ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 4, April 2017

Analysis of Dynamic Properties of Aluminum 6061 Reinforced With Varying Percentage of Graphene

[1] M R Srinivasa, [2] Y S Rammohan
[1][2] Department of Mechanical Engineering
[1] PES college of Engineering Mandya, Karnataka, India, [2] BMS college of Engineering Bengaluru, Karnataka, India

Abstract: -- **In present scenario of manufacturing, Aluminum plays an important role in the field of new materials. Aluminum alloys, because of its low density and excellent strength, toughness, and resistance to corrosion, finds important applications in the aerospace field. In modern manufacturing process graphene is widely used for making composite materials due to its novel properties like electrical conductivity, optical property, mechanical properties, and thermal properties. Graphene, one of the allotropes of elemental carbon, is a planar monolayer of carbon atoms arranged into a two-dimensional (2D) honeycomb lattice with a carbon–carbon bond. Graphene has the highest elastic modulus and strength. In present research work Aluminium 6061 is used as a matrix and graphene as a reinforcement and modal analysis is done using Al 6061 with varying percentage of Graphene.**

Keywords: ***ANSYS 15.0, Alumimium Metal matrix (MMC), Graphene, Varying Percentage.***

I. INTRODUCTION

Metal Matrix Composites (MMCs) have evoked a keen interest in recent times for potential applications in aerospace and automotive industries owing to their superior strength to weight ratio and high temperature resistance. Reinforcement to the aluminium alloys with graphene enhances the mechanical properties like strength, hardness, and thermal conductivity of the aluminium composite material. In the present project, the main aim is to improve the dynamic properties of the composite material. Aluminum is reinforced with Graphene to improve its mechanical properties.

Graphene, one of the allotropes (carbon nanotube, fullerene, diamond) of elemental carbon, is a planar monolayer of carbon atoms arranged into a two-dimensional (2D) honeycomb lattice with a carbon–carbon bond length of 0.142 nm.**[2]**

Effect of sintering temperature on structural and mechanical properties of graphene reinforced aluminum matrix composites has been investigated by **Pulkit Garg et. el.**,

This has been taken as a reference in the present research work where Graphene has been used as reinforcement with varying percentage. **[3]**

Jingyue Wang et.el. has studied the reinforcement with graphene nanosheets in aluminum matrix composites. Since Graphene has high fracture strength of 125 GPa, it is an ideal reinforcement for composite materials. Aluminum composites reinforced with graphene nanosheets (GNSs) were fabricated. [**4]** Considering this, AA 6061 as a matrix was chosen to carry out a research and Modal analysis was used to determine the inherent dynamic characteristics of a system in forms of natural frequencies, and mode shapes, and a mathematical model was formulated by using the results of the Modal Analysis for its dynamic behavior. The effects of Young's Modulus, Poisson's Ratio and Density, were also evaluated for AA 6061 matrix with varying percentage of Graphene reinforcement using ANSYS 15.0 **[4] [5] [6]**

II ANALYSIS

The present work is carried out with AA 6061 as metal matrix, with Graphene as reinforcement.
The Chemical composition of AA 6061 is as follows:

Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Al
0.4 - 0.8	0 - 0.7	0.15 - 0.4	0 - 0.15	0.8 - 1.2	0.04 - 0.35	0 - 0.25	0 - 0.15	Bal

Table 2.1

1. *Mechanical Properties of Aluminium 6061 Alloys*

Table 2.2

Sl .No.	Property	Value
1	Density	2700 Kg/m^3
2	Young's Modulus of Elasticity	69 MPa
3	Poisson's Ratio	0.33

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 4, April 2017

2. *Mechanical properties of Graphene*

Table 2.3

S.No.	Property	Value
1	Density	2200 kg /m^3
2	Young's Modulus of Elasticity	1 TPa
3	Poisson's Ratio	0.2

Graphene has demonstrated a variety of intriguing properties including high electron mobility at room temperature (250,000 cm^2/Vs.) exceptional thermal conductivity (5000 W m^{-1} K^{-1}) and superior mechanical properties with Young's modulus of 1 TPa. Its potential applications include single molecule gas detection, transparent conducting electrodes, composites and energy storage devices such as super capacitors and lithium ion batteries. **[7] [8] [9]**

