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OPTIMAL DESIGN AND ANALYSIS OF COMPOSITE DRIVE SHAFT FOR A LIGHT COMMERCIAL VEHICLE

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Abstract: Almost all automobile vehicles having transmission shafts. Present time the main issue of automobile industry are weight reduction. 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. Substituting composite structures for conventional metallic structures has many advantages because of higher specific stiffness and strength of composite materials. The advanced composite materials such as graphite, carbon, Kevlar and Glass with suitable resins are widely used because of their high specific strength and high specific modulus. The achievement of weight reduction with adequate improvement of mechanical properties has made composite a very good replacement material for conventional steel drive shaft. Advanced composite materials seem ideally suited for long power drive shaft applications. 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. 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. This present work includes, modelling 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.

Keywords- Composite Materials, Drive Shaft, Material property, FEA, ANSYS and Pro-E.

I. INTRODUCTION

The Drive shaft was invented by Louis Renault (French) in 1898. In British English, the term "drive shaft" is restricted to a transverse shaft which transmits power to the wheels, especially the front wheels. A drive shaft connecting the gearbox to a rear differential is called a propeller shaft, or prop-shaft. A drive shaft, driving shaft, propeller shaft, or cardan shaft is a mechanical device for transferring power from the engine or motor to the point where useful work is applied. 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, aluminium and carbon-fiber drive shafts, riffle-drilled axels, and aluminium hubs are all examples of replacement or modified parts used to reduce the amount of rotating mass. Power transmission can be improved through the reduction of inertial mass and light weight. Substituting composite structures for conventional metallic structures has many advantages because of higher specific stiffness and higher specific strength of composite materials. Composite materials can be tailored to efficiently meet the design requirements of strength, stiffness and composite drive shafts weight less than steel or aluminium. In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacture in the present scenario. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. Drive shaft must operate in high and low power transmission of the fluctuating load. Due this fluctuating load it becomes fail and tends to stop power transmission. Thus it is important to make and design this shaft as per load requirement to avoid failure. Now a day’s two pieces steel shaft are mostly used as a drive shaft. However, in this paper an attempt is made to evaluate the suitability of composite material for the purpose of automotive drive shaft application. The drive shaft is one of the potential items for weight reduction in automobiles as it accounts for 17% to 22% (from the advertises and references) of the unstrung weight. Drive shafts are carriers of torque they are subject to torsion and shear stress, which represents the difference between the input force and the load. They thus need to be strong enough to bear the stress, without imposing too great an additional inertia by virtue of the weight of the shaft. . On some four wheel drive vehicles one propeller shaft is used to power the rear wheels as with rear wheel drive and a second propeller shaft is used to power the front wheels. In this case the second propeller shaft is replaced between a transfer gear box and the front axle. Hence, it can be observed that a drive shaft is one of the most important components, which is responsible for the actual movement of the vehicle once the motion is produced in the engine. The dimension for both steel drive shaft and composite drive shaft are considered. The primary objective is to compare their torque transmission capability, stiffness and weight savings of composite drive shaft.

II. PREVIOUS RESEARCH

There are various researches for the comparison between composite drive shaft and laminated drive shaft for various types of vehicle.

D. Dinesh and F. Anand Raj [1] Optimum Design And Analysis Of a Composite Drive Shaft For An Automobile By Using Genetic Algorithm And Ansys. V. Narayana, D. Mojeswararao and M.N.V.R.L. Kumar [2] Material optimization of composite drive shaft assembly in comparison with conventional steel drive shaft. Bhushan K. Suryawanshi and Prajitsen G. Damle [3] Review of Design of Hybrid Aluminum/ Composite Drive Shaft for Automobile. R. P. Kumar Rompicharla and Dr. K. Rambabu [4] Design and Optimization of Drive Shaft with Composite Materials. Sagar R Dharmadhikari, Sachin G Mahakalkar, Jayant P Giri and Nilesh D Khutafale [5] Design and Analysis of Composite Drive Shaft using ANSYS and Genetic Algorithm. R. P Kumar Rompicharla1 and Dr. K. Rambabu [6] Design And Analysis Of Drive Shaft With Composite Materials. M. Arun and K. Somasundara Vinoth [7] Design and Development of Laminated Aluminum Glass Fiber Drive Shaft for Light Duty Vehicles. Ummuhaani, A and Sadagopan P [8] Design, Fabrication and Stress Analysis of a Composite Propeller Shaft. Kishor Ghatage and Narayanrao Hargude [9] Static, modal and buckling analysis of Automotive composite Drive Shaft. R. Srinivasa Moorthy, Yonas Mitiku and K. Sridhar [10] Design of Automobile Driveshaft using Carbon/Epoxy and Kevlar/Epoxy Composites.

III. DESIGN OF COMPOSITE DRIVE SHAFT

3.1. Specification of Problem

The fundamental natural bending frequency for light commercial vehicle propeller shaft should be starting torque is 1000 rpm and the torque transmission capability of the drive shaft should be maximum in starting rpm. The drive shaft outer diameter should not exceed 100 mm due to space limitations.

