Design and optimization of automobile propeller shaft with composite materials using FEM Analysis

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***Abstract* - The main aim of this work is to accomplish FEM analysis and to optimize the design & weight with composite materials. For that it has been tried to identify most suitable composite material which may the alternates in place of conventional material, for that five material have been analyze for same design configuration load and dimensions. These materials are SM45C alloy steel as conventional propeller shaft material, Thermoplastic polyimide with 30% carbon fiber, Kevlar Epoxy, Epoxy carbon_UD, and Epoxy EGlass_UD. The FEM analysis have been done all the above material to get the best material as an alternate in place of conventional propeller shaft material and result are discussed that material like thermoplastic polyimide with 30% carbon fiber Epoxy carbon UD may be used as alternate material for propeller shaft. it has been seen from the study that the thermoplastic polyimide with 30% carbon fiber is the most favorable material as alternate in place of conventional material because the maximum stress generated as same as conventional propeller shaft material and the natural frequency of the thermoplastic polyimide with 30% carbon fiber is very closed to conventional material. The weight is optimizing up to the 82.04% as compared to conventional propeller shaft material.**

***Key word* - propeller shaft, composite material, FEM analysis, Design & weight optimization etc.**

1. INTRODUCTION:

A propeller shaft also called as cardan shaft or driving shaft is associated with a mechanical component which is used for rotational purpose transmitting torque and rotation and subjected to torsional or shear stress. The propeller shafts must be strong enough, low notch sensitivity factor, having heat treated and high wear resistant property so that it can sustain high bending and torsional load. The common material for construction is high quality steel of grade SM45C.Due to high specific strength and high specific modulus the advanced composite materials like Epoxy composite, Carbon fibers, Kevlar, Glass fibers and thermoplastic polyamide etc. with suitable resins are widely used for long propeller shaft. For this application advanced composite materials seems ideally suited.

2. LITERNATURE REVIEW:

A. Hambali1, S.M. Sapuan & N. Ismail1 and Y. Nukman [1] This paper describes an approach, based on the analytical hierarchy process (AHP) that assists decision makers or manufacturing engineers determining the most appropriate manufacturing process to be employd in manufacturing of composite automotive bumper beam at the early stage of product development process.

R. P. Kumar Rompicharla & Dr. K. Rambabu [2] they investigate automotive drive Shaft is a very important component of vehicle. The overall objective of this paper is to design and analyze a composite drive shaft for power transmission. Substituting composite structures for conventional metallic structures has many advantages because of higher specific stiffness and strength of composite materials.

Khoshravan & M.R. Paykani [3] this paper presents a design method and a vibration analysis of a carbon/epoxy composite drive shaft. The design of the composite drive shaft is divided into two main sections: First, the design of the composite shaft and second, the design of its coupling. Some parameters such as critical speed, static torque, fiber orientation and adhesive joints were studied. Tsai-Hill failure criterion was implemented to control the rupture resistance of the composite shaft and then its critical speed analysis and modal analysis were carried out using ANSYS.

R. Srinivasa Moorthy, at el [4] They Use of advanced composites has resulted in remarkable achievements in many fields including aviation, marine and automobile engineering, medicine, prosthetics and sports, in terms of improved fatigue and corrosion resistances, high specific strength and specific modulus and reduction in energy requirements owing to reduction in weight. The aim of this work is to replace the conventional steel driveshaft of automobiles with an appropriate composite driveshaft.

Sagar R Dharmadhikari, at el [5] This paper deals with the review of optimization of drive shaft using the Genetic Algorithm and ANSYS. Substitution of composite material over the conventional steel material for drive shaft has increasing the advantages of design due to its high specific stiffness and strength. This paper discusses the past work done on composite drive shafts using ANSYS and Genetic Algorithm.

Parshuram D & Sunil Mangsetty [6] The main concept of this paper is to reduce the weight of automotive drive shaft with the utilization of composite material. Composite materials have been used in automotive components because of their properties such as low weight, high specific stiffness, corrosion free, ability to produce complex shapes, high specific strength and high impact energy absorption etc.

Harshal Bankar at el [7] The objective of the drive shaft is to connect with the transmission shaft with the help of universal joint whose axis intersects and the rotation of one shaft about its own axis results in rotation of other shaft about its axis.

BHIRUD PANKAJ PRAKASH & BIMLESH KUMAR SINHA [8] They Substituting composite structures for conventional metallic structures has many advantages because of higher specific stiffness and strength of composite materials. In the recent days, The overall objective of this work is to analyze a composite drive shaft for power transmission and replacement of conventional steel drive shafts with a Kevlar/epoxy or E glass polythene resin composite drive shaft for an automotive application.

Amol B Rindhe and S R Wagh [9] They investigate heavy duty vehicles driveshaft is one of the important components. Generally a two-piece alloy steel drive shaft is used in automotive which can be replaced by a single piece of composite material driveshaft. Our main aim is to study its design procedure along with finite element analysis some important parameter will be obtained. The composite drive shaft made up of high modulus material is designed by using CAD software and tested in ANSYS for optimization of design or material check and providing a best material.

V. S. BHAJANTRI at el [10] They conclude from these analyses: The High Strength Carbon/Epoxy and High Modulus Carbon/Epoxy Composite drive shafts have been designed to replace the steel drive shaft of an automobile. The weight savings of the High strength carbon/epoxy and high modulus carbon/epoxy shafts were equal to 50 % approximately of the steel shaft.

Deepti kushwaha & Gaurav Saxena [11] They investigate that The weight reduction of the drive shaft can have a certain role in the general weight reduction of the vehicle and are a highly desirable goal. Substituting composite structures for conventional metallic structures has many advantages because of higher specific stiffness and strength of composite materials. This present work includes, modeling and analysis of both the steel and composite drive shaft by changing in diameter have been done using Pro-E and ANSYS 12.1 software and concludes that the use of composite materials for drive shaft would induce less amount of stress which additionally reduces the weight of the vehicle.

3. OBJECTIVE:

1. The main objectives of this present research are listed as follows:
2. To investigate the existing design of automotive/automobile propeller shafts.
3. To check the design of propeller shaft mathematically with a conventional material.
4. To check also design of propeller shaft mathematically with composite material.
5. To perform FEM analysis with conventional as well as composite materials.
6. To compare the result with mathematical and FEM analysis.
7. Finally optimize the design of propeller shaft which should be compatible and cost effective.
8. Interprets the results of all conditions and analysis.