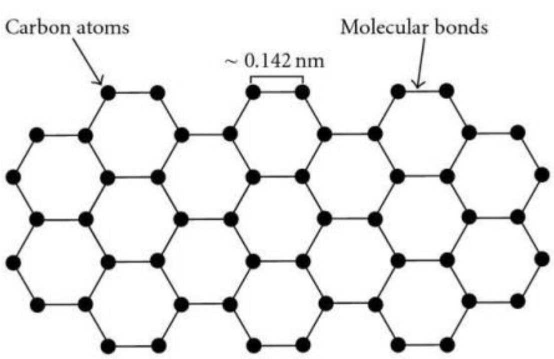


Figure: 1 c structure of a graphene

FORMULATION

1. Volume Fractions

$$V_F = \frac{v_v}{v_c} \qquad (1)$$

$$Vm = \frac{v_m}{v_c} \qquad (2)$$

$$V_F + V_m = 1 \qquad (3)$$

Where,

V_f = fiber volume fraction

V_m = matrix volume fraction

2. *Mass Fractions*

$$W_m = \frac{w_m}{w_c} \qquad (4)$$

$$W_f = \frac{w_f}{w_c} \qquad (5)$$

$$W_f + W_m = 1 \qquad (6)$$

Where,

(W_f) = mass fraction (weight fraction) of the fibers

(W_m) = mass fraction matrix

3. *Density*

$$\frac{1}{\rho_c} = \frac{W_m}{\rho_m} + \frac{W_f}{\rho_f} \qquad (7)$$

$$W_f = \frac{\rho_f}{\rho_c} V_f \qquad (8)$$

$$W_m = \frac{\rho_m}{\rho_c} V_m \qquad (9)$$

Where,

$\rho_{c,m,f}$ = density of composite materials .matrix and fiber.

4. *Longitudinal Young's modulus, (E)*

$$E = E_f V_f + E_m V_m \qquad (10)$$

Where,

E_f and E_m = young modulus of fiber and matrix.

5. *Poisson's ratio*

$$\mu_c = \mu_m V_m + \mu_f V_f \qquad (11)$$

Where,

μ_c , μ_m and μ_f = density of composite materials ,matrix and fiber respectively.

CALUCLATION

0.25% by wt. using Graphene in Aluminium Matrix

Let us consider total weight of composite w_c= 100 gm

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 4, April 2017

Therefore, $w_f = 0.25$ gm

$w_m = 99.75$ gm

Caluclated value of Weight fractions are as follows

Therefore,

$W_f = 0.0025$ and $W_m = 0.9975$

1. Density

$$\frac{1}{\rho_c} = \frac{0.9975}{2700} + \frac{0.0025}{2200}$$

$\rho_c = 2698.47$ Kg/m^3

2. Longitudinal Young's modulus

$$0.0025 = \frac{2200}{2698.47} V_f$$

$V_f = 0.00306$ m^3

$$0.9975 = \frac{2700}{2698.47} V_m$$

$V_m = 0.99694$ m^3

$E_c = 1 \times 10^{12} \times 0.00306 + 69 \times 10^{9} \times 0.99694$

$E_c = 71.84$ GPa

3. Poisson's ratio

$\mu_c = 0.33 \times 0.99694 + 0.2 \times 0.00306$

$\mu_c = 0.3295$

Table 2.4

S.No.	Percentage Variation of Graphene	Density Kg/m^3	Poisson's Ratio	Young's modulus GPa
1	0.00	2700.00	0.3300	69.00
2	0.25	2698.47	0.3295	71.84
3	0.50	2696.49	0.3292	74.707
4	0.75	2695.51	0.3288	77.55
5	1.00	2693.88	0.3284	80.36

