

DESIGN AND ANALYSIS OF COMPOSITE PROPELLER SHAFT FOR AN AUTOMOTIVE APPLICATION

M. Sunil Kumar¹, B. Om Prakash²

¹ PG Scholar Department of Mechanical Engineering, JNTUA College of Engineering, JNTUA, Ananthapuram, Andhra Pradesh, INDIA

² Assistant Professor, Department of Mechanical Engineering, JNTUA College of Engineering, JNTUA, Ananthapuram, Andhra Pradesh, INDIA

ABSTRACT: *This paper deals with design and analysis of composite propeller shaft by replacing the conventional stainless steel with composite materials by using ANSYS. The materials which use in this analysis were E-glass epoxy, high strength carbon epoxy, and high modulus carbon epoxy. Conventional propeller shaft is a two piece steel propeller shaft in order to make it as a single long continuous shaft we are using composite materials. Static, model and buckling analysis on these materials is done by using ANSYS software.*

Keywords-*E-glass /epoxy, Specific modulus, Degrees of Freedom, Torque*

I. INTRODUCTION

Propeller shaft is a mechanical instrument which is used in automobiles. Most popularly this propeller shaft is known as the propeller shaft, while coming to the construction it was long cylindrical structure consists of three universal joints. Propeller shaft is used to transfer the rotary motion to the differential by using the helical gear box. This rotary motion is used to run the rear wheels. In many cases we use stainless steel shaft for the fabrication of propeller shaft. This propeller shaft has wide applications in automobile world, used in the vehicles like trucks, buses, aero planes etc.

II. PROBLEM DESCRIPTION

Stainless steel was mainly used because of its high strength. But this stainless steel shaft has less specific strength and less specific modulus. Stainless steel has less damping capacity. Because of its higher density of molecules of stainless steel, its weight is very high. Because of increase in weight fuel consumption will increase, the effect of inertia will be more.

Because of increase in weight of the propeller shaft we are replacing the stainless steel with the composite materials, which are very less weight when compared to that of stainless steel. The cost of composite materials is less when compared to that of stainless steel.

III. COMPOSITE MATERIALS AND IT'S CLASSIFICATION

Composite materials are used in the fabrication of propeller shaft instead of stainless steel. Composite materials have high specific strength and high specific modulus. Thermal conductivity properties are varying for these composite materials. Because of using various composite materials in layer by layer the Conductivity properties vary for each material, because of this reason there was drastic increase in thermal conductivity. The molecular density is less when compared to that of stainless steel the weight will be decreased. Mainly we use E-glass epoxy HS carbon epoxy Kevlar glass fiber materials are used in manufacturing.

Composite materials are classified according to their properties

1. Polymer matrix
2. Composites Metal matrix composites
3. Ceramic matrix composites

These composite materials are classified based on the matrices composite material composites. Polymer matrices are not stronger than metal matrix; these composites are made in composite resin.

3.1 Applications of Composite Materials.

Automotives: Glass/epoxy leaf springs for heavy trucks, clutch plates, propeller shafts, frames, engine blocks etc.

Space: Remote manipulator arm, high gain antenna, antenna ribs, struts etc.

Aircrafts: driveshaft, rudders, elevators etc.

3.2 Comparison of Stainless Steel with Composite Materials

PROPERTY	STAINLESS STEEL	COMPOSITE MATERIALS
SPECIFIC STRENGTH	LOW	HIGH
SPECIFIC MODULUS	LOW	HIGH
WEIGHT	HIGH	LOW
COST	HIGH	LOW
CORROSION	HIGH	LOW
THERMAL CONDUCTIVITY	MEDIUM	MEDIUM
DAMPING CAPACITY	MEDIUM	HIGH

IV. TYPES OF PROPELLER SHAFT

There are various type of transmission shaft among them following are important

1. Transmission shaft.
2. Machine shaft.
3. Spindle.
4. Automobile propeller shaft.
5. Ship propeller shaft.
6. Helicopter tail rotor shaft.

These propeller shafts can be manufactured by replacing the stainless steel with the composite materials.