4. METHODOLOGY:

4.1 Mathematical analysis:

The shafts are usually cylindrical in section solid or hollow. They are made of mild steel, alloy steel, copper alloys and now days of composite materials.

The shaft may be subjected to Torsional, Bending load, Axial load and Combination of above three loads

$$\frac{\tau}{R} = \frac{C\theta}{l} \qquad \dots\dots\dots(1)$$

$$T = \tau.\frac{\pi R^3}{2} = \tau.\frac{\pi}{16}D^3 \qquad \text{(for solid shaft)}$$

$$T = \frac{\pi}{16}\,\tau\left[\frac{D^4 - d^4}{D}\right] \qquad (for\,hollow\ shaft)$$

$$\left[J = \frac{\pi}{32}D^4\right] \ polar\ moment\ of\ inertia\ for\ solid$$

$$J = \frac{\pi}{32}(D^4 - d^4) \qquad (for\,hollow\ shaft)$$

$$\frac{T}{J} = \frac{\tau}{R} \qquad \dots\dots\dots\dots\dots(2)$$

from equation (1) and (2)

$$\frac{T}{J} = \frac{\tau}{R} = \frac{C\theta}{l} \qquad \dots\dots\dots.(3)$$

This equation called torsion equation.

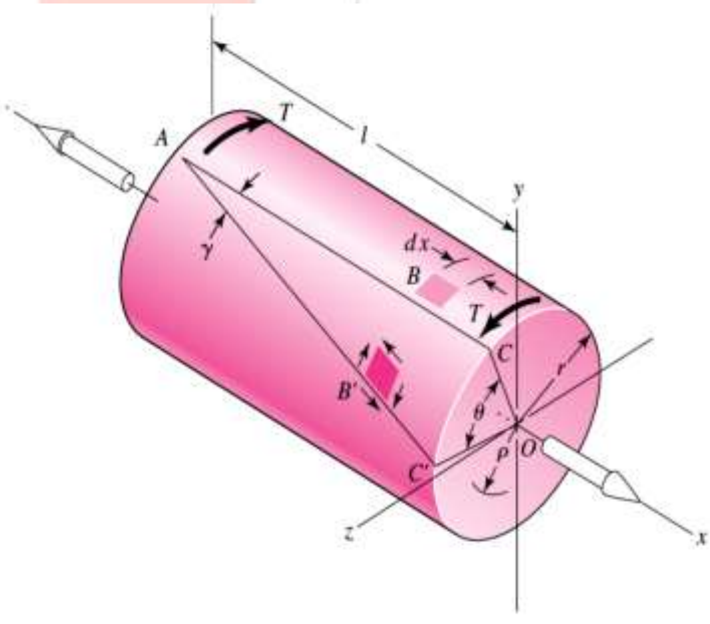

Figure 4.1: torsion of solid shaft

Power transmitted by the shaft:

$$P = \frac{F \times 2\pi RN}{60}\ watts \qquad (\because T = F \times R)$$

$$P = \frac{2\pi NT}{60 \times 1000}$$

Where T is the mean/average torque in N-m

Design of propeller shaft is subjected to axial loading in addition to combined torsion and bending loads. Bending equation

$$\frac{M}{I} = \frac{\sigma_b}{Y} \qquad or \qquad \sigma_b = \frac{32M}{\pi d^3}$$

And stress due to axial load

$$= \frac{F}{\frac{\pi}{4} \times d^2} = \frac{4F}{\pi d^2} \qquad (solid\ shaft)$$

$$= \frac{F4}{\pi[(d_o)^2 - (d_i)^2]} \qquad (hollow\ shaft)$$

$$= \frac{F}{\pi(d_o)^2\ (1 - k^2)} \qquad \ldots\ldots\ldots\ldots (\therefore k = d_i/d_o)$$

$\therefore$ *result stress (tensile or compressive) for solid shaft,*

$$\sigma_1 = \frac{32M}{\pi(d_o)^3\ (1 - k^4)} + \frac{4F}{\pi(d_o)^2\ (1 - k^2)}$$

$$= \frac{32M_1}{\pi(d_o)^3\ (1 - k^4)}$$

$$\left[substitute\ \ M_1 = M + \frac{Fd_o(1 + k^2)}{8}\right]$$

For the long shafts subjected to compressive loads a ***column factor*** (α) must be considered:
$\therefore$ Stresses due to the compressive load

$$\sigma_c = \frac{\alpha \times 4F}{\pi d^2} \qquad (solid\ shaft)$$

$$= \frac{\alpha \times 4F}{\pi(d_o)^2\ (1 - k^2)} \qquad (hollow\ shaft)$$

The value of column factor (α) for compressive loads may be obtained from the following relation:
Column factor

$$\alpha = \frac{1}{1 - 0.0044\ (L/K)} \ \text{When}\ \left(\frac{L}{K}\right) < 115$$

$$\alpha = \frac{\sigma_y\ (L/K)^2}{C\pi^2 E} \ \text{When}\ \left(\frac{L}{K}\right) > 115$$

The equations for equivalent twisting moment (T_e) and equivalent bending moment (M_e) may be written as:

$$T_e = \sqrt{\left[K_m \times M + \frac{\alpha F d_o(1 + k^2)}{8}\right]^2 + (K_t \times T)^2} \qquad Where:\ T_e = \frac{\pi}{16} \times \tau {d_o}^3(1 - k^4)$$

And

$$M_e = \frac{1}{2}\left[K_m \times M + \frac{\alpha F d_o(1 + k^2)}{8} + \sqrt{\left\{K_m \times M + \frac{\alpha F d_o(1 + k^2)}{8}\right\}^2 + (k_t \times T)^2}\right] \qquad Where\ M_e$$

$$= \frac{\pi}{32} \times \sigma_b (d_o)^3 (1 - k^4)$$

4.2 Design of propeller shaft:

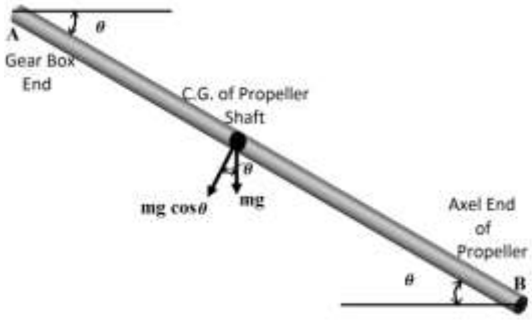

Figure 4.2: Design of propeller shaft

Calculation for Moment of Inertia of propeller shaft:

Outer Diameter of section	: 76.14 mm
Inner Diameter of section	: 64.81
Area of section	: 1286.61 mm^2
Position of centroid - X	: 38.205 mm
Position of centroid - Y	: 38.205 mm
Moment of Inertia Ixx	: 807247.94 mm^4
Moment of Inertia Iyy	: 807247.94 mm^4
Section Modulus Zxx	: 21129.34 mm^3
Section Modulus Zyy	: 21129.34mm^3
Radius of gyration rxx	: 25.05mm
Radius of gyration ryy	: 25.05 mm

Polar moment of inertia:

$$J = \frac{\pi}{32}(D^4 - d^4)$$

Maximum Torsional stress:

$$\frac{T}{J} = \frac{\tau}{R} \quad or \quad \tau = \frac{T(D - d)}{2J}$$

Maximum static Deflection δ:

$$\delta = \frac{5 \times m \times g \times \cos\theta \times L^3}{384 \times E \times J}$$

Critical speed of the shaft (N_c):

$$N_c = \frac{30}{\pi}\sqrt{\frac{g}{\delta}}$$

Structure Analysis of SM45C alloy Steel Propeller shaft:

The complete structure analysis of the propeller shaft in present case follows three major steps. Preprocessor, solutions and post processor. Preprocessor involve CAD geometry, Meshing and Boundary conditions.

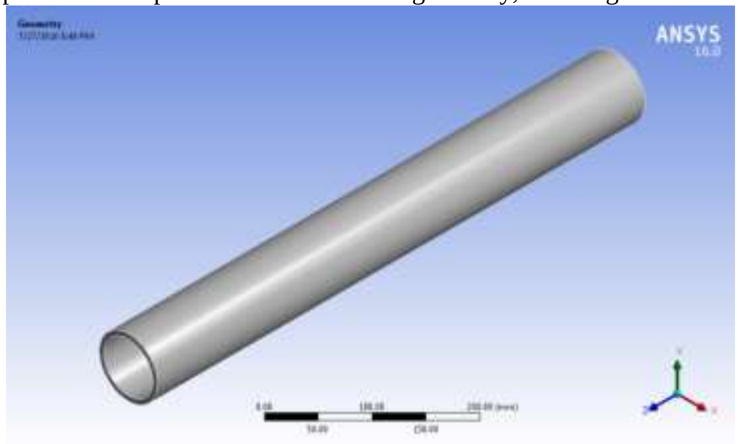

Figure: 4.3 CAD geometry of propeller shaft

CAD modelling: For geometry construction the length of propeller shaft is taken as 640 mm, Outer Diameter of circular section: 76.14 mm and Inner Diameter of circular section: 64.81mm.

Material property of SM45C alloy Steel: Table 4.1

Parameters	Specification
Tensile Ultimate Strength	686 Mpa
Tensile Yield Strength	490 Mpa
Density	8760 kg/m^3
Poisson's Ratio	0.290
Young's Modulus	210 x 10^3 Mpa
Bulk modulus	1.6667E+5 Mpa
Shear modulus	8.1395E+4 Mpa

Source: http://www.otaisteel.com

Maximum torque transmitted by shaft (τ) = 225 N-m, Inclination angle θ = 2degree, Density ρ = 7860 Kg/m^3, Rotational speed N = 2800 rpm

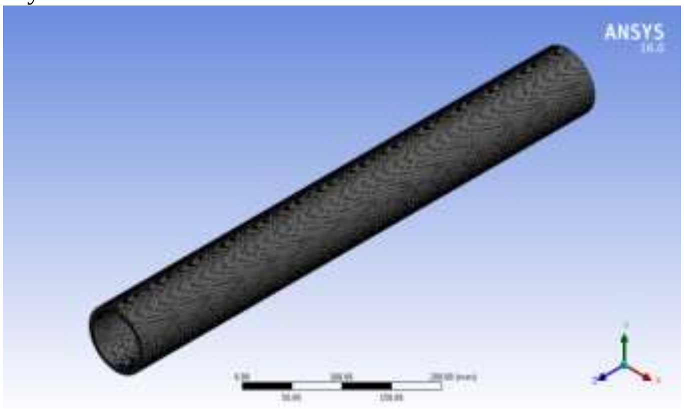

Figure 4.4: Meshing Total No. Node: 544130 & Elements: 110124

Meshing: The mesh created in this work is shown in figure No. 4.4 the total Node is generated is 544130 and total elements is 110124. It is clear from the mesh geometry that the result accuracy depends on the mesh quality.

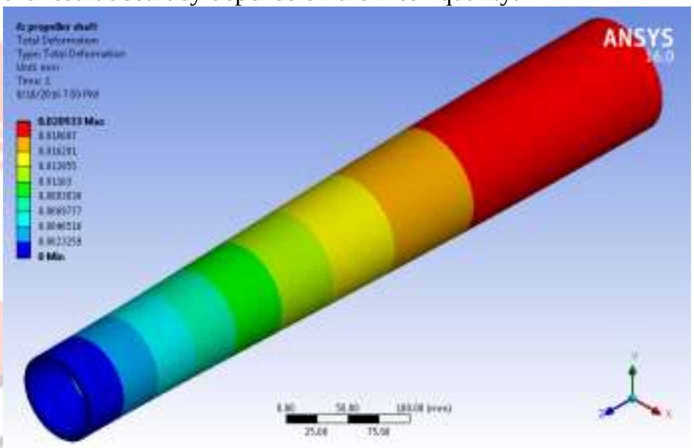

Figure 4.5: Total deformation of propeller shaft for SM45C alloy Steel

The total deformation of propeller shaft for SM45C alloy Steel has been obserbed in figure 4.9, its maximum and minimum values are 0.021 mm & 0 mm.

Material property:

Boundary condition and Loading:

- The one end of the propeller shaft is constrained in all direction
- The moment of 225 Nm is applied at other end.
- Set material property of SM45C alloy Steel from ANSYS library created during Analysis.
- The solver used for this FEM analysis is Mechanical APDL solver.