C. *MODEL (GEOMETRY) CREATING*

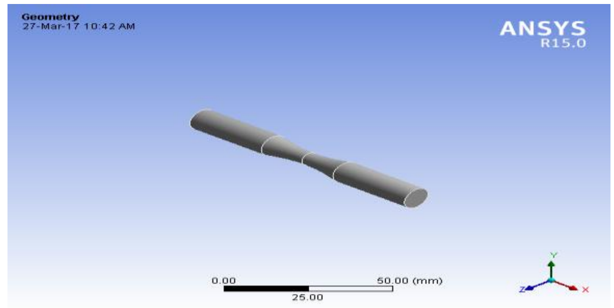


Figure:2, 2-D CAD Model

D. GENERATE MESHING

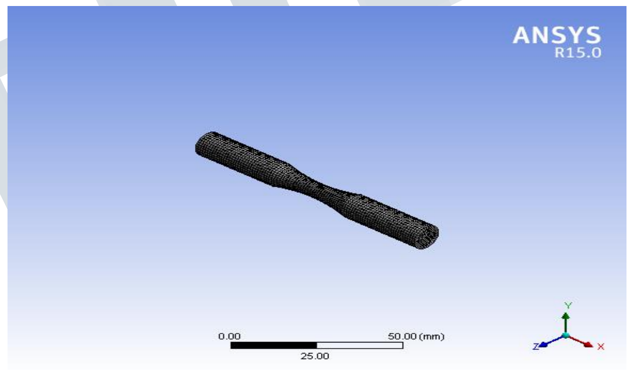


Figure:3, Meshed Model

Present research work uses the following constituents to find the dynamic properties of a composite material using ANSYS 15.0

Case 1: Aluminium + and 0.00% of graphene

Case 2: Aluminium + 0.25 % by weight of graphene

Case 3: Aluminium + 0.50 % by weight of graphene

Case 4: Aluminium + 0.75 % by weight of graphene

Case 5: Aluminium + 1.00 % by weight of graphene

MODAL ANALYSIS OF AA 6061 WITH VARYING PERCENTAGE OF GRAPHENE

Case 1: Aluminium 6061 + 0.00% of graphene

IFERP
connecting engineers... developing research
ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 4, April 2017

