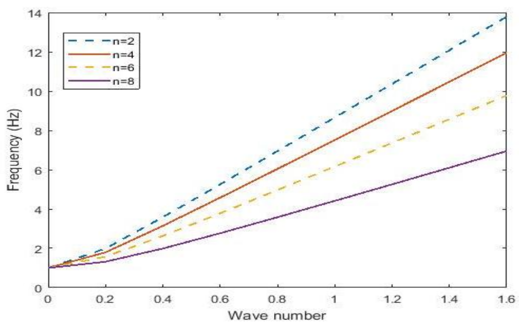

Fig.3
Frequency distribution with wave number via $\gamma = 0.10, \Gamma = 1.0$.

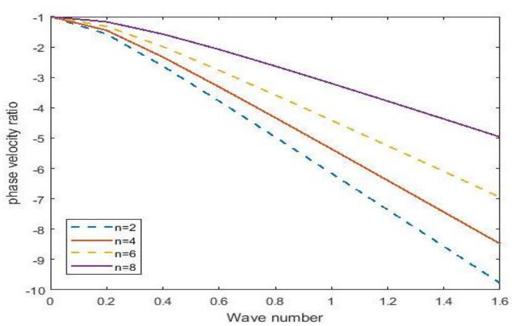

Fig.4
Phase velocity distribution with wave number via $\gamma = 0.05, \Gamma = 0.5$.

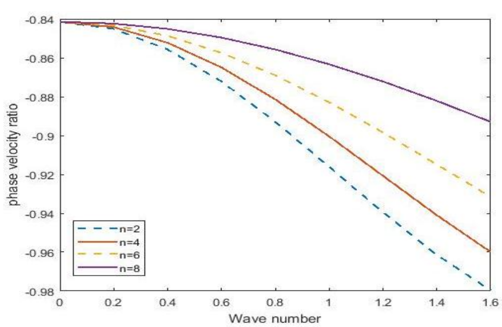

Fig.5
Phase velocity distribution with wave number via $\gamma = 0.10, \Gamma = 1.0$.

Figs. 6 and 7 investigates the dispersion curves for the magnetic field of magneto thermo electro elastic Nanofiber with wave number in case with $\gamma = 0.05, \Gamma = 0.5$ and $\gamma = 0.1, \Gamma = 1.0$ via different mode numbers. From the Figs.6-7, it is observed that the magnetic field reaches higher values at higher wave number for the increasing values of surface effect parameter and excitation frequency. Figs.8-10 shows the plot of piezoelectric strain with wave number for the different surface effects, excitation frequency and temperature values $\gamma = 0.05, 0.1, 0.15, \Gamma = 0.5, 1.0, 1.5 \& T = 30, 40, 50$ via varies mode values of the Nanofiber. It is indicated from Figs.8-10 that the piezoelectric strain values increase as the wave number increases for varies value of $\gamma, \Gamma \& T$ via different modes of bending. At $\gamma = 0.1, 0.15, \Gamma = 1.0, 1.5 \& T = 40, 50$, there is a dispersive nature in the wave progress which may explains the influence of the surface effect and temperature rise.

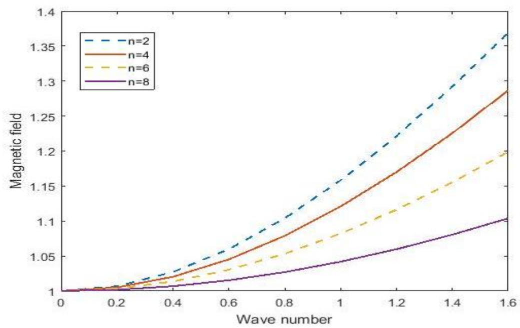

Fig.6
Magnetic field scale with wave number via $\gamma = 0.10, \Gamma = 0.5$.

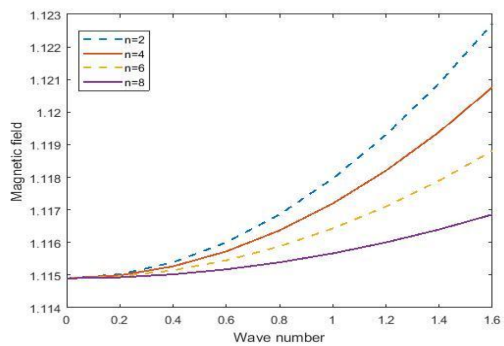

Fig.7
Magnetic field scale with wave number via $\gamma = 0.10, \Gamma = 1.0$.