4.1 Improvements Made To the Propeller shaft.

- ✓ Long continuous propeller shaft is made by replacing the discontinuous two piece conventional propeller shaft.
- ✓ Reducing the weight of the propeller shaft. Increase in natural frequency.
- ✓ Decrease in bending stress using various stacking sequence.
- ✓ Increase in torque transmission and torsion buckling activities

4.2 Comparison of Mechanical Properties

MECHANICAL PROPERTY	STAINLESS STEEL	HSCARBON/E-GLASS EPOXY
YOUNGS MODULUS	207Gpa	210Gpa
SHEAR MODULUS	80Gpa	70Gpa
SHEAR STRENGTH	370Mpa	420Mpa
DENSITY	7600Kg/m3	1600Kg/m3

4.3 Analysis of Composite Propeller shaft Using ANSYS

ANSYS is an analysis tool which was used by mechanical engineers to check the feasibility of any product before launching into the market. Various analysis can be done before launching the product into the market. Various types of analysis techniques were used among them static, model, buckling, CFD etc.

In this scenario we consider buckling, model, and static analysis by finite element technique. From these analysis techniques we got the following results.

4.4 Finite Element Analysis

Finite element analysis is a computer based numerical technique is used to for calculating the strength and behavior of the engineering structures. The structure on which the analysis can be done is divided into large number of finite elements and required stress at the desired point can be calculated. The accuracy of the structure depends on the no of finite elements made.

4.5 Static Analysis

Static analysis deals with the conditions of equilibrium of the bodies acted upon by the forces. Types of static analysis

- Linear
- Non linear

Kinds of loads that can be applied in static analysis includes

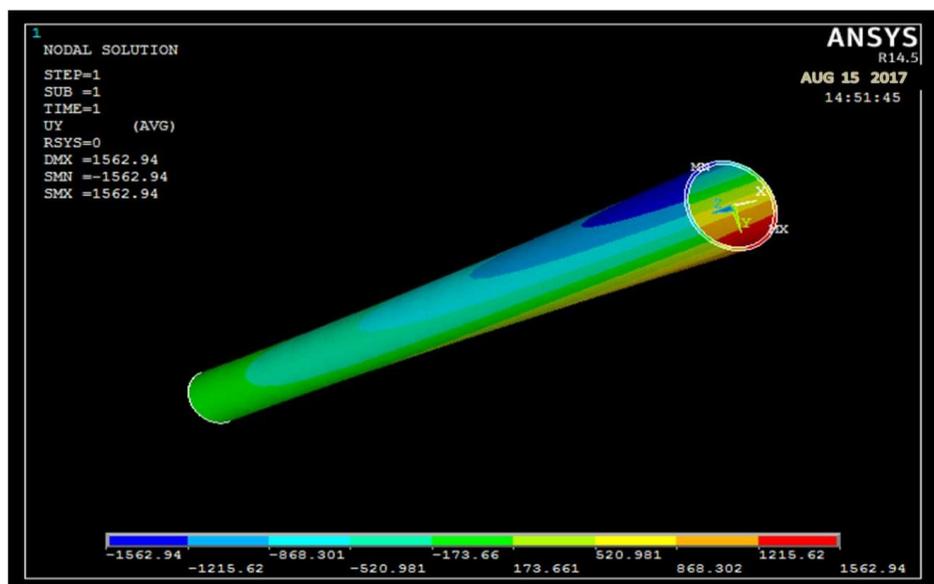
1. Pressures, moments, and externally applied forces.
2. Non-zero displacements imposed.
3. Inertial forces such as gravity and gravity.

