

Modeling and Analysis of Propeller Shaft and Its Coupling

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Abstract

In Present scenario, any kind of Vehicle transmits Power from the drive systems to differential through the advent use of Drive shafts. Drive Shaft is a shaft for imparting torque from power source or prime mover to machinery. Nearly all of driveshaft is metal shafts or metal tubes that has special joint. The major failure occurred in drive shaft is due vibration, torsional stress and bending stress was experienced by driveshaft due to the weight of the car or misalignment of journal bearing. Drivers will lose control of their vehicle if the drive shafts failure occurs during high speed cornering. And also by varying the material we can reduce the weight of the rotating mass and increase the response. It allows more energy to go into rotating the tires instead of rotating dead weight. The above stated problem can be reduced by adopting the alternative material over it. Our project aims to reduce the weight of the drive shaft and conducting an analysis on it by varying the material in order to reduce the fuel consumption. We are making use of mechanical analysis tool “ANSYS” to conduct the analysis on propeller shaft and coupling. The analysis to be carried out may attain a well-developed Drive shaft which can be utilized in the recent automobile development domain of its first kind.

Keywords: Drive Shaft, Journal bearing, fuel consumption, mass, weight

I. INTRODUCTION

A. Propeller Shaft

A driveshaft is the connection between the transmission and the rear axle of the car. The transmission is linked to the driveshaft by a yoke and universal joint, or u-joint, assembly. The driveshaft transmits the power to the rear end through another yoke and u-joint assembly. The power is then transferred by the rig and pinion or rear differential to the rear wheels.

The entire driveline of the car is composed of several components, each with rotating mass. The rule of thumb is that 17-22% of the power generated by the engine is lost to rotating mass of the drive train. The power is lost because it takes more energy to spin heavier parts. This energy loss can be reduced by decreasing the amount of rotating mass. Light weight flywheels and transmission gears, aluminum and carbon-fiber drive shafts, riddle-drilled axels, and aluminum hubs are all examples of replacement or modified parts used to reduce the amount of rotating mass.

B. Purpose of Drive Shaft

To reduce to the amount of rotating mass in the drive train, a light weight driveshaft will be used. The race car, pitted in an unending battle against the clock, is modified to squeeze every bit of horsepower out of it. The drag car is full of racing equipment, but currently has a steel driveshaft. The new drive shaft should take less 4 energy to spin therefore more of the energy produced by the engine can be transferred to the wheels.

In addition to increasing the efficiency, the composite shaft will be safer than a steel driveshaft. When a steel shaft fails, it projects shrapnel in all directions. There is also a possibility that the shaft may dig into the ground and catapult the vehicle into the air. When a composite shaft fails, it breaks into small fiber fragments posing no danger.

C. Functions of Drive Shaft

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 drive shaft must also operate through constantly changing angles between the transmission, the differential and the axles. As the rear wheels roll over bumps in the road, the differential and axles move up and down. This

movement changes the angle between the transmission and the differential. 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.

D. Composite

Composites consist of two or more materials or material phase that are combined to produce a material that as superior properties to those of its individual constituents. 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). 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.

E. Carbon Fiber/Epoxy Composite

Carbon-fiber-reinforced polymer, carbon-fiber-reinforced plastic or carbon-fiber reinforced thermoplastic (or often simply carbon fiber, or even carbon), is an extremely strong and light fiber-reinforced polymer which contains carbon fiber. The binding polymer is often a thermoset resin such as epoxy, but other thermoset or thermoplastic polymers, such as polyester, vinyl ester or nylon, are sometimes used.

The composite may contain other fibers, such as aramid e.g. Kevlar, Twaron, aluminum, or glass fibers, as well as carbon fiber. The properties of the final CFRP product can also be affected by the type of additives introduced to the binding matrix (the resin). The most frequent additive is silica, but other additives such as rubber and carbon nanotubes can be used. CFRPs are commonly used in the transportation industry; normally in cars, boats and trains, and in sporting goods industry for manufacture of bicycles, bicycle components, golfing equipment and fishing rods.