The torque transmission capability of the drive shaft is taken as 462 Nm and the length and the outer diameters here are considered as 890 mm and outer diameter of the shaft is 55mm respectively. The drive shaft of transmission system was designed optimally to meet the specified design requirements.

Fibres Selection

The commonly used fibers in automobile are carbon, glass, keviar, etc. Among all these, the glass fibre has been selected on the basis of cost factor and strength. The many types of glass fibres are C-glass, S-glass and E-glass. The C- glass fibre is designed to give better improved surface finish. S-glass fibre is design to give very high modular, which is used particularly in aeronautic industries. The E-glass fibre is a high quality glass, which is used as standard reinforcement fibre for all the present systems well complying with mechanical property requirements. Thus E-glass fibre was found appropriate for this application.

Table1. Mechanical Properties of SM45

Properties	Value	Unit
Young's Modulus	207	Gpa
Shear Modulus	80	GPa
Poisson Ratio	0.3	-
Density	7600	Kg/m3
Yield Strength	370	Mpa
Shear Strength	275	MPa

Table2. Mechanical Properties of E- glass/epoxy

Mechanical Properties	Units	E-Glass Epoxy
Longitudinal Young’s Modulus	52.36	GPa

Transverse Young's Modulus	8.02	GPa
Major Poisson Ratio	0.24	-
In plane Shear Modulus	3.097	GPa
Ultimate Longitudinal Tensile Strength	954.8	MPa
Ultimate Longitudinal Compressive Strength	69.2	MPa
Transverse Tensile Strength	27.29	MPa
Ultimate Transverse Compressive Strength	38.66	MPa
In plane shear strength	12.72	MPa
Density	2000	Kg/m3

3.2. Design Parameters and Experimentation

For Design parameter Maruti gipsy are considered based on the specification and available standards of automobile drive shafts. The drive shaft can be solid circular or hollow circular. Here hollow circular cross section is chosen. Because, the hollow circular shafts are stronger in per kg weight than solid circular shaft.

Table3. Drive Shaft Specification

Parameter	**Steel**	**Composite**
Length (L)	890 mm	890 mm
Outer Diameter (do)	55 mm	55 mm
Inner Diameter (di)	47 mm	44 mm
Thickness (t)	4 mm	5.5 mm

The below diagram is showing the design of steel drive shaft and composite drive shaft has made in Pro -E wildfire 4.0 and the analytical parameters like von misses stress and deformation have done in ANSYS 12.1 software.