4.6 Model Analysis

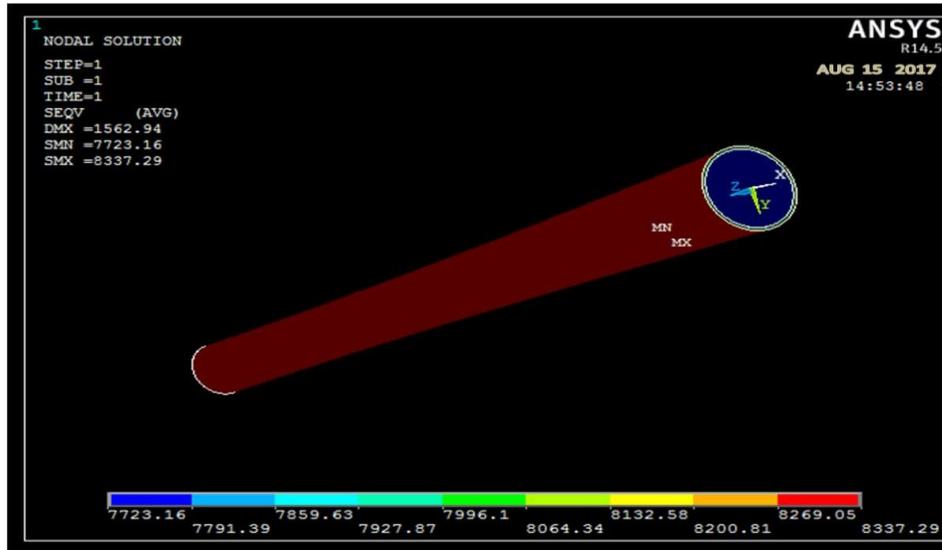
The body under the equilibrium was disturbed from its state by the action of some external inherent force then the system undergoes vibrations these vibrations are called free vibrations. It will vibrate with its natural frequency and its amplitude. Model analysis is used to determine the natural frequencies and mode shape of the structures.

4.7 Analysis on E-Glass Epoxy

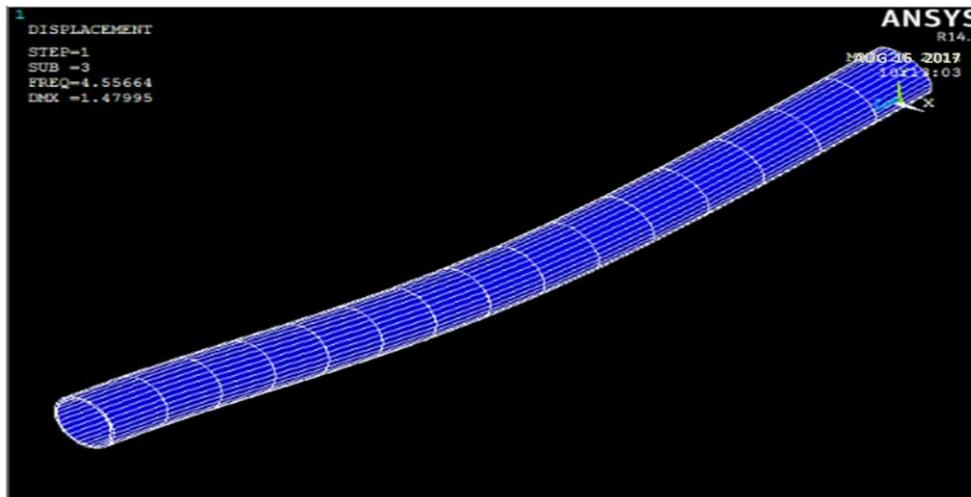
E-glass epoxy has the following results in von-mises and in all DOF



