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Design and Analysis of a Propeller Shaft in CAE tool and ANSYS

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Abstract:

A Propeller Shaft is a device on which a propeller is attached to and transfers the power from the engine to the propeller. In the design of automobiles, the industry is exploiting in order to obtain reduction of weight without significant decrease in vehicle quality and reliability. This is due to the fact that the reduction of weight of a vehicle directly impacts its fuel consumption. Particularly in city driving, the reduction of weight is almost directly proportional to fuel consumption of the vehicle. A Propeller Shaft is a longitudinal drive shaft used in vehicles where the engine is suited at the opposite end of the vehicle to the drive wheels. A propeller shaft is an assembly of one or more tubular shaft connected by universal, constant velocity or flexible joints. Thus, in this project work the propeller shaft of a vehicle was chosen and analyzed by replacing it with different materials

Keywords: Propeller Shaft, catiav5, ANSYS, Steel-Reference Material, Boron, Kevlar, Aluminum, Glass, Carbon, analysis

I. INTRODUCTION

In the process of designing a vehicle, one of the most important objectives is the conservation of energy and the most effective way to obtain this goal is the reduction of weight of the vehicle. There is almost a direct proportionality between the weight of the vehicle and its fuel consumption, particularly in city driving. The automotive industry is exploiting composite material technology for structural component construction in order to obtain reduction of weight, without decrease in vehicle quality and reliability. Properties can be tailored to increase the torque they carry as well as the rotational speed at which they operate. In this project, the conventional propeller shaft has been replaced with different types of material to carry out a comparative analysis, thus determining the most suitable replaceable material

II. AIM AND SCOPE OF THE WORK:

The project aims to reduce the weight of the propeller shaft assembly by using different materials. For this project work, the drive shaft of a car was chosen. The modeling of the propeller shaft assembly was done using Catia V5. A Leaf spring has to be designed to meet the stringent design requirements for automobiles. A comparative study of five different materials was conducted to choose the best-suited material. Steel (SMC 45) was chosen for reference and the rest of the five different materials were analyzed. The analysis was carried out using ANSYS 10.0 Workbench for the following materials.

The first was Steel (SM C 45) which was used for reference purpose
Two Composites

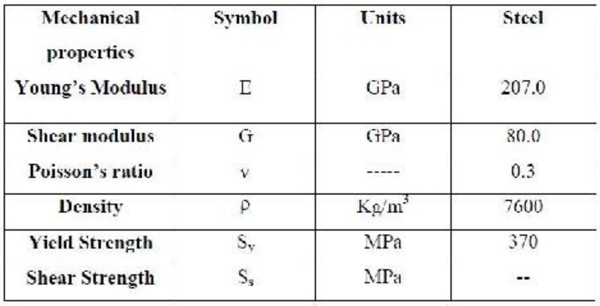
- Boron
- Kevlar

And a combination of

- Aluminum
- Glass
- Carbon

III. MATERIAL PROPERTIES:

Steel (SM C 45)



Mechanical properties	Symbol	Units	Steel
Young's Modulus	E	GPa	207.0
Shear modulus	G	GPa	80.0
Poisson's ratio	ν	-----	0.3
Density	ρ	Kg/m^3	7600
Yield Strength	S_y	MPa	370
Shear Strength	S_s	MPa	--

The standard material properties of steel are given as follows

S.no	parameters	values
1	Outer Radius (R_o)	0.02m
2	Inner Radius (R_i)	0.01m
3	Length (L)	0.5m

Table-1: Mechanical Properties of Steel (SMC45)

Material Properties for Boron
Density = 2600 kg/m^3 ,Young's Modulus = 3 Gpa, Poisson's Ratio = 0.21

Material Properties for Kevlar

Density = 1440 kg/m^3 ,Young's Modulus = 130 Gpa ,Poisson's Ratio = 0.34

Material Properties for Aluminum
Density = 2700 kg/m^3, Poisson's Ratio = 0.35
Young's Modulus = 70 Gpa

Material properties for Glass
Density = 2540 kg/m^3, Young's Modulus = 72.4Gpa, Poisson's Ratio = 0.34

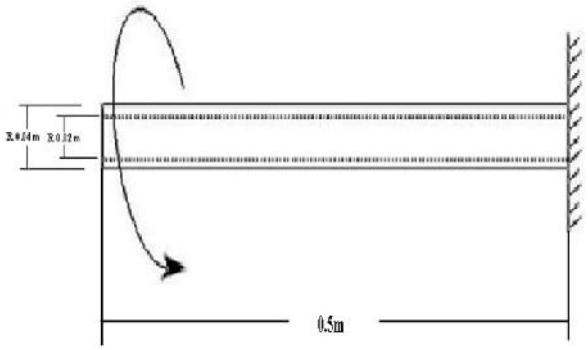
Material Properties for Carbon
Density = 1800 kg/m^3
Poisson's Ratio = 0.2
Young's Modulus = 225 Gpa

IV. DESIGN CONSIDERATION FOR A PROPELLER SHAFT

Description of the Problem:

The fundamental natural bending frequency for passenger cars, small trucks, and vans of the propeller shaft should be higher than 6,500 rpm to avoid whirling vibration and the torque transmission capability of the Propeller shaft should be larger than 3,500 Nm. The Propeller shaft outer diameter should not exceed 100 mm due to space limitations. The Propeller shaft of transmission system is to be designed optimally for following specified design requirements as shown in Table.

S. No	Name	Notation	Units	Value
1	Ultimate Torque	T_{max}	N-m	3500
2	Max Speed	N_{max}	Rpm	6500
3	Max Diameter	D	mm	90



Propeller Shaft Design Formulae for Calculations:

Deflection:

$Y_{Max} = \frac{ML^2}{2EI}$

E = Young's Modulus of Steel (SM C 45)

L = Length of the shaft

I = Moment of inertia

Maximum Shear Stress:

$\tau_{Max} = \frac{T \times Ro}{J}$

T = Torque

R_o = Outer Radius

τ_{Max} = Shear Stress

Maximum Von-Misses Stress:

$\frac{[T \times (\frac{do}{2})]}{I}$

T = Torque

d_o = Outer Diameter

I = Moment of inertia

Design Calculations

For the hollow shaft, Let

R_o = 0.04 m ; R_i = 0.02 m ; l = 0.5 m ; E = 207e9 pa and Torque=3500 Nm

Where R_o = Outer Radius

R_i = Inner Radius

l = Length of the shaft

E = Young's Modulus of Steel (SM45C)

