International Review of Applied Engineering Research.
ISSN 2248-9967 Volume 4, Number 1 (2014), pp. 21-28

http://www.ripublication.com/iraer.htm

# Design, Comparison and Analysis of a Composite Drive Shaft for an Automobile

**Arun Ravi**

*PG Schola, M.Tech- CIM; TKM College of Engineering; Kollam, Kerala, India.*

**Abstract**

Almost all automobiles (at least those which correspond to design with rear wheel drive and front engine installation) have transmission shafts. The weight reduction of the drive shaft can have a certain role in the general weight reduction of the vehicle and is a highly desirable goal, if it can be achieved without increase in cost and decrease in quality and reliability. It is possible to achieve design of composite drive shaft with less weight to increase the first natural frequency of the shaft and to decrease the bending stresses using various stacking sequences. By doing the same, maximize the torque transmission and torsional buckling capabilities are also maximized[4].This work deals with the replacement of a conventional steel drive shaft with High Strength Carbon drive shafts for an automobile application.Keywords: Propeller shaft, Composites, Carbon Fibre High strength, Structural Steel\

## 1. Introduction

The advanced composite materials such as Graphite, Carbon, Kevlar and Glass with suitable resins are widely used because of their high specific strength (strength/density) and high specific modulus (modulus/density)[1]. Advanced composite materials seem ideally suited for long, power driver shaft (propeller shaft) applications. Their elastic properties can be tailored to increase the torque they can carry as well as the rotational speed at which they operate. The drive shafts are used in automotive, aircraft and aerospace applications[3]. The automotive industry is exploiting composite material technology for structural components construction in order to obtain the reduction of the weight without decrease in vehicle quality and reliability[2]. It is known that energy conservation is one of the most important objectives in vehicle design and reduction of weight is one of the most effective measures to obtain this result. Actually, there is almost a direct proportionality between the weight of a vehicle and its fuel consumption, particularly in city driving.Main objective of the present study is to

1. Modeling of the High Strength Carbon/Epoxy composite drive shaft using ANSYS.
2. Static and Buckling analysis are to be carried out on the finite element model of the High Strength Carbon/Epoxy composite drive shaft using ANSYS.
3. To investigate
   a) The stress and strain distributions in High Strength Carbon composite drive shafts.
   b) Calculate mass reduction when using the High Strength Carbon

## 2. Materials and Methods

### 2.1 Modeling of implant & surrounding bone

The 3D Model of Propeller Shaft is done using Solidworks which enables design automation and product development processes and thereby brings about an optimum design.The major dimensions of propeller shaft considered for present analysis are as follows :-

A. Hollow shaft

I. Outside diameter of hollow shaft = Outside diameter of solid shaft

doh = 100mm,dih= 50mm K=dih/doh=0.5 L= 900mm

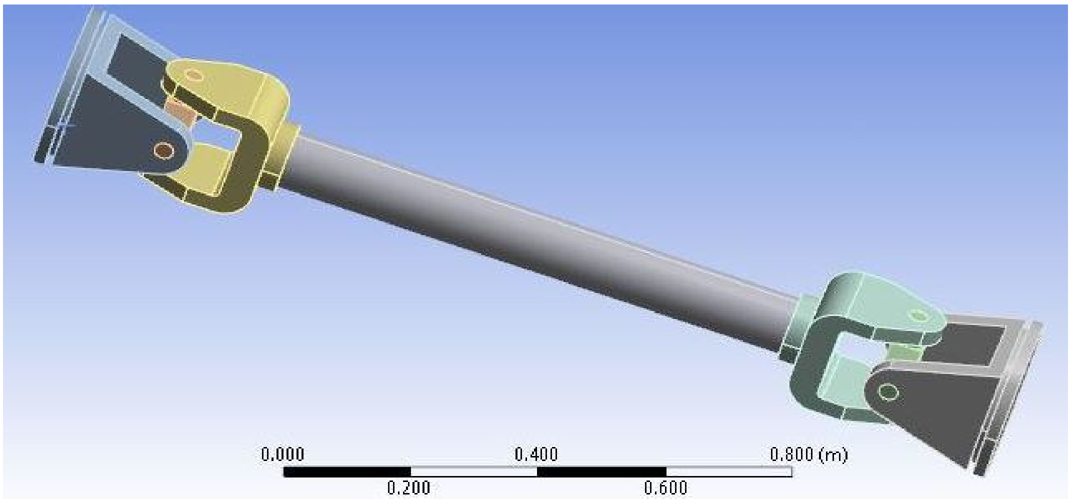


**Fig. 1**: 3D modelMaterial properties.

In this study the mechanical properties of the propeller shaft are treated to be Isotropic, homogenous and linear elastic. The High Strength Carbon are selected for composite drive shaft which is being compared with Structural Steel, which is presently used nowadays. The Table shows the properties of the High Strength Carbon and Structural Steel.

