ISSN No: 2348-4845
International Journal & Magazine of Engineering, Technology, Management and Research
A Peer Reviewed Open Access International Journal

Composite Analysis of Forward Drive Shaft

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ABSTRACT

This project deals with the design of front wheel drive shaft for maximum power transmitted from FWD car. This project includes detailed finite element analysis of front wheel drive shaft for torsional and bending loads. The project involves performing analysis for drive shaft with conventional steel material and also with different composite materials like carbon/Epoxy, E-glass/Epoxy and Kevlar/Epoxy. A number of papers were published previously on the similar lines, but most of them were restricted only for static and modal analysis only. This project is extended in performing harmonic and shock analysis also.

In this project, the design of front wheel drive is done by theoretical formulas for both steel and composite material for torsional and bending loads. A static, modal, harmonic and shock analysis is done for different composite materials with different layer orientation to calculate weight, deflections, stresses and vibration characteristics of the front wheel drive. The results obtained from the analysis are compared and the best material is proposed based on the weight to strength ratio. Design of front wheel drive shaft is done in NX CAD software and Ansys11.0 software is used for static analysis of front wheel driveshaft.

INTRODUCTION DRIVE SHAFT

A driveshaft or driving shaft is a device that transfers power from the engine to the point where work is applied. In the case of automobiles, the drive shaft transfers engine torque to the drive axle, which connects the two wheels together on opposite sides and with which they turn. The driveshaft is also sometimes called propeller shaft. Drive shafts are essentially carriers of torque. Before they became a vogue, older automobiles used chain drive and even generators to transmit power to the wheels. Drive shaft today, however, have U-joints, devices which help them to move and down during suspension. Some drive shafts also have another kind of joint, called slip joints, which allow them to adjust their lengths to the movement of the suspension.

Adjustments aside, drive shafts are of different lengths depending on their use. Long shafts are used in front-engined, rear-drive vehicles while shorter ones are used when power must be sent from a central differential, transmission, or transaxle. Because of the load they Carrie, driveshaft must be strong enough to bear the stress that is required in the transmission of power.

LITERATURE SUVEY

[1]AnupamSinghal, R. K. Mandloi: have published a entitled on "Failure Analysis of Automotive FWD Flexible Drive Shaft ". According to this, Drive shafts are carriers of torque. They are subject to torsion and shear stress, equivalent to the difference between the input torque and the load. They must therefore be strong enough to bear the stress, whilst avoiding too much additional weight as that would in turn increase their inertia.

[2]D.DINESH, F.ANAND RAJU: have written a title on "Optimum Design And Analysis Of A Composite Drive Shaft For An Automobile By Using Genetic Algorithm And Ansys". In this title substituting composite structures for conventional metallic structures has many advantages because of higher specific stiffness

Cite this article as: P.Balagangi Reddy & C. Raghunatha Reddy, "Composite Analysis of Forward Drive Shaft", International Journal & Magazine of Engineering, Technology, Management and Research, Volume 5 Issue 12, 2018, Page 63-70.

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and strength of composite materials. This work deals with the replacement of conventional two-piece steel drive shafts with a single-piece e-glass/epoxy, high strength carbon/epoxy and high modulus carbon/epoxy composite drive shaft for an automotive application.

[3]BHIRUD PANKAJ PRAKASH, BIMLESH KUMAR SINHA: has published a journal on "ANALYSIS OF DRIVE SHAFT". This paper includes Composite materials can be tailored to efficiently meet the design requirements of strength, stiffness and composite drive shafts weight less than steel or aluminum of similar strength. It is possible to manufacture one piece of composite. Drive shaft to eliminate all of the assembly connecting two piece steel drive shaft. Also, composite materials typically have a lower modulus of elasticity. As a result, when torque peaks occur in the driveline, the driveshaft can act as a shock absorber and decrease stress on part of the drive train extending life.