T = Applied Torque

$$\text{Deflection} = Y_{Max} = \frac{ML^2}{2EI} = \frac{3500 \text{ x } (0.5^2)}{2 \text{ x } (207e^9) \text{x } (1.178e^{-7})}$$

$$= 0.0179 \text{ m}$$

Then:

$$\text{Maximum Shear Stress: } \tau_{Max} = \frac{T \times Ro}{J}$$

$$= \frac{3500 \times 0.02}{\left[\frac{\pi}{2}\right] \text{x} [Ro^4 - Ri^4]}$$

$$= \frac{70}{2.35626 \times 10^{-7}}$$

= 2.9708 e 8 Pa

Maximum Von-Misses Stress:

$$= \frac{[T \times \left(\frac{do}{2}\right)]}{I}$$

$$= \frac{3500 \times \left(\frac{0.04}{2}\right)}{\left[\frac{\pi}{64}\right] \times [(0.04)^4 - (0.02)^4]}$$

= 594178454.2

= 5.9417 e 7 Pa

V. STRUCTURAL ANALYSIS OF PROPELLER SHAFT

In this work propeller shaft is selected for structural analysis using ANSYS. The various materials using finite element analysis software ANSYS 10.0 CLASIC

MODELING OF PROPELLER SHAFT IN CATIA V5:

The propeller shaft is designed by required dimensions into the modeling software Catia V5. The geometry of the propeller shaft is designed in Catia V5 is imported to the analysis software in the IGES format.

The designed propeller shaft is below

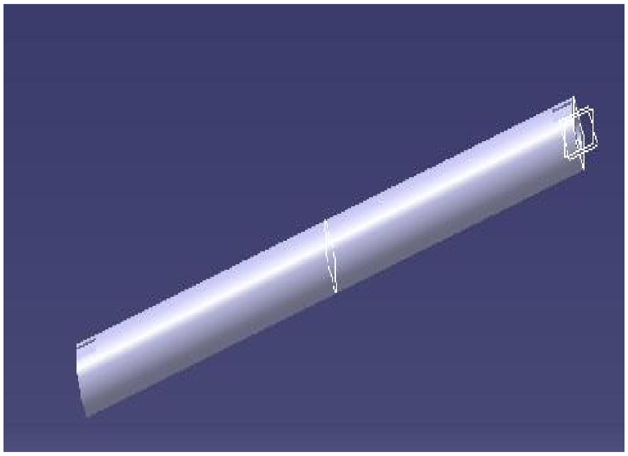
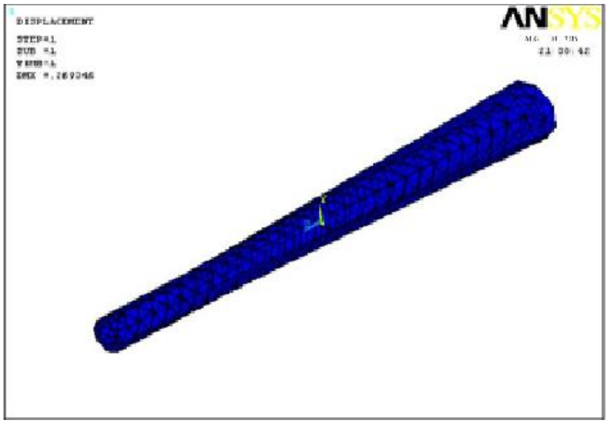


Fig 5.1 Propeller Shaft

Propeller Shaft Model and Mesh

The modeling of propeller shaft using Catia V5 and the same is used for structural analysis. In this work 8 NODE (SOLID 45) elements selected for meshing. The finite element mesh of the piston model used in ANSYS is shown Figure.



