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Design And Analysis Of Propeller Shaft Using Visco Elastic Damping Materials

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ABSTRACT

Automotive drive Shaft is a very important components of vehicle. The overall objective of this paper is to design and analyze a composite drive shaft for power transmission. Substituting composite structures for conventional metallic structures has many advantages because of higher specific stiffness and strength of composite materials. In the present buckling analysis is performed to find out buckling factor. Model and harmonic analysis has done to find out natural frequency of shaft and resonance frequency of different materials. Impulse loading condition also taken into analysis to find out damping factor of particular materials.

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). 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. 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.

Description of the Problem

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.

Aim and Scope of the Work

This work deals with the replacement of a conventional steel drive shaft with E-Glass/ Epoxy, High Strength Carbon/Epoxy and High Modulus Carbon/Epoxy composite drive shafts for an automobile application.

Analysis

1.Modeling of the High Strength Carbon/Epoxy composite drive shaft usingANSYS.

2.Static, Modal and Buckling analysis are to be carried out on the finite element model of the High Strength Carbon/Epoxy composite drive shaft usingANSYS.

3.Toinvestigate

a)The stress and strain distributions in E-Glass/ Epoxy, High Strength Carbon/Epoxy and High Modulus Carbon/Epoxy composite drive shafts using classical lamination theory(CLT).

b) The effect of centrifugal forces on the torque transmission capacity of the composite driveshafts.

c) The effect of transverse shear and rotary inertia on the fundamental lateral natural frequency of theshaft.

Composites consist of two or more materials or material phases that are combined to produce a material that has superior properties to those of its individual constituents. The constituents are combined at a macroscopic level and or not soluble in each other. The main difference between composite and an alloy are constituent materials which are insoluble in each other and the individual constituents retain those properties in the case of composites, where as in alloys, constituent materials are soluble in each other and forms a new material which has different properties from their constituents.

PROPULSION SHAFT

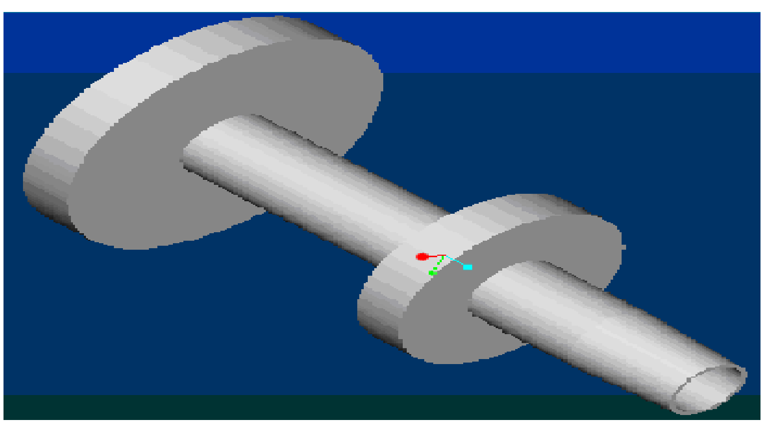
The torque transmission capability of the propeller shaft for ship should be larger than 3,500 Nm and fundamental natural bending frequency of the propeller shaft should be higher than 6,500 rpm to avoid whirling vibration. The outer diameter of the propeller shaft should not exceed 100 mm due to space limitations. The propeller shaft of transmission system is shown in figure for following specified design requirements as shown in Table. The description of shaft is given in fig . Due to space limitations the outer diameter of the shaft is restricted to 90.24mm.

PROBLEM DESCRIPTION

The one-piece hollow composite drive shaft should satisfy three design specifications, such as static torque transmission capability, torsional buckling capacity and the fundamental natural bending frequency. For given specification, the damping factor for Steel, carbon Epoxy and E- Glass Epoxy are to be calculated and compared with and without damping material (Rubber).

Sl. No.	Parameter	Notation	Units	Value
1.	Torque	T	N-m	3500
2.	Max Speed	N	RPM	6500
3.	Length	L	m	1.250

Table 1: Problem Specification



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Sl. No.	Properties	Units	Steel	Carbon Epoxy	E-Glass Epoxy
1	Young‟s Modulus E11	N / m^2	$2.068e^{11}$	$1.34\ e^{11}$	$50\ e^{9}$
2	Young‟s Modulus E22	N / m^2	$2.068\ e^{11}$	$7\ e^{9}$	$12\ e^{9}$
3	Density	kg / m^3	7830	1600	2000
4	Poisson Ratio	-	0.3	0.3	0.3
5	Shear Modulus G	N / m^2	$0.8e^{11}$	$5.8e^{9}$	$5.6e^{9}$

Fig 1:Pictorial representation of shaft transmission system

Table 2: Material Properties

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STRUCTURAL ANALYSIS OF PROPELLER SHAFT