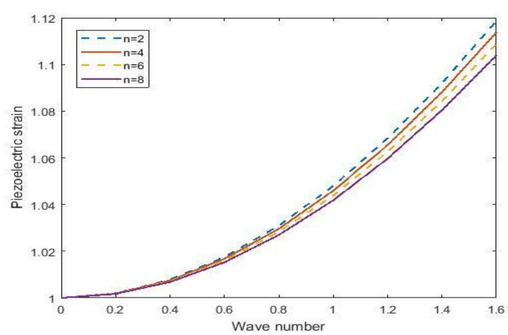

Fig.8
Distribution of Piezoelectric strain with wave number via $\gamma = 0.05, \Gamma = 0.5, T = 30^0 C$.

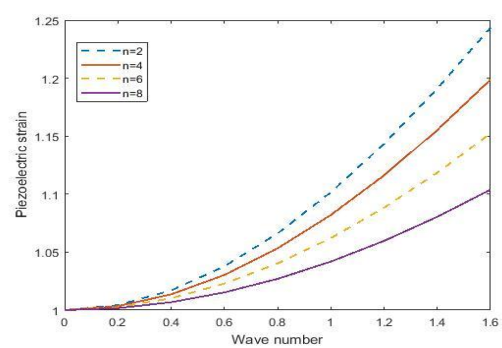

Fig.9
Distribution of Piezoelectric strain with wave number via $\gamma = 0.10, \Gamma = 1.0, T = 40^0 C$.

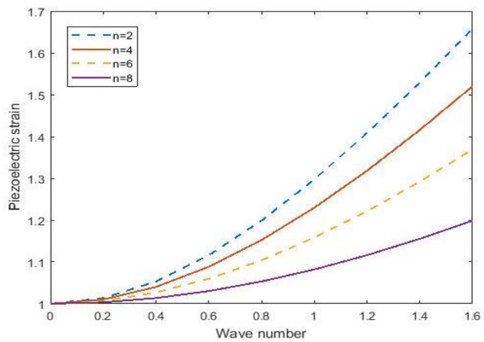

Fig.10
Distribution of Piezoelectric strain with wave number via $\gamma = 0.15, \Gamma = 1.5, T = 50^0 C$.

Figs.11-13 displays the comparison between the dynamic displacement and the parameter *x/L* of the Nanofiber for the different values surface effects, excitation frequency and temperature. From Figs.11-13, it appears that the dynamic displacement values first increases and then decreases in the considered values of the parameter *x/L* for the different modes of deflection. At the higher values of surface effect, excitation frequency and temperature (at $\gamma = 0.1, 0.15, \Gamma = 0.5, 1.0 \,\&\, T = 40, 50$), it is noted some crossing over lines which may denotes the transport of energy from one mode to another due to the surface effect and other interacted forces. The 3D plot in Figs. 14-15, clarifies the dependence of mode shape with distance x and time t. It is concluded that the increase in distance and time parameter values will decrease the mode shape of the Nanofibers.

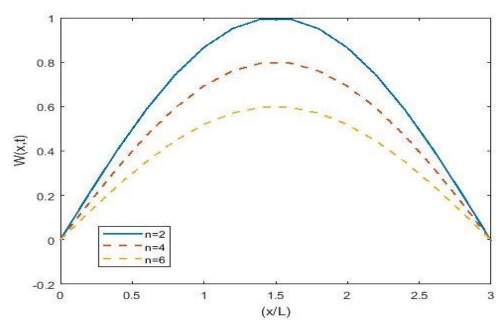

Fig.11
Variation of displacement versus (*x/L*) with $\gamma = 0.05, \Gamma = 0.5$, $T = 30^0 C$.

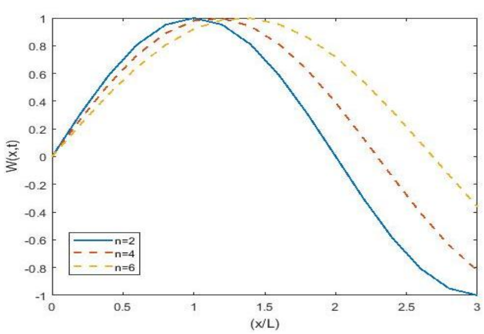

Fig.12
Variation of displacement versus (*x/L*) with $\gamma = 0.10 \Gamma = 1.0$, $T = 40^0 C$.

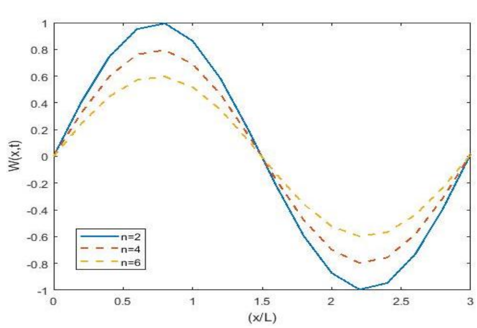

Fig.13
Variation of displacement versus (*x/L*) with $\gamma = 0.15, \Gamma = 1.5$, $T = 50^0 C$.