STRUCTURAL ANALYSIS WITH DIFFERENT MATERIALS

5.1.1.1 Structural analysis in steel propeller shaft

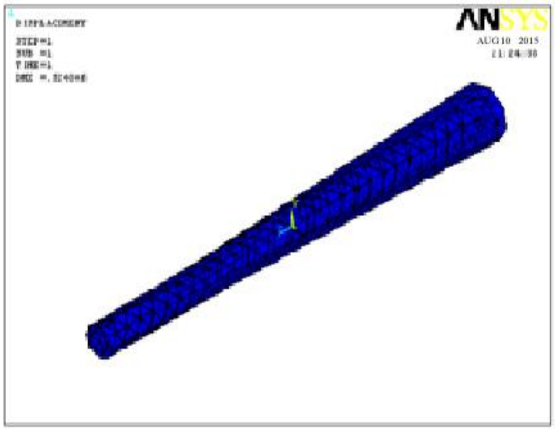


Fig.5.1.1.1 Steel displacement

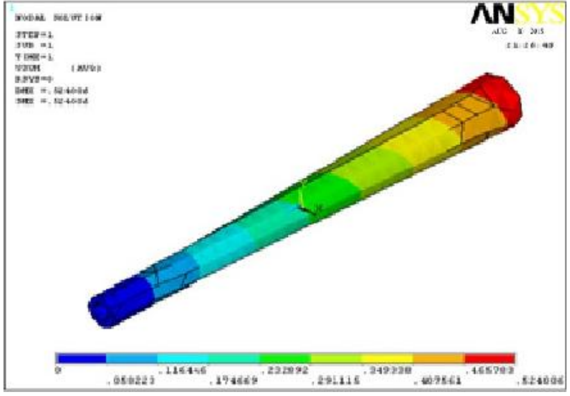


Fig.5.1.1.2 Steel Usum

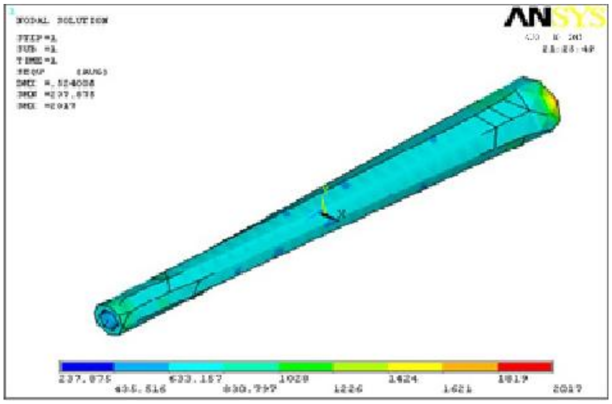


Fig.5.1.1.3 Steel Seqv

5.1.2: Structural analysis in boron propeller shaft

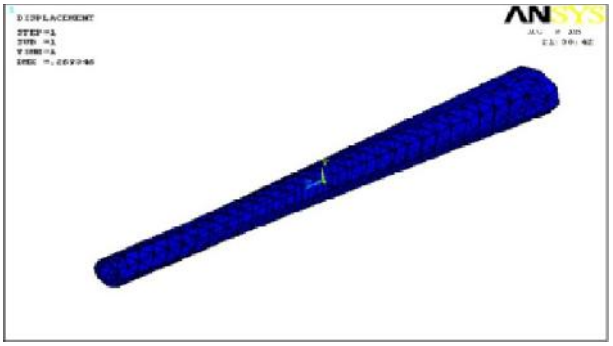


Fig.5.1.2.1 Boron displacement

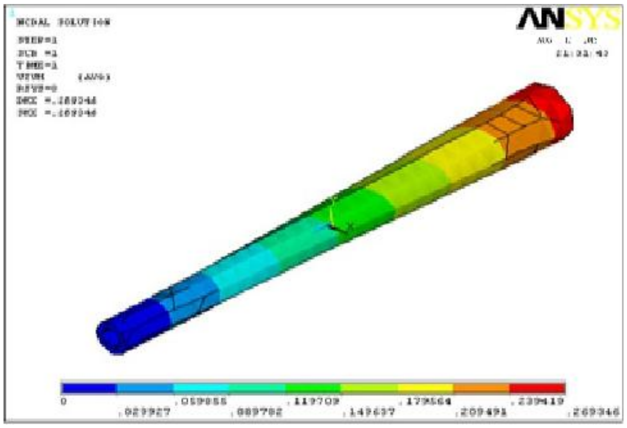


Fig.5.1.2.2 Boron Usum

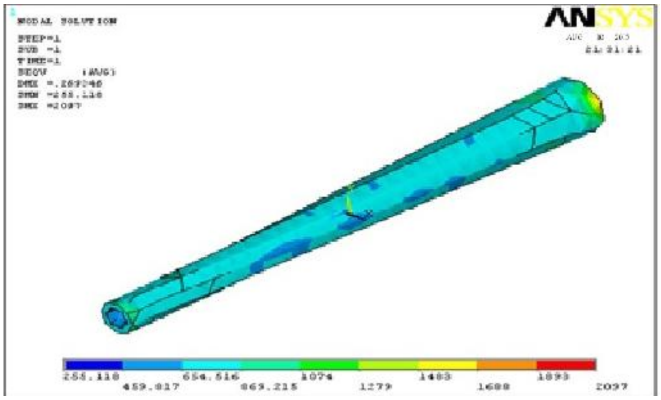


Fig 5.1.2.3 Boron Seqv

5.1.3 Structural analysis in KEVLAR propeller shaft

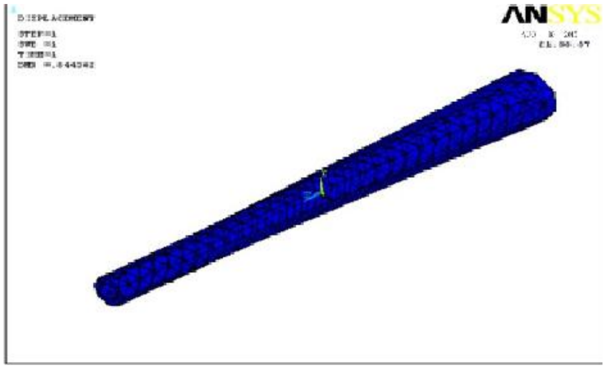


Fig 5.1.3.1 Kevlar displacement

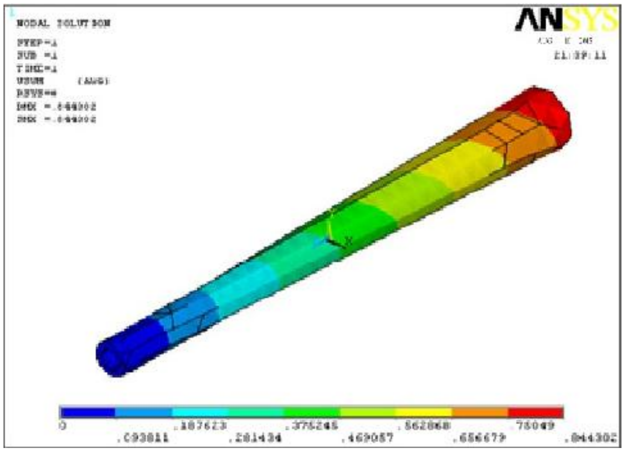


Fig 5.1.3.2 Kevlar Usum

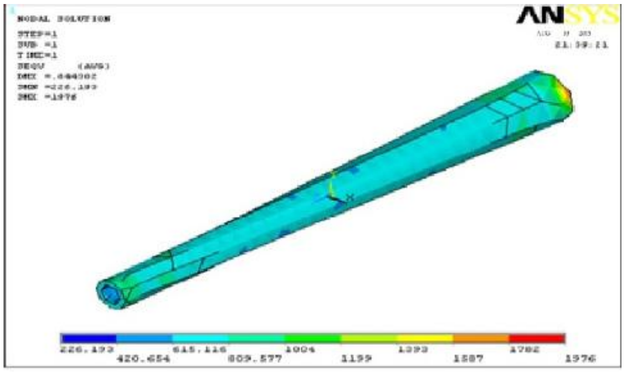


Fig 5.1.3.3 Kevlar Seqv

5.1.4 Structural analysis in Aluminium propeller shaft