II. EXPERIMENTAL SET UP

A. Design of Shaft:

The figure 2.1 (a) and 2.1 (b) shows the design of the existing Aluminium drive shaft and the proposed carbon fiber drive shaft.

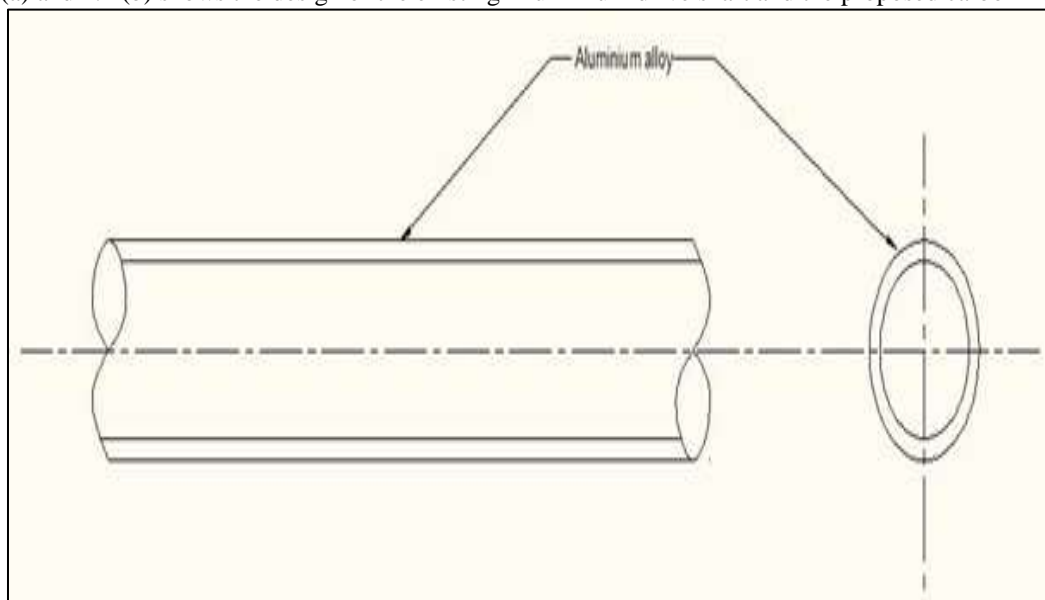


Fig. 2.1 (a): schematic diagram Aluminium drive shaft

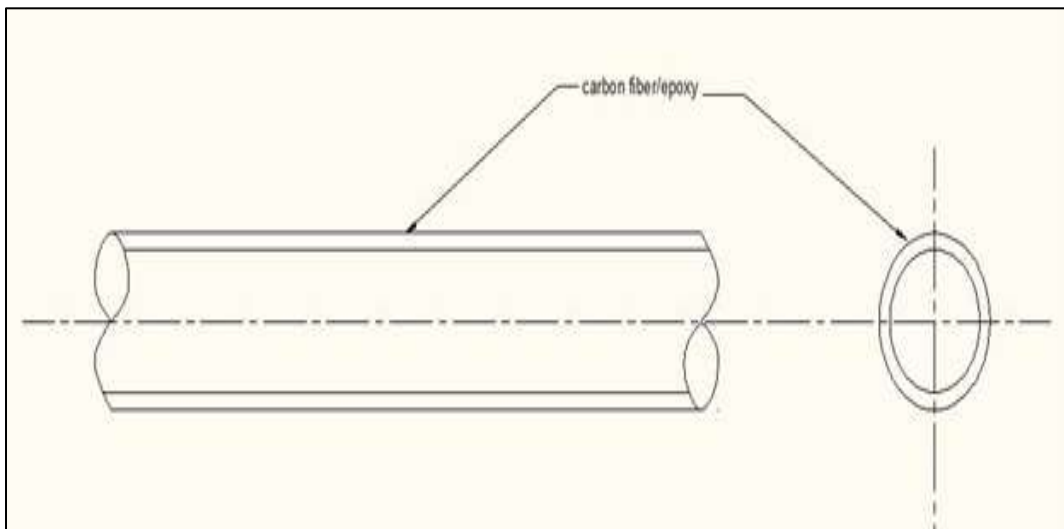


Fig. 2.1 (b): Schematic diagram of carbon fiber / epoxy drive shaft

B. Mechanical Properties:

The table 2.1 (a) and 2.2 (b) shows

The material property of aluminium alloy and carbon fiber/epoxy.

Table - 2.1 (a)

Material property of aluminium alloy

MECHANICAL PROPERTIES	UNITS	ALUMINIUM
Young's modulus	MPa	71000
Shear modulus	MPa	26692
Poisson ratio	-----	0.33
Density	Kg / m ³	2770
Shear strength	MPa	26692
Bulk modulus	MPa	69608
Tensile yield strength	MPa	280
Tensile Ultimate strength	MPa	310
Compressive Yield Strength	MPa	280

Table - 2.2 (b)

Material property of Carbon fiber/epoxy

MECHANICAL PROPERTIES	UNITS	CARBON FIBER/EPOXY
Young's modulus	MPa	
Shear modulus	MPa	
Poisson ratio	-----	
Density	Kg / m ³	
Yield strength	MPa	
Shear strength	MPa	
Bulk modulus	MPa	
Tensile yield strength	MPa	
Tensile Ultimate strength	MPa	
Compressive Yield Strength	MPa	

C. Analysis Procedure on Ansys:

- 1) The 3D model is created in CATIA as per the calculated dimensions of shaft and coupling assembly in design calculation part.
