# Design and Analysis of Composite Drive Shaft for Automotives

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**Abstract- In the design of automobiles, the industry is exploring composite material in order to obtain reduction of weight without significant decrease in vehicle quality and reliability. Composite materials have been used in automotive components because of the properties such as low weight, high specific stiffness, corrosion free ability to produce complex shapes, high specific strength and high impact energy absorption etc. 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 the fuel consumption of the vehicle. In this project the entire drive shaft assembly of light utility vehicle was chosen and analysed by replacing it with composite materials. This work deals with the analysis of conventional drive shaft with Glass Epoxy. The torsional characteristics of Glass reinforced Epoxy composite shafts with twisting moment or torque were investigated using simple torsion testing machine. The analysis is carried out using ANSYS.**

Keywords – **Composite shaft, Glass Fiber, Epoxy resin, ANSYS.**

## I. INTRODUCTION

The advanced composite materials such as Graphite, Carbon and Glass with suitable resins are widely used because of their high specific strength (strength/density) and high specific modulus (modulus/ density). Advanced composite materials seem ideally suited for long, power driver 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. A drive shaft of composites offers excellent vibration damping, cabin comfort, reduction of wear on drive train components and increasing tires traction. In addition, the use of one piece torque tube reduces assembly time, inventory cost, maintenance, and part complexity [1]. Nowadays, composite materials are used in large volume in various engineering structures including spacecrafts, airplanes, automobiles, boats, sports' equipments, bridges and buildings. Widespread use of composite materials in industry is due to the good characteristics of its strength to density and hardness to density. The possibility of increase in these characteristics using the latest technology and various manufacturing methods has raised application range of these materials. Application of composite materials was generally begun only at aerospace industry in 1970s, but nowadays after only three decades, it is developed in most industries. Meanwhile, the automotive industry considered as a mother one in each country, has benefited from abilities and characteristics of these advanced materials. Along with progress in technology, metallic automotive parts are replaced by composite ones. The composite drive shaft has many benefits such as reduced weight and less noise and vibration [2].

## II. DRIVE SHAFT

### A. *FUNCTIONS OF DRIVE SHAFT-*

A drive shaft, propeller shaft is a mechanical component for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them. Drive shafts are carriers of torque. They are subject to torsion and shear stress, equivalent to the difference between the input torque and the load. They must therefore be strong enough to bear the stress, whilst avoiding too much additional weight as that would in turn increase their inertia.

- First, it must transmit torque from the transmission to the differential gear box.
- During the operation, it is necessary to transmit maximum low-gear torque developed by the engine.

- The drive shafts must also be capable of rotating at the very fast speeds required by the vehicle. The length of the drive shaft must also be capable of changing while transmitting torque. Length changes are caused by axle movement due to torque reaction, road deflections, braking loads and so on. A slip joint is used to compensate for this motion. The slip joint is usually made of an internal and external spline. It is located on the front end of the drive shaft and is connected to the transmission [3].

## III. MATERIAL SELECTION AND METHODS

FIBRES - Fibers are the principal constituent in a fiber-reinforced composite material. They occupy the largest volume fraction in a composite laminate and share the major portion of the load acting on a composite structure. Proper selection of the type, amount and orientation of fibers is very important, because it influences the following characteristics of a composite laminate.

a. Specific gravity
b. Tensile strength and modulus
c. Compressive strength and modulus
d. Fatigue strength and fatigue failure mechanisms
e. Electric and thermal conductivities
f. Cost

The various types of fibers currently in use are

a. Glass Fibers
b. Carbon Fibers
c. Aramid Fibers
d. Boron Fibers
e. Silicon Carbide Fibers

## III. SELECTION OF FIBRE

Glass fibers - Its advantages include its low cost, high strength, high chemical resistance, and good insulating properties. The disadvantages are low elastic modulus, poor adhesion to polymers, low fatigue strength, and high density, which increase shaft size and weight. Also crack detection becomes difficult.

