JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Vibration Analysis of Three Dimensional FG Plate

[1]Mrinal Gautam ,[2] Manish Chaturvedi
[1]Research Scholar ,[2]Associate Professor
[1] Mechanical Engineering,
[1] University Department, Rajasthan Technical University, Akelgarh, Kota, Rajasthan, 324010, India

Abstract : The composition and structure of FGM is varied progressively over its volume, resulting in commensurate transforms in the material elements. The COMSOL 5.5 software has created a finite element technique of FGM plate for modal analysis. The thickness, longitudinal, and axial directions of the material properties vary by power law distribution. Primary, a simulation was run using a model developed by another researcher. The research was carried out on square FGM plates for different boundary conditions. A FEM was used to do modal analysis for various values of power index for different modes. In this study, CCCC boundary condition natural frequencies are higher than CFFF.

***IndexTerms* - Functionally Graded Material Plate; Natural Frequencies ; Power Law; Finite Element Method**

I. Introduction

Functionally graded materials (FGMs) are materials combined by different mechanical properties that can exhibit special functionalities. Due to their capability for obtaining spectacular functionalities, they have been commonly applied in the engineering sciences in the last thirty years, such as aerospace, civil, construction and electronics [1–3].
Liu et al. [4] explained the consequences of in-plane material inhomogeneity on the fundamental frequency of FGM plates [5]. Attia et.al [6] performed using various four variable refined plate theories, free vibration analysis of functionally graded plates with temperature-dependent features. Chen et al. [7] applied the meshless local natural neighbor interpolation method to study free vibration of FG plates. It was suggested that the method is not useful for the analysis of very thin plates The primary purpose of this research is to develop a finite element method for vibration analysis of three-dimensional FGM plates.

.

II. Property Distribution

Consider three- dimensional FGM plate with a width b, length a, and thickness h. The FG plate is made up of two parts: metal and ceramic. In present work, property distribution in x, y and z direction. p_x , p_y and p_z are the gradient index [8].

$$E(z) = (E_c - E_m)\, V_c + E_m \tag{1}$$

$$V_c = \left(\frac{x}{a}\right)^{p_x} \left(\frac{y}{b}\right)^{p_y} \left(\frac{z}{h} + \frac{1}{2}\right)^{p_z} \tag{2}$$

III. FEM MODELLING

In present work , Dimensions of the tri-directional FG plate are a=1m, b=1m and h=0.01 m and mechanical properties values i.e ceramic part (Alumina(Al_2O_3)) E_c=380X10^9 Pa, ν_c=0.3, ρ_c= 3800 kg/m^3 and metal part (SUS304stainless steel)E_m=207X10^9Pa,ν_m=0.3,ρ_m=8166kg/m^3inthatorder [9].

IV. RESULTS

The results of reference [9] were used to validate the numerical results produced in this investigation.

Table 1: For n=5, For CCCC boundary condition first four natural frequencies (Hz) of FG plate

Mode Shapes	Ref [9]	Present Study
1^{st}	96	100.54
2^{nd}	190	204.89
3^{rd}	190	204.9
4^{th}	282	301.89