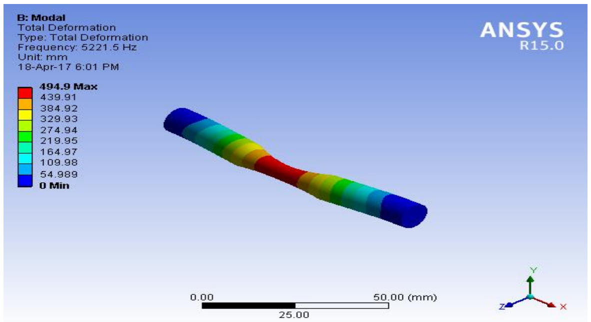


Figure:4, Total deformation-1

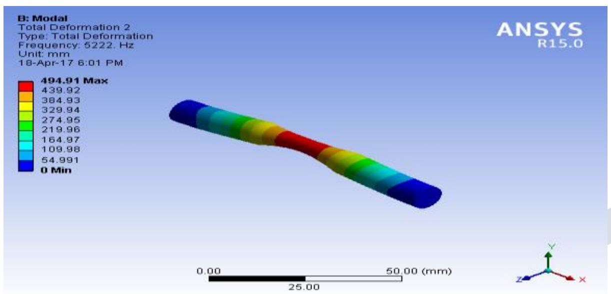


Figure:5, Total deformation-2

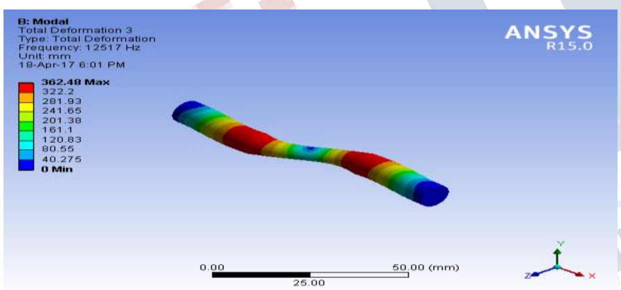


Figure:6, Total deformation-3

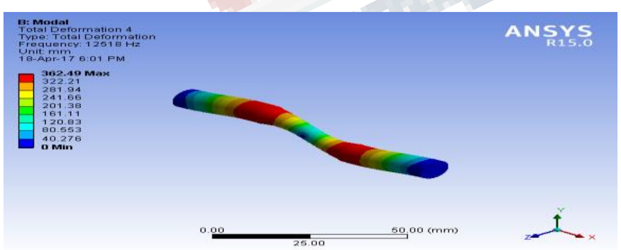


Figure:7, Total deformation-4

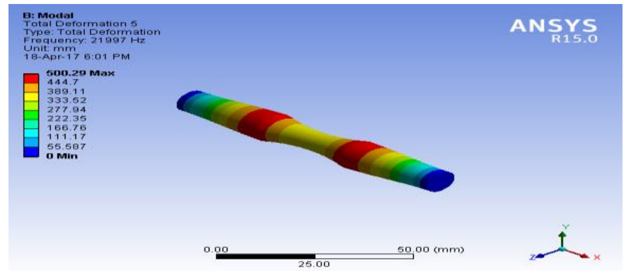


Figure:8, Total deformation-5

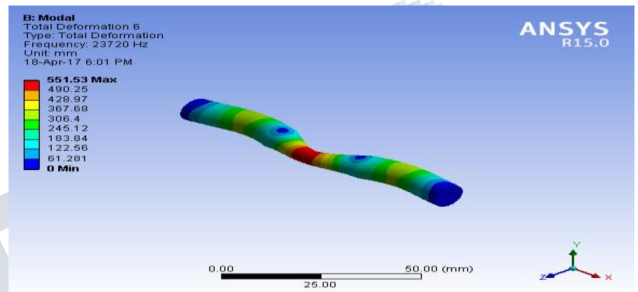


Figure:9, Total deformation-6

Case 2: Aluminium + 0.25 % by weight of graphene

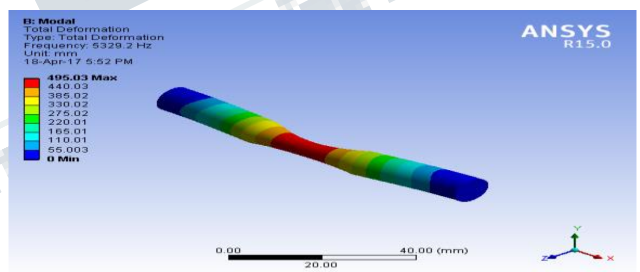


Figure:10, Total deformation-1

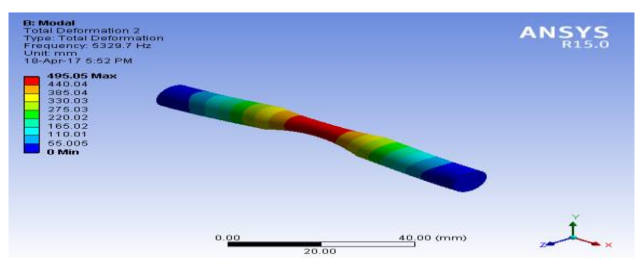


Figure:11, Total deformation-2

IFERP
connecting engineers... developing research
ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 4, April 2017