- 2) This model has to be analyzed in ANSYS Software for the structural analysis.
- 3) File → Import → IGES → Model.igs.
- 4) Ansys workbench → read input from → select igs file → generate → export.
- 5) Preference → Structural → OK.
- 6) Preference → Element type → Add/Edit/Delete → Add → Solid 185 → Elastic.
- 7) Preference → Real constants → Add/Edit/Delete → Add .
- 8) Preference → material Properties → Material Models → Structural → Linear Elastic → isotropic → EX= 2270, PRXY= 0.3.
- 9) Preference → Meshing → Mesh Tool → Mesh → Pick all → OK.

- 10) Preference→ Loads → Define load→ Apply → moment value→ Structural → Displacement→ On line→ Pick line→ All Dof = 0.
- 11) Preference→ Loads→ Define load→ Apply→ Structural → Force/Moment→ On nodes → Define load→ Apply→ Moment = 250Nmm.
- 12) Solution→ Solve→ Current LS→ solve
- 13) General post processing→ Plot results→ Contour plot→ Nodal solution→ Stress→ Vonmises Stress→ Ok
- 14) General post processing→ Plot results→ Contour plot→ Deform → Under form shape → ok

III. MODELLING AND ANALYSIS OF DRIVE SHAFT

A. Modelling of Drive Shaft:

The modelling of drive shaft is done using CATIA software because it is one of the most widely used software for automobile parts modelling.