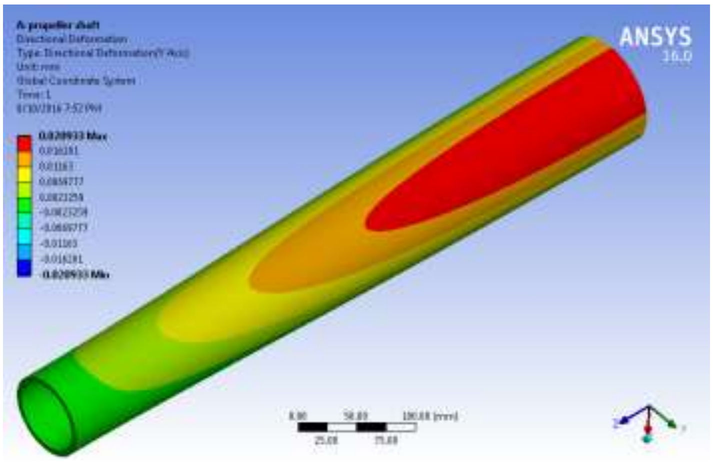

Figure 4.6: Directional deformation of propeller shaft for SM45C alloy Steel

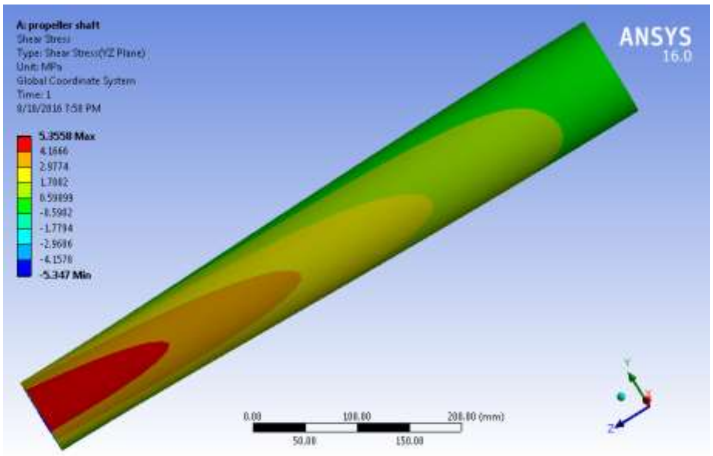

Figure 4.7: Shear stress on YZ plane of propeller shaft for SM45C alloy Steel

The Directional deformation of propeller shaft for SM45C alloy Steel has been obserbed in figure 4.10, its maximum and minimum values are 0.0209 mm & -0.0209 mm. The maximum and minimum values Shear stress is 5.3558 Mpa & -5.347 Mpa.

4.3.2 Structural analysis for E-glass Epoxy: CAD geometry, meshing and boundary conditions remain same as SMC45C steel alloy.

Material property of composite material E-Glass Epoxy: Table 4.2

Parameters	**Specification**
Density	2000 Kg/m^2
Young Modulus (X- direction)	45000 MPa
Young Modulus (Y- direction)	10000 MPa
Young Modulus (Z- direction)	10000 MPa
Poisson's Ratio XY	0.3
Poisson's Ratio YZ	0.61
Poisson's Ratio XZ	0.3
Shear Modulus XY	5200 MPa
Shear Modulus YZ	3846.2 MPa
Shear Modulus XZ	5000 MPa
Orthotropic Stress	
Tensile (X- direction)	1100 MPa
Tensile (Y- direction)	35 MPa
Tensile (Z- direction)	35 MPa
Compressive (X- direction)	675 MPa
Compressive (Y- direction)	-120 MPa
Compressive (Z- direction)	-120 MPa
Shear XY	80 MPa
Shear YZ	46 - 154 MPa
Shear XZ	80 MPa

Source: ANSYS Library

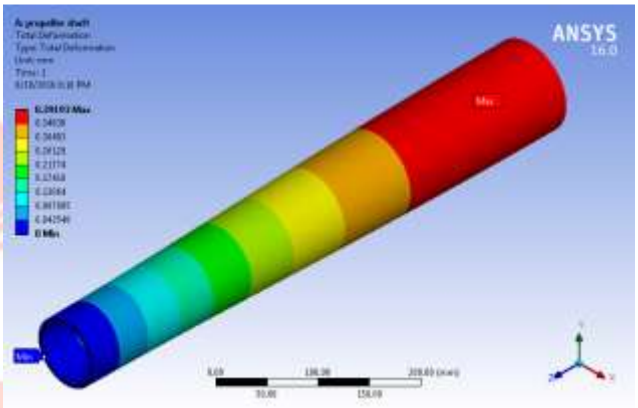

Figure 4.8: Total deformation of propeller shaft for E-glass Epoxy composite

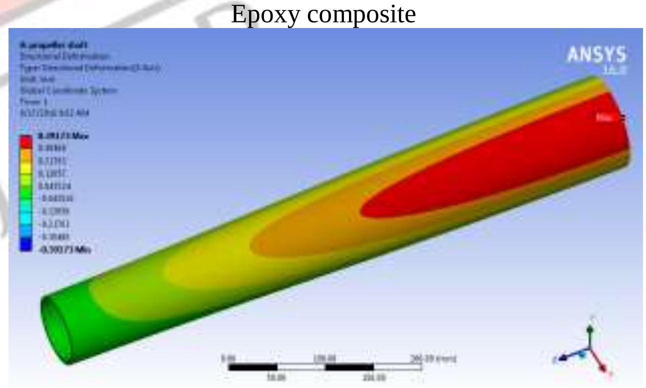

Figure 4.9: Directional deformation of propeller shaft for E-glass Epoxy composite

The total deformation of propeller shaft for E-glass Epoxy composite has been obserbed in figure 4.14, its maximum and minimum values are 0.39 mm & 0 mm. The maximum and minimum values of Directional deformation are 0.39 mm & -0.39 mm.
The Shear stress of propeller shaft for E-glass Epoxy composite has been obserbed in figure 4.18, the maximum and minimum values are 5.1198 Mpa & -5.1117 Mpa. the maximum and minimum value of Shear stress is shown in the above figure itself which are obtained at two different ends.

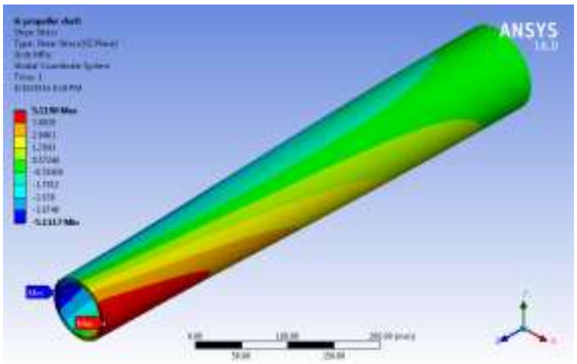

Figure 4.10: Shear stress on YZ plane of propeller shaft for E-glass Epoxy composite

4.3.3 Structural analysis for Epoxy carbon_UD: CAD geometry, meshing and boundary conditions remain same as SMC45C steel alloy.