Fig.1 Design of steel drive shaft

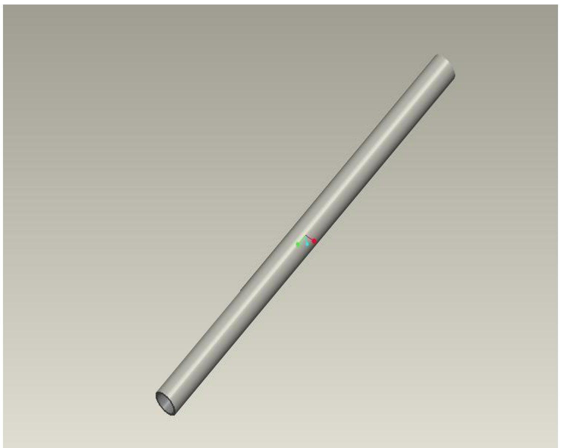

Fig.2 Design of composite drive shaft

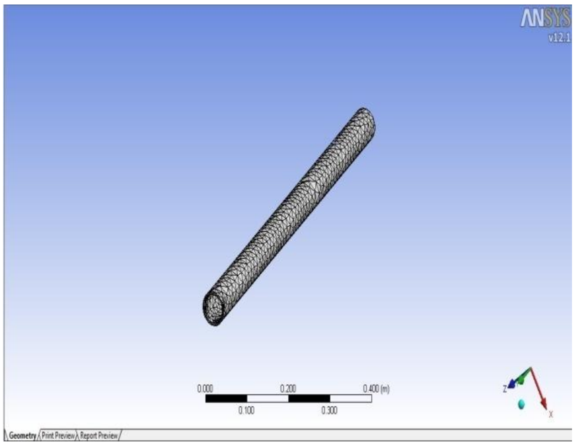

Fig.3 Meshing diagram of composite drive shaft

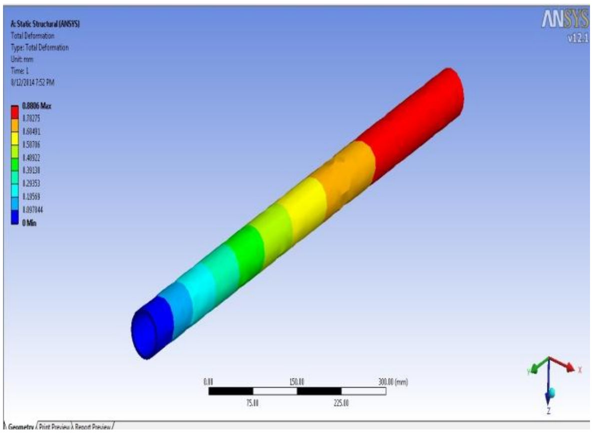

Fig.4 Deformation diagram of steel drive shaft

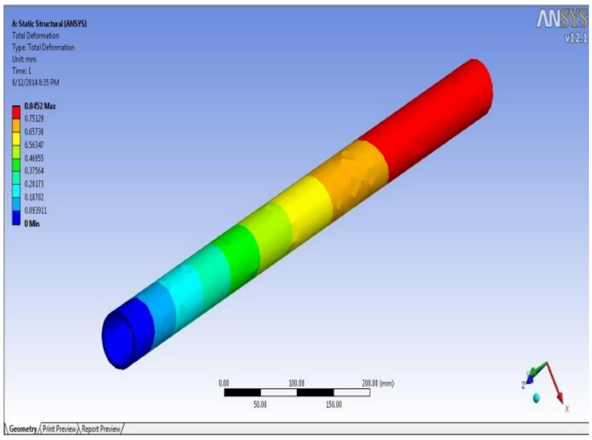

Fig.5 Deformation diagram of composite drive shaft

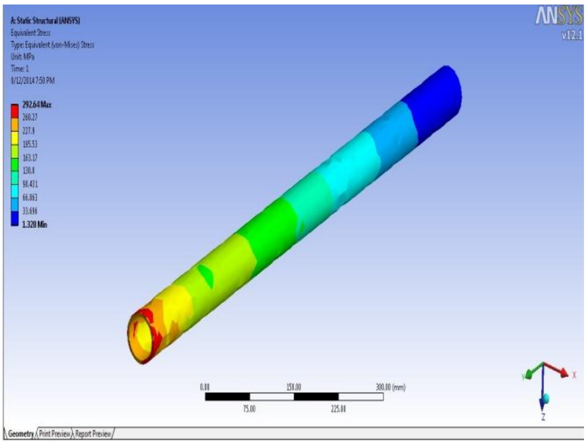

Fig.6 Von misses stress diagram of steel drive shaft

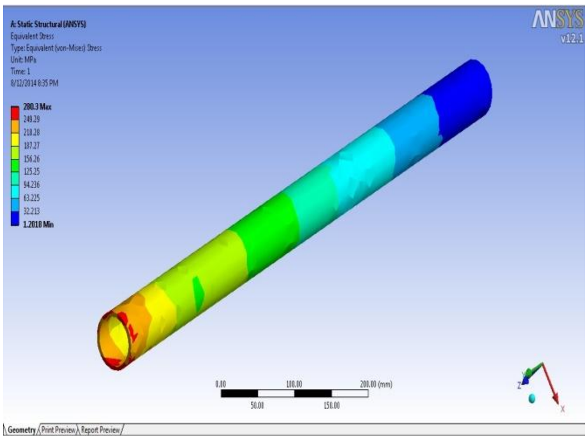

Fig.7 Von misses stress diagram of composite drive shaft

IV. RESULTS AND DISCUSSION

On the basis of above analytical design and analysis data, we have resulted out the table below.

Table4. FEA Analysis

Parameters	SM45	Composite
Torque (Nm)	462	462

t (mm)	4	5.5
Max. Stress (MPa)	292.64	280.3
Max. Deformation(mm)	0.880	0.845
Weight (Kg)	4.33	1.52

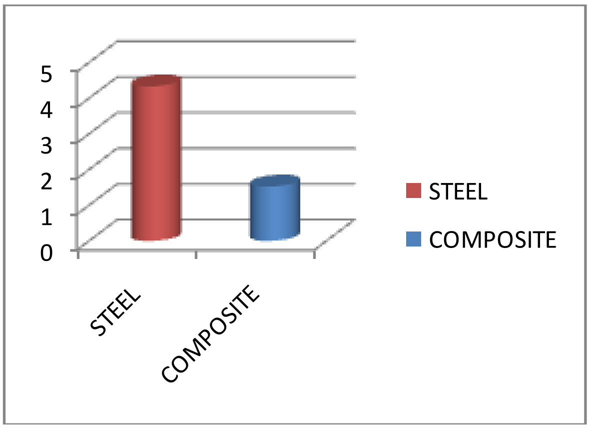

Fig.8 Graphical comparison of weights in steel drive shaft and composite drive shaft:

V. CONCLUSION

This work involves the comparison of steel drive shaft material SM45 and Composite material drive shaft based under static analysis. The model is preferred in Pro-E 4.0 and then analysis is perform through ANSYS 12.1 from the results, it will be concluded that the design of a composite drive shaft has very effective than steel drive shaft.

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