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Design And Analysis Of Composite Drive Shaft For An Automobile

[#1]V. S. Jadhav, [#2]A. N. Patil

[#12] Dr. D.Y. Patil SOE, Lohgaon, Pune, India

ABSTRACT

An automotive drive shaft is a rotating shaft that transmits power from the engine to the differential gear of rear wheel drive (RWD) vehicles. Conventional steel drive shafts are usually manufactured in two pieces to increase the fundamental bending natural frequency because the bending natural frequency of a shaft is inversely proportional to the square of the span length. But the two-piece steel driveshaft involves three universal joints, an intermediary thrust bearing and a supporting bracket in its assemblage, which increases the total weight of the vehicle. Since one-piece composite drive shaft will suffice in the place of a two-piece steel driveshaft, it substantially reduces the inertial mass. Moreover, a composite driveshaft can be perfectly designed to effectively meet the strength and stiffness requirements. Since composite materials generally have a lower elasticity modulus, during torque peaks in the driveline, the drive shaft can act as a shock absorber.

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I. INTRODUCTION

Composite materials are basically hybrid materials formed of multiple materials in order to utilize their individual structural advantages in a single structural material. The constituents are combined at a macroscopic level and are not soluble in each other. The key is the macroscopic examination of a material where in the components can be identified by the naked eye. Different materials can be combined on a microscopic scale, such as in alloying of metals, but the resulting material is, for all practical purposes, macroscopically homogeneous, i.e. the components cannot be distinguished by the naked eye and essentially acts together. Naturally, not all of these properties are improved at the same time nor is there usually any requirement to do so. In fact, some of the properties are in conflict with one another, e.g., thermal insulation versus thermal conductivity. The objective is merely to create a material that has only the characteristics needed to perform the designed task. The advantage of composite materials is that, if well designed, they usually exhibit the best qualities of their components or constituents and often some qualities that neither constituent possesses. Some of the properties that can be improved by forming a composite material are strength, fatigue life, stiffness, temperature-dependent behavior, corrosion resistance, thermal insulation, wear resistance, thermal conductivity, attractiveness, acoustical insulation and weight. There are two building blocks that constitute the structure of composite materials. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix. The reinforcing phase material may be in the form of fibers, particulates, flakes. The matrix phase materials are generally continuous. Examples of composite systems include concrete reinforced with steel, epoxy reinforced with graphite fibers, etc.

II. OBJECTIVES

The main objective of this work is to design and analysis of composite drive shaft for an automobile.

The main objective will be obtained through following secondary objectives as follows:

Simulation of convectional two piece steel drive shaft and proposed one piece composite drive shaft by using analytical method. Finite element analysis of convectional two piece steel drive shaft and proposed one piece composite drive shaft by using 3D modeling software CATIA V5 R20 and simulation software Hyper Mesh 11 and Ansys 14.5.

III. LITERATURE REVIEW

In the recent days a lot of research has been taken up by various people on the concept of the use of composite materials for power transmitting members. Works taken up by the following people are significant in connection with the present work.

T. Rangaswamy, et al., [1] presented a paper titled, 'Optimal Design and Analysis of Automotive Composite Drive Shaft'. The overall objective of this paper was to design and analyse a composite drive shaft for power transmission applications. In this work a Genetic Algorithm (GA) has been successfully applied to minimize the weight of shaft which is subjected to the constraints such as torque transmission, torsion buckling capacities and fundamental natural frequency.

M. A. Badie, et al.,[2] presented in a paper titled, 'Automotive Composite Drive Shaft's Investigation Of The Design Variables Effects', finite element analysis was performed to investigate the effects of fibers winding angle and layers stacking sequence on the critical speed, critical buckling torque and fatigue resistance. A configuration of a hybrid of one layer of carbon epoxy(0º) and three layers of glass-epoxy (±45º, 90º) was used.

Y.A. Khalid et al., [3] in paper titled, 'Bending Fatigue Behaviour of Hybrid Aluminium/Composite Drive Shafts' throws light on the experimental study of a bending fatigue analysis carried out on hybrid aluminium/composite drive shafts. Glass fiber with a matrix of epoxy resin and hardener were used to construct the external composite layers needed.