Material property of composite material Epoxy carbon_UD: Table 4.3

Parameters	Specification
Density	1540 Kg/m^3
Young's modulus X direction	2.09E+03 Mpa
Young's modulus Y direction	9450 Mpa
Young's modulus Z direction	9450 Mpa
Possion's Ratio xy	0.27
Possion's Ratio yz	0.4
Possion's Ratio xz	0.27
Shear modulus xy	5500 Mpa
Shear modulus yz	3900 Mpa
Shear modulus xz	5500 Mpa
Orthotropic Stress	
Tensile (X- direction)	1979 Mpa
Tensile (Y- direction)	26 Mpa
Tensile (Z- direction)	26 Mpa
Compressive (X- direction)	-893 Mpa
Compressive (Y- direction)	-139 Mpa
Compressive (Z- direction)	-139 Mpa
Shear XY	100 Mpa
Shear YZ	50 Mpa
Shear XZ	100 Mpa

Source: ANSYS Library

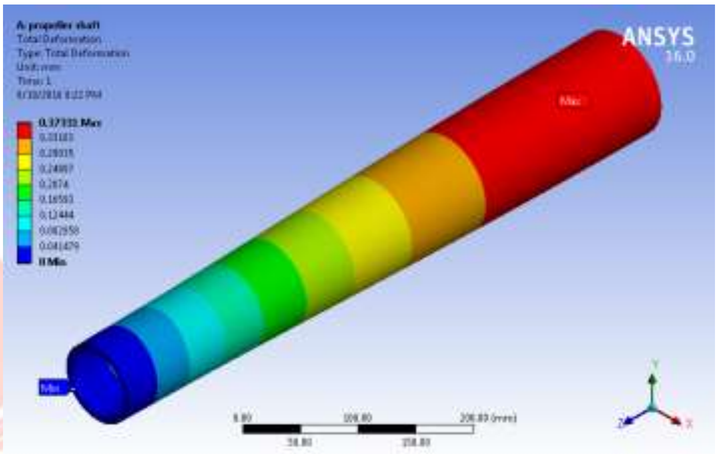

Figure 4.11: Total deformation of propeller shaft for Epoxy carbon_UD

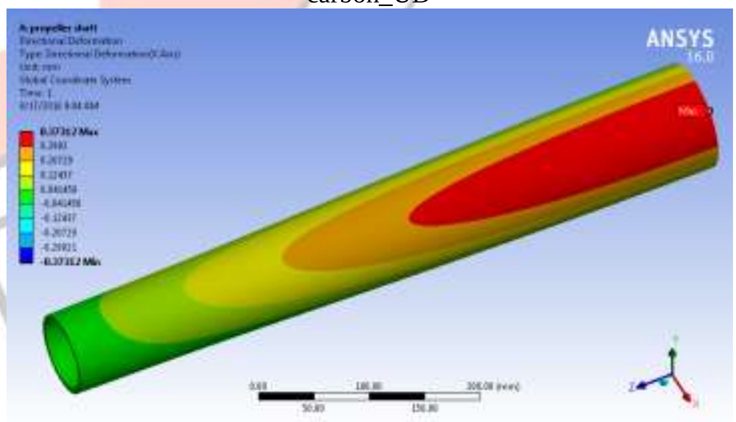

Figure 4.12: Directional deformation of propeller shaft for Epoxy carbon_UD

The total deformation of propeller shaft for Epoxy carbon_UD has been obserbed in figure 4.19, its maximum and minimum values are 0.37 mm & 0 mm.
The Directional deformation of propeller shaft for Epoxy carbon_UD has been obserbed in figure 4.20, its maximum and minimum values are 0.37 mm & -0.37 mm.
The maximum and minimum values of Shear stress are 5.0513 Mpa & -5.0434 Mpa.

4.3.4 Structural analysis for Kevlar Epoxy: CAD geometry, meshing and boundary conditions remain same as SMC45C steel alloy.

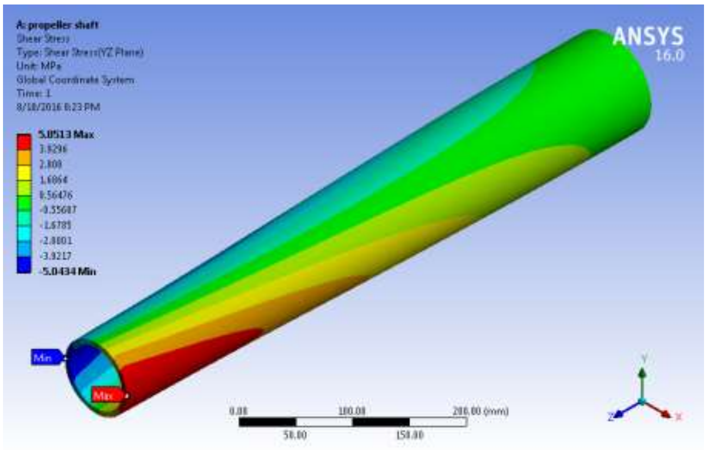

Figure 4.13: Shear stress on YZ plane of propeller shaft for Epoxy carbon_UD

Material property of composite material Kevlar Epoxy: Table 4.4

Parameters	Specification
Density	1400 Kg/m^3
Young's modulus X direction	80000 Mpa
Young's modulus Y direction	55000 Mpa
Young's modulus Z direction	80000 Mpa
Possion's Ratio xy	0.34
Possion's Ratio yz	0.34
Possion's Ratio xz	0.4
Shear modulus xy	2200 Mpa
Shear modulus yz	1800 Mpa
Shear modulus xz	2200 Mpa