## IV. SELECTION OF RESIN SYSTEM

Epoxy resin - The important considerations in selecting resin are cost, temperature capability, elongation to failure and resistance to impact (a function of modulus of elongation). The resins selected for most of the drive shafts are either epoxies or vinyl esters [4]. Here, epoxy resin was selected due to its high strength, good wetting of fibres, lower curing shrinkage, and better dimensional stability.

## V. SELECTION OF MATERIAL

Based on the advantages discussed above, the high strength and high modulus Glass/Epoxy materials are selected for composite drive shaft. The Table 1. shows the property of the glass epoxy material used for composite drive shaft.

## VI. PROPERTIES OF E-GLASS REINFORCED EPOXY

| **Mechanical Properties** | **E-GLASS/EPOXY** |
|---|---|
| Longitudinal Young's Modulus | 52.36 GPa |
| Transverse Young's Modulus | 8.02 GPa |
| Major Poisson Ratio | 0.24 |
| Ultimate Longitudinal Tensile Strength | 954.8 MPa |
| Ultimate Longitudinal Compressive Strength | 69.2 MPa |
| Density | 1980 Kg/m3 |

Table 1. Properties of E-Glass reinforced epoxy

## VII. FABRICATION

Fifty five layers of Glass/Epoxy were wrapped around aluminium tubes of length equal to 379mm and diameter of 39mm. Resin system was prepared mixing Epoxy, and hardener with the volume fraction ratio of 4:1. The specimen was fabricated in such a way that the stress level in the central gauge section must greater than in all other structure points. The aim of the reinforced ends is to avoid failure within the end region and eliminate or, at least, minimize concentration of stresses. This additional stresses make as end failure for loads smaller than those tolerated by the same drive shaft with uniform stress distribution. After the solidification and the curing time is done, the lathe machine would be used to cut the specimen ends to its final dimensions [5].

## VIII. TORQUE TEST OF THE COMPOSITE SHAFT

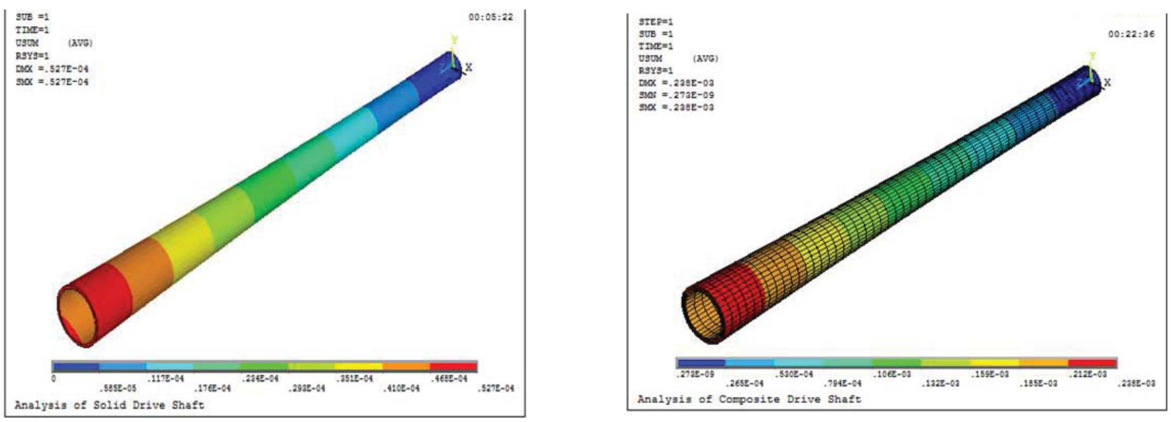
Torsion testing machine was used to perform the test. The testing machine with a specimen mounted on it. The torque was applied manually by a handle at a geared head. The maximum static torsion was obtained after the failure of the specimens.

## IX. MODEL ANALYSIS OF DRIVE SHAFT

Ansys 14 workbench has chosen for performing the analysis (Fig.1). The analysis are carried out by fixing the shaft at one end and torque is applied at the other end. Total deformation test is also done.

