iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 Issue: XII Month of publication: December 2018

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue XII, Dec 2018- Available at www.ijraset.com

Design and Optimization of Composite Propeller Shaft for Light Motor Vehicle

Mr. Mali Sandip R[1], Mr. Patil Suresh S [2], Mr. Harugade Mukund L[3]
[1]*ME (Design Engineering) Student, Department of Mechanical Engineering, PVPIT Budgaon, Sangli, India*
[2]*Associate professor, Department of Mechanical Engineering, PVPIT Budgaon, Sangli, India*
[3]*Assistant professor, Department of Mechanical Engineering, PVPIT Budgaon, Sangli, India*

Abstract: This paper deals with design and analysis of a composite propeller shaft. During the transmission of power from the engine to the differential gear box of a rear wheel drive vehicle there is a problem of failure after long run of the vehicle due to low specific stiffness and strength of the material. The propeller shaft should be capable to provide smooth power transmission at varying speeds required by the vehicle. A single piece propeller shaft can be preferred in present market instead of a two piece propeller shaft so that the weight of the propeller shaft can be reduced. Presently used materials in the market for manufacturing are Steel. The purpose of this paper is to design the propeller shaft made of glass fiber and compare results with steel shaft. Also torque transmission capacity calculated by torsion test for both shafts. And also by suitable FEA software determining natural frequency and mode shape of the shaft. Using similar FEA software predicted failure of composite propeller shaft.
Keywords: Composite shaft, Weight optimisation, FEA, Mode shape analysis etc.

I. INTRODUCTION

The propeller shaft is a unit of the automobile transmission system that connects the gear box output shaft to the input shaft of the differential at the rear axle. It transmits the power from the engine, clutch and gear box to the driving wheels of the vehicle through final drive and differential unit. It has to perform two functions. One is to transmit motion at an angle which is varying frequently and the other is to accommodate changes in length between the gear box and rear axle. Due to its longer length and high speeds, the propeller shaft has a tendency to vibrate at certain critical speeds. The critical speed varies directly as the shaft diameter and inversely as the square of its length. To keep theoretical speed frequency above the driving speed range, the propeller shaft s need to be made with diameter as large as possible compared to its length. However, the increase in diameter increases its moment of inertia which would decrease its acceleration and deceleration. To minimize the whirl, achieve the decrease in shaft length. For small vehicles single length and for large vehicles center of the shaft is supported by a bearing unit. In this paper design and optimization of composite shaft is done.

II. LITERATURE REVIEW

Anamika, Anindya Bhar et al [1] In the present study, the finite element analysis of design variables of composite materials orientation and stacking sequence provided an insight into their effects on drive shaft's, The study also done weight optimization of drive shaft. FEA results showed that the natural frequency increases with decreasing fiber angles.

Srikanth Reddy et al [2] this paper deals with design and analysis of a drive shaft. During the transmission of power from the engine to the differential gear box of a rear wheel drive vehicle there is a problem of failure after long run of the vehicle due to low specific stiffness and strength of the material. The drive shaft should be capable to provide smooth and continues power transmission at varying speeds required by the vehicle. A single piece drive shaft can be preferred in present market instead of a two piece drive shaft so that the weight of the drive shaft can be reduced. Presently used materials in the market for manufacturing are Cast Iron, Cast Steel. The purpose of this paper is to design the drive shaft made of Ni-Cr steel and compare it with steel material. The design is done in Solid works software and analyzed using ANSYS.

A. n. s sheik Abdul Rahman et al [3] in this paper, the aim is to replace a forged steel drive shaft by a composite drive shaft with enhanced mechanical property with less weight. In the conventional steel drive shaft failure analysis of various methodologies was carried out to find root causes of shaft failure. In this paper aluminum was chosen as matrix metal of composite, and reinforcement materials are aluminum oxide (Al2O3) and zirconium diboride (ZrB4) was fabricated. Various mechanical test are to be conducted to determine the mechanical properties. Based on the results of the properties the modelling of the drive shaft assembly is to be done using solid works 2012 and analyzed using ANSYS 12.0 software. New composite material of hybrid aluminum metal matrix composite that would give the maximum weight reduction without affecting the dynamic factors of drive shaft at resonance state, while conforming to the stringent design parameters of passenger cars and light commercial vehicle with the help of ANSYS 12.0 software is to be developed. The various stress analysis will be performed based on finite element analysis and static structural simulation method. The stiffness of the drive shaft will be studied by plotting load versus deflection curve for whole working load range which shows the linear relationship. Using the constant amplitude loading, the fatigue damage and life of the shaft will be studied. G V Mahajan et al [4] in this paper design and vibrational analysis of composite propeller shafts. The aim is to replace a metallic drive shaft by a composite shaft. Designing of a composite shaft is divided in two main parts: design of the composite shaft and design of couplings. In composite shaft design parameters such as critical speed, static torque and adhesive joints are studied; the behavior of materials is considered nonlinear isotropic for adhesive, linear isotropic for metal and orthotropic for composite shaft. Analysis can be done on finite element software (ANSYS).