Source: ANSYS Library

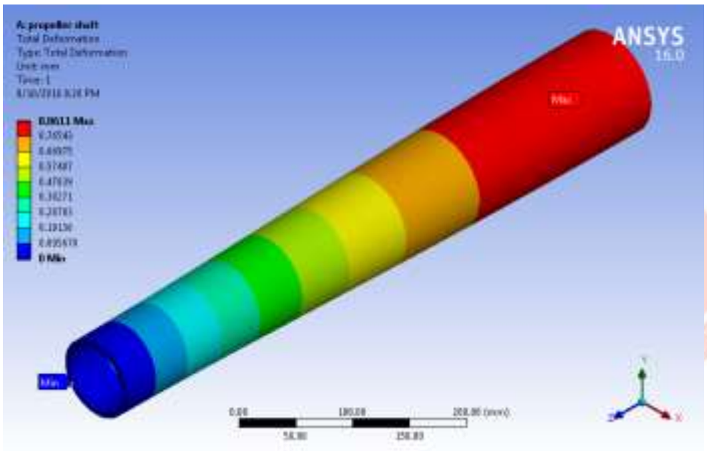

Figure 4.14: Total deformation of propeller shaft for Kevlar Epoxy

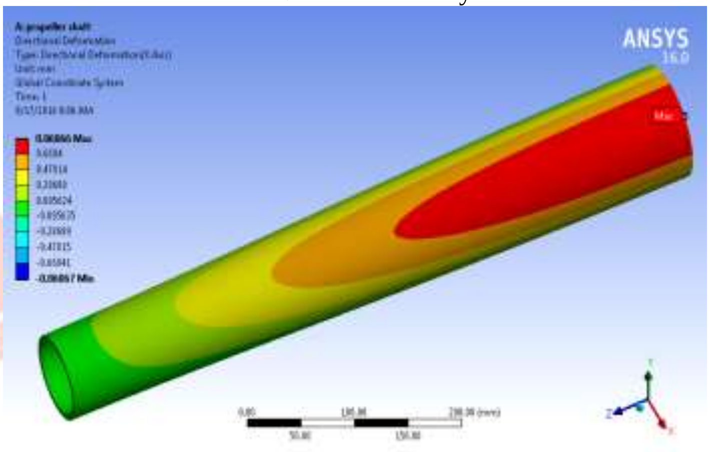

Figure 4.15: Directional deformation of propeller shaft for Kevlar Epoxy

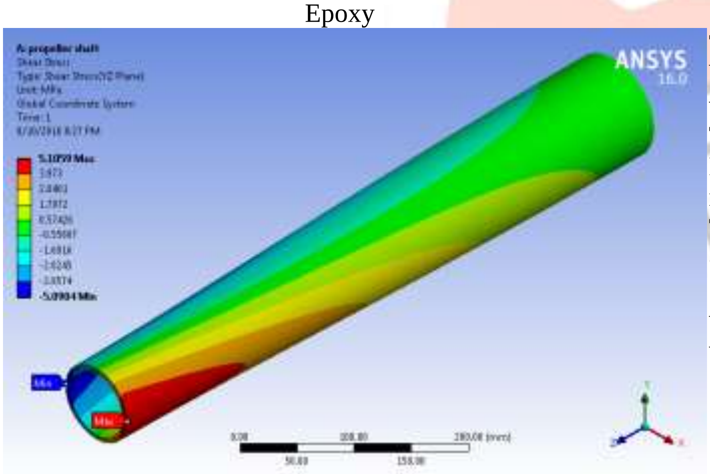

Figure 4.16: Shear stress on YZ plane

The total deformation of propeller shaft for Kevlar Epoxy has been obserbed in figure 4.24, its maximum and minimum values are 0.8611 mm & 0 mm.

The Directional deformation of propeller shaft for Kevlar Epoxy has been obserbed in figure 4.25, its maximum and minimum values are 0.86 mm & -0.86 mm.

The Shear stress of propeller shaft for Kevlar Epoxy has been obserbed in figure 4.28, the maximum and minimum values are 5.1059 Mpa & -5.0904 Mpa. the maximum and minimum values of Shear stress are shown in the above figure itself which are obtained at two different ends.

4.3.5 Structural analysis for Thermoplastic polyimide 30% carbon fiber: CAD geometry, meshing and boundary conditions remain same as SMC45C steel alloy.

Material property of composite material Thermoplastic polyimide 30% carbon fiber: Table 4.5

Parameters	Specification
Density	1410 Kg/m^3
Young modulus	1.9E+04 MPa
Poission's Ratio	0.3
Bulk modulus	1.5833E+04 MPa
Shear modulus	7.3077E+03 MPa
Tensile yield strength	215 Mpa
Tensile ultimate strength	330 Mpa

Source: http://www.makeitfrom.com

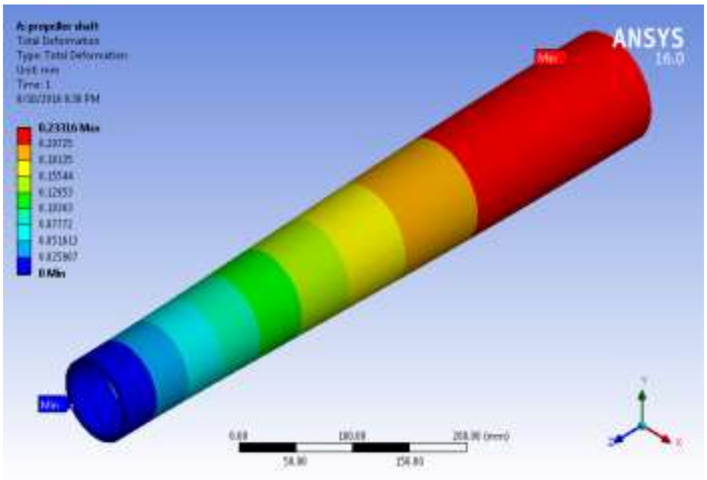

Figure 4.17: Total deformation of propeller shaft for Thermoplastic polyimide 30% carbon fiber

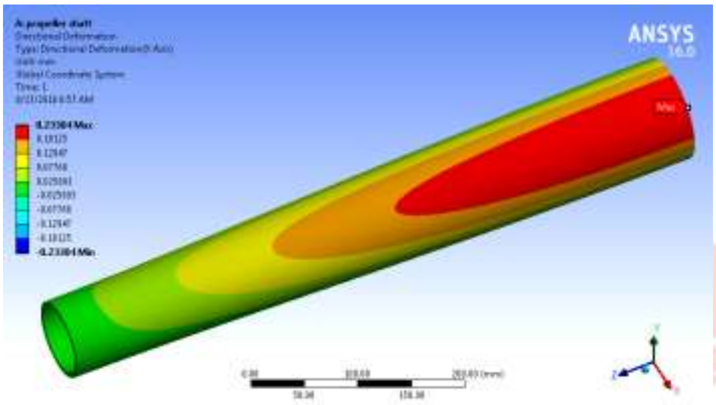

Figure 4.18: Directional deformation of propeller shaft for Thermoplastic polyimide 30% carbon fiber