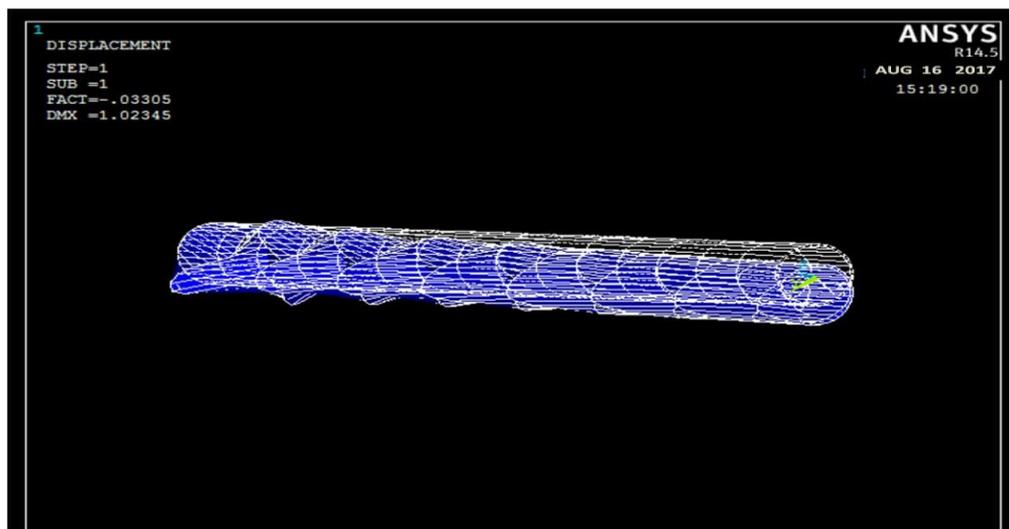
All DOF Analysis for E-Glass Epoxy



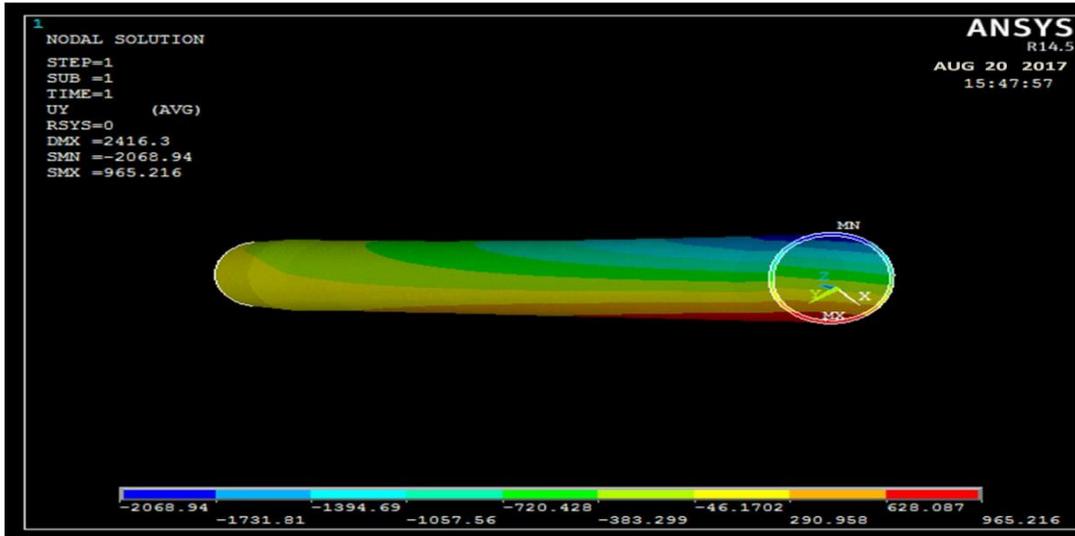
Von-Mises Analysis of E-Glass Epoxy



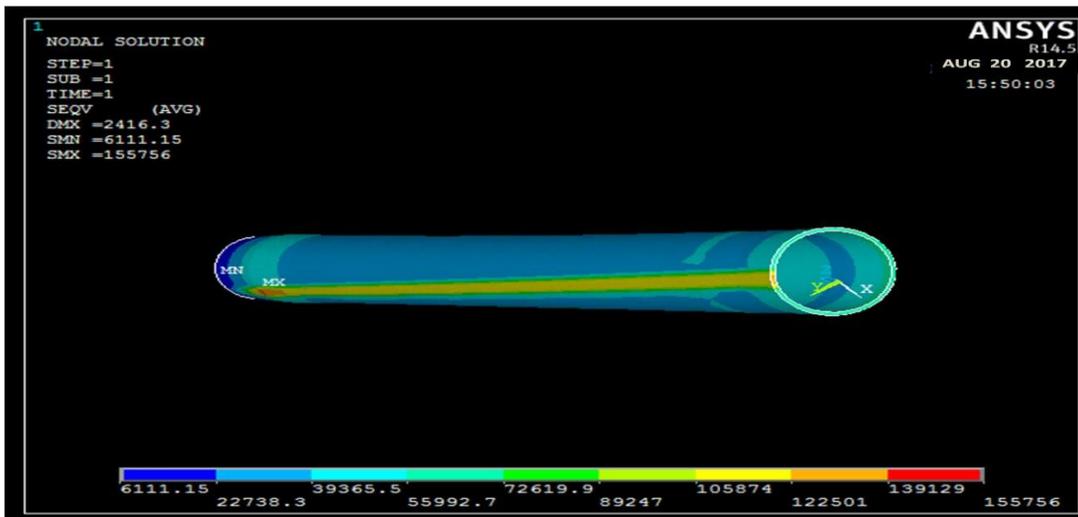
Model Analysis For E-Glass Epoxy



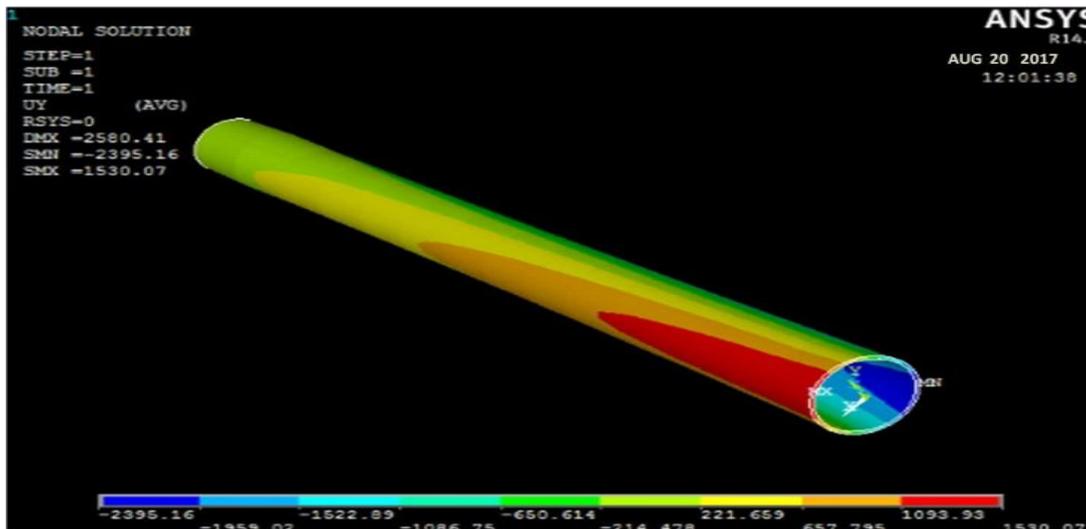
Buckling Analysis of E-Glass Epoxy



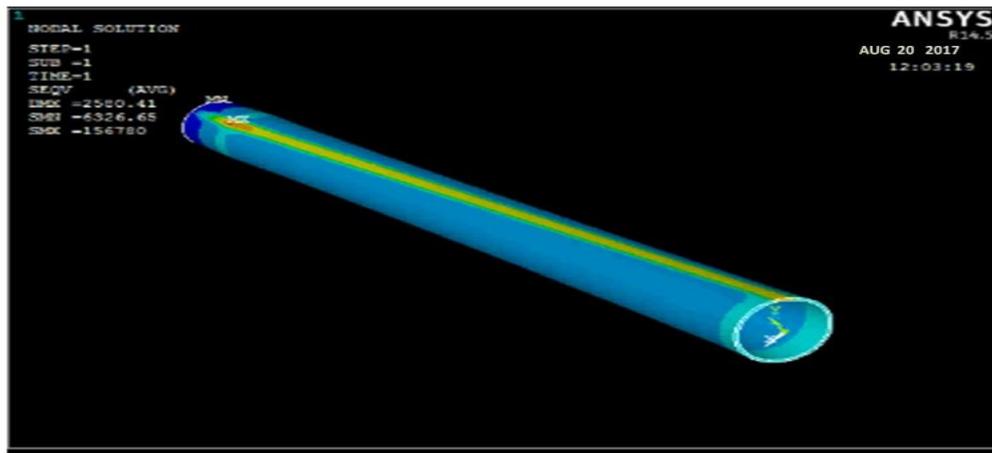
All DOF Analysis For HS-Carbon Epoxy



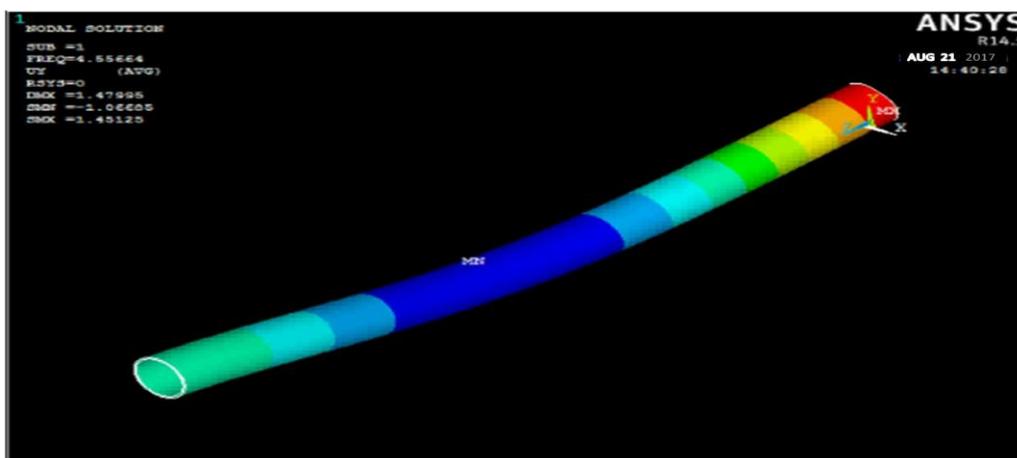
Von-Mises Analysis for the HS-Carbon Epoxy



All DOF For HM Carbon Epoxy



Von Mises Analysis For HM-Carbon Epoxy



Model Analysis For HM Carbon Epoxy

Conclusion

Hence by using composite materials weight of the propeller shaft was successfully decreased. Finite element analysis was used in this work to predict the deformation of the shaft. Bernoulli–Euler and Timoshenko beam theories was