[4]V. S. BHAJANTRI , S. C. BAJANTRI , A. M. SHINDOLKAR , S. S. AMARAPURE: have written a paper on "DESIGN AND ANALYSIS OF COMPOSITE DRIVE SHAFT". This paper presents that Substituting composite structures for conventional metallic structures has much advantage because of higher specific stiffness and strength of composite materials.

Composite materials have been widely used to improve the performance of various types of structures. Compared to conventional materials, the main advantages of composites are their superior stiffness to mass ratio as well as high strength to weight ratio.

[5]Sagar R Dharmadhikari, 1 Sachin G Mahakalkar, 2 Jayant P Giri, 3 Nilesh D Khutafale: submitted a paper on ""Design and Analysis of Composite Drive Shaft using ANSYS and Genetic Algorithm". This paper presents Drive shaft is the main component of drive system of an automobile. Use of conventional steel for manufacturing of drive shaft has many disadvantages such as low specific stiffness and strength. Conventional drive shaft is made up into two parts to increase its fundamental natural bending frequency.

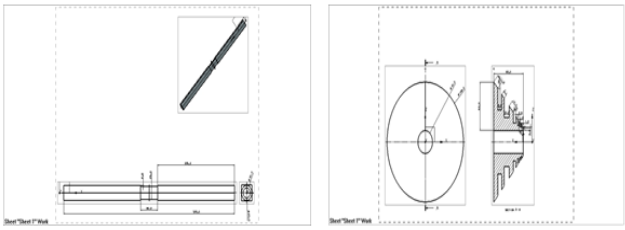
PROBLEM DEFINITION AND METHODOLOGY

In Front wheel drive (FWD) car, maximum power is transmitted through drive shaft. This power transmission mainly depends on size of drive shaft. The drive shaft is subjected to torsional stresses and bending stresses. To achieve more reliability, less cost and high quality, the drive shaft should be with less weight and more strength and stiffness. Because of this reason weight optimization of front wheel drive shaft plays a major role in achieving these major goals like less cost, high quality and reliability. Composite materials are play major role in optimization of weight of shaft.

MODELING OF ONE-PIECE DRIVE SHAFT

2D SKETCH OF ONE-PIECE DRIVE SHAFT:

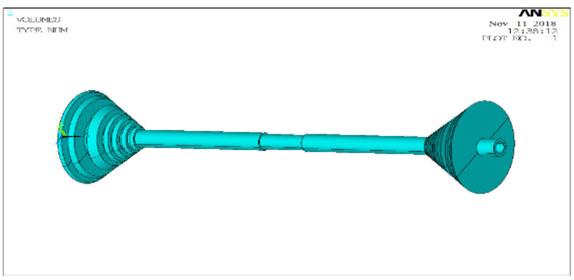
2d sketch and 3D model of one-piece drive shaft done in unigraphics software based on input.



FINITE ELEMENT ANALYSIS OF ONE-PIECE DRIVE SHAFT

STATIC ANALYSIS OF ONE- PIECE DRIVE SHAFT:

A static analysis can however include steady inertia loads and time varying loads that can be approximated as static equivalent loads. The 3d model of the Drive shaft is created in NX-CAD and converted into paranoid. The paranoid file is imported into ANSYS and finite element analysis is carried out using ANSYS software.



MATERIAL PROPERTIES:

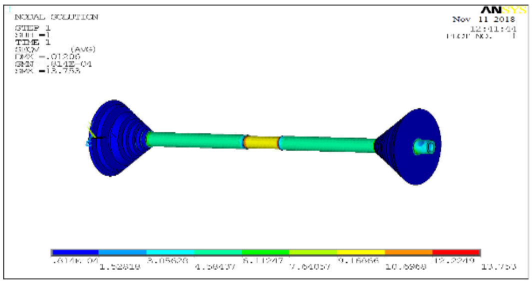
1 Material used for Drive shaft is Stainless steel alloy:

Young's Modulus: **200 GPa**
Poisson's Ratio: **0.3**
Density: **7850 Kg/m3**
Yield strength: **300 MPa**