V. S. Bhajantri et al [5] this paper steel shaft is replaced by composite shaft. In this work optimisation of stacking sequence can be done. Showing variation in stress by fiber angle orientation change.in this paper comparison done for steel and composite shaft for max stress and deflection

III. DESIGN OF SHAFT

The propeller shaft will be designed for Maruti Omni car or light passenger vehicle. The propeller shaft will be designed considering constraints and required specifications of the Omni car. The maximum engine torque for the Maruti Suzuki Omni is 59 Nm and the maximum gear ratio is 1:2.6. Hence the torque transmission capability of the driveshaft should be larger than the 708 Nm and the fundamental natural bending frequency must exceed minimum natural bending frequency of the passenger car, therefore it should be more than the 80 Hz. The maximum torque transmission capability of the propeller or drive shaft should be larger than the 3,500 Nm. The outer diameter of the propeller should be such that it should not exceed 100 mm due to space limitation. Here, the outer diameter of the steel shaft is taken as 52.5 mm with 3.32 mm thickness. The driveshaft is to be designed for the following design requirements as shown in table I

TABLE I Design requirements and specifications

Sr No	Name	Unit
1	Engine torque (T)	59 Nm
2	Ultimate Torque (Tmax)	3500 Nm
3	Max. Speed of Shaft (rpm)	5000 Rpm
4	Outer Diameter (mm)	52.5 mm
5	Inner Diameter (mm)	45.86 mm
6	Length of shaft (mm)	660 mm

A. *Design of Steel Propeller Shaft*:

Various formulas for designing shaft as given below

1) *Mass Of Steel Propeller Shaft (M)* -

m=$\rho AL=\rho \times \pi/4 \times ({D_0}^2 \times {D_i}^2) \times L$

Where,

ρ=7800 kg/m^3 for steel

d_o= outer diameter

d_i = inner diameter

Now we get,

m=7800$\times$ $\pi/4$ $\times$($0.0525^2 \times 0.0448^2$) X 0.660

m = 3.316 kg

2) *Torque Transmission Capacity Of Steel Shaft*: Torsional strength of steel shaft is calculated by using the following equation,

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{l}$$

Where, τ is the shear strength of the shaft.

$$\tau = \frac{G.\theta.r}{l}$$

Where G= 80 Gpa and θ= 5^0

$$\tau = \frac{80 \times 10^9 \times 5 \times \pi \times 0.026}{0.660 \times 180}$$

$$\tau = 275.02\, N/mm^2$$

The torsional strength of the steel shaft will be calculated by,

$$\frac{T}{J} = \frac{\tau}{r}$$

Where J is the polar moment of inertia.

$$J = \frac{\pi}{32}(d_o^4 - d_i^4)$$

$$J = 3.49 \times 10^{-7}\ m^4$$

Hence, substituting all known values in torque equation, we get,

$$T = 3691\ Nm$$

The torque transmission capacity of the steel shaft is 3691 Nm.

3) Torsional Buckling Strength of Steel Shaft

Tcr= $(2\pi r^2 t)(0.272)(Ex\ Ey^3)^{0.25}(t/r)^{1.5}$

Where,

r_m= mean radius of the shaft=0.024 m

t = wall thickness of the drive shaft

E = Young's modulus

By substituting all known values in the above equation,

$$T_b = 56263\ Nm\ (> 3500\ Nm)$$

Hence, $T_b > T_{max}$

Therefore, the design is safe under torsional buckling.

4) Bending Natural Frequency of Steel Shaft: The bending natural frequency of the steel shaft is given by,

$$f_{n_b} = \frac{\pi}{2}\sqrt{\frac{EI}{m'L^4}}$$

Here, a moment of inertia of hollow shaft is given by,

$$I_x = \frac{\pi}{64}(d_o^4 - d_i^4)$$

$$= 1.749 \times 10^{-7} m^4$$

The mass per unit length of the steel shaft is given by,

$$m' = \rho\frac{\pi}{4}(d_o^2 - d_i^2) = 5.02\ kg/m$$

Upon substitution, the fundamental bending natural frequency is,

$$f_{n_b} = 308.44\ Hz\ (> 80Hz)$$

Thus, $f_{n_b} > f_{n_b\,(min)}$

Thus, the designed steel propeller shaft meets all the requirements.

5) Critical speed of shaft: The critical speed of shaft can be calculated by the following formula,

$$N_{cr} = 60 \times F_{nb}$$

$$N_{cr} = 18480\ r.p.m$$

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue XII, Dec 2018- Available at www.ijraset.com

B. Design of Composite Propeller Shaft

1) Selection of Reinforcement Fiber for the Shaft

TABLE II- Properties of commonly used fibers

Material	Young's modulus (Gpa)	Shear Modulus (Gpa)	Axial Poisson's Ratio	Ultimate strength tension (Mpa)	Strain to Failure (%)	Density (Kg/m3)
Carbon fiber HM	385	20	0.23	3630	0.4	2170
E-Glass Fiber	72	27.7	0.23	3450	4.7	2580
S-Glass Fiber	87	33.5	0.3	4710	5.6	2460
Kevlar 49 Fiber	124	5	0.3	3850	2.8	1440
Steel	206	81	0.27	648	4	7800
Aluminium	69	25.6	0.35	234	3.5	2600

2) *Selection of Resin System:* The mixture of the polymer material with various additives or chemically reactive components is known as the Resin.

TABLE III- properties of commonly used resin

Material	Young's modulus (Gpa)	Shear Modulus (Gpa)	Axial Poisson's Ratio	Ultimate strength tension (Mpa)	Strain to Failure (%)	Density (Kg/m3)
Epoxy	3.1	1.2	0.3	70	4.0	1200
Polyester	3.5	1.4	0.3	70	5.0	1100

3) *Design Considerations:* The Maruti Suzuki Omni's propeller shaft is selected Let Assume the following-

a) The thickness of the driveshaft is taken as 10.4 mm.

b) The Length of the driveshaft is 660 mm.

c) The outer diameter of the shaft is 56 mm.

d) The shaft needs to withstand the Torsional buckling (T_b) such that $T_b > T_{max}$.

e) The minimum bending natural frequency is 80 Hz for propeller shaft.

f) The maximum torque transmission capacity of the propeller shaft in passenger cars is 3500 Nm.

g) The factor of safety = 3.