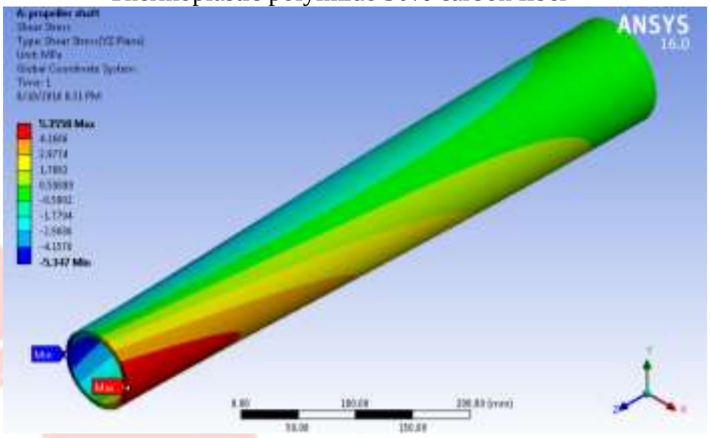

Figure 4.19: Shear stress on YZ plane of propeller shaft for Thermoplastic polyimide 30% carbon fiber

The total deformation of propeller shaft for Thermoplastic polyimide 30% carbon fiber has been obserbed in figure 4.29, its maximum and minimum values are 0.233 mm & 0 mm.

The directional deformation of propeller shaft for Thermoplastic polyimide 30% carbon fiber has been obserbed in figure 4.29its maximum and minimum values are 0.233 mm & -0.233 mm.

The Shear stress of propeller shaft for Thermoplastic polyimide 30% carbon fiber has been obserbed in figure 4.33, the maximum and minimum values are 5.3558 Mpa & -5.347 Mpa.

5. RESULT AND DISCUSSION:

In the present work five different materials including conventional material used the results are shown in graphs.

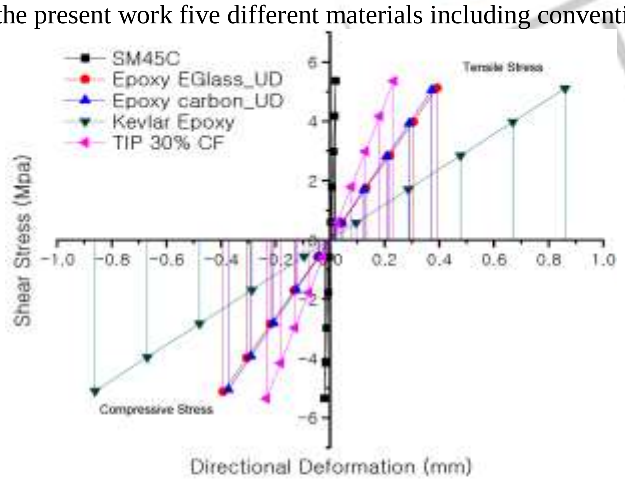

Figure 5.1: Comparative result for Directional Deformation Vs Shear stresses

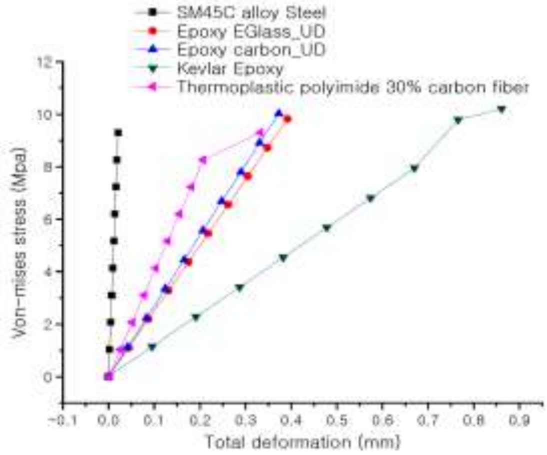

Figure 5.2: Comparative result for Total Deformation Vs Von-mises stress

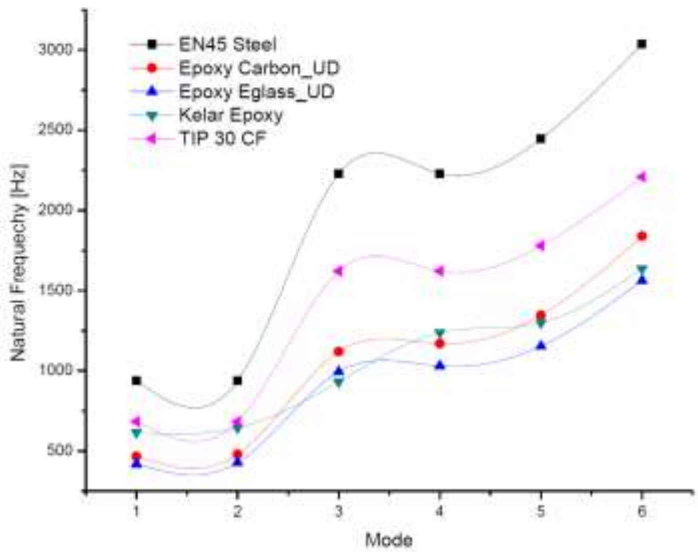

Figure 5.3: Comparative result of Natural Frequencies

Natural Frequencies of different materials are shown in figure 5.3. it is experienced that the deflection of shaft convey the relationship between inertia force and rigidity of the shaft which includes all the load applied on the horizontal shaft. natural frequency of shaft depends upon the magnitude of unbalanced shaft and of the length, diameter , types of bearing support etc. the value of natural frequencies in the present case are different for different materials such as for SM45C the maximum and minimum values are 3037.6Hz and 937.45Hz, For Epoxy carbon_UD the maximum and minimum values are 1839.2 Hz and 466.09 Hz, For E-glass Epoxy composite the maximum and minimum values are1562.3Hz & 416.63Hz, for Kevlar Epoxy the maximum and minimum values are 1634.6 Hz and 614.85 and For Thermoplastic polyimide 30% carbon fiber the maximum and minimum values are 2209.1 Hz and 681.77Hz.