**Table 1**: Material Property of HS Carbon/Epoxy and HM Carbon/ Epoxy

| Structural | |
|---|---|
| Young's Modulus | 4.e+005 MPa |
| Poisson's Ratio | 0.36 |
| Density | 6.e-006 kg/mm³ |
| Tensile Yield Strength | 2500. MPa |
| Compressive | 3150. MPa |

**Table 2**: Material Property Steel (SM45C).

| | |
|---|---|
| Young's Modulus | 2.e+005 MPa |
| Poisson's Ratio | 0.3 |
| Density | 7.85e-006 kg/mm³ |
| Thermal Expansion | 1.2e-005 1/°C |
| Tensile Yield Strength | 250. MPa |
| Compressive Yield Strength | 250. MPa |
| Tensile Ultimate Strength | 460. MPa |
| Compressive Ultimate Strength | 0. MPa |

**2.2 Finite element model**

For the present study ANSYS Workbench 12.0 is used. The propeller shaft model is imported into Workbench. The imported model is meshed using Tetrahedral and Hexahedral elements.

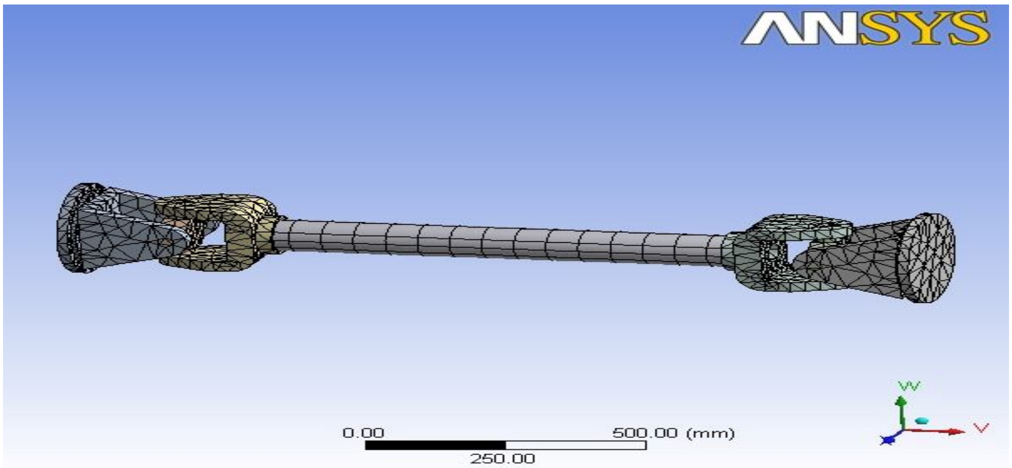


**Fig. 2**: FE model.

**2.3 Loading and boundary conditions**

Maximum load condition for a shaft is the condition at which the Differential (Wheel) movement is arrested and the Gearbox is on action. So that we are applying three boundary conditions, a Moment of 350000 Nm (anti-clockwise), a Rotational Velocity of 650 rad/s ( anti-clockwise) and a fixed end

## 3. Result

In the present FEA study Total deformation, equivalent Stress, Equivalent strain are considered for evaluating the results.The Total Deformation of the Carbon Fibre (High Strength) of Diameter 100 – 50 is calculated and the values obtained are the Maximum Deformation is 9.5236 e -5m and the minimum deformation is 0.