Element Types used:

Name of the Element: SOLID 92
Number of Nodes: 10
DOF: UX, UY & UZ

RESULTS:



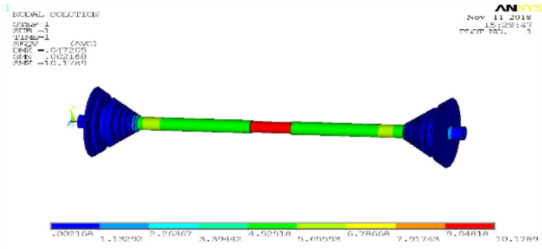
From static analysis results for steel material, the resultant displacement found on one-piece drive shaft is **0.01206 mm.** The Vonmisses stress formed on drive shaft is **13.753Mpa.** The yield strength of steel material is **300 MPa**. The Von mises stress of drive shaft was less than the yield strength of the material. Hence the drive shaft was safe in design for static conditions.

STATIC ANALYSIS OF COMPOSITE MATERIALS USED FOR ONE- PIECE DRIVE SHAFT:

Material used for drive shaft is composite materials (E-Glass/Epoxy):

Longitudinal Modulus (E_x): **50 GPa**
Transverse Modulus (E_Y): **12 GPa**
Shear modulus (G_{ay}): **5 .6GPa**
Shear modulus (G_{ym}): **5.6 GPa**
Shear modulus (G_{xz}): **5.6 GPa**
Poisson's Ratio: **0.33**
Density: **2000 Kg/m3**
Ply orientation: **-45^o, 0^o, 0^o, 45^o**

RESULTS:



Von misses Stress formed on one piece drive shaft

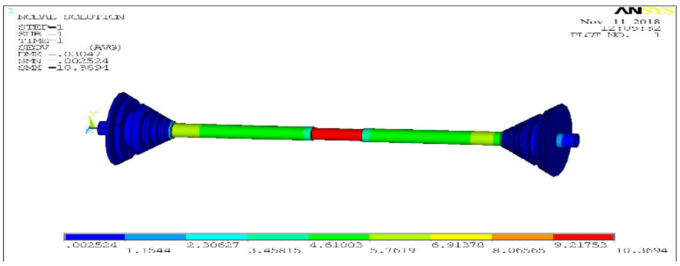
From static analysis results for E-glass /epoxy, the resultant displacement found on drive shaft is **0.047205 mm.** The Von misses stress formed on drive shaft is **10.1789MPa.** The yield strength of E-glass/Epoxy material is **870 MPa**. The Von mises stress of drive shaft was less than the yield strength of the material. Hence the drive shaft was safe in design for static conditions.

Composite materials (Kevlar/Epoxy):

Material used for drive shaft is composite materials (Kevlar/Epoxy):

Longitudinal Modulus (E_x): **79.2 GPa**
Transverse Modulus (E_Y): **7.25 GPa**
Shear modulus (G_{xy}): **4.25 GPa**
Shear modulus (G_{yz}): **4.25 GPa**
Shear modulus (G_{xz}): **4.25 GPa**
Poisson's Ratio: **0.34**
Density: **1384 Kg/m3**
Ply orientation: **-45^o, 0^o, 0^o, 45^o**

RESULTS



Von mises Stress formed on one piece drive shaft

From static analysis results for Kevlar/epoxy, the resultant displacement found on drive shaft is **0.03047**

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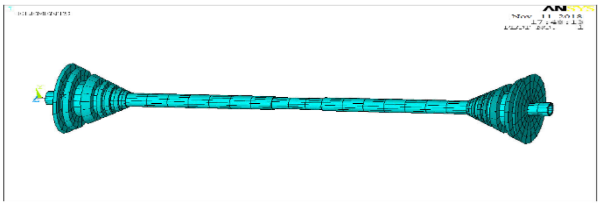
mm. The Von misses stress formed on drive shaft is **10.3694MPa.** The yield strength of Kevlar/Epoxy material is **800 MPa**. The Von mises stress of drive shaft was less than the yield strength of the material. Hence the drive shaft was safe in design for static conditions.