STEEL SHAFT FOR SHELL 188:

Sl. No.	Parameters	Values
1	Outer Diameter	0.09024 m
2	Thickness	2.1 e^{-3}

Table 3:Specification for Steel Shaft

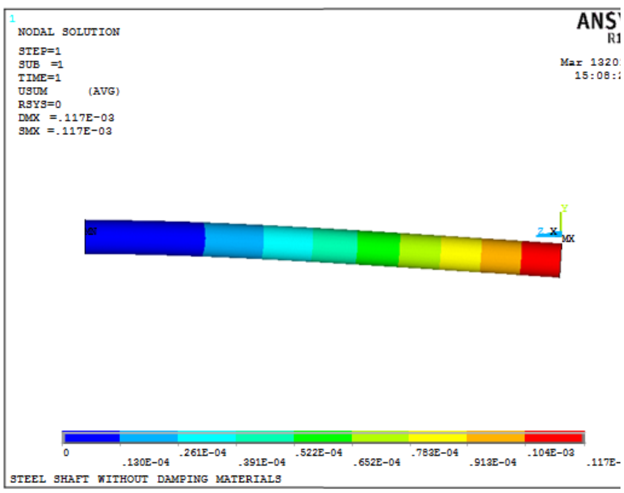

Fig 2:Static Deflection for Steel Shaft

CARBON EPOXY SHAFT:

Sl. No.	Parameters	Values
1	Outer Diameter	0.09024 m
2	Thickness of each layer	1.5 e^{-4} m
3	Number of layers	13
4	Element	Shell 188

Table 4:Specification for Carbon Epoxy Shaft

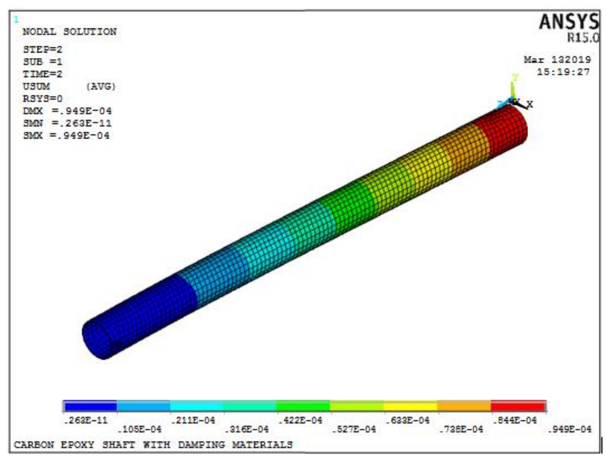

Fig 3:Static Deflection for Carbon Epoxy Shaft

E-GLASS EPOXY SHAFT MATERIAL

Sl. No.	Parameters	Values
1	Outer Diameter	.09024 m
2	Thickness of each layer	1.5 e^{-4} m
3	Number of layers	23
4	Element	Shell 99

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Table 5:Specification for E- Glass Epoxy Shaft

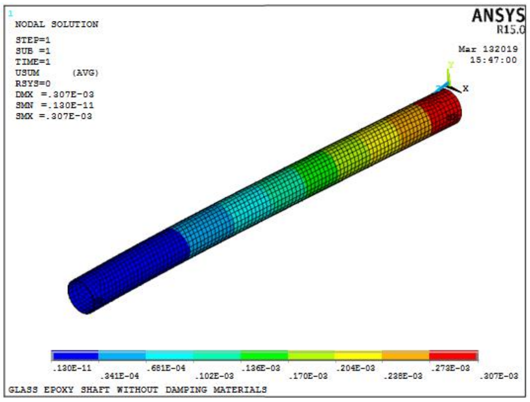


Fig 4:Static Deflection for E-Glass Epoxy Shaft

Fig 5:**Torsional deformation of steel shaft.**

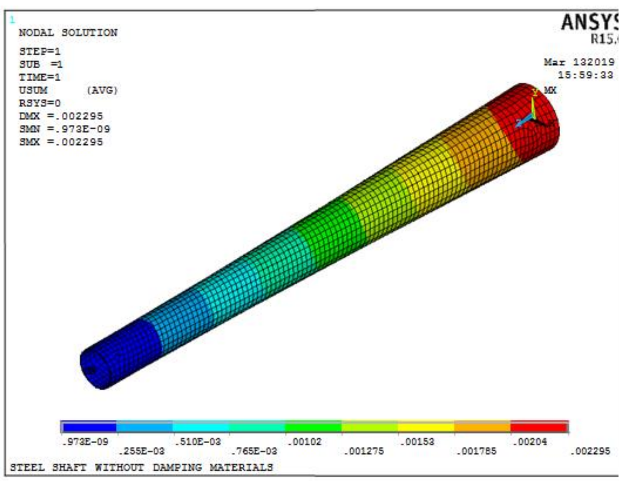
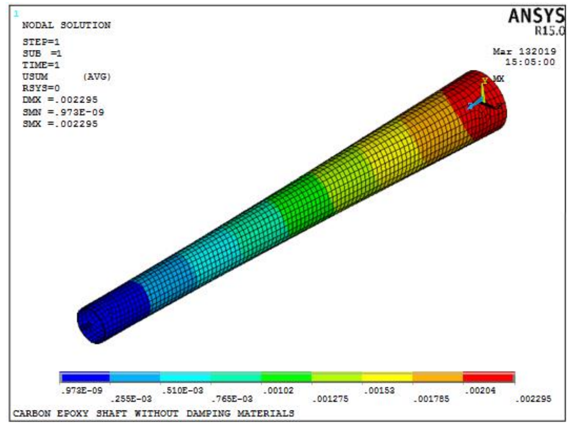