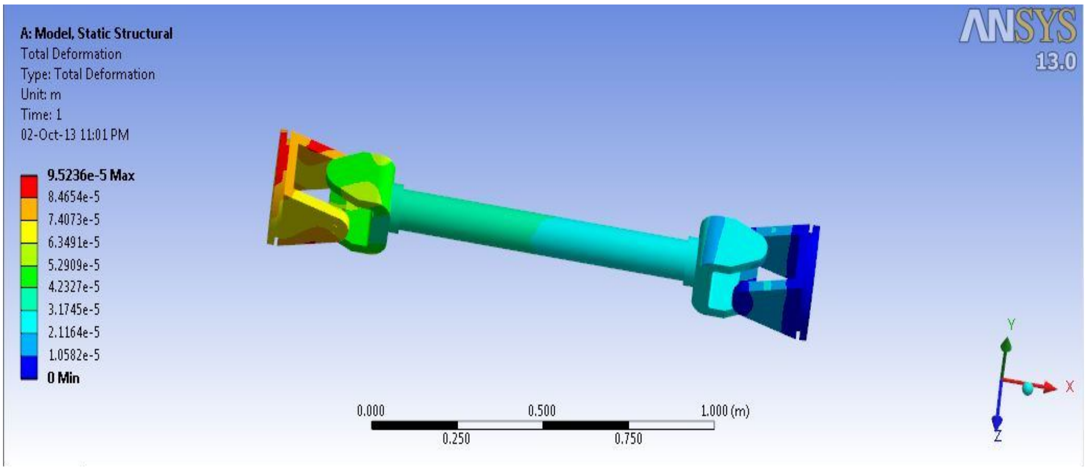


**Fig 3**: Total deformation (carbon fibre).

The Total Deformation of the Structural Steel of Diameter 100 – 50 is calculated and the values obtained are the Maximum Deformation is 0.00022551m and the minimum deformation is0.

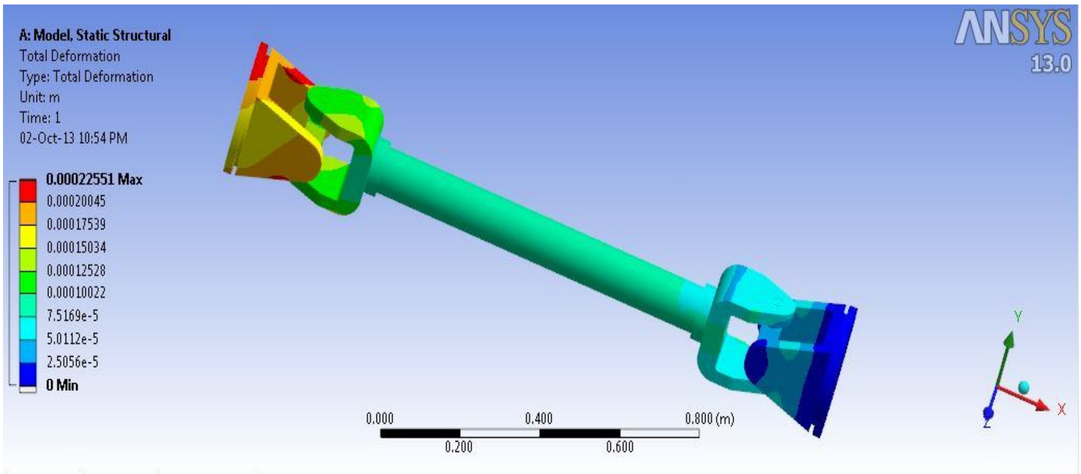


**Fig. 4**: Total deformation (structural steel).

The Equivalent elastic Strain of the Carbon Fibre (High Strength) of Diameter 100 – 50 is calculated and the values obtained are the Maximum Strain is 0.00027629 and the minimum deformation is 1.6017e-6.