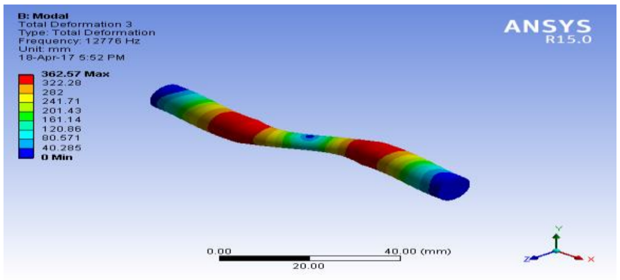


Figure:12, Total deformation-3

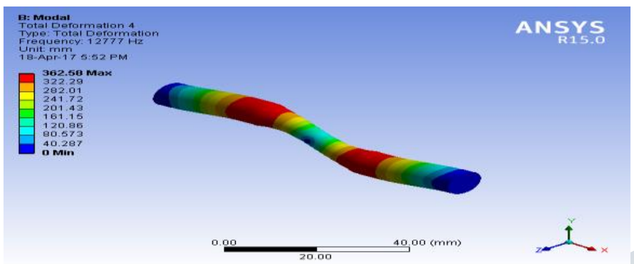


Figure:13, Total deformation-4

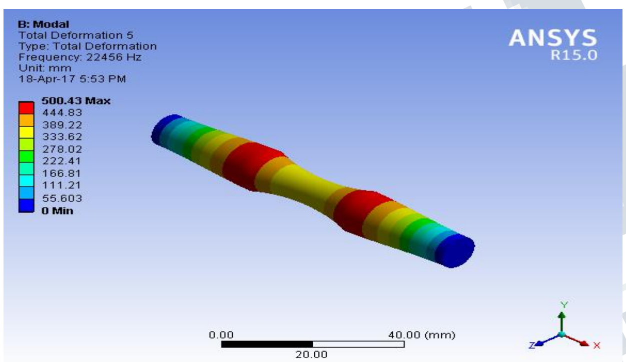


Figure:14, Total deformation-5

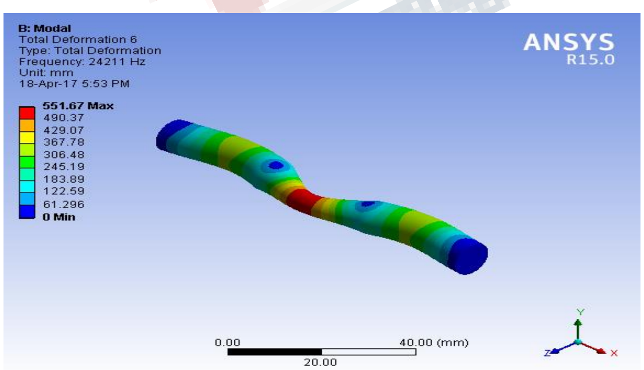


Figure:14, Total deformation-6

Case 3: Aluminium + 0.50 % by weight of graphene

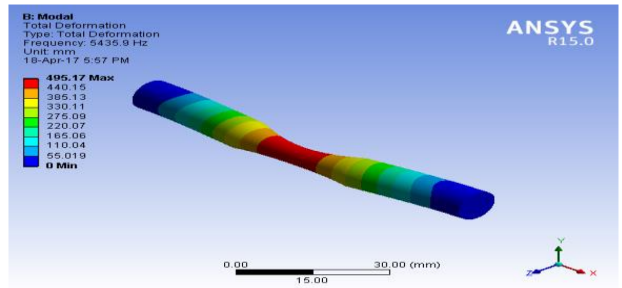


Figure:15, Total deformation-1

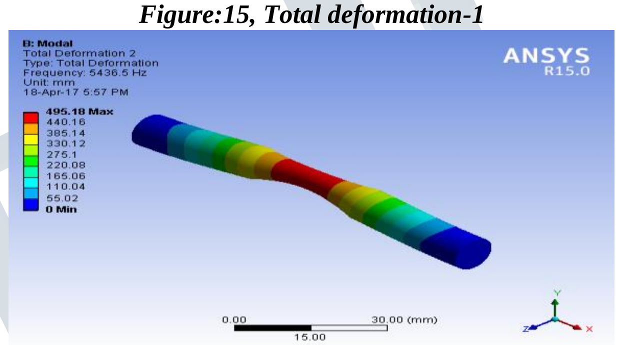


Figure:16, Total deformation-2

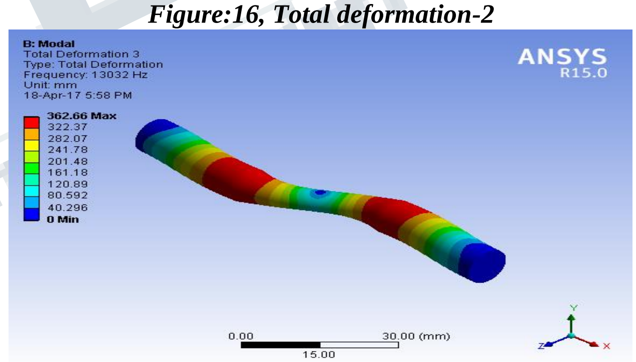


Figure:17, Total deformation-3

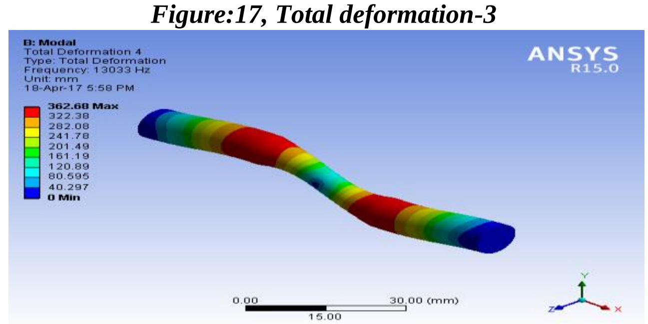


Figure:18, Total deformation-4

ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 4, April 2017

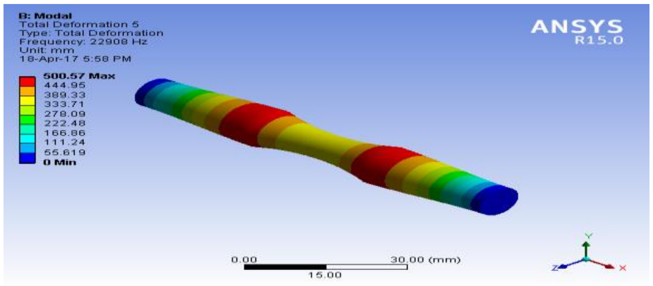