The available volume fraction is from 60% to 85%. Here, 60% fiber volume fraction of Carbon/Epoxy shaft (V_f = 60%) is selected, as its properties are readily available with ply thickness as 0.13mm. Therefore, total layers will be,

$$n = \frac{\text{thickness of shaft}}{\text{ply thickness}}$$

$$n = \frac{10.4}{0.13}$$

$$n = 80\ layers$$

4) *Torsional Strength of Composite Propeller Shaft*

$$\tau = \frac{G.\theta.r}{l}$$

$$\tau = 31.77\ N/mm^2$$

Thus, the torsional strength of the composite shaft will be calculated by,

$$T = \frac{\tau \times J}{r}$$

Therefore, putting all values together, we get,

$$T = 928 \text{ Nm}$$

The torque transmission capacity of the steel shaft is 928 Nm

5) Torsional Buckling Strength of Composite Shaft

$$T_b = 2\pi r_m^2 t \times 0.272 \times (E_x \times E_y^3)^{\frac{1}{4}} \times \left(\frac{t}{r_m}\right)^{\frac{3}{2}}$$

Substituting values in above equations.

$$T_b = 62.826 \times 10^3 \text{ Nm } (> 3500 \text{ Nm})$$

Hence, $T_b > T_{max}$

Therefore, the design is safe under torsional buckling.

6) Bending Natural Frequency of Composite Shaft: The bending natural frequency of the composite shaft is given by.

$$f_{n_b} = \frac{\pi}{2}\sqrt{\frac{E_x I}{m' L^4}}$$

Here, a moment of inertia of hollow shaft is,

$$I_x = 4.07 \times 10^{-7} m^4$$

The mass per unit length of the composite shaft is,

$$m' = 3.09 \text{ kg/m}$$

Upon substitution, the fundamental bending natural frequency is,

$$f_{n_b} = 189.41 \text{ Hz } (> 80\text{Hz})$$

Here, the fundamental bending natural frequency of the composite shaft is greater than the minimum bending natural frequency. Therefore, the designed composite shaft is safe.

7) Critical speed of shaft: The critical speed of shaft can be calculated by the following formula,

N_{Cr} =60 $\times F_{nb}$

N_{Cr} =11364 r. p. m

8) Mass of Composite Shaft: Density of glass/epoxy fiber is 2080 kg/m^3.

M = $\rho \times \frac{\pi}{4}(D_o^2 - D_i^2) \times L$

M = 2.04 Kg

The mass of the composite propeller shaft is 2.04 kg.

IV. OPTIMISATION

A. Teaching Learning Based Optimization (TLBO) for weight

1) DESIGN VARIABLES: D_I, D_O, V_F

2) RANGE OF VARIABLES:

D_I = 30 – 35 MM

D_O = 50 - 65 MM

V_F = 0.5 – 0.6

B. Constraints

M = 2.5KG

C. Objective Function

M = P A L

$$\rho_c = \rho_f \frac{V.Fr}{V.FC} + \rho r \frac{V.Fr}{V.Fc}$$

POPULATION SIZE = 5

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue XII, Dec 2018- Available at www.ijraset.com

TABLE IV- Initial Population

Vf	Do(mm)	Di(mm)	F(x) = M(kg)
0.60	50	30	1.692
0.57	54	30	2.088
0.60	57	35	2.142
0.5	60	28	2.773
0.55	58	33	2.323

TABLE V- Final Population

Vf	Do(mm)	Di(mm)	F(x) = M(kg)
0.60	50.3612	33	1.530
0.5907	50.34	30.96	1.655
0.60	50.5	33	1.545
0.5988	50.26	31.27	1.636
0.5999	51.4	33	1.642

Form this table Torque transmitting capacity and torque buckling capacity is calculated,

1) D_i = 33 mm
2) D_o = 50.5 mm
3) t = 8.75 mm
4) V_f = 0.6
5) M = 1.546kg
6) T = 595.19 Nm
7) Tb =39025 Nm

The weight of the glass fiber shaft is optimized. The mass of shaft M= 1.546 kg and torque transmission capacity is 595.19 Nm. Now we have to optimize torque transmission capacity. This can be achieved by optimizing stacking sequence.

D. Optimization of Stacking Sequence

Here, we assume stacking sequence as $[\theta_1/\theta_2/\theta_3/\theta_4]$. In order to have good fatigue resistance as well as torsional stiffness, fiber orientation angle of $\pm 45^\circ$ is used. The best stacking is to locate the layers of $\pm 45^\circ$ fiber orientation angles together and far near the inner face of the shaft.

We optimize only $[\theta_1/\theta_2]$ For D_i = 33 mm and D_o = 50.5 mm and L=660 mm as shown in the table below,

TABLE VI- Optimization of Stacking Sequence

Sr.no	θ_1	θ_2	Stacking sequence	T(Nm)	T_b(Nm)
0	40	-40	[+40°/-40°]	848.1028759	17569.28371
1	41	- 41	[+41°/-41°]	854.7459414	17517.19686
2	42	-42	[+42°/-42°]	859.9466359	17510.82122
3	43	-43	[+43°/-43°]	863.6796222	17554.31582
4	44	-44	[+44°/-44°]	865.9267135	17651.83235
5	**45**	**-45**	**[+45°/-45°]**	**866.6769624**	**17807.45841**
6	46	-46	[+46°/-46°]	865.9267135	18025.14906
7	47	-47	[+47°/-47°]	863.6796222	18308.64663
8	48	-48	[+48°/-48°]	859.9466359	18661.38893
9	49	-49	[+49°/-49°]	854.7459414	19086.40729
10	50	-50	[+50°/-50°]	848.1028759	19586.21651