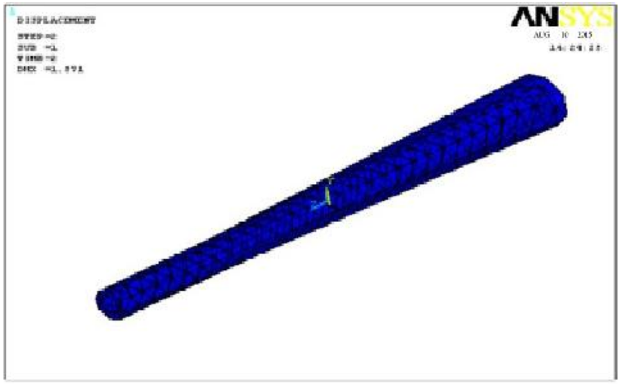


Fig 5.1.4.1Aluminium displacement

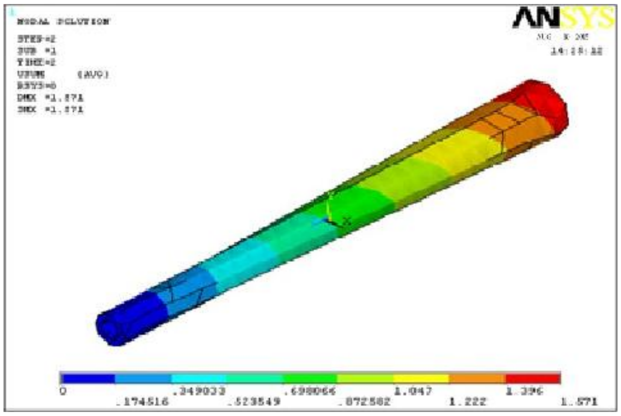


Fig 5.1.4.2 Aluminium Usum

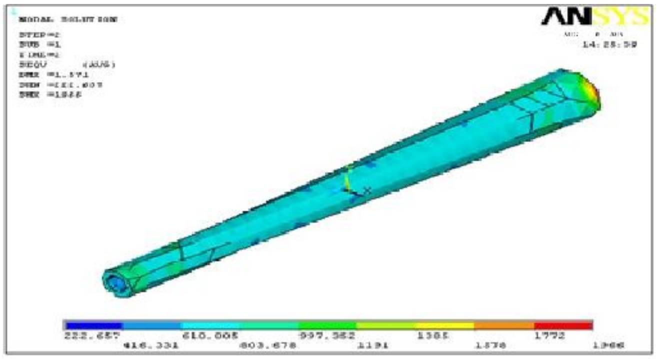


Fig 5.1.4.3 Aluminium Seqv

5.1.5: Structural analysis in glass propeller shaft

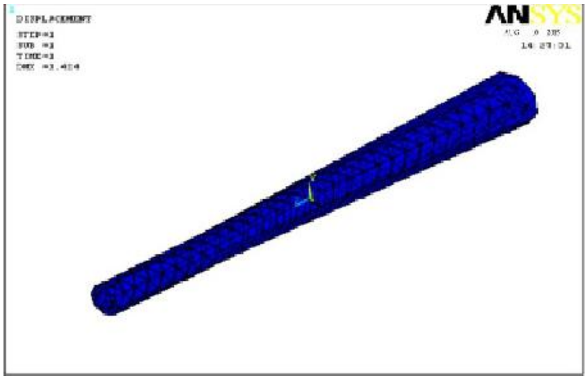


Fig 5.1.5.1 Glass Displacement

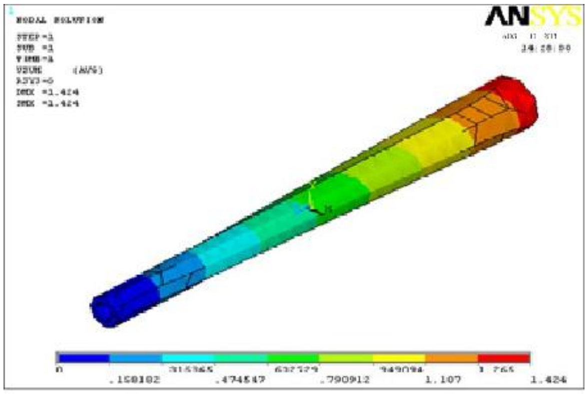


Fig 5.1.5.2 Glass Usum

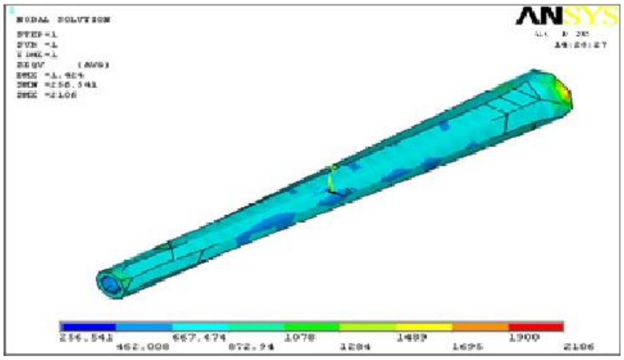


Fig 5.1.5.3 Glass Seqv

5.1.6 Structural analysis in carbon propeller shaft

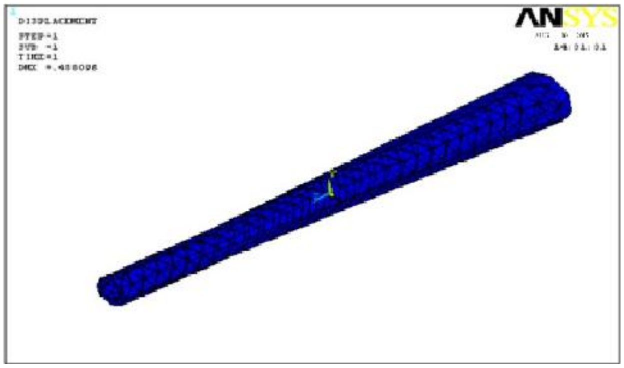


Fig 5.1.6.1 Carbon Displacement

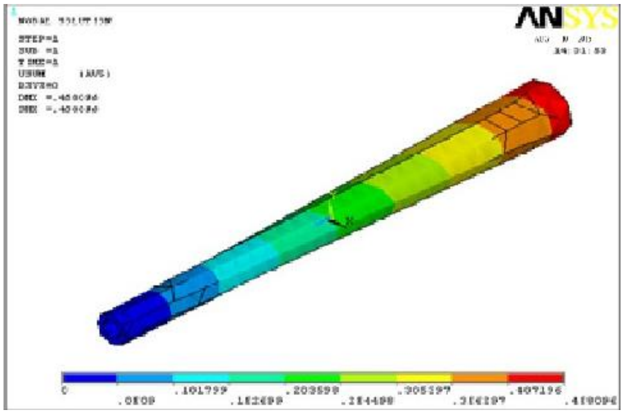


Fig 5.1.6.2 Carbon Usum

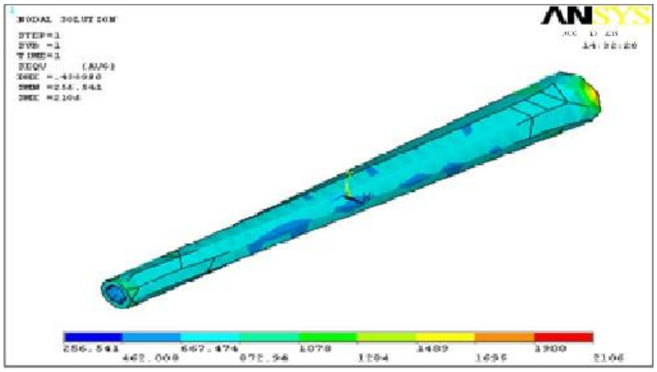


Fig 5.1.6.3 Carbon Seqv

VI RESULTS AND DISCUSSIONS:

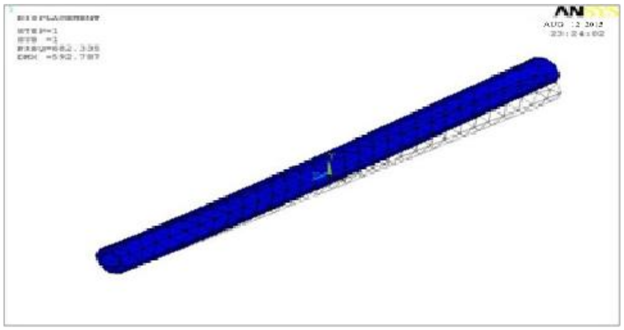
A total of five materials were chosen for the comparative analysis, including steel, which was used for reference.