Figure:19, Total deformation-5

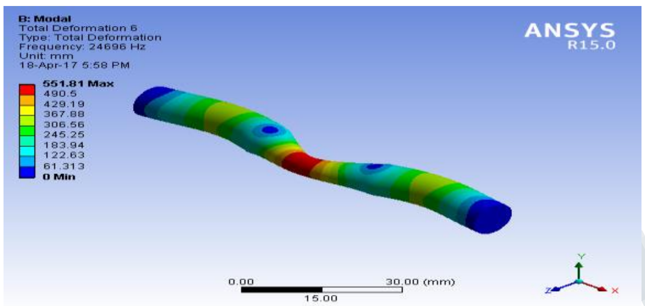


Figure:20, Total deformation-6

Case 4: Aluminium + 0.75 % by weight of grapheme

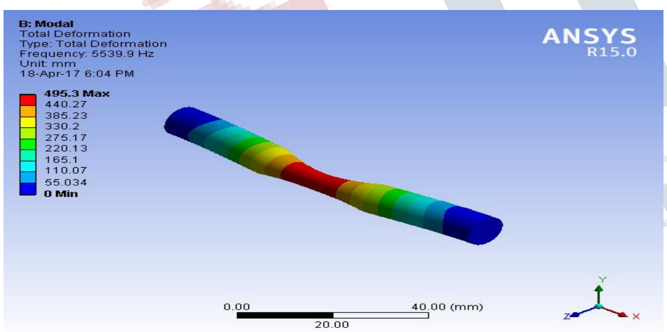


Figure:21, Total deformation-1

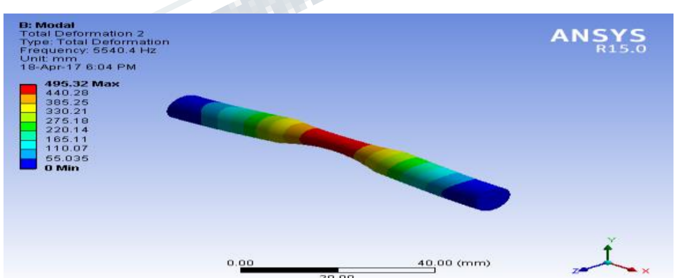


Figure:22, Total deformation-2

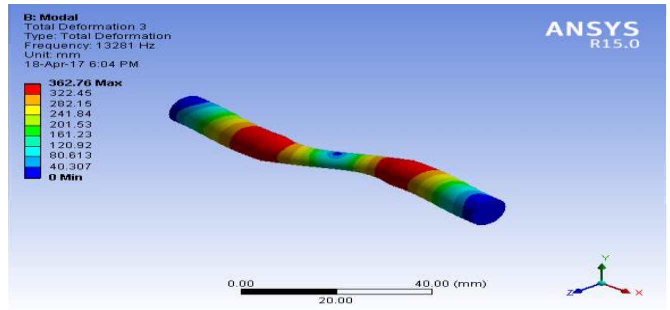


Figure:23, Total deformation-3

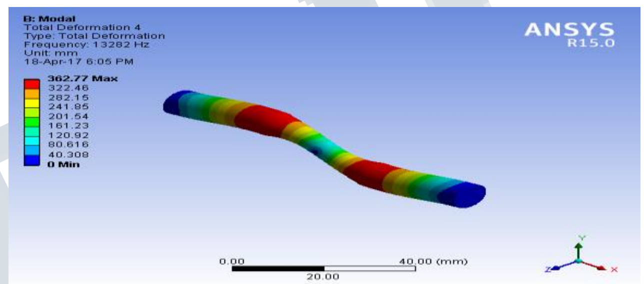


Figure:24, Total deformation-4

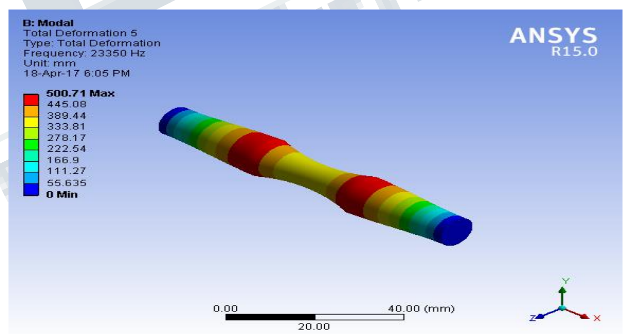


Figure:25, Total deformation-5

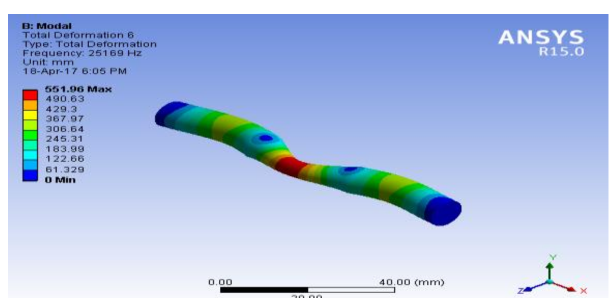


Figure:26, Total deformation-6

IFERP
connecting engineers... developing research
ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 2, Issue 4, April 2017

