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Comparative Analysis on Plates Using Functionally Graded Material with Different Material

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ABSTRACT

In this thesis, the thermal responses, stresses and deformations, frequencies due are investigated analytically for functionally graded material plates and compared with that of Structural Steel and Aluminum. Mathematical correlations are done to determine the material properties of functionally graded material with metal Steel using Ceramic as interface zone for each layer up to 10 layers. FGM's are considered for volume fractions of K=2 and K=4.

Thermal, Static, Modal and Random vibration analyses are performed on the plates for Structural Steel and Aluminum using Solid Element and for FGM material k = 2, and k = 4 using Shell Element. Analysis is done in Ansys.

Introduction

Pure metals are of little use in engineering applications because of the demand of conflicting property requirement. For example, an application may require a material that is hard as well as ductile, there is no such material existing in nature. To solve this problem, combination (in molten state) of one metal with other metals or non-metals is used. This combination of materials in the molten state is termed alloying (recently referred to as conventional alloying) that gives a property that is different from the parent materials. Bronze, alloy of copper and tin, was the first alloy that appears in human history .Bronze really impacted the world at that time, it was a landmark in human achievement and it is tagged the 'Bronze Age' in about 4000 BC [1]. Since then, man has been experimenting with one form of alloy or the other with the sole reason of improving properties of material. There is limit to which a material can be dissolved in a solution of another material because of thermodynamic equilibrium limit .When more quantity of the alloying material is desired, then the traditional alloying cannot be used. Another limitation of conventional alloying is when alloying two dissimilar materials with wide apart melting temperatures; it becomes prohibitive to combine these materials through this process. Powdered Metallurgy (PM) is another method of producing part that cannot be produced through the conventional alloying, as alloys are produced in powdered form and some of the problems.

Associated with the conventional alloying are overcome. Despite the excellent characteristics of powdered metallurgy, there exist some limitations, which include: intricate shapes and features that cannot be produced using PM; the parts are porous and have poor strength .Although these limitations are of advantage to some applications (e.g. filter and non structural applications) but are detrimental to others. Another method of producing materials with combination of properties is by combining materials in solid state, which is referred to as composite material.

LITERATURE SURVEY

The work done by Natarajana [1], In this paper, a cell based smoothed finite element method with discrete shear gap technique is employed to study the static bending, free vibration, mechanical and thermal buckling behaviour of functionally graded material (FGM) plates. The plate kinematics is based on the first order shear deformation theory and the shear locking is suppressed by the discrete shear gap method In the work done by Swarup Sahoo[2], This analytical

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work deals with prediction of the stresses developed in a Functionally Graded Timoshenko Beam that has been reinforced with Carbon Nanotubes (CNTs), which is subjected to thermal and mechanical loads. High temperatures have been applied to the upper and lower surfaces of the beam with a certain temperature difference between the two layers for the formation of a temperature gradient.

OBJECTIVE OF THE PROJECT

This paper aims at the evaluation of the thermal responses, stresses and deformations, frequencies due are investigated analytically for functionally graded material plates and compared with that of Structural Steel and Aluminum. Mathematical correlations are done to determine the material properties of functionally graded material with metal Steel using Ceramic as interface zone for each layer up to 10 layers. FGM's are considered for volume fractions of K=2 and K=4. Thermal, Static, Modal and Random vibration analyses are performed on the plates for Structural Steel and Aluminum using Solid Element and for FGM material k = 2, and k = 4 using Shell Element. Analysis is done in Ansys.