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue XII, Dec 2018- Available at www.ijraset.com

From above table, stacking sequence for shaft is given below for shaft having Di = 33 mm and D_o = 50.5 mm and L=660 mm,

1) Optimum Stacking Sequence: [+45°/-45°]
2) T = 867 Nm
3) T_b = 17807 Nm
4) f_{nb} = 115 Hz (>80 Hz)

V. EXPERIMENTAL INVESTIGATION

A. Test rig for Torsional Strength

Fig 1-Test rig for torsional strength

TABLE VII- Result for steel shaft

Sr No	Torque	The angle of twist (in degree)
1	0	0
2	170	0.3
3	270	0.5
4	350	0.6
5	540	1
6	690	1.3
7	790	1.6
8	940	1.9
9	1080	2.1
10	1240	2.4
11	1390	2.7
12	1450	2.9
13	1710	3.2

TABLE VIII- Result for composite shaft

Sr No	Torque	The angle of twist (in degree)
1	0	0
2	80	0.6
3	180	1.2
4	260	1.7
5	360	2.3
6	460	2.9
7	550	3.5
8	650	4
9	760	4.6
10	840	5.2
11	990	6.3
12	1140	7.4
13	1210	8
14	1270	8.6
15	1350	9.1

B. Test rig for Natural Frequency

Fig 2-Test rig for Natural Frequency

Result obtained in natural frequency test for steel shaft and the composite shaft is given below,

TABLE IX Test rig for Natural Frequency

Sr no	Shaft	Frequency
1	Steel shaft	287 Hz (> 80Hz)
2	Composite shaft	261 Hz (> 80Hz)

VI. FINITE ELEMENTAL ANALYSIS

A. Finite Element Analysis of Steel Propeller Shaft

1) *Static Analysis:* Directional deformation (Y-axis) for steel propeller shaft when the moment of 3500 Nm is applied. From this deformation, the angle of twist for the shaft can be calculated.

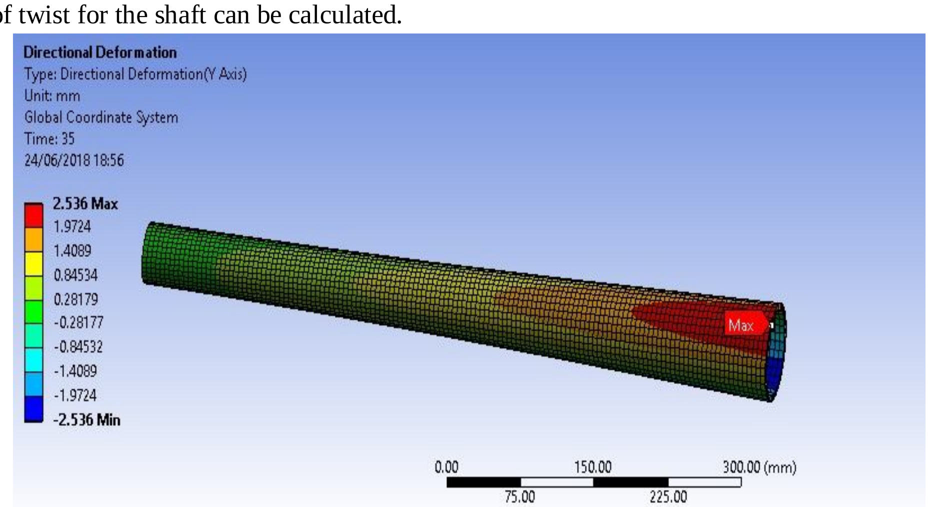


Fig 3- static analysis for steel shaft

2) *Modal Analysis:* In the modal analysis, the steel propeller shaft is simply supported at both the ends i.e. Y directional displacement is assumed to be zero at both the ends. Fig.4 shows result in values for first natural frequency and corresponding mode shape for steel propeller shaft. It is observed that the first natural frequency of the steel shaft is greater than the permissible natural frequency (80 Hz).

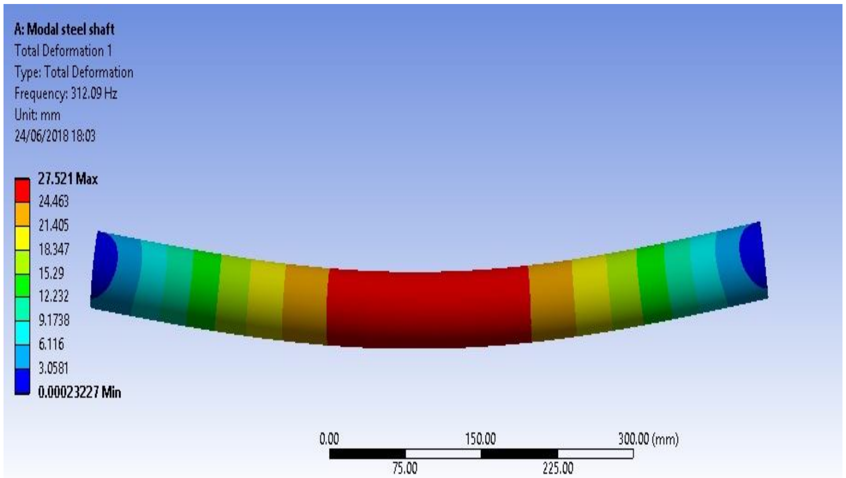


Fig 4- Modal analysis for steel shaft

3) *Buckling Analysis:* Now showing torsional buckling for steel propeller shaft at 3500 Nm