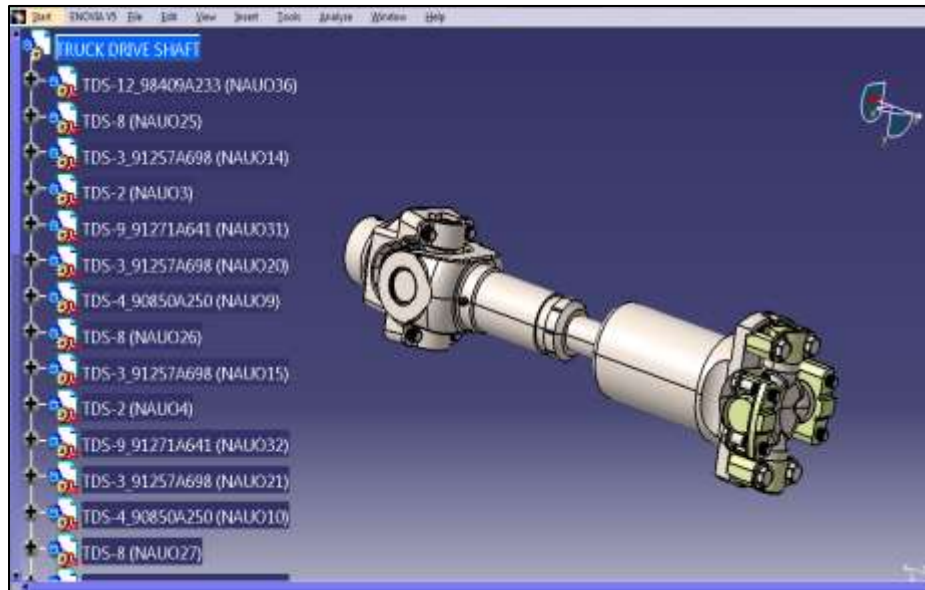


Fig. 3.1: Drive shaft (CATIA modelling)

The above image shows the front view of the assembled drive shaft that is used to transmit the power from engine to differential in a heavy vehicle truck.



Fig. 3.2: different view of drive shaft

B. Analysis of Drive Shaft:

The CATIA model is then saved in IGS format, which is a global format used to import a model in different software like ansys, pro E and etc. then the analysis is carried out.

This sub division shows the analysis result of both the existing (aluminium) drive shaft and the proposed model (carbon fiber) drive shaft. The deformation, stress, modal and twisting analysis is carried out for both the steel and carbon fiber drive shaft and a detail comparison has been made in further chapters.

Here the analysis is carried out for both the aluminium and carbon fiber/epoxy drive shaft at same torque value of 250 N mm to compare the deformation, stress withstanding capacity to justify our project.

C. Aluminium Drive Shaft:

The fig. 3.3 shows the deformation rate of the drive shaft at the moment of 250 Nmm. With a maximum deformation of 0.0016996 mm and minimum deformation rate is 0mm.

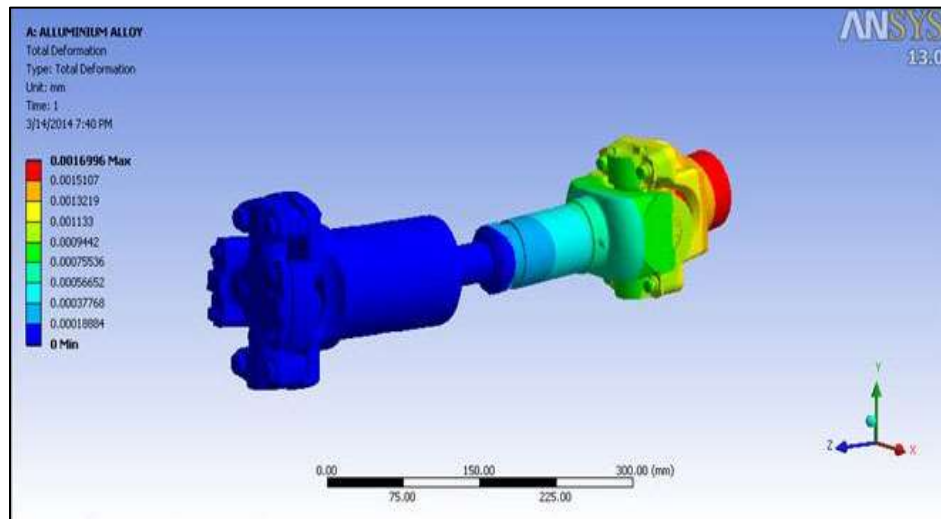


Fig. 3.3: Deformation rate of aluminum drive shaft

The fig 3.4 gives the stress distribution of the drive shaft at 250 Nmm torque applied to it. It shows the maximum stress rate as 0.24563 Mpa and the minimum stress rate at 0 Mpa. But the stress occurred in the shaft is 0.1091 Mpa which shows it is safe to use.