Case 5: Aluminium + 1.00 % by weight of grapheme

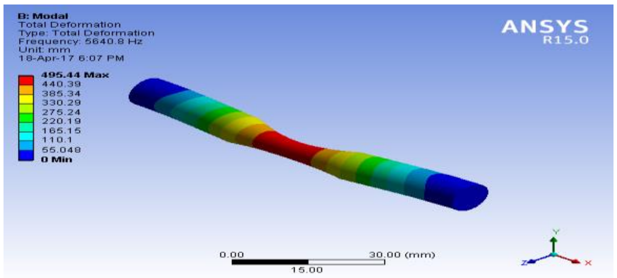


Figure:27, Total deformation-1

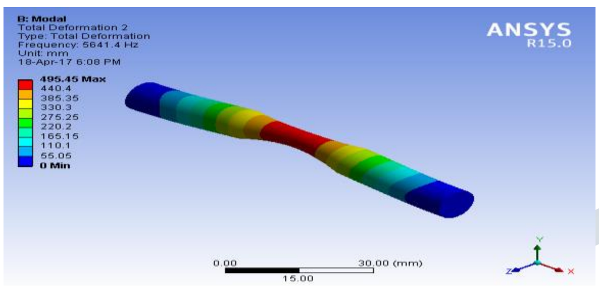


Figure:28, Total deformation-2

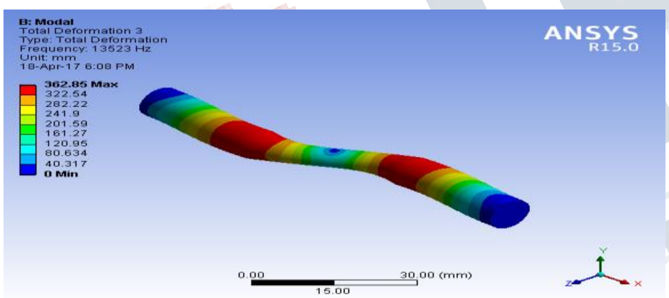


Figure:29, Total deformation-3

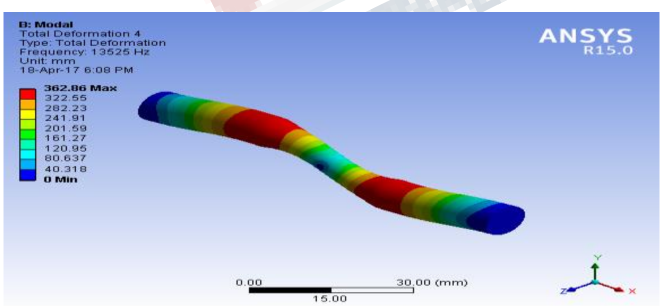


Figure:30, Total deformation-4

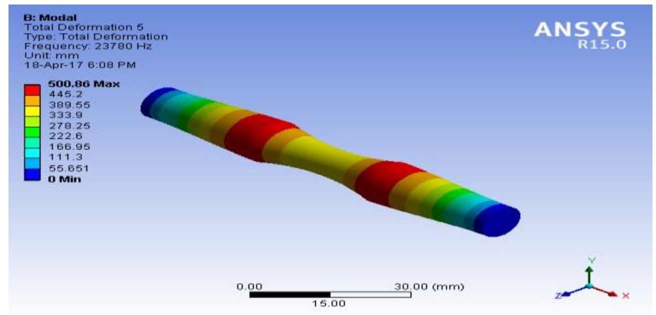


Figure:31, Total deformation-5

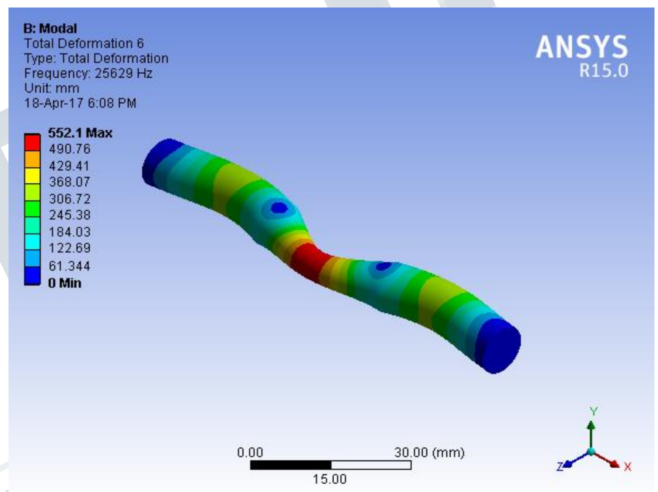
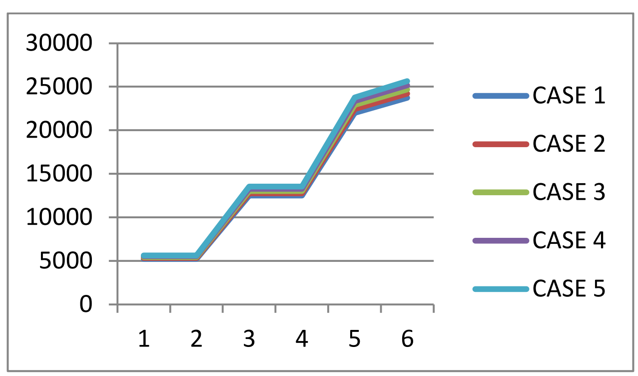


Figure:32, Total deformation-6

III RESULTS AND DISCUSSIONS



Graph:1, Mode vs Frequency

WT. % OF G	AA6061 +0%G	AA6061 +0.25%G	AA6061 +0.50%G	AA6061 +0.75%G	AA6061 +1%G
MD1	5221.5	5329.2	5435.9	5539.9	5640.8
MD2	5222	5329.7	5436.5	5540.4	5641.4
MD3	12517	12776	13032	13281	13523
MD4	12518	12777	13033	13282	13525
MD5	21997	22456	22908	23350	23780
MD6	23720	24211	24696	25169	25629

G;Graphene **Table No. 3.1**

CONCLUSION

In the present research work, it is concluded that there is gradual increase in frequency with respect to modes, by varying the weight percentage of Graphene. It is also observed that density, as well as Poisson's ratio decreases by increasing the weight percentage of Graphene with AA-6061. Young's Modulus increases with an increase in weight percentage of Graphene with AA-6061.