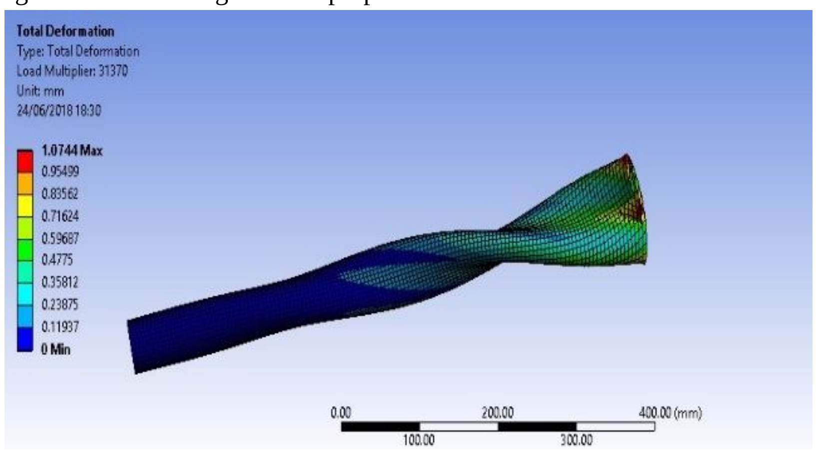


Fig 5- Buckling analysis for steel shaft

B. Finite Element Analysis of Composite Propeller Shaft

1) *Static Analysis:* Directional deformation (Y-axis) for composite propeller shaft when the moment of 500 Nm is applied. From this deformation, the angle of twist for the shaft can be calculated.

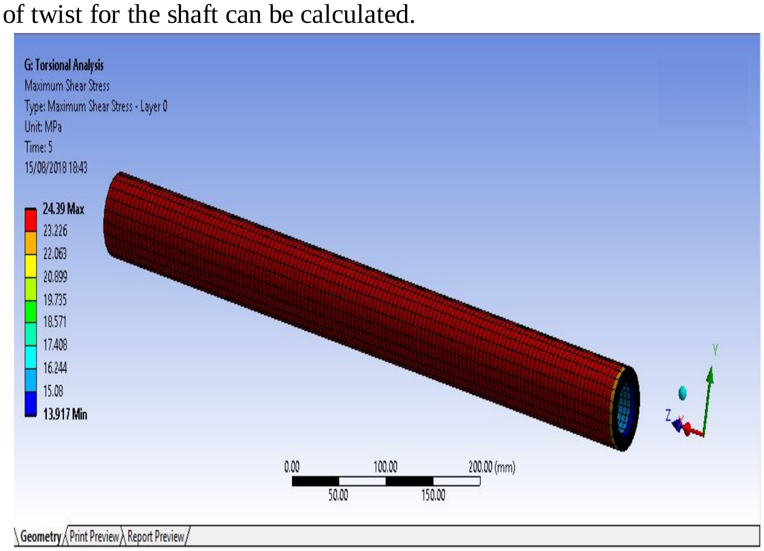


Fig 6- static analysis for composite shaft

2) *Modal Analysis:* Fig shows result in values for first natural frequency and corresponding mode shape for the composite propeller shaft. It is observed that the first natural frequency of the composite shaft is greater than the permissible natural frequency (80 Hz).

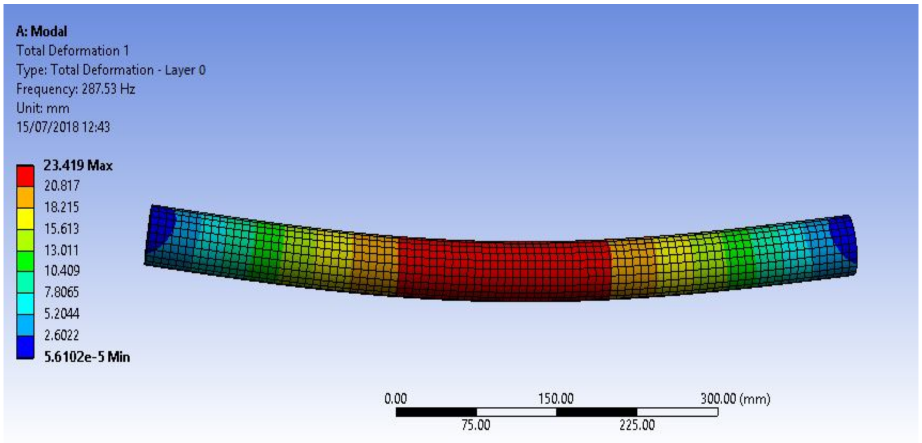


Fig 7- Modal analysis for composite shaft

3) Buckling Analysis**:** Shows values of total deformation obtained with the load multiplier for the composite propeller shaft. It is observed that the buckling strength of the composite propeller shaft is greater than the permissible value. (3500Nm)