S.No	MATERIAL	DEFLECTION Max	STRESS Max	STRESS Min
1	STEEL	0.52401	2017	237.875
2	BORON	0.26935	2097	415.505
3	KEVLAR	0.8443	1976	226.193
4	ALUMINIUM	1.571	1966	222.657
5	GLASS	1.424	2106	256.657
6	CARBON	0.454	2106	256.541

VI. MODAL ANALYSIS OF PROPELLER SHAFT

6.1 STEEL:

S.NO	FREQUENCY	DEFLECTION MAX
1	682.335	592.787
2	690.768	591.99
3	4191	613.97
4	4259	615.107
5	11282	590.285



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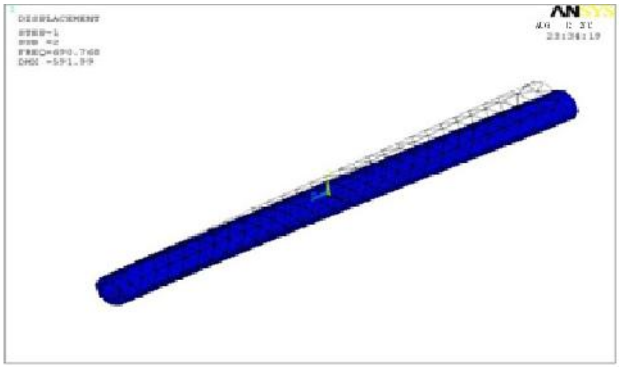

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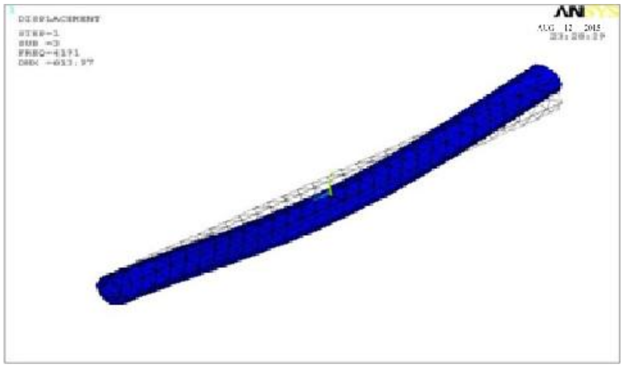

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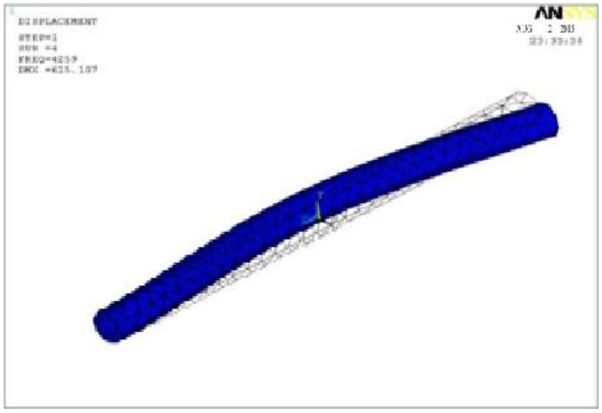

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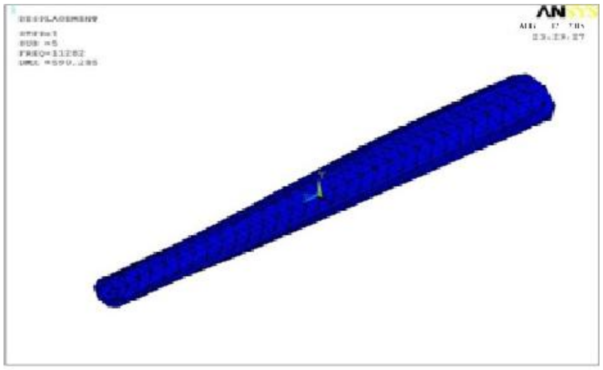
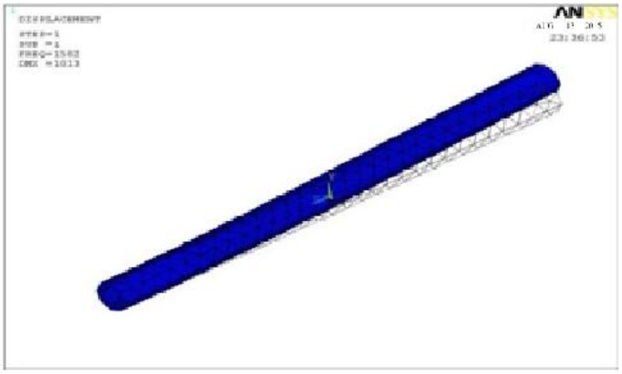


Mode5

6.2 BORON

S.NO	FREQUENCY	DEFLECTION MAX
1	**1582**	**1013**
2	**1605**	**1011**
3	9727	1050
4	9915	1052
5	2645	1055



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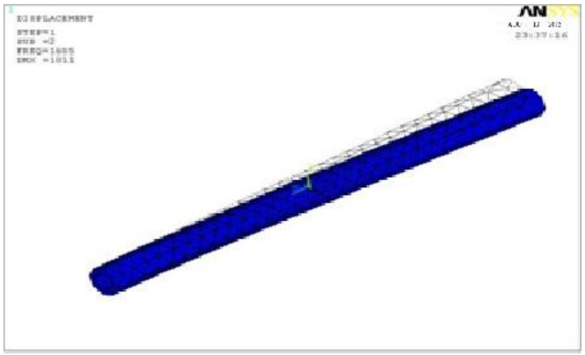

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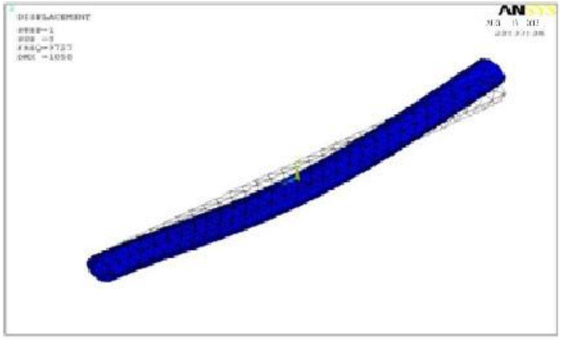

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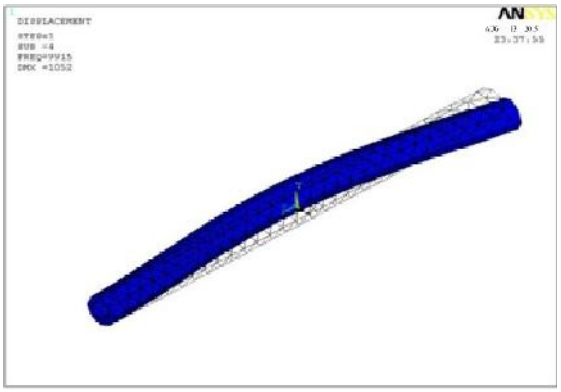