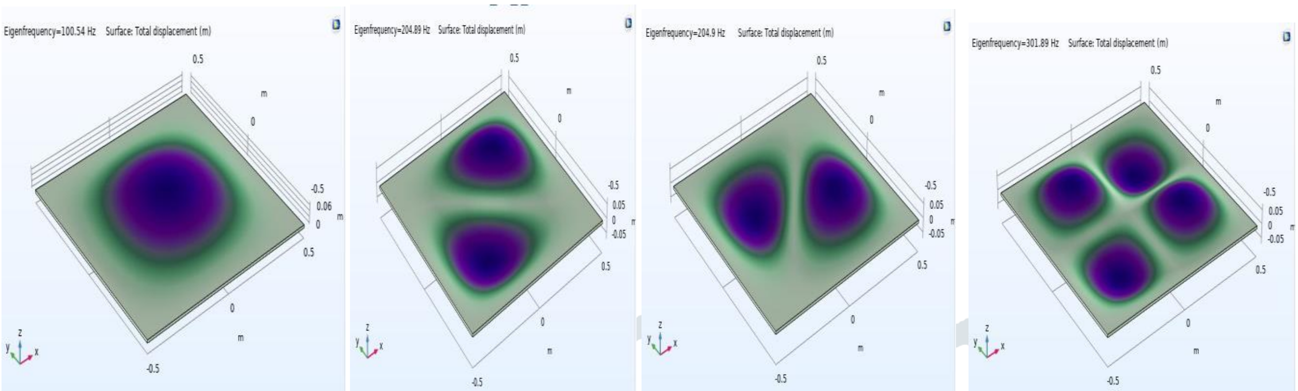

Fig1: For n=5, For CCCC boundary condition first four mode shapes

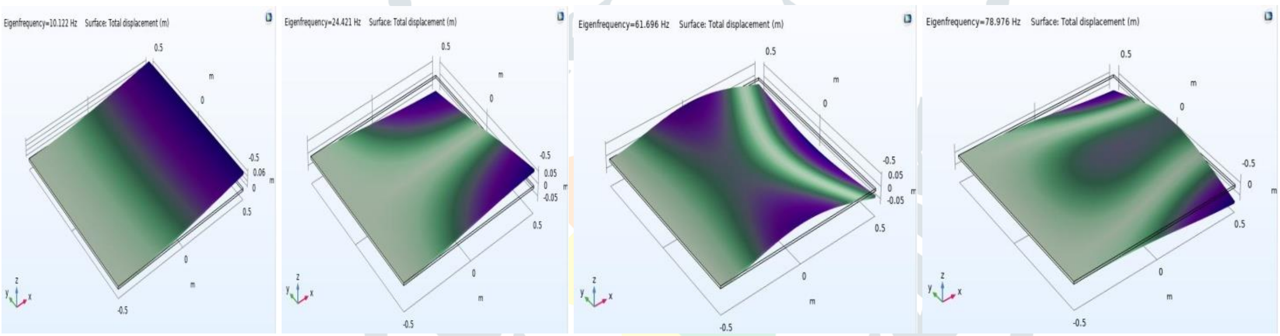

Fig 2: For n_x=0, n_y=0, n_z=1, CFFF boundary condition first four mode shapes

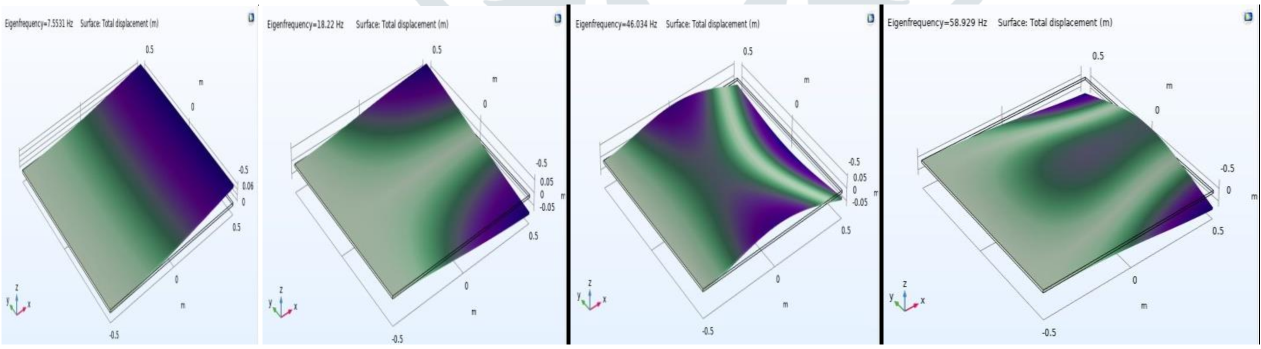

Fig 3: For n_x=0, n_y=0, n_z=3, CFFF boundary condition first four mode shapes

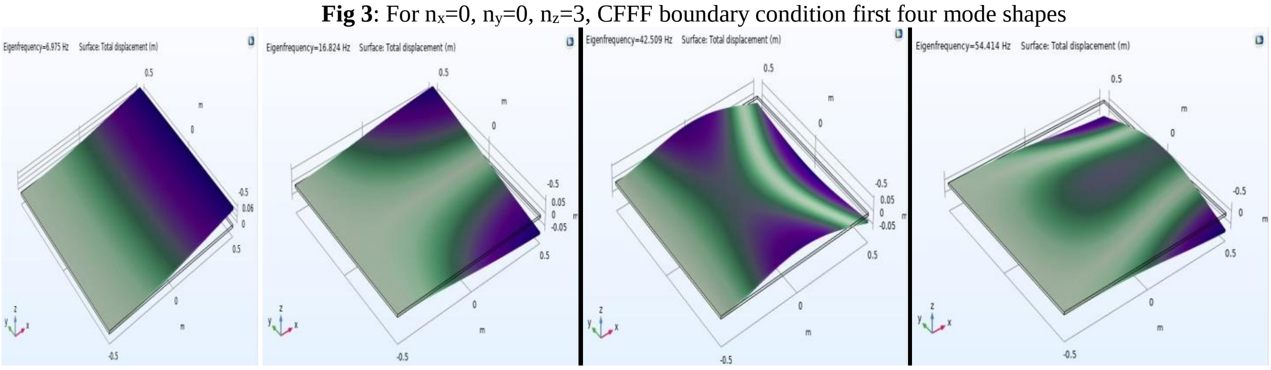

Fig 4: For n_x=0, n_y=0, n_z=5, CFFF boundary condition first four mode shapes

As a result of the foregoing findings (Fig 2-4), natural frequency was higher in the CCCC mode than in the CFCF and CFFF modes in each of the first four vibration modes, indicating that increasing the fixturing on a structure also increases natural frequency for power index n.

V. Conclusion

Initially, a FEM analysis was performed in the same way as other studies. COMSOL Multiphysics was used to do a modal analysis of a tri-directional FGM plate. Investigation of modal analysis of tri-directional functionally graded material plate is taken into account. Mechanical properties are varied in x, y and z directions in that order. Natural frequencies decrease as the power index increase in the z direction and for every modes , the power index is constant in the x and y direction. Natural frequencies was higher in the CCCC mode than in the CFFF modes.

REFERENCES

[1] Birman V, Byrd LW. 2007. Modeling and analysis of functionally graded materials and structures. Appl Mech Rev; 60(1–6):195–216.