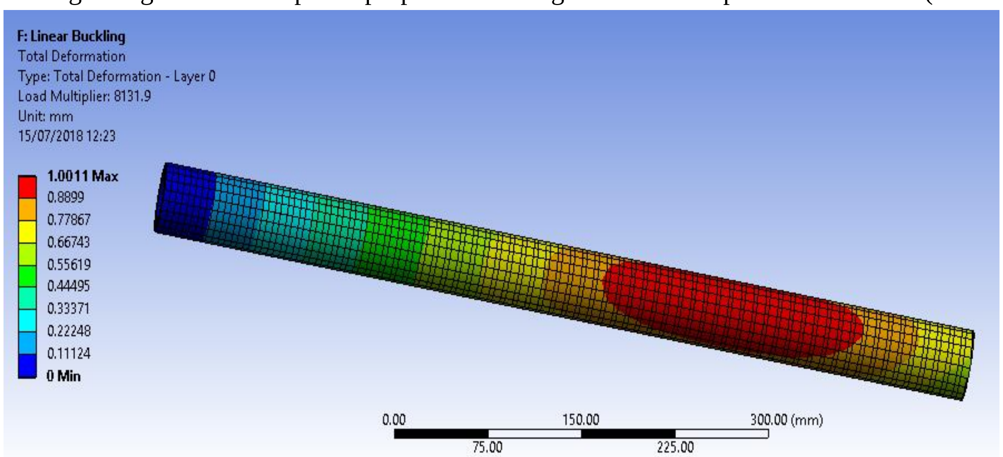


Fig 8- Buckling analysis for composite shaft

4) *Failure of composite shaft as per Tsai Wu criteria:* Tsai-Wu failure criterion is a generalized form of Von-Mises criterion which is extended for a composite material in principal material coordinate system and condition of no failure is given by,

$$F(\sigma_1, \sigma_2, \sigma_3, \tau_{12}, \tau_{23}, \tau_{13}) < 1$$

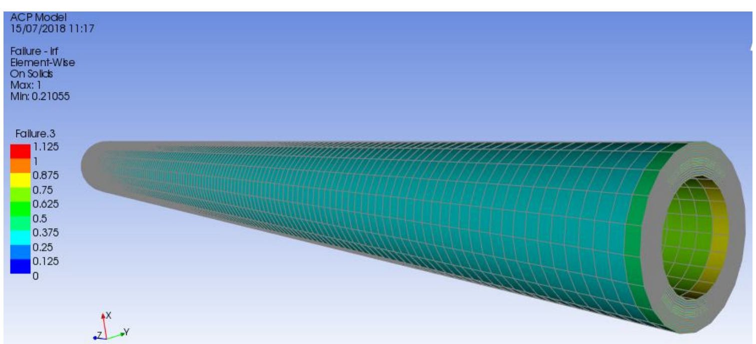


Fig 9 Failure analysis for composite shaft

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue XII, Dec 2018- Available at www.ijraset.com

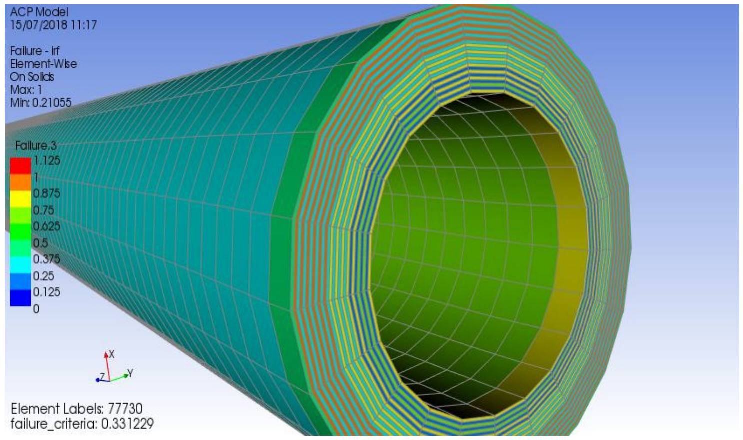


Fig 10 Failure analysis for composite shaft (zoom view

According to Tai Wu criteria failure occurs of composite propeller shaft at 2049 Nm of torque.

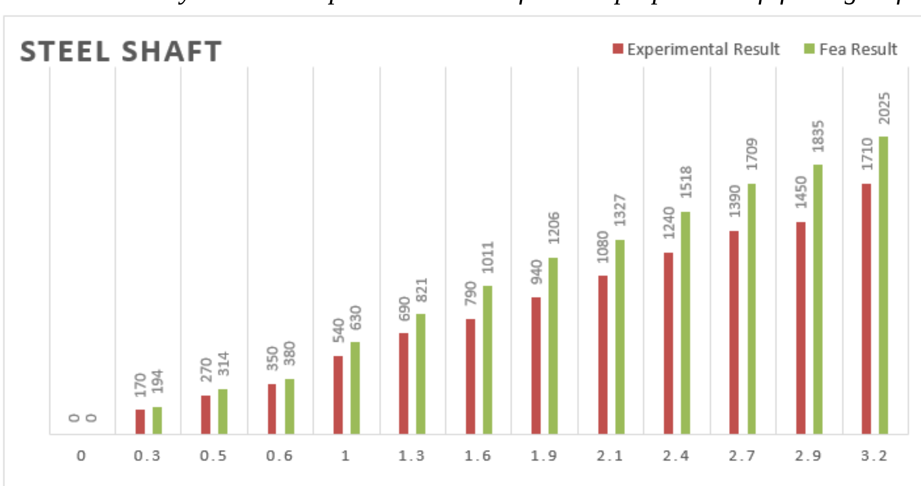
VII. RESULT AND DISCUSSION

A. Comparison of Steel Shaft and Composite Shaft

TABLE X Comparison of steel and composite shaft

		Steel Propeller Shaft	**Composite Propeller Shaft**		
Sr. No.	**Parameters**	**Theoretical**	**Theoretical**	**Theoretical without angle Optimization**	**Theoretical with angle Optimization**
1	Thickness (t in mm)	3.32	10.4	8.75	8.75
2	Weight (M in Kg)	3.316	2.04	1.546	1.546
3	Torque Transmission Capacity (T in Nm)	3691	928	595.19	867
4	Torsional Buckling Strength (T_b in Nm)	56263	62826	39025	17807
5	Bending Natural Frequency (f_{nb} in Hz)	308	189.41	175	115
6	Critical speed (r. p. m)	18840	13364	10500	6900