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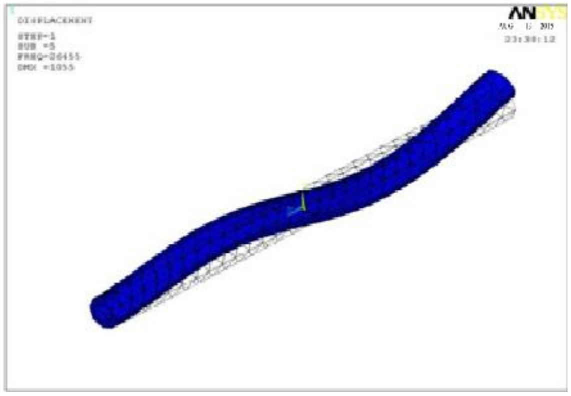

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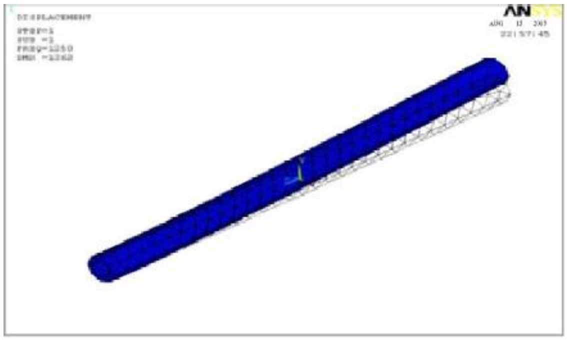
6.3 KEVLAR:

S.NO	FREQUENCY	DEFLECTION MAX
1	**1250.4**	**1362**
2	**1264.1**	**1361**
3	7679.9	1411
4	7786.3	1413
5	20414	1342



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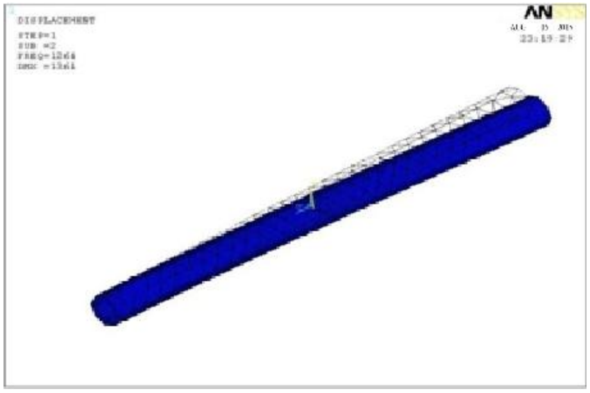

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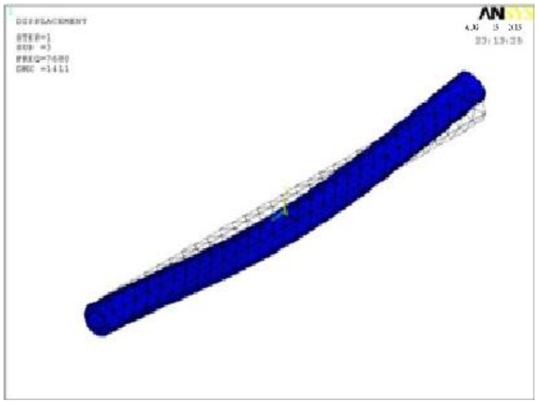

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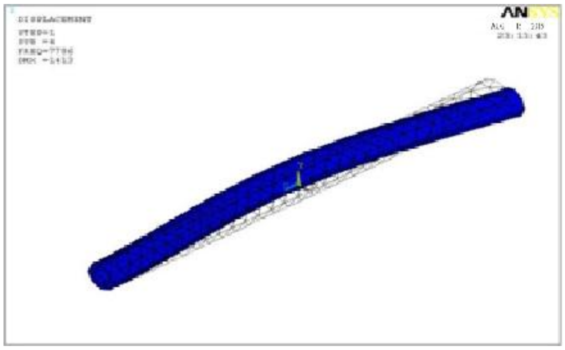

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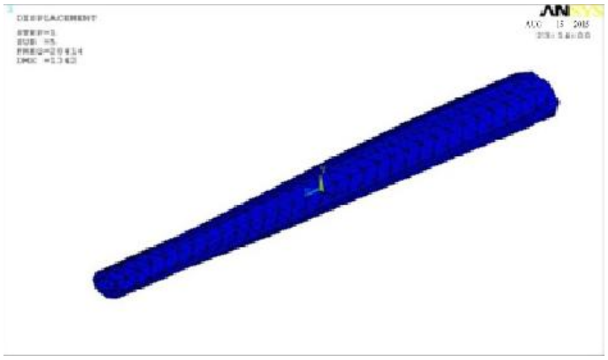
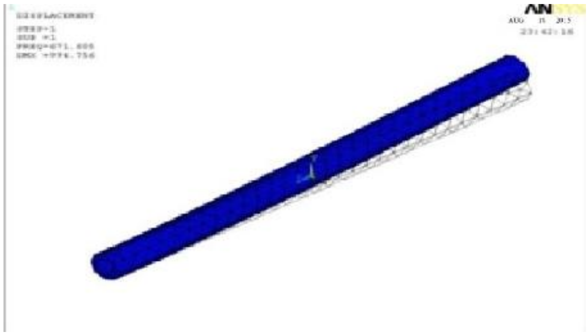


Mode5

6.4 ALUMINIUM:

S.NO	FREQUENCY	DEFLECTION MAX
1	**671.605**	**994.756**
2	**678.653**	**993.799**
3	4125	1030
4	4179	1032
5	10930	979.541



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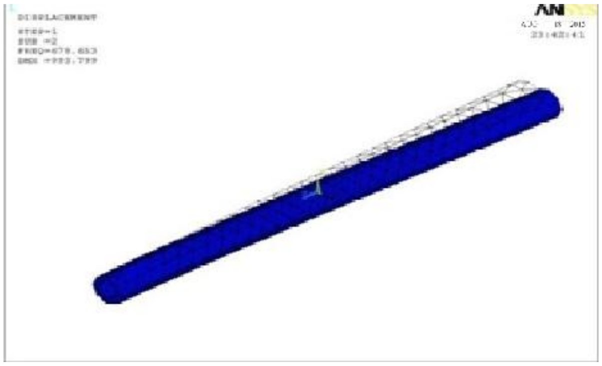

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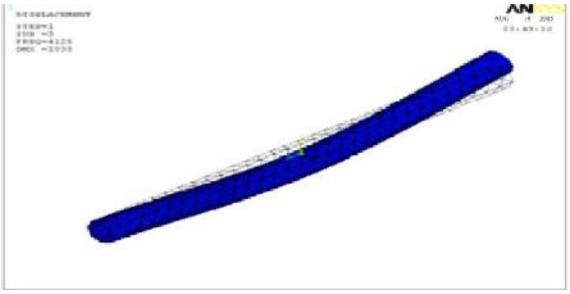