3D MODEL OF PLATE

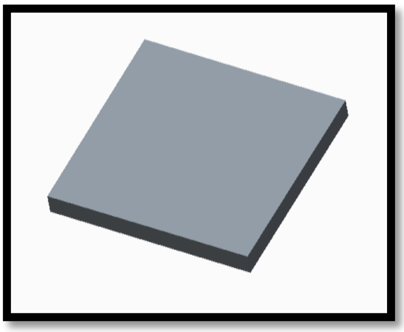


Fig 1 - Final model

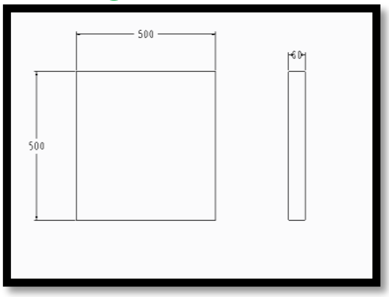


Fig 2 – 2D Drafting of plate

THEORITICAL CALCULATIONS FOR YOUNG'S MODULUS, DENSITY AND THERMAL CONDUCTIVITY FOR FGM PLATE

YOUNGS MODULUS

1) For k=2;z=

$E(Z)=(Et-Eb)(z/h+1/2)^K+Eb$

2)For k=2;z=-

$E(Z)=(Et-Eb)(z/h+1/2)^K+Eb$

DENSITIES

1)For k=2;z=1

$\rho(Z)=(\rho t-\rho b)(z/h+1/2)^K+\rho b$

THERMAL CONDUCTIVITY

$K(Z) = (K_t-K_b)(z/h+1/2)^k+K_b$

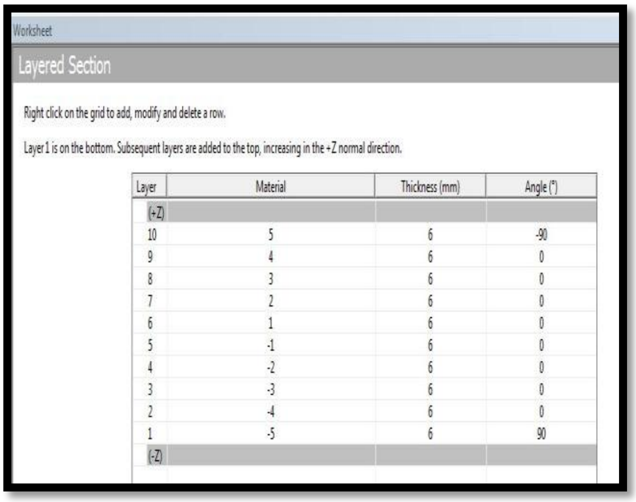
ANALYSIS OF FUNCTIONALLY GRADED MATERIAL PLATE

BOUNDARY CONDITIONS

The FGM plate is analyzed for applied pressure is 25 MPa. The value is taken from the journal paper, Thermal-Static Structural Analysis of Isotropic Rectangular Plates by Mervin Ealiyas Mathews, Shabna M.S,as specified in references [4]

STRUCTURAL ANALYSIS FOR FGM PLATES USING SHELL ELEMENT

K=2



Worksheet

Layered Section

Right click on the grid to add, modify and delete a row.

Layer 1 is on the bottom. Subsequent layers are added to the top, increasing in the +Z normal direction.

Layer	Material	Thickness (mm)	Angle (°)
(+Z)			
10	5	6	-90
9	4	6	0
8	3	6	0
7	2	6	0
6	1	6	0
5	-1	6	0
4	-2	6	0
3	-3	6	0
2	-4	6	0
1	-5	6	90
(-Z)			

Fig 3 – Thickness values in worksheet

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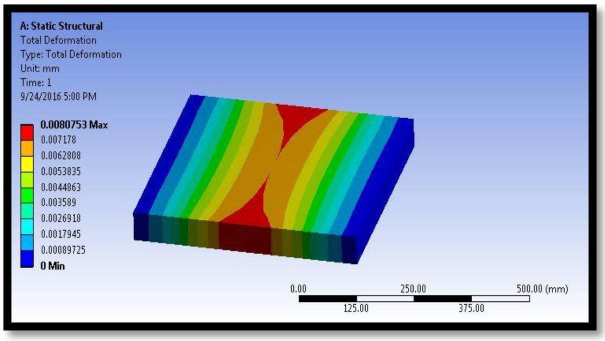