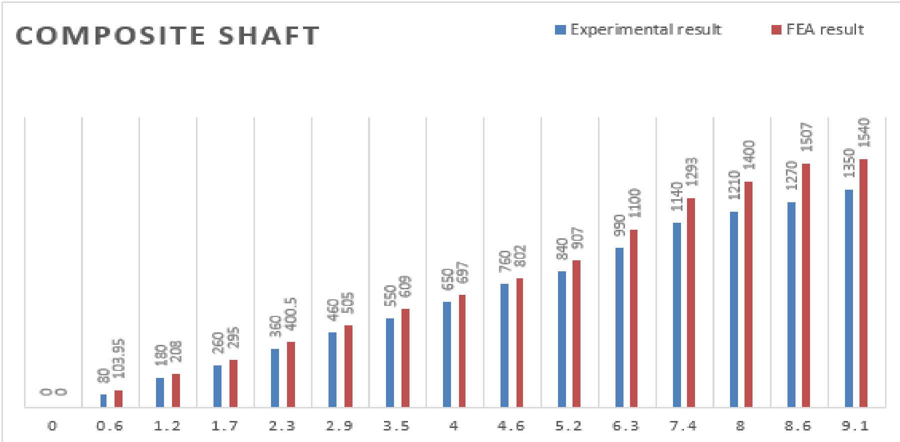
B. Comparison of the result obtained by FEA and Experimental result for Steel propeller shaft for angle of twist



Graph 1 Comparison of the result obtained by FEA and Experimental result for Steel propeller shaft for angle of twist

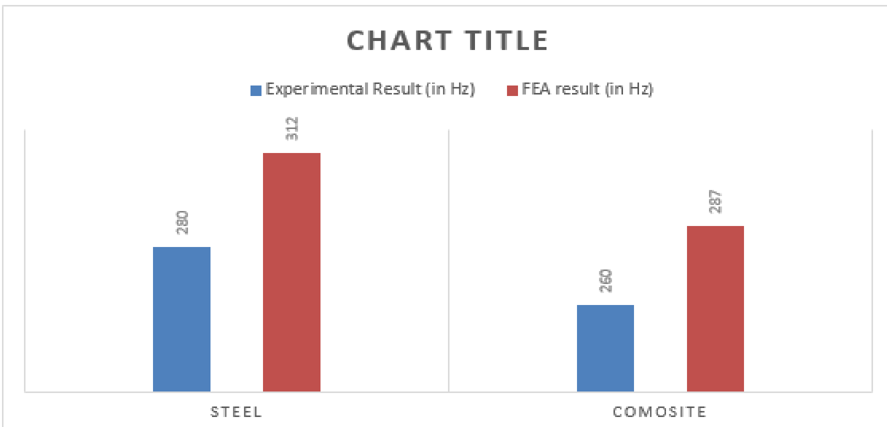
International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue XII, Dec 2018- Available at www.ijraset.com

C. Comparison of the result obtained by FEA and Experimental for Composite propeller shaft for angle of twist



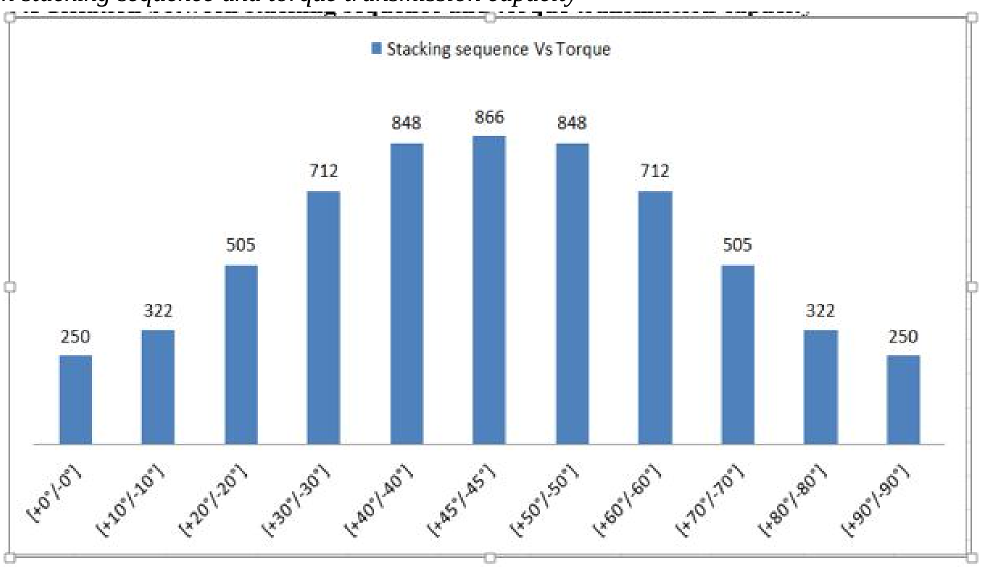
Graph 2 Comparison of the result obtained by FEA and Experimental for Composite propeller shaft for angle of twist

D. Comparison of Natural frequency obtained by experimental investigation and FEA result for steel shaft and composite shaft



Graph 3 Comparison of Natural frequency obtained by experimental investigation and FEA result for steel shaft and composite shaft

E. Relation between stacking sequence and torque transmission capacity



Graph 4 Relation between stacking sequence and torque transmission capacity

F. Comparison of Weight calculated Theoretical and actual for steel shaft and composite shaft*:*

Table XI Comparison of Weight calculated Theoretical and actual for steel shaft and composite shaft

Sr No	Material	Theoretical weight (in Kg)	Actual weight (in Kg)
1	Steel shaft	3.316	3.490
2	Composite shaft	1.546	1.540

The composite shaft having minimum weight as compared to a steel shaft.