[2] Sayyad AS, Ghugal YM. 2015. On the free vibration analysis of laminated composite and sandwich plates: a review of recent literature with some numerical results. Compos Struct; 129:177–201.

[3] Safri SNA, Sultan MTH, Jawaid M, Jayakrishna K. 2018. Impact behaviour of hybrid composites for structural applications: a review. Compos B Eng; 133:112–21.

[4] D. Y. Liu, C. Y. Wang, and W. Q. Chen, 2010. “Free vibration of FGM plates with in-plane material inhomogeneity,” Composite Structures, vol. 92, no. 5, pp. 1047–1051,.

[5] A. Alibeigloo and K. M. Liew, 2014. “Free vibration analysis of sandwich cylindrical panel with functionally graded core using three-dimensional theory of elasticity,” Composite Structures, vol. 113, pp. 23–30,

[6] Attia, Amina, et al. 2015)"Free vibration analysis of functionally graded plates with temperature-dependent properties using various four variable refined plate theories." Steel and composite structures 18.1 : 187-212.

[7] S. S. Chen, C. J. Xu, G. S. Tong, and X. Wei, “Free vibration of moderately thick functionally graded plates by a local natural neighbor interpolation method,” Engineering Analysis with Boundary Elements, vol. 61, pp. 114–126, 2015.

[8] Do, Dieu TT, H. Nguyen-Xuan, and Jaehong Lee. "Material optimization of tri- directional functionally graded plates by using deep neural network and isogeometric multimesh design approach." Applied Mathematical Modelling 87 (2020): 501-533.

[9] Tabatabaei, SJ Shahidzadeh, and A. M. Fattahi. "A finite element method for modal analysis of FGM plates." Mechanics Based Design of Structures and Machines (2020): 1-12.

.