MODAL ANALYSIS OF ONE PIECE DRIVE SHAFT

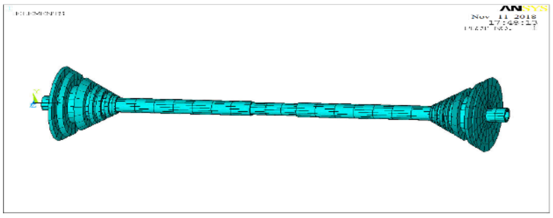
MODAL ANALYSIS OF DRIVE SHAFT FOR E-GLASS/EPOXY MATERIAL:



Finite Element Model of one-piece drive shaft

MODAL ANALYSIS OF DRIVE SHAFT FOR KEVLAR/EPOXY MATERIAL:

Modal analysis was carried out on drive shaft to determine the first 5 natural frequencies and mode shapes of a structure. From the modal analysis, a total of 5 natural frequencies are observed.



Finite Element Model of one-piece drive shaft

Weight absorbed from modal analysis results are given below

MATERIAL

MATERIAL	WEIGHT
Steel material	6.52 Kg
E-Glass/Epoxy	1.61 Kg
Kevlar/Epoxy	1.12 Kg

From the results of modal analysis of drive shaft using Kevlar/Epoxy material, following observations are made:

The total weight of the drive shaft is observed for the analysis is 0.112094E-02 tonnes.

It is observed that the maximum mass participation of 0.2771E-19Tones in X-direction for the frequency of 68.43 Hz.

It is observed that the maximum mass participation of 0.5067E-03Tones in Y-direction for the frequency of 68.43 Hz.

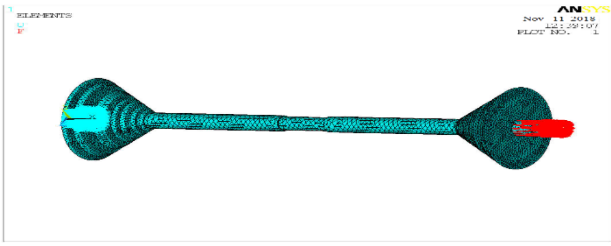
It is observed that the maximum mass participation of 0.5067E-03Tones in Z-direction for the frequency of 68.43 Hz.

HARMONIC ANALYSIS OF ONE-PIECE DRIVE SHAFT

HARMONIC ANALYSIS OF ONE-PICE DRIVE SHAFT USING STEEL MATERIAL

HARMONIC ANALYSIS:

- A force of 2126.04 N is applied at one end of drive shaft.
- Another end constrained in all DOF.
- Drive shaft rotates with an angular speed of 125.6 rev/s.



Boundary conditions and loading of drive shaft.

HARMONIC ANALYSIS OF ONE-PICE DRIVE SHAFT USING KEVLAR/EPOXY

HARMONIC ANALYSIS:

- A force of 2126.04 N is applied at one end of drive shaft.
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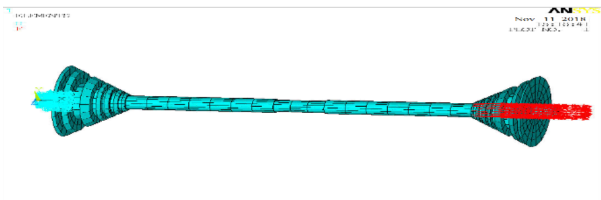

Boundary conditions and loading of drive shaft.