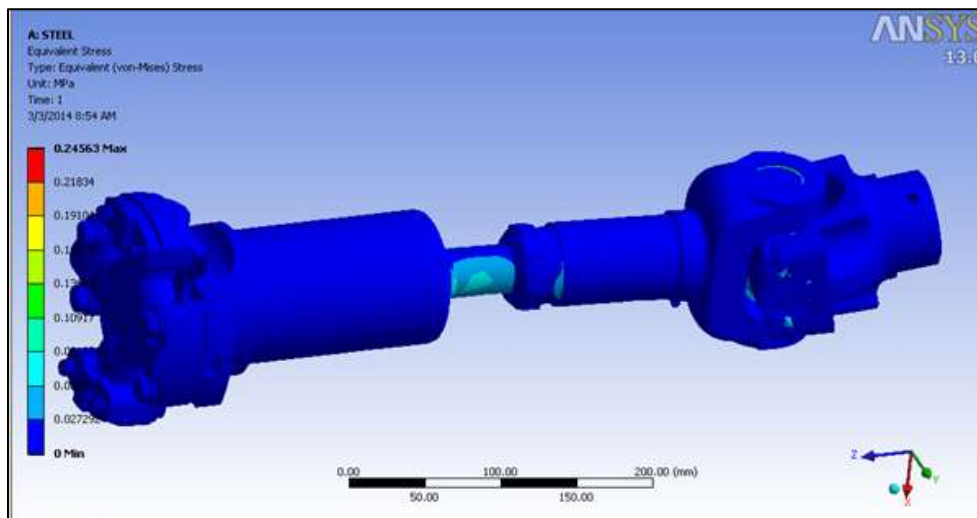


Fig. 3.4: stress distribution of aluminum drive shaft

D. Carbon Fiber:

The image 3.5(a) shows structural idea about the carbon fiber drive shaft with applying moment to it. In this one end is fixed and at the other end the torque is applied (250 Nmm). The red color represents the area where the moment is applied and the purple color represent the fixed end. The ambient temperature is considered to the fact. The image 3.5 (b) shows the discretization data which makes it much easier to understand, here triangular default mesh is carried out which is one of the artificial discretization. The space inside the element is called as typical element and intersection of two points is called node.