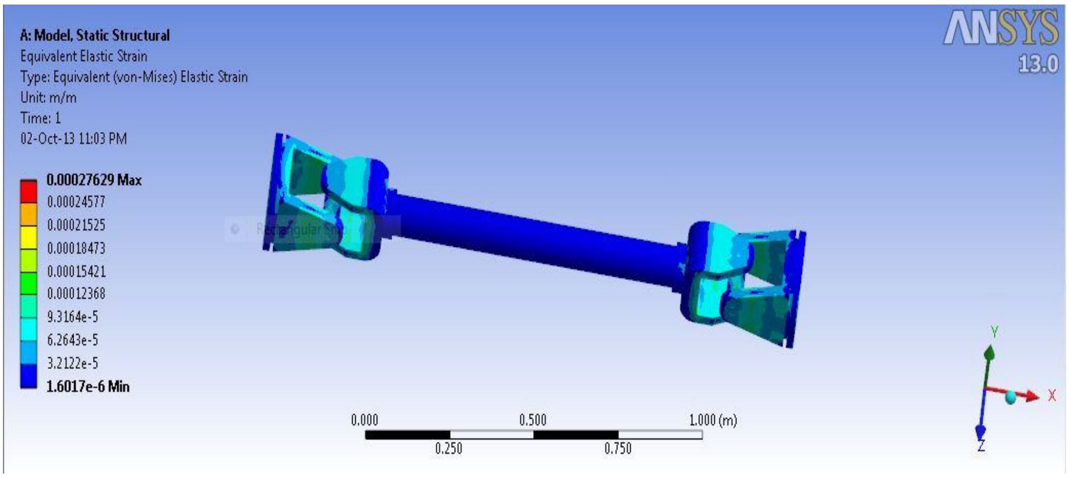


**Fig. 5**: Equivalent elastic Strain ( carbonfibre).

The Equivalent elastic Strain of the Structural Steel of Diameter 100 – 50 is calculated and the values obtained are the Maximum Strain is 0.00071851 and the minimum deformation is 4.1424e-6.

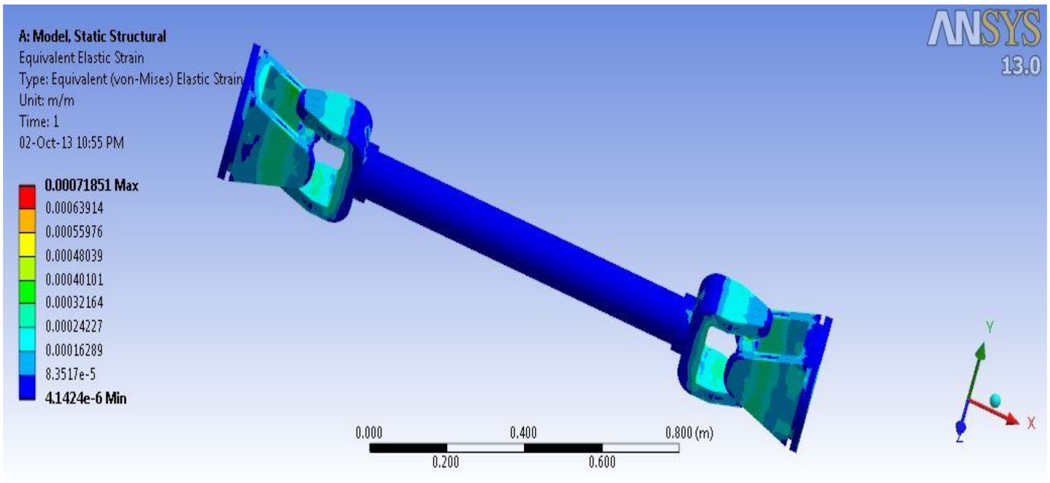


**Fig. 6**: Equivalent elastic Strain (Structural steel)

The Equivalent elastic Stress of the Carbon Fibre (High Strength) of Diameter 100 – 50 is calculated and the values obtained are the Maximum Stress is 1.1052e8 Pa and the minimum deformation is 6.4086e5 Pa.

The Equivalent elastic Stress of the Structural Steel of Diameter 100 – 50 is calculated and the values obtained are the Maximum Stress is 1.437e8 Pa and the minimum deformation is 8.2848e5Pa.