A. R. Abu Talib et al., [4] presented their work 'Developing a Hybrid, Carbon/glass Fiber-reinforced, epoxy Composite Automotive Drive Shaft'. In this study a finite element analysis was used to design composite drive shaft incorporating carbon and glass fibers with an epoxy matrix. A configuration of one layer of carbon-epoxy and three layer of glass-epoxy with 00, 450 and 900. The results shown that in changing the fibers winding angle from 00 to 900, the loss in the natural frequency of the shaft. While shifting from best to worst stacking sequence, the drive shaft causes a loss in its buckling strength, which represents a major concern over the shear strength in the drive shaft design.

A. Gebresilassie [5] presented the paper 'Design and Analysis of Composite Drive Shaft for Rear-Wheel Drive Engine', aimed at evaluation of the suitability of composite material such as E-Glass/Epoxy for the purpose of automotive drive shaft application. A one-piece composite shaft was optimally analyzed using Finite Element Analysis Software for E-Glass/Epoxy composites with the objective of minimizing the weight of the shaft, which is subjected to the constraints such as torque transmission, critical buckling torque capacity and bending natural frequency.

A. *Design Calculations*

Design Considerations:

The following specifications were assumed suitably, based on the literature and available standards of automobile drive shafts:

1. The torque transmission capacity of the driveshaft (T) = 2000 N-m.
2. The shaft needs to withstand torsional buckling (Tb) such that Tb> T.
3. The minimum bending natural frequency of the shaft (fnb(min)) = 80 Hz.
4. Outside radius of the driveshaft (ro)= 60 mm.
5. Length of the driveshaft = 1.8 m.

B. *ANSYS Results*

IV.MATERIAL:STEEL

Properties of steel material used for conventional drive shaft are mentioned in below TABLE I.

TABLE I

Steel
E = 207000 MPa
ν= 0.3
G = 80000 MPa
ρ = 7600 Kg/m3

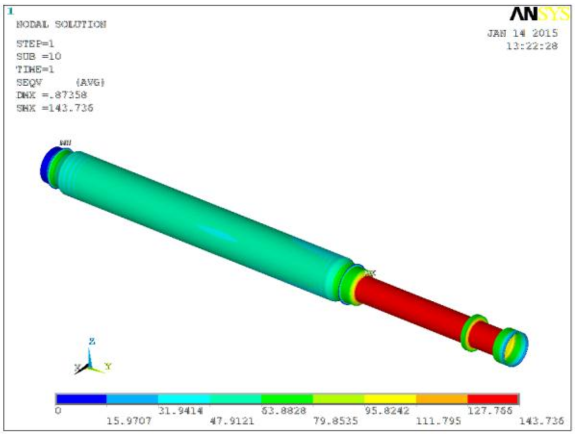

Fig1. Stress plot of Conventional Shaft

Material: Carbon fiber

Properties of Carbon/Epoxy material used for composite drive shaft are mentioned in below TABLE II

TABLE III

Carbon Epoxy Fiber
EX= 126900 MPa
EY= 11000 MPa
EZ= 126900 MPa
νXY= 0.2
νXY= 0.2
νXY= 0.2
GXY=6600MPa
GXZ = 4200 MPa
GYZ = 4880 MPa

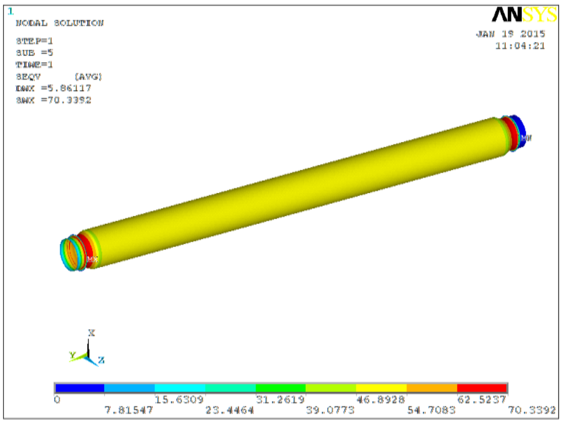

Fig 2. Stress Plot of Carbon epoxy fiber

C. *Results*

Stress Result from Both

TABLE IIIII

Sr. No	Material	Hand calculation Shear Stress (MPa)	ANSYS Stress (MPa)
1	Steel	80	143
2	CF	293	70

V.CONCLUSION

All From above result I have to concluded that we can use carbon fiber material for drive shaft in any vehicle. By hand calculation result and ANSYS result I found that stress in composite shaft is much less than original shaft. In composite shaft weight reduction is up to 50%.

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