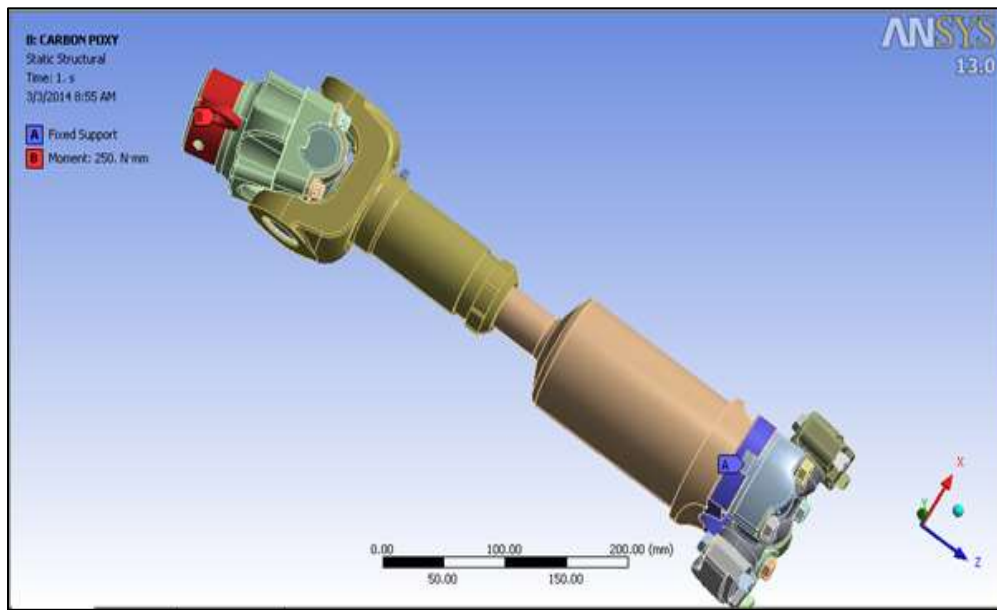


Fig. 3.5(a): Structural image of drive shaft

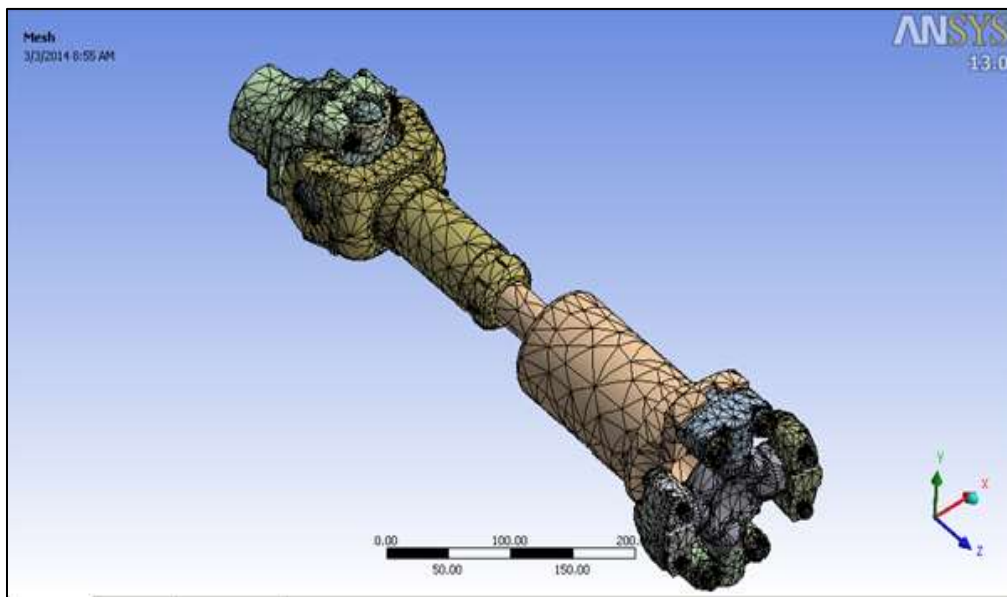


Fig. 3.5 (b): Meshing of drive shaft

The image 3.5 (c) shows the deformation rate of the carbon fiber drive shaft at a torque of 250 Nmm. The deformation rate is represented by various colors from red to blue. The maximum deformation is represented by red color and it occurs at 6.063×10^{-4} mm and minimum deformation is represented by blue color that occurs at 0 mm. The maximum deformation of carbon fiber is very much low when compared to the aluminium drive shaft.