Fig 6:**Torsional deformation of carbon epoxy shaft**



RESULTS DUE TO BUCKLING FACTOR	
MATERIALS	DEFORMATION
STEEL	50.23
CARBONEPOXY	-7.07
GLASSEPOXY	5.0762

MODAL ANALYSIS

STEEL SHAFT USING SHELL ELEMENT

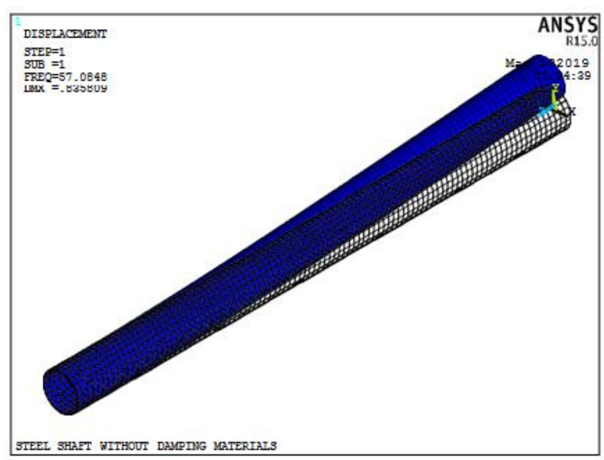


Fig 7:Modal Analysis for Steel Shaft using Shell281

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CARBON EPOXY SHAFT

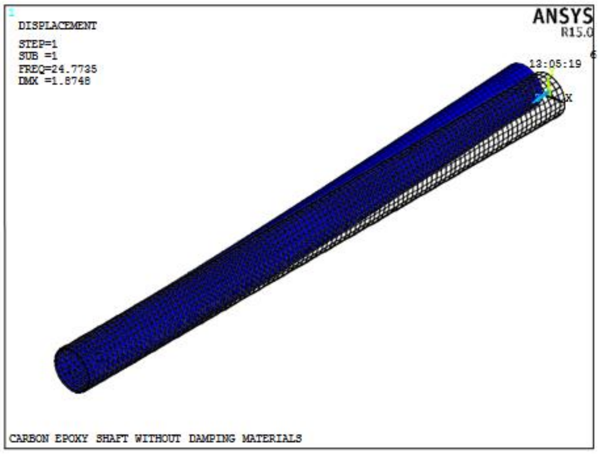


Fig 8:Modal Analysis for Carbon Epoxy Shaft

E-GLASS EPOXY SHAFT

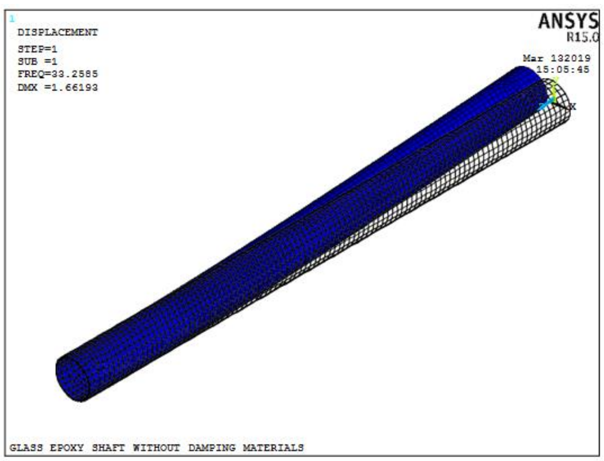


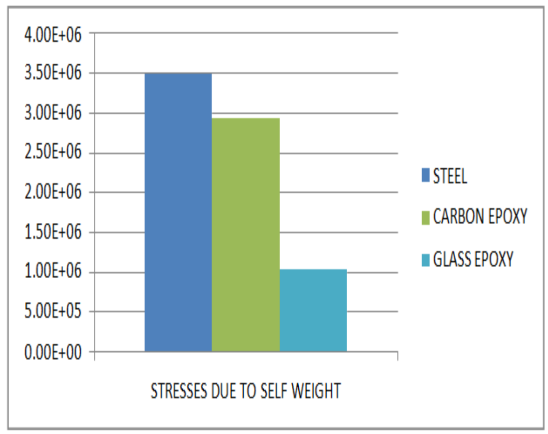
Fig 9:Modal Analysis for E-Glass Epoxy Shaft