Fig 3 – Total Deformation for fgm plate

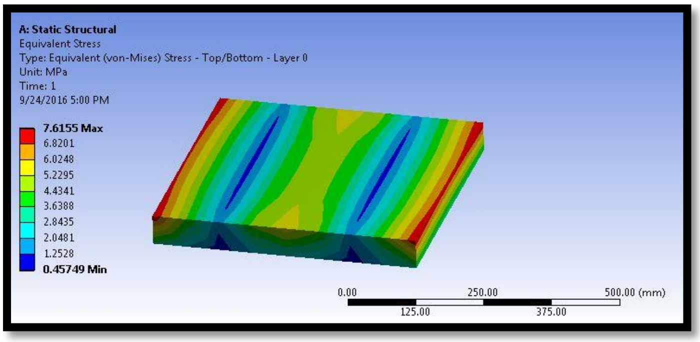

Fig 4 – Equivalent stress for fgm plate

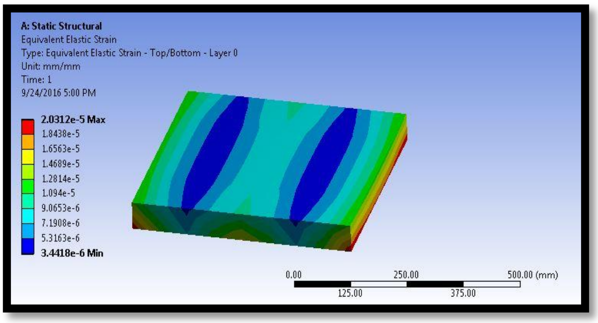

Fig 5 – Equivalent strain for fgm plate

MODAL ANALYSIS FOR PLATES

K=2

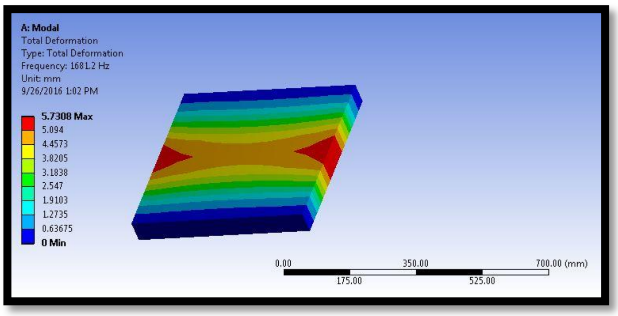

Fig 6– Total Deformation at Mode1 for fgm plate

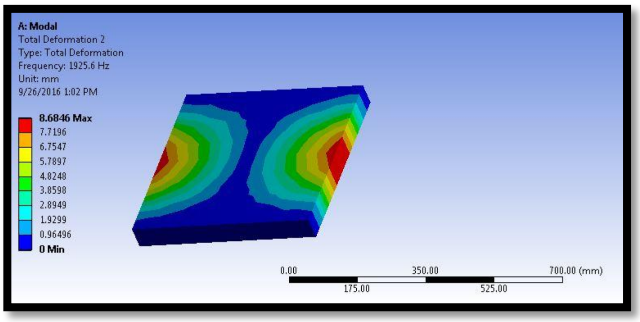

Fig 7 – Total Deformation at Mode2 for fgm plate

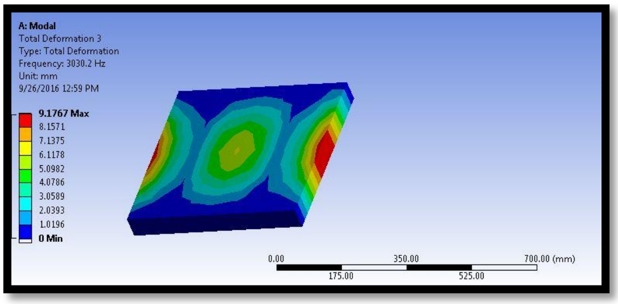

Fig 8 – Total Deformation at Mode3 for fgm plate

RANDOM VIBRATION ALANALYSIS FOR PLATE

K=2

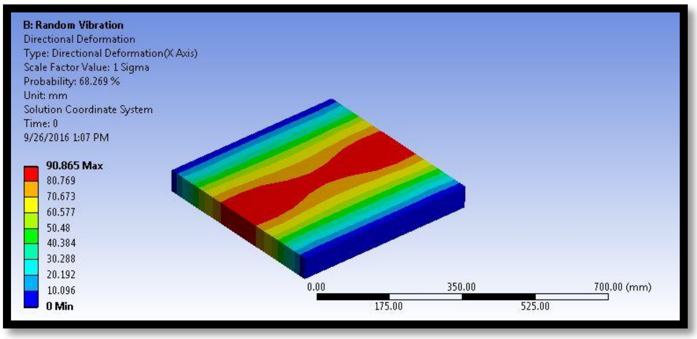

Fig 9 – Directional Deformation for fgm plate

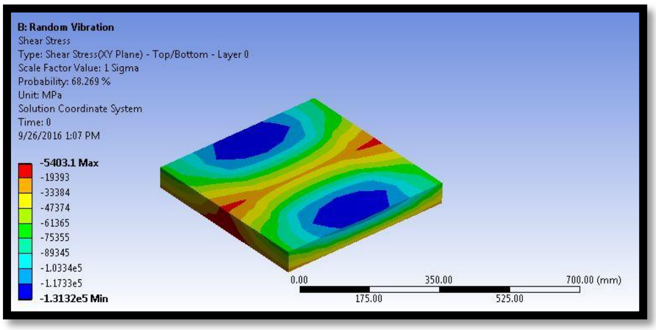

Fig 10 – shear stress for fgm plate

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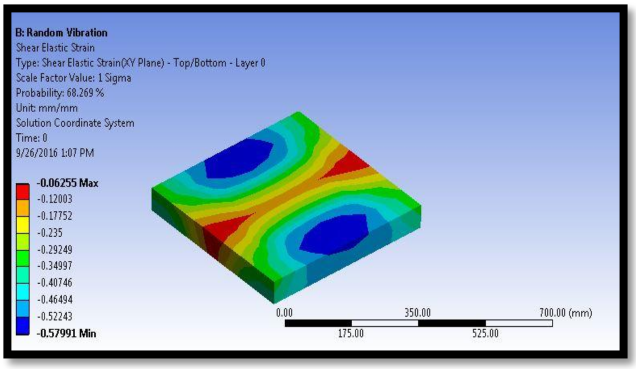