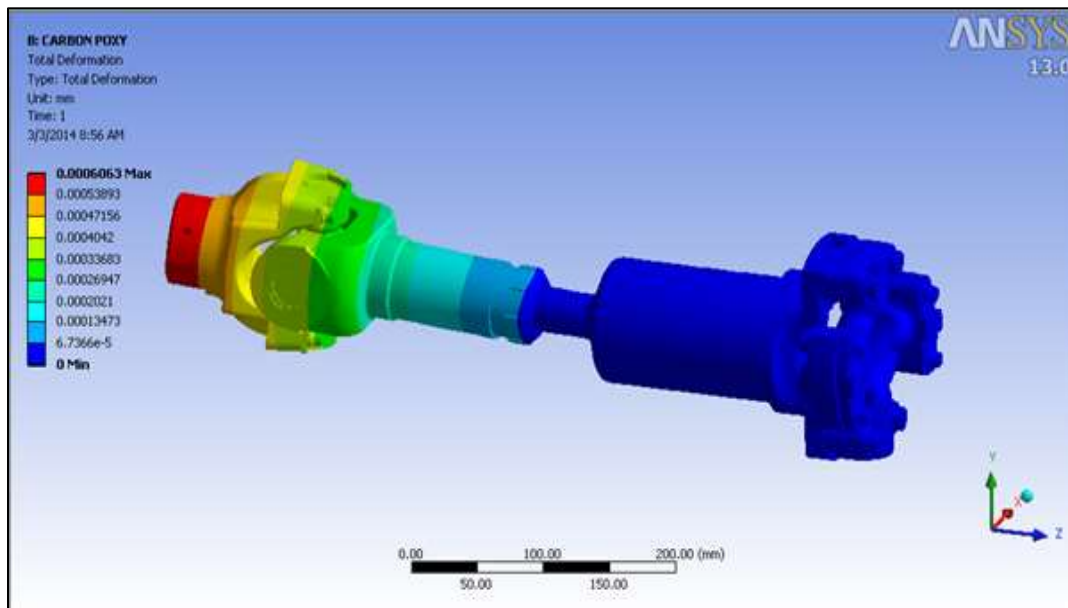


Fig. 3.5 (c): Total deformation rate of carbon fiber drive shaft

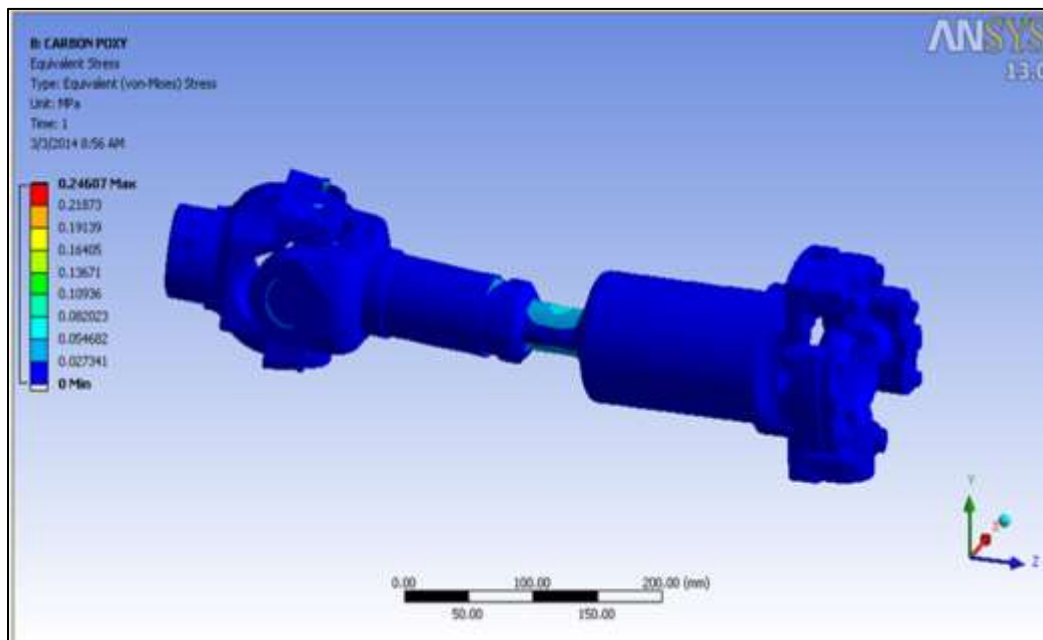
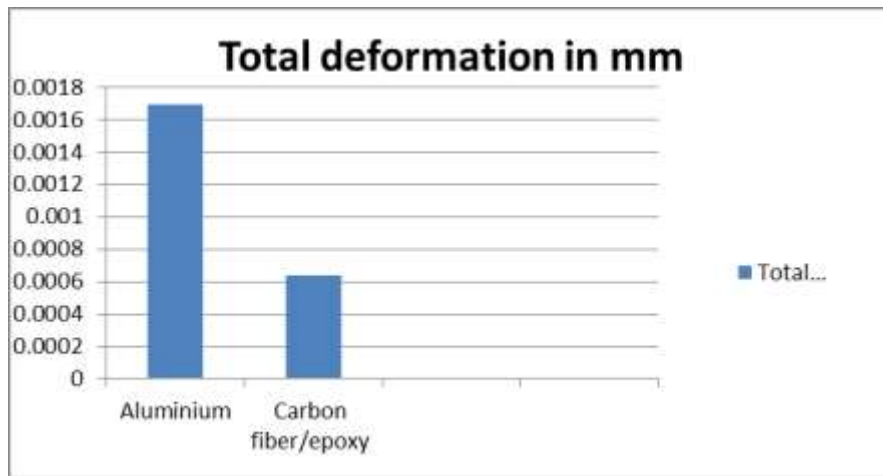