Fig. 1. 3-D diagram of composite propeller shaft

## X. ANSYS ANALYSIS




(a). DEFORMATION OF STEEL (b). DEFORMATION OF GLASS FIBER

Fig.2 (a), (b). Deformation of steel and composite shafts

## XI. DESIGN CALCULATION

SPECIFICATION OF STEEL DRIVE SHAFT

Length L = 379mm

Diameter d = 22mm

**Design of steel drive shaft [3]**

Mass m $= \rho AL$

$= 7600*3.14/4*22^{2*}\ 379$

$= 1.09$Kg

Deflection $\boldsymbol{\delta}$ $= WL/\ 2AE$

$= 10.68*379/(2*3.14/4*22^2 * 2.07e^5)$

$= 2.565^{-5}$ mm

Calculation of bending moment

M $= (\sigma_b /Y)* I$

Bending stress $\sigma_b = \sigma_t$

$\sigma_t = 500 N/mm^2$

$Y = d/2$

$= 22/2$

$= 11mm$

INERTIA

$I = (3.14/64)*22^4$

$= 1.1e^4 \ mm^4$

Bending moment $M = (500/11)*1.1e^4$

$= 542$ N-m

Design of Composite Drive shaft

To find the diameter of Glass fiber

Torque t $= Ss*\pi/16*d^3$

$d = 39mm$

Mass m $= \rho AL$

$= 1980*3.14/4*39^{2*}\ 379$

$= 0.9Kg$

Deflection $\delta$ $= WL/ 2AE$

$= 8.82*379/ (2*3.14/4*39^2 *2.07e^5)$

$= 1.6e\text{-}4$ mm

Calculation of bending moment

$M = (\sigma_b /Y)* I$

Bending stress $\sigma_b = \sigma_t$

$\sigma_t = 3445 N/mm^2$

$Y = d/2$

$= 39/2$

$= 19.5mm$

INERTIA

$I = (3.14/64)*39^4$

$= 1.1e^4 \ mm^4$

Bending moment $M = (3445/19.5)*1.1e^4$

$= 1996$ N-m

## XII. RESULT AND DISCUSSION

| S.NO | MATERIAL | DEFORMATION | DIAMETER | BENDING MOMENT | WEIGHT |
|---|---|---|---|---|---|
| 1 | STEEL | 0.5 | 22mm | 580N-m | 10.69Kg |
| 2 | GLASS/EPOXY | 0.2 | 39mm | 2060N-m | 8.2 Kg |

In the above tabular column, the experimental results were presented. It is noted that Glass/Epoxy has less deformation and reduced weight than the conventional steel drive shafts. The replacement of composite materials has resulted in considerable amount of weight reduction about 20% when compared to conventional steel shaft. It was observed that the 39mm diameter shaft is suitable due to its structural stability. As per the above results the shaft is suitable for drive shaft due to low stress, less weight and less manufacturing cost. Using this type of shaft, we can increase the mechanical efficiency by reducing the weight and this type of shaft are easy to manufacture and cost effective. Thus more power can be transmitted through the reduced inertial mass and light weight. As the weight of the vehicle is reduced, the fuel efficiency is increased. This is due to the fact that, the reduction of weight of the vehicle directly impacts its fuel consumption. Particularly in city driving, the reduction of weight is almost directly proportional to the fuel consumption of the vehicle. Experiments have been carried out to characterize the shaft subjected to a twisting moment loading using simple torsion testing machine, the analysis part carried out through ansys has given very good agreement with the experimental results, it can found in the diagram (fig. 2.(a), (b)) [6-7].

## XIII. CONCLUSION

In this paper comparison of drive shaft for steel and composite is carried out based on maximum deformation induced in the shaft and design procedure is studied. The composite drive shaft made up of high modulus Glass fibre / epoxy composites have shown very good results as compared with the steel structure with slight negligence of young's modulus value.

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