RESULTS

Table 5: Comparison of Results for Shaft

RESULTS DUE TO SELF WEIGHT		
MATERIALS	DEFORMATION	STRESSES
STEEL	1.17E-04	3.49E+06
CARBON EPOXY	9.49E-05	2.93E+06
GLASS EPOXY	3.07E-04	1.04E+06

1.From the above table carbon epoxy having minimum deformation and glass epoxy material are having more deformation.



From the above table glass epoxy having minimum bending stresses and steel material are having more stresses.

:RESULTS DUE TO 120 N-M TORSSION		
MATERIALS	DEFORMATION	STRESSES
STEEL	0.0022	6.40E+07
CARBON EPOXY	0.002295	6.42E+07
GLASS EPOXY	0.00125	6.15E+07

Table 6: Torssion results

1.From the above table carbon epoxy having minimum deformation and glass epoxy material are having more deformation.

2.carbon epoxy with damping materials are having more bending stresses as compared to remaining materials and glass epoxy

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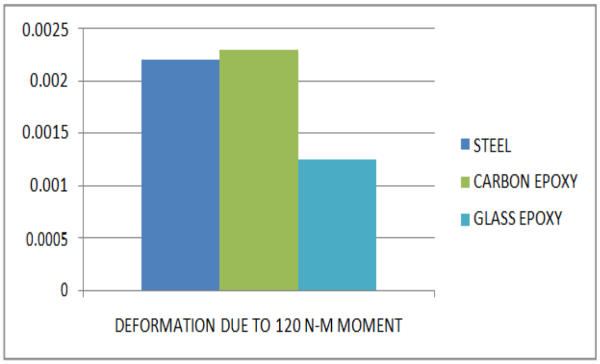
materials having minimum stresses.



RESULTS DUE TO BUCKLING FACTOR	
MATERIALS	DEFORMATION
STEEL	50.23
CARBONEPOXY	-7.07
GLASSEPOXY	5.0762

Table 7: Buckling factor

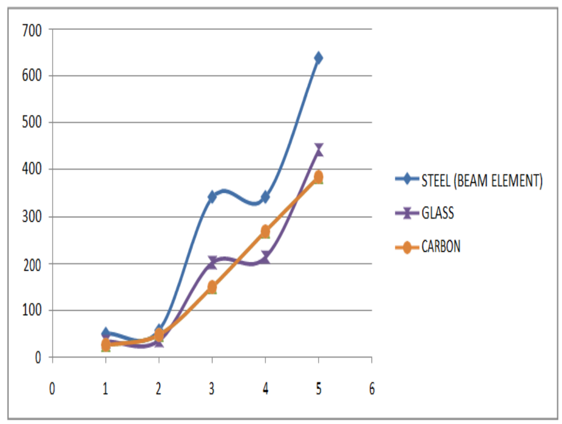
1.Steel materials having 50.23 buckling factor when we applied 500 N compressionload..

2.carbon epoxy materials having -7.07 buckling factor when we applied 500 N compression load. Here we have negative factor means if we applied pulling load it canbuckle.

3.carbon epoxy materials having 5.076 buckling factor when we applied 500 N compression load. Here we have negative factor means if we applied pulling load it canbuckle.

9.4 NATURAL FREQUENCIES				
	STEEL (BEAM ELEMENT)	STEEL	CARBON	GLASS
MODE1	56.7	50	24.77	33.2
MODE2	338.2	57.08	47.5	35.34
MODE3	884.02	341	150	201.5
MODE4	1025.86	341.5	269	213
MODE5	1592	639	385	442

Table 8: Natural Frequencies



steel first natural frequency is increased by 8% then the glassepoxy

CONCLUSIONS

• Different analysis has been performed for Steel Shaft, Carbon Epoxy Shaft and E-Glass EpoxyShaft.

• The Static, Modal and Transient Dynamic Analyses have been carried out using Finite

ElementAnalysis.

- Carbon epoxy having minimum deformation and glass epoxy material are having more deformation.
- Glass epoxy having minimum bending stresses and steel material are having more stresses.
- An optimal relation between design parameters such as the length, diameter, spacing, and Young‟s modulus of fibers and the shear modulus of viscoelastic matrix has been derived for achieving maximum damping performance. It has been found that for maximum damping performance, and optimum weight propeller shaft is carbon epoxymaterial.

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