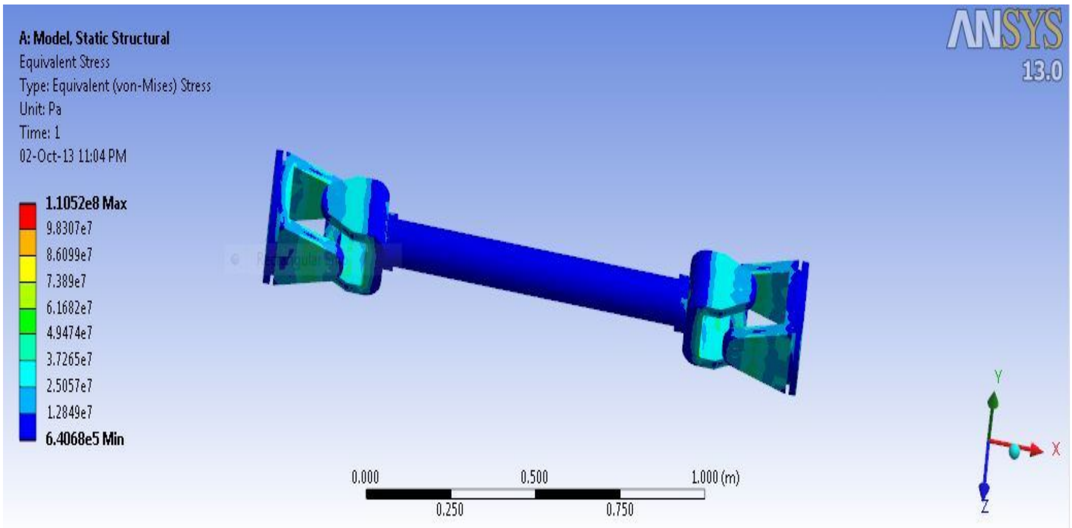


**Fig. 7**: Equivalent elastic Stress (Carbon Fibre)

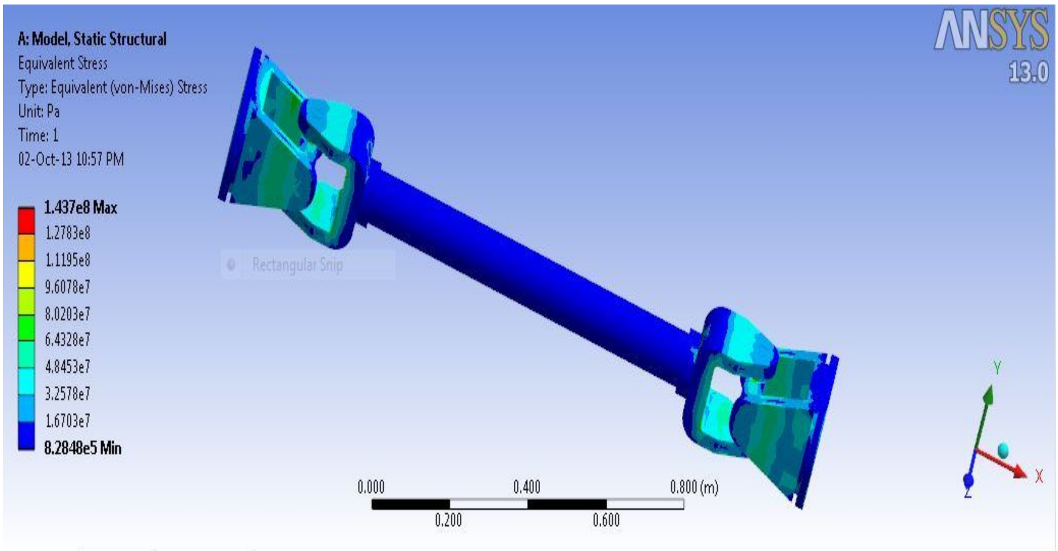


**Fig. 8**: Equivalent elastic Stress (structural steel)

## 4. Conclusion

From the FE result obtained, following design optimization of the propeller shaft can be proposed.

1. The High Strength Carbon composite drive shafts have been designed to replace the steel drive shaft of an automobile.2.A one-piece composite drive shaft for rear wheel drive automobile has been designed with High Strength Carbon composites with the objective of minimization of weight of the shaft which was subjected to the constraints such as torque transmission, torsional buckling capacities and natural bending frequency.3.The High Strength Carbon composite drive shafts have been analysed to replace the steel drive shaft of an

automobile.4.The weight savings of the HS Carbon is 24 %(100-50 & Solid) compared to same dimensions of steel shaft.5.The deflection of Steel, High Strength Carbon is given as:

**Table 3**

| Diameter | Carbon Fibre (High Strength) | Steel |
|---|---|---|
| 100-50 | 0.0041303 | 0.01103100 |

All dimensions are in mm.

6. Drive shaft of different diameters are selected for analysis made up of composite material and steel, finally suggesting a hollow shaft of 100-50 ,(condition: outside diameter using High Strength Carbon as best one.

## References

[1] Dai Gil Lee, Jin Kook Kim and Durk Hyun Cho, "Design and Manufacture of an Automotive Hybrid Aluminum/Composite Drive Shaft, Journal of Composite Structures, 2004, Vol.63, pp87-89

[2] Jones, R.M., Mechanics of Composite Materials, 2e, McGraw- Hill Book Company, New York. 1998, Vol.58, pp78-80

[3] Beardmore.P and Johnson C.F Design And Model Analysis Of Composite Drive Shaft For Automotive Application International Journal of Engineering Science and Technology, April 2011, ISSN : 0975-5462, Vol. 3 No. 4.