Fig 11 – shear stress for fgm plate

THERMAL ANALYSIS FOR PLATES K=2

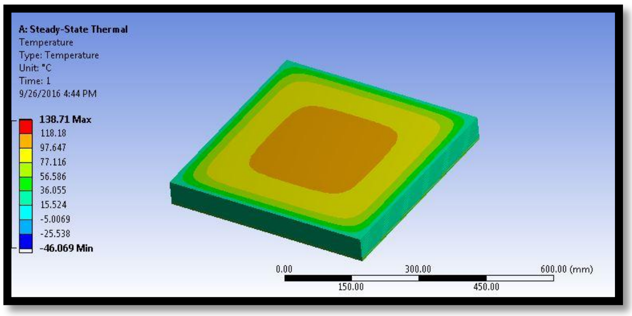


Fig 12 – Temperature for fgm plate

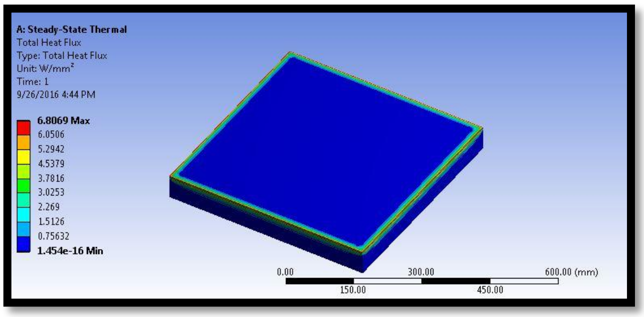


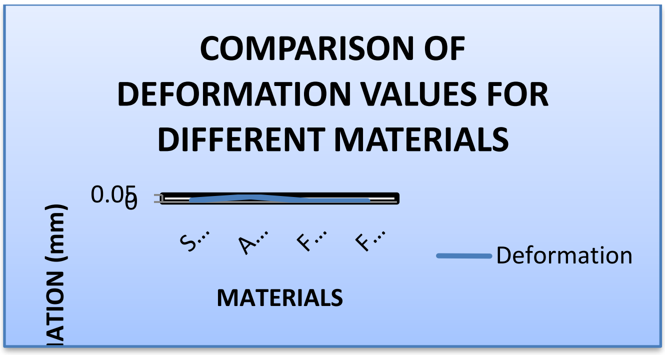
Fig 12 – Heat flux for fgm plate

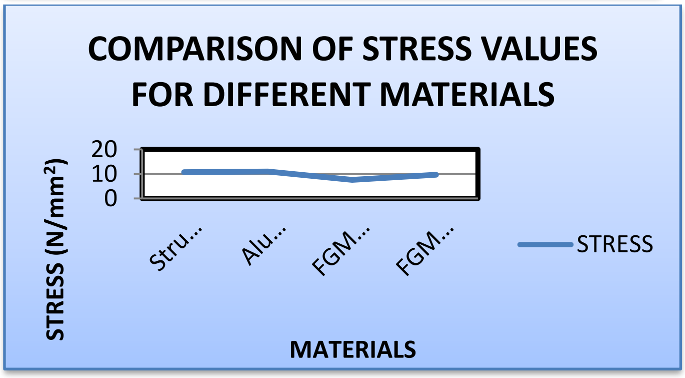
RESULT & DISCUSSIONS

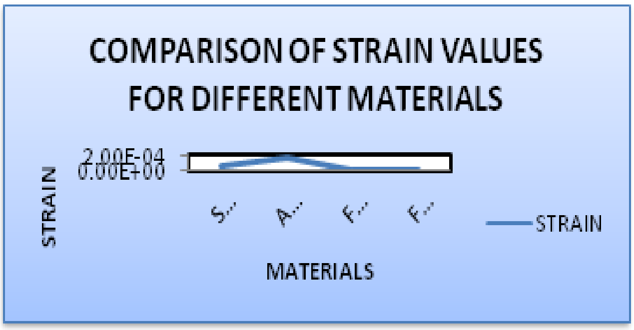
STRUCTURAL ANALYSIS

Material		Deformation(mm)	Strain	Stress (Mpa)
Structural steel		0.013187	5.3522e-5	10.704
Aluminum		0.038755	0.00016155	10.985
FGM	K=2	0.0080753	2.0312e-5	7.6155
	K=4	0.008001	1.7047e-5	9.6155

Table – Static analysis results of plate