Actual shaft weight optimization in % = 3.490 – 1.540/3.490*100

= 55.87 %

Therefore glass fiber composite shaft 55.87% lighter than steel shaft and able to transmit designed torque

VIII. CONCLUSION

A. The shaft design is difficult due to various loads acting on it. There is two options either the shaft is solid or hollow. The solid shaft can transmit maximum torque but it also increases in weight of the shaft and hence the first mode natural frequency decreases. The outer surface of the shaft facing mostly stress coming on it and inner layer experiencing less stress. Because of inner layers weight is increasing hence hallow shaft is selected.

B. The stress distribution and maximum deformation of the shaft are all depend on the stacking sequence of the shaft. The angle determination is a very important factor while designing a composite shaft. For this work, Optimum Stacking Sequence is [+45°/-45°] for the length of 660 mm.

C. After determining diameter, length and optimum stacking sequence shaft are manufactured. And it observed that Glass fiber composite shaft 55.87% lighter than steel shaft and able to transmit designed torque.

D. The glass fiber composite shaft is designed to meet safe design requirement as to transmit designed torque, and bending natural frequency for the composite shaft is 260 Hz.

E. Static analysis, modal analysis and buckling analysis of composite shaft is done by FEA software.

F. Teacher-learner based optimization technic is used for optimization of the diameter of the shaft.

G. Using FEA software determined natural frequency and mode shape of the propeller shaft.

H. Using FEA software predicted failure for the composite propeller shaft. The shaft is failing according to Tsai Wu criteria at a torque of 2049 Nm.

REFERENCES

[1] Anindya Bhar "Free vibration analysis and weight optimization of composite drive shaft" Indian J sci research 77-81, 2017.
[2] Shrikant reedy "Evaluation on the failure of an automobile drive shaft" International journal on latest trends in engineering technology, Vol 8, Issue 8, Pp 59-67
[3] A n s sheikh "Design to replace steel drive shaft in an automobile with hybrid aluminum metal matrix composites" International journal and magazine of engineering and technology, ISSN no 2348-4845
[4] G V Mahajan " Composite Material: A Review over Current Development and Automotive Application" IJOSR, Volume 2, Issue 11, November 2012 1 ISSN 2250-3153
[5] V S Bhajantri "Design and analysis of composite drive shaft" IJRET, ISSN-2319-1163
[6] V. Jose Ananth Vino, Dr. J H Husssain "Design, and analysis of propeller shaft" International journal of innovative research in science, Engineering and technology vol 4, issue 8, August 15
[7] S R Dharmadhikari "Design and analysis of composite drive shaft using ANSYS and GA" IJOR vol 3, Issue 1, Jan-Feb 13 pp 490-496
[8] S. Shinde "Design and optimization of propeller shaft made up of composite materials" International engineering journal pp 1046-1053
[9] Bhirud Pankaj Prakash "Analysis of drive shaft" international journal of mechanical and production engineering, ISSN 2320-2092, vol 2, issue 2, Feb 14
[10] Salaisivabalan T, Natarajan R "Design, and analysis of propeller shaft of an automobile using composite materials" international journal of innovative research of science, engineering, and technology, vol 5, issue 5, may 2015
[11] Parshuram D, "Design and analysis of hybrid drive shaft for automotive" The International Journal of Engineering And Science (IJES), vol 2, issue 2, P 160-171,2013
[12] Bipin Wankhede "Failure analysis of automotive front wheel drive shaft "Journal of information knowledge and research in mechanical engineering, ISSN 0975-668XI, vol 4, issue 1
[13] Chaitanya Rothe "Design and Analysis of Composite Material Drive Shaft" International Journal of Innovative and Emerging Research in Engineering Volume 2, Special Issue 1 2015
[14] H. bankar, "Material optimization and weight reduction of the drive shaft by using composite material" IOSR journal, volume 10, issue 1, Nov-dec 13
[15] SP Maske "Failure analysis and design modification of propeller shaft of bus" IJRASET, vol 4, Issue 10.ISSN 2321-9653

[16] D Khushwa "Optimal analysis and composite drive shaft for a light motor vehicle" IJAERD, ISSN 2348-6406.
[17] B.C brahmana "Structural design of composite drive shaft for rear wheel drive engine" Industrial science, Vol 1, Issue 5, June 2014
[18] S.S Dhore "FEA and Optimisation of composite drive shaft" IJIERT, ISSN: 2394-3696, Vol 3, Issue 10 oct 2016
[19] Arun Ravi "Design and analysis of drive shaft" International review of applied engineering research, ISSN NO-2248-9967, Issue 1 Vol 4, Pp21-28.
[20] Dr. R Mohan "design and analysis of composite drive shaft" IJSER, ISSN NO-2229-5518 Vol 7, Issue 5, May 2016.
[21] S.R Mohan "Design and FEA of automotive propeller shaft using composite materials " SSRG International journal of mechanical engineering, special issue April 2017
[22] P Jaya Naidu "Analysis of drive shaft for automotive applications" IOSR vol 10, Issue 2, nov 2013, pp-43-46
[23] D.S Ghorpade "Design and analysis of composite drive shaft "IJORET March 2015
[24] V Maheta "Design, Analysis and optimization of composite drive shaft" IJIRST, Vol 1, Issue 12, May 2015