Fig. 3.5(d): stress distribution of aluminum drive shaft

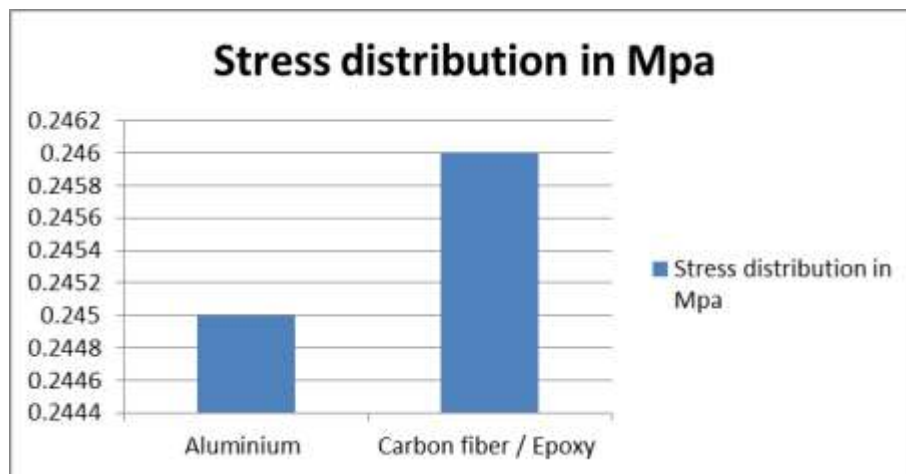
IV. RESULTS AND DISCUSSION

The table 5.1 shows the output of Comparison between aluminium and carbon fiber/epoxy and its feasibility. When compared to the aluminum drive shaft. The details were stated below in the table. We have tested both the aluminum and carbon fiber/epoxy drive at same value of torque at 250 Nmm.

MATERIAL	ALUMINIUM	CARBON FIBER/ EPOXY
DEFORMATION IN mm	0.00169	0.000636
STRESS MPA	0.245	0.246



Graph 4.1 (a)



Graph 5.2 (b)

On comparing the result value of aluminum and carbon fiber/epoxy drive shaft, we prefer carbon fiber for usage.

V. CONCLUSION

The usage of composite materials has resulted in considerable amount of weight saving in the range of 81% to 72% when compared to conventional steel drive shaft. Taking into account the weight saving, deformation, stress induced and resultant frequency it is evident that carbon/epoxy composite has the most encouraging properties to act as replacement to aluminium. The present work was aimed at reducing the fuel consumption of the automobiles in particular or any machine, which employs drive shaft, in general. This was achieved by reducing the weight of the drive shaft with the use of composite materials.

By using advanced composite materials, the weight of the drive shaft assembly can be tremendously reduced. This also allows the use of a single drive shaft (instead of a two piece drive shaft) for transmission of power to the differential parts of the assembly. Apart from being lightweight, the use of composites also ensures less noise and vibration.

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