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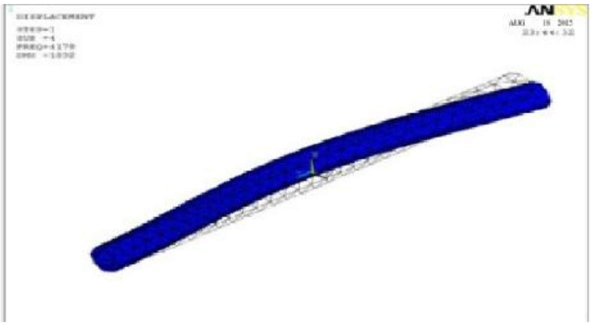

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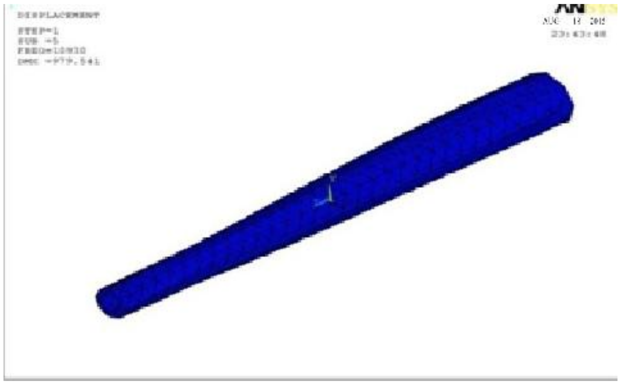

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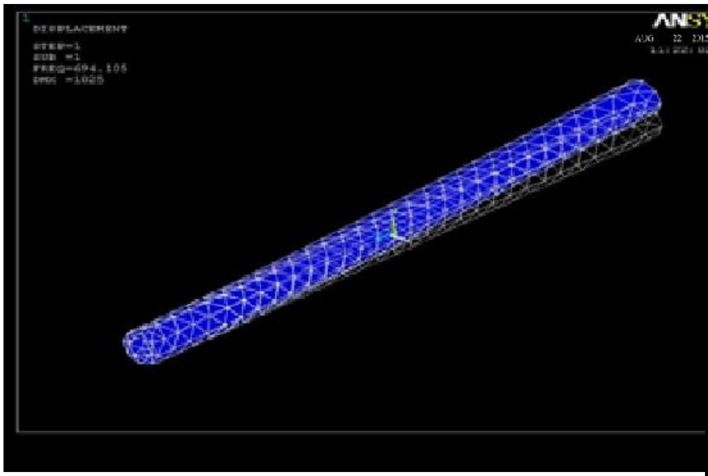
6.5 GLASS:

S.NO	FREQUENCY	DEFLECTION MAX
1	**694.105**	**1025**
2	**704.157**	**1023**
3	4268	1062
4	4351	1064
5	11611	1068



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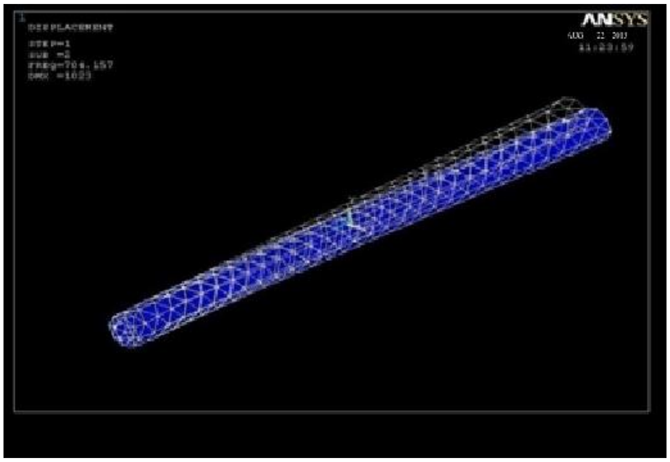

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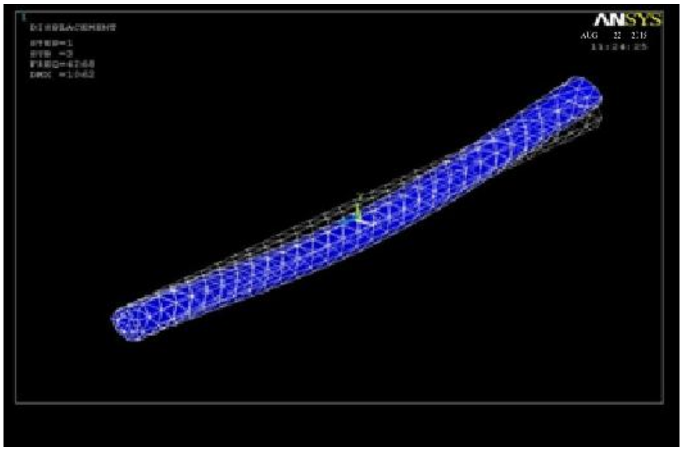

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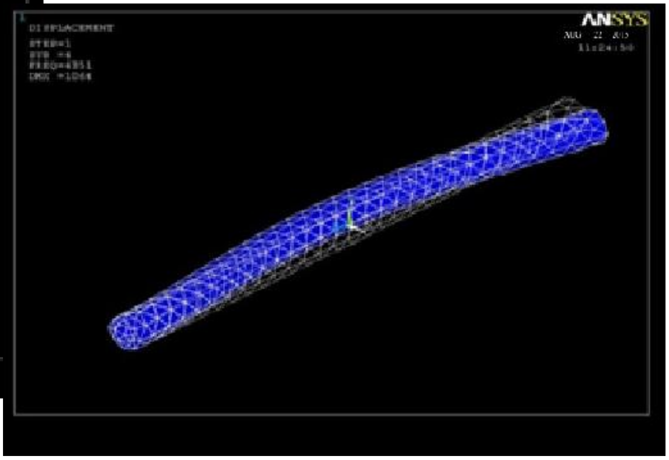