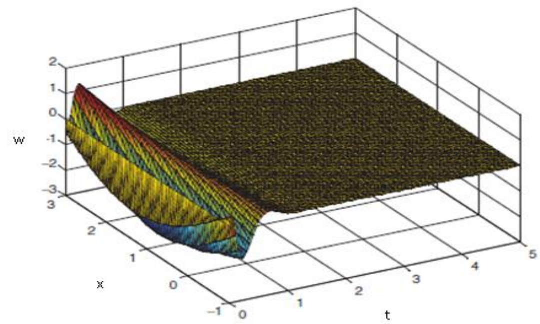

Fig.14
Variation of mode shape with distance x and time t via $\gamma = 0.05, \Gamma = 0.5, T = 30^0 C$.

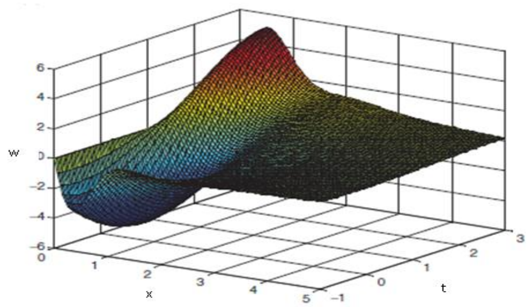

Fig.15
Variation of mode shape with distance x and time t via $\gamma = 0.15, \Gamma 1.0, T = 40^0 C$.

Table 1., exhibit the numerical results of the natural frequencies via Euler's and Timoshenko beam theories for different surface effect parameter and length values. From these tables it is observed that the frequencies are decreasing when the length values increases .The result also show that as the surface effect increases the effect of length values diminishes. Table. 2 presents the comparative study between current result and the numerical results of the natural frequency of isotropic Nanofiber at L/H = 100,v = 0.19, T = 300 K and h = 100 mm obtained by Karnovsky and lebed and Mohammad Rafiee et al.[26,27]. Results predicts the reasonable agreement with the literature.

Table 1
Comparison of frequency via Euler-Bernoulli and Timoshenko beam theory with surface effect (L/H = 10,v = 0.175, T = 300 K, h = 100 mm).

Surface effect	Euler-Bernoulli beam theory			Timoshenko beam theory		
	L=100	L=200	L=300	L=100	L=200	L=300
0.12	0.1329	0.0761	0.0572	0.1237	0.0132	0.0433
0.17	0.1344	0.0774	0.0583	0.1367	0.0154	0.0550
0.22	0.1358	0.0786	0.0593	0.1296	0.0175	0.0666
0.27	0.1371	0.0797	0.0602	0.1322	0.0194	0.0682
0.32	0.1384	0.0807	0.0611	0.1246	0.0212	0.0696

Table 2
Comparison of frequency for an isotropic fiber (L/H = 100,v = 0.19, T = 300 K, h = 100 mm).

Mode no.	Karnovsky and lebed [26]	Mohammad Rafiee et al.[27]	Present
1	0.063409	0.064586	0.0699
2	0.174791	0.178034	0.1753
3	0.34266	0.349018	0.3479
4	0.566435	0.576945	0.5706
5	0.856156	0.861856	0.8691

5 CONCLUSIONS

Investigation is made to study the effect of longitudinal magnetic, thermal and piezoelectric on propagation of sound waves of Nanofiber via surface force and parametric excitation using Timoshenko form of beam theory. Dispersion equations of Nanofiber are obtained in flexural direction. Vibration characteristics of physical variables are studied from graphs tabulated values. The observation is concluded that

- The values of frequency increases as wave number increases via surface effect and excitation frequency.
- Phase velocity decreases as wave number increases in the presence of excitation frequency and surface effect of the Nanofiber.
- The amplitude of magnetic field increases when the value of surface effect and parametric excitation increases.
- The values of piezoelectric strain increases and in wave propagation trend when the wave number increases with increasing values of surface effect, excitation frequency and temperature
- The surface effect, excitation frequency and temperature field vectors have an important role on the distribution of dynamic displacement.
- It is observed that the frequencies decay when the length values increases where as grow when the surface effect increases.
- The effect of distance and time also influences the mode shape of the Nanofiber while bending. deformation of a Nanofiber depends on the nature of force applied and also by the magneto-thermo-piezo effect.

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