6. CONCLUSION:

This present research work mainly focuses on replacing conventional material with composite material of propeller shaft. For that following points have been concluded from present work

- **For SM45C alloy Steel**: The maximum & minimum value of total deformation developed during the FEM analysis of propeller shaft at Torque of 225 Nm are 0.0209 mm & 0 mm, The maximum & minimum value of Directional deformation are 0.0209 mm & -0.0209 mm, The maximum Von-mises stress is 9.2966 Mpa, maximum & minimum value of shear stresses are 5.3558 Mpa & -5.347 Mpa the deformations and stresses are safe in all respect and the mass of the propeller shaft is 6.4639 kg.
- **For E-glass Epoxy composite:** The maximum & minimum value of total deformation developed during the FEM analysis of propeller shaft at Torque of 225 Nm are 0.39 mm & 0 mm, The maximum & minimum value of Directional deformation are 0.39 mm & -0.39 mm, The maximum Von-mises stress is 9.8152 Mpa, maximum & minimum value of shear stresses are 5.1198 Mpa & -5.1117 Mpa the deformations and stresses are safe in all respect and the mass of the propeller shaft is 1.6469 kg.
- **For Epoxy carbon_UD:** The maximum & minimum value of total deformation developed during the FEM analysis of propeller shaft at Torque of 225 Nm are 0.37 mm & 0 mm, The maximum & minimum value of Directional deformation are 0.37 mm & -0.37 mm, The maximum Von-mises stress is 10.024 Mpa, maximum & minimum value of shear stresses are 5.0513 Mpa & -5.0434 Mpa the deformations and stresses are safe in all respect and the mass of the propeller shaft is 1.2681 kg.
- **For Kevlar Epoxy:** The maximum & minimum value of total deformation developed during the FEM analysis of propeller shaft at Torque of 225 Nm are 0.8611 mm & 0 mm, The maximum & minimum value of Directional deformation are 0.86 mm & -0.86 mm, The maximum Von-mises stress is 10.212 Mpa, maximum & minimum value of shear stresses are 5.1059 Mpa & -5.0904 Mpa the deformations and stresses are safe in all respect and the mass of the propeller shaft is 1.1528 kg.
- **For Thermoplastic polyimide 30% carbon fiber:** The maximum & minimum value of total deformation developed during the FEM analysis of propeller shaft at Torque of 225 Nm are 0.233 mm & 0 mm, The maximum & minimum value of Directional deformation are 0.233 mm & -0.233 mm, The maximum Von-mises stress is 9.2966 Mpa, maximum & minimum value of shear stresses are 5.3558 Mpa & -5.347 Mpa the deformations and stresses are safe in all respect and the mass of the propeller shaft is 1.161 kg.

It has been concluded that thermoplastic polyimide with 30% carbon fiber, Epoxy carbon UD may be used as alternate material for propeller shaft. It has been seen from the study that the thermoplastic polyimide with 30% carbon fiber is the most favorable material as alternate in place of conventional material because the maximum stress generated as same as conventional propeller shaft material and the natural frequency of the thermoplastic polyimide with 30% carbon fiber is much closed to conventional material. The weight is optimizing up to the 82.04% as compared to conventional propeller shaft material.

Finally, it may be concluded that the thermoplastic polyimide with 30% carbon fiber composite shaft has the following advantages over conventional shaft:

- Less density
- Stiffness is equivalent to SM45C Steel
- Composite material is completely fee from corrosion.
- Composite material s the best alternative for the Automobile component and propeller shaft.

7. FUTURE SCOPE:

The study of propeller shaft is a vast domain, hence further work need to be carried out to study the new design of the propeller shaft. Some of the Future works that can be carried out are fallows:

- Dynamic analysis can be carried out to determine the vibration levels on the propeller shaft.
- Fabrication of prototype of composite propeller shaft.
- Analysis can be done on reinforced composite material prototype as alternative material in order to reduce in the weight.

8. REFERENCE

[1] Hambali1, S.M. Sapuan & N. Ismail1 and Y. Nukman "Composite Manufacturing Process Selection Using Analytical Hierarchy Process" International Journal of Mechanical and Materials Engineering Vol.4 No.1, 49 -61(2009).

[2] R. P. Kumar Rompicharla & Dr. K. Rambabu " Design and Optimization of Drive Shaft with Composite Materials" International Journal of Modern Engineering Research Vol.2, Issue 5 pp-3422-3428 Sep-Oct. 2012

[3] Khoshravan & M.R. Paykani "Design of a Composite Drive Shaft and its Coupling for Automotive Application" Journal of Applied Research and Technology vol.10, pp 826-834 December 2012.

[4] R. Srinivasa Moorthy, Yonas Mitiku & K. Sridhar " Design of Automobile Driveshaft using Carbon/Epoxy and Kevlar/Epoxy Composites" American Journal of Engineering Research e-ISSN: 2320-0847 P-ISSN: 2320-0936 Vol. 2, Issue-10, pp 173-179 (2013).

[5] Sagar R Dharmadhikari at el "Design and Analysis of Composite Drive Shaft using ANSYS and Genetic Algorithm- a Critical Review" International Journal of Modern Engineering Research ISSN: 2249-6645 Vol.3, Issue 1, pp 490-496 Jan-Feb (2013).

[6] Parshuram D & Sunil Mangsetty "Design and Analysis of Composite/Hybrid Drive Shaft for Automotives" The International Journal of Engineering And Science ISSN: 2319 – 1813 ISBN: 2319–1805 Vol. 2 Issue 01 PP160-171 (2013).

[7] Harshal Bankar, Viraj Shinde & P. Baskar " Material Optimization And Weight Reduction Of Drive Shaft Using Composite Material" IOSR Journal of Mechanical and Civil Engineering Vol.10 Issue 1 PP 39-46 (Nov - Dec 2013)

[8] Bhirud Pankaj Prakash, Bimlesh Kumar Sinha "Analysis of Drive Shaft" International Journal of Mechanical and Production Engineering, ISSN: 2320-2092 Vol. 2 Issue 2 Feb-2014.

[9] Amol B Rindhe and S R Wagh "Failure Analysis And Evaluation Of A Composite Material Automotive Driveshaft By Using Fem—A Review" Int. J. Mech. Eng. & Rob. Res. ISSN 2278 – 0149 Vol. 3 No. 2 April 2014.

[10] V. S. Bhajantri, S. C. Bajantri, A. M. Shindolkar, S. S. Amarapure " Design And Analysis Of Composite Drive Shaft" International Journal of Research in Engineering and Technology eISSN: 2319-1163 pISSN: 2321-7308 Vol. 03 Special Issue: 03 May-2014.

[11] Deepti kushwaha & Gaurav Saxena "Optimal Design and Analysis of Composite Drive Shaft for a Light Commercial Vehicle" International Journal of Advance Engineering and Research Development pp 107-113 August 2014.