REFERENCES

[1] Xin Tang, Vikas Prakash and John Lewandowski "Dynamic Tensile Deformation of Aluminum Alloy 6061-T6 and 6061-OA"

[2] I.A. Ovid'ko "Metal-Graphene Nanocomposites with Enhanced Mechanical Properties"

[3] Pulkit Garg, Pallav Gupta, Devendra Kumar and Om Parkash, "Structural and Mechanical Properties of Graphene reinforced Aluminum Matrix composites"

[4] Jingyue Wang, Zhiqiang Li, Genlian Fan, H H Pang "Reinforcement with graphene nanosheets in aluminum matrix composites"

[5] Chi-Hoon Jeon, Yong-Ha Jeong, Jeong-Jin Seo, Huynh Ngoc Tien, Sung-Tae Hong, Young-Jin Yum , Seung-Hyun Hur, and Kwang-Jin Lee "Material Properties of Graphene/Aluminum Metal MatrixFabricated by Friction Stir Processing"

[6] Mina Bastwros, Gap-Yong Kim, Can Zhu, Kun Zhang, Shiren Wang, Xiaoduan Tang, Xinwei Wang, "Effect of ball milling on graphene reinforced Al6061composite fabricated by semi-solid sintering "

[7] A. Ramesh 1, J. N. Prakash 1*, A. S. Shiva Shankare Gowda2 and Sonnappa Appaiah"Comparison of the Mechanical Properties of AL6061/Albite and AL6061/Graphite Metal Matrix Composites".

[9]The thesis of graphene A K Geim and K S Novoselvo Manchester centre for Mesoscience and Nanotechnology University of Manchester Oxford road M13 9PL, United Kingdom.