MODAL ANALYSIS

MATERIAL		MODE 1		MODE 2		MODE 3	
		Deformation (mm)	Frequency (Hz)	Deformation (mm)	Frequency (Hz)	Deformation (mm)	Frequency (Hz)
Structural steel		5.1542	1179.8	7.7911	1364.5	8.4108	2172.5
Aluminum		9.0672	1188.3	13.466	1358.6	14.309	2171.4
FGM	K=2	5.7308	1681.2	8.6846	1925.6	9.1767	3030.2
	K=4	5.8137	1748.1	8.8513	1982.6	9.2961	3141.5

Table – modal analysis results of plate

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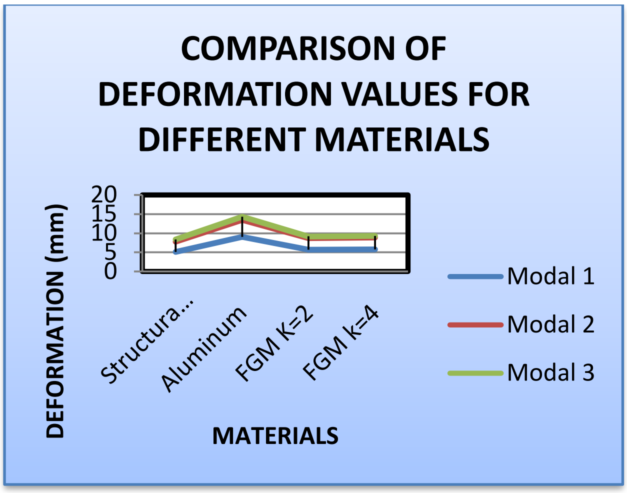
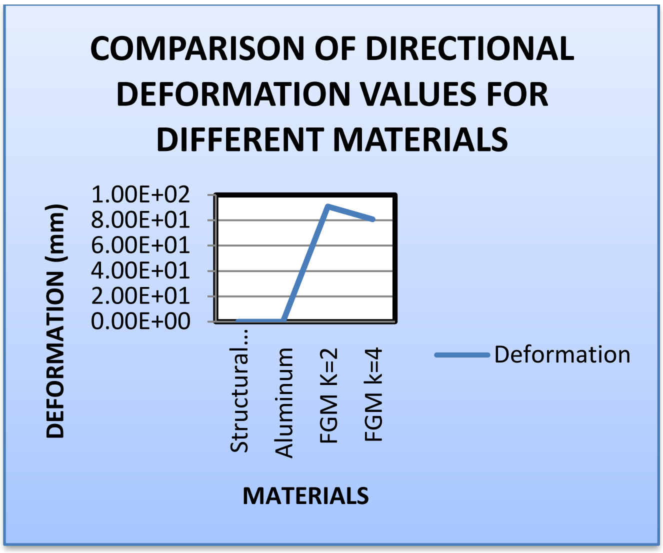
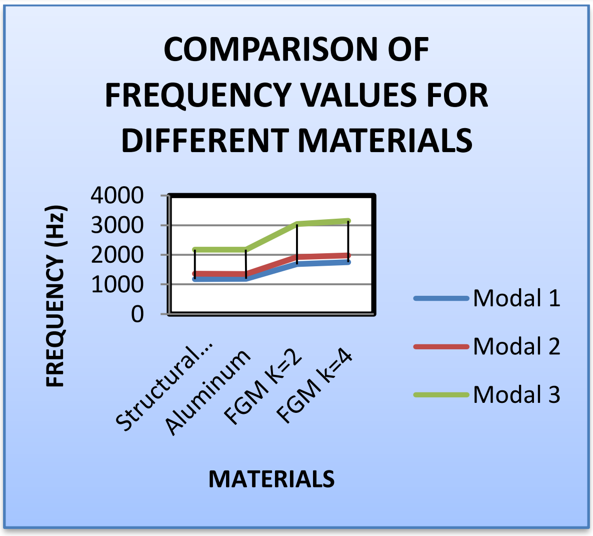
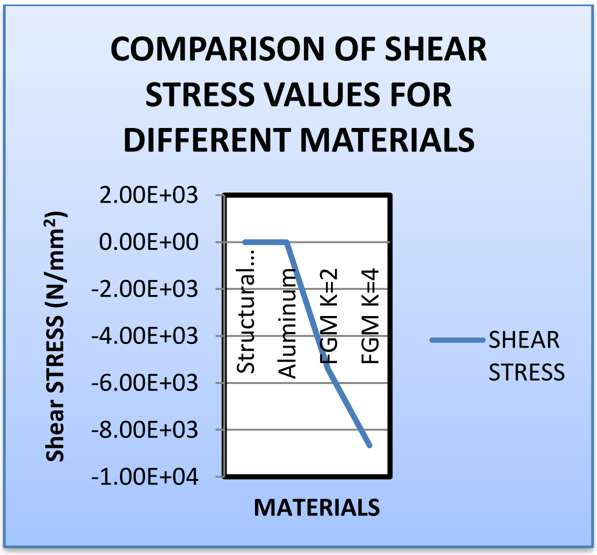