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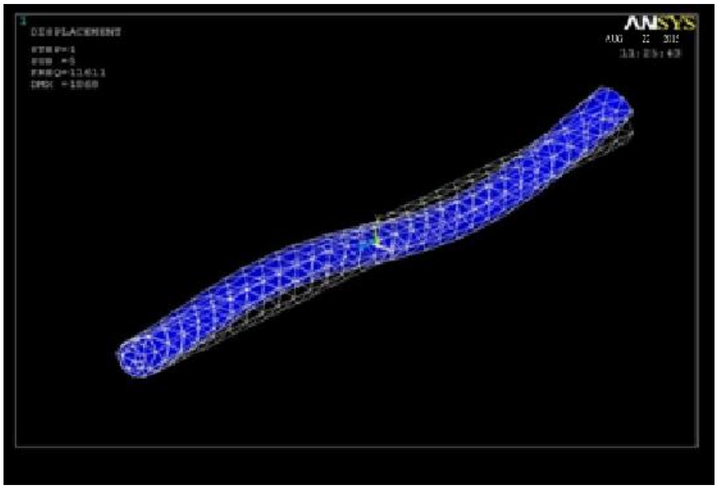
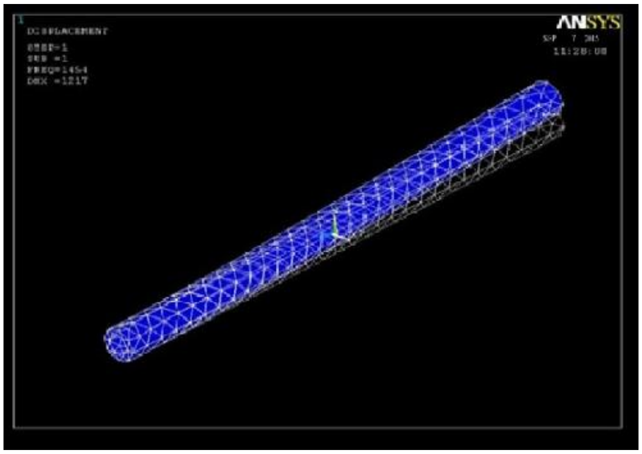


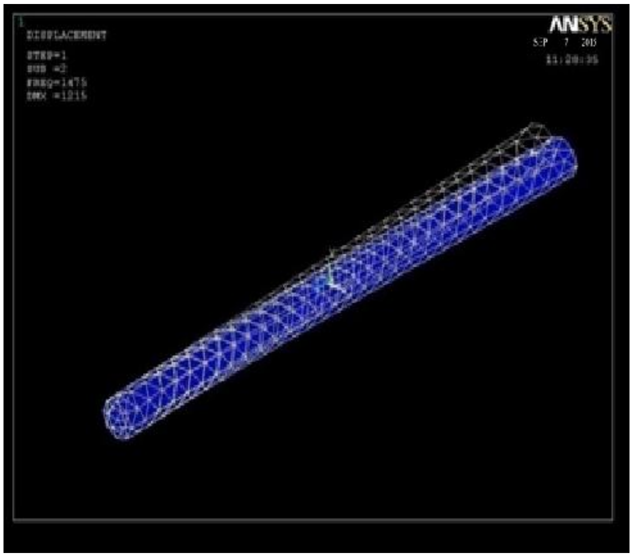
Mode5

6.6 CARBON:

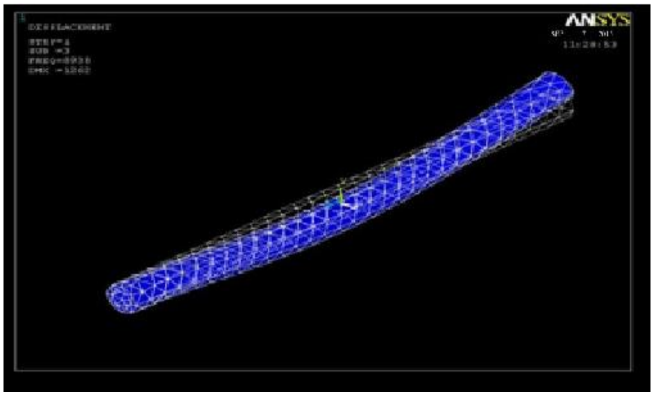
S.NO	FREQUENCY	DEFLECTION MAX
1	**1454**	**1217**
2	**1475**	**1215**
3	8958	1262
4	9112	1264
5	24314	1269



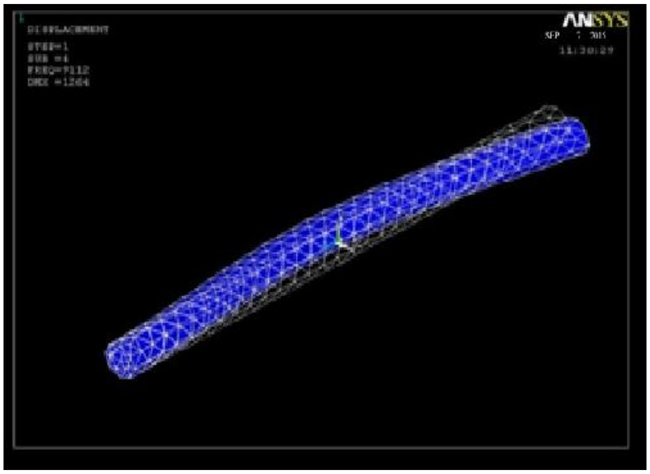
Mode1



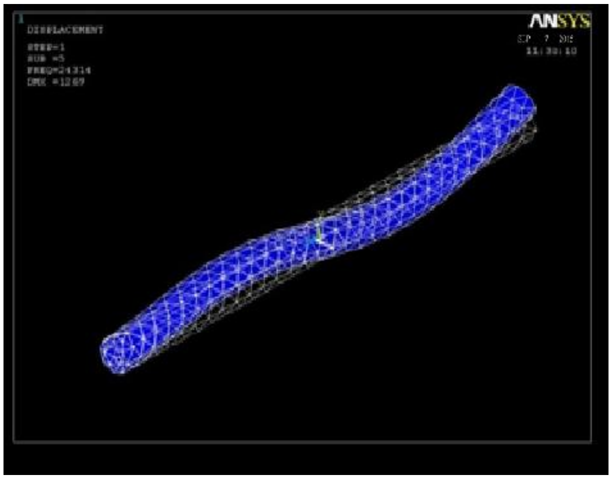
Mode2



Mode3



Mode4



Mode5

VII CONCLUSION

The presented work was aimed at reducing the fuel consumption of the automobiles in particular or any machine, which employs Propeller shafts, in general. This was achieved by reducing the weight of the Propeller shaft with the use of different materials. The Propeller shaft of a vehicle was chosen for determining the dimensions, which were then used for creating a model in Catia V5. Being a complex assembly of a number of parts, it had to be analyzed only for Propeller shaft in ANSYS 10. A total of five materials were chosen for the comparative analysis, including steel, which was used for reference.

Taking into consideration the weight saving, deformation, shear stress induced and resonant frequencies it is observed that Boron has the most encouraging properties to act as the replacement for steel out of all the materials.

VIII REFERENCES:

1. A.K. Kaw, Mechanics of Composite Materials, CRC Press, 1997.
2. Dwayne A., “Composites and Advanced Materials” (Centennial of Flight Commemoration Act Public Law 105-389 105th Congress (November 13, 1998)).
   NASA. U.S. Centenial of Flight Commission.(2003).
3. Mallick, P Newman, K. composite materials tech. hanser publishers inc (1990).
4. Vijayarangan, S., Rajendran, I. Optimal Design of a Composite Leaf Spring Using Genetic Algorithm Computers and Structures 79 2001: pp. 1121 – 1129.

5. Beardmore, P. et al. The Potential for Composites in Structural Automotive Applications J. of Composites Science and Technology 26 1986: pp. 251 – 281.