used to know the natural frequency. Hence single piece high strength carbon/epoxy composite propeller shaft has been proposed to design to replace two piece conventional steel propeller shaft of automobile.

References

- [1].John W.et.al.engineers Guide to composite materials, American society for metals, 1986. Beardmore, P.et al. the potential for composites in structural Automotive Applications J. of composites science and Technology 26 1986: pp. 251-281.
- [2]. T. RANGASWAMY, et al.”Optimal sizing and stacking sequence of composite drive shaft” ISSN1392-1320 materials science (medziagotyra). Vol. 11, no.2. 2005.
- [3]. Rajeev S and Krishnamurthy, C.S,1992 “Discrete optimization of structure using genetic Algorithm ” Journal of structural Engg .ASCE Vol. 118PP. 1233-1250.
- [4]. Pollard, A. polymer Matrix composites in drive line applications, GNK Tech., uk, 1989.
- [5]. Goldberg, D. E. Genetic Algorithms in Search, Optimization and Machine Learning, Reading MA, Addison-Wesley.
- [6]. Vijayarangan, S., Rajendran, I. Optimal Design of a Composite Leaf Spring Using Genetic Algorithm Computers and Structures 79 2001: pp. 1121 – 1129.
- [7]. T.Rangaswamy, et. al “Optimal Design and Analysis of Automotive Composite Drive Shaft”, International Symposium of Research Students on Materials Science and Engineering December 2002-04 Chennai India
- [8]. Kim C D et. al. 1992, “Critical speed Analysis of Laminated Drive Shafts”, Composite Engg. Vol.3, pp. 633-643.
- [9]. J. H. Park, J. H. Wang 2001, “Stacking sequence Design of Composite Laminates for maximum Strength Using Genetic Algorithm”, Journal of Composite Structures, Vol.52 , pp. 217-231.