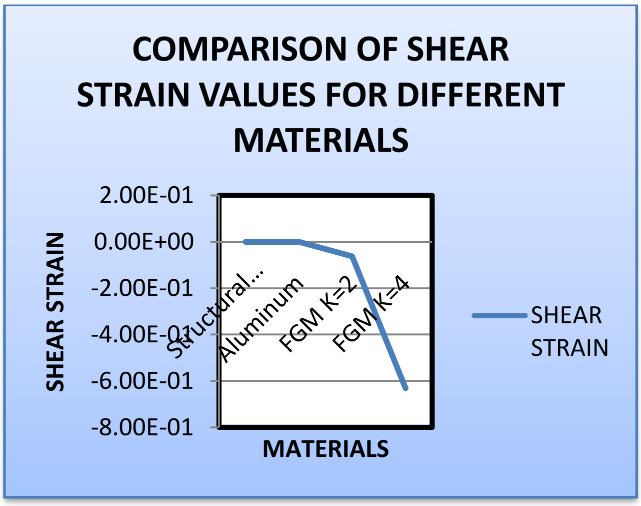




RANDOM VIBRATION ALANALYSIS

Material		Directional Deformation(mm)	Shear Stress (Mpa)	Shear Strain
Structural steel		7.965e-8	6.1031e-5	7.934e-10
Aluminum		2.2361e-8	6.0767e-6	2.4307e-10
FGM	K=2	90.865	-5403.1	-0.06255
	K=4	80.661	-8661.6	-0.063102

Table – Random vibration analysis results of plate



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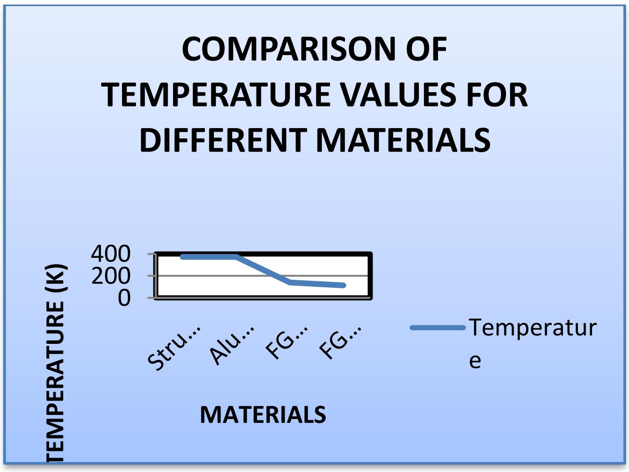
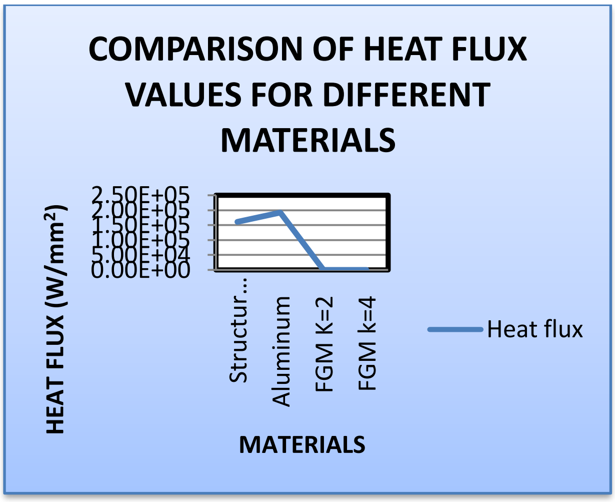
THERMAL ALANALYSIS

Material		Temperature	Heat flux ()
Structural steel		373.15	1.6043e5
Aluminum		373.15	1.9189e5
FGM	K=2	138.71	6.8069
	K=4	113.41	3.8183

Table – Thermal analysis results of plate





CONCLUSION

By observing the structural analysis results, for deformation values, the values are less when FGM is used than Steel and Aluminum. The deformation is increasing from k=2 to k=4. By observing the result and graph for stress values, the values are less when FGM is used than Steel and Aluminum. The stress is increasing from k=2 to k=4. By observing the modal analysis results, for deformation values, the values are less when FGM is used. By observing the result and graph for frequency values, the values are more when FGM is used than Steel and Aluminum. So the vibrations will increase when FGM is used for plates. It is more for K=4. By observing the result Random Vibration analysis, for directional deformation values, the values are more when FGM is used than Steel and Aluminum. The deformation is increasing from k=2 to k=4. By observing the result and graph for shear values values, the values are less when FGM is used than Steel and Aluminum. The stress is decreasing from k=2 to k=4. The negative value for shear stress for FGM material specifies that the stress is negative since it points in a negative direction on a negative plane. By observing the thermal analysis, for heat flux values, the values are less when FGM is used than Steel and Aluminum. The values displayed for FGM are for each layer.

REFERENCES

[1] Weicheng Cui, Yongjun Wang, PrebenTerndrup Pedersen “Strength of ship plates under combined loading”. Elsevier Science Ltd- 2001.

[2] JeomKee Paik, JuHye Park, Bong Ju Kim “Analysis of the Elastic Large Deflection Behavior for Metal Plates under Nonuniformly Distributed Lateral Pressure with In-Plane Loads”. Journal of Applied Mathematics, Hindawi Publishing Corporation, 2012.

[3] Vanam B. C. L, Rajyalakshmi M, Inala R “Static analysis of an isotropic rectangular plate using finite element analysis”.Journal of Mechanical Engineering Research- 2012.

[4] Mervin Ealiyas Mathews1, Shabna M.S2, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)

[5] William L. Ko “Mechanical- and Thermal-Buckling behavior of Rectangular Plates with

Different Central Cutouts".National Aeronautics and Space Administration- 1998.

[6] K. C. Deshmukh, M. V. Khandait, S. D. Warbhe, V. S. Kulkarni "Thermal stresses in a simply supported plate with thermal bending moments".International Journal of Applied Mathematics and Mechanics- 2010.

[7] ANSYS Element Reference.Release 12.0. April-2009.

[8] Ankitkumar B. Makwana1 , Khushbu C. Panchal2 , Anish H. Gandhi , International Journal of Advanced Mechanical Engineering. ISSN 2250-3234 Volume 4, Number 5 (2014), pp. 495-500

[9] Rajesh Sharma1 ,Vijay Kumar Jadon2 and Balkar Singh, International Journal of Advances in Materials Science and Engineering (IJAMSE) Vol.4, No.4, October 2015.

[10] Manish Bhandar, Ashirvad, Ashirvad, International Journal of Computer Applications (0975 – 8887)

[11] Natarajana , AJM Ferreirab,f, S Bordasc , E Carrerad,f, M Cinefrad , AM Zenkoure,f, Preprint submitted to Mathematical Problems in Engineering January 2, 2014.