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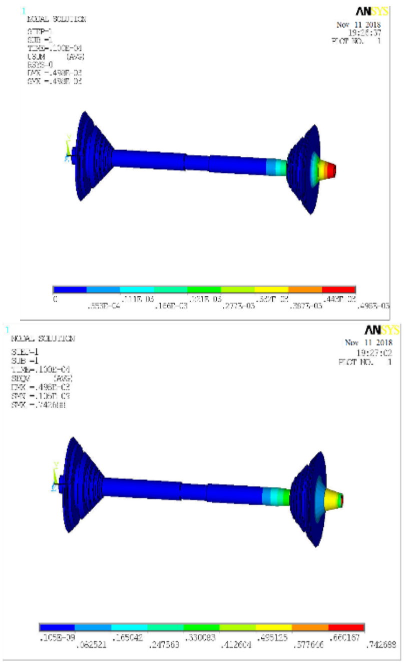
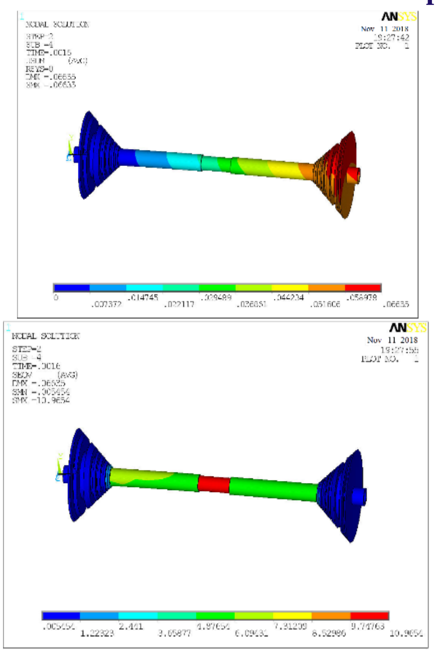
9.1 Results obtained from transient analysis of drive shaft using E-Glass/Epoxy material.

9.1.1 Displacements and Stresses at load step-1:



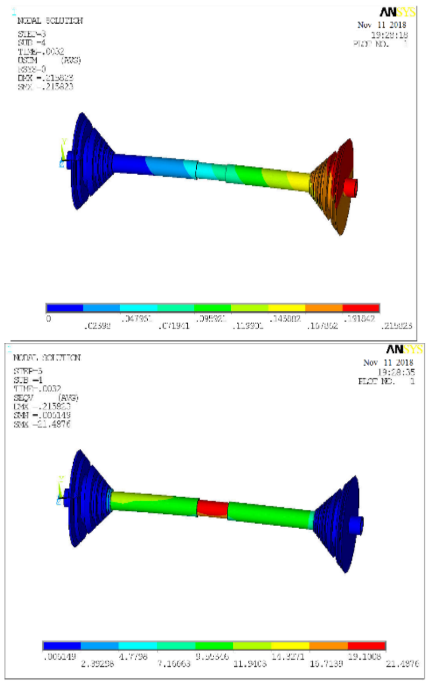
9.1Fig: Total displacement and von misses observed on drive shaft at load step-1

9.1.2 Displacements and Stresses at load step-2:



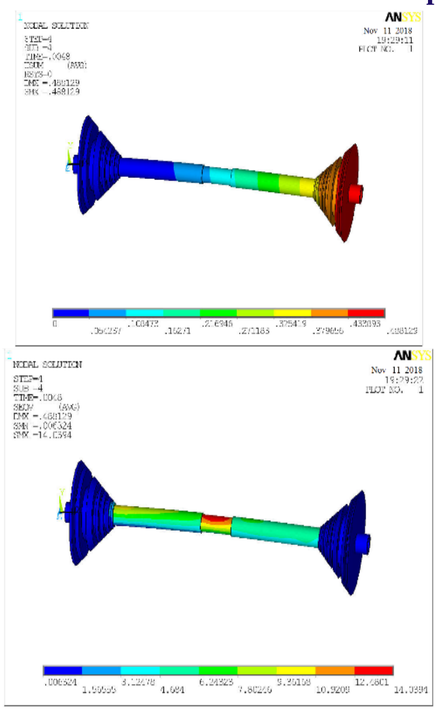
9.2Fig: Total displacement and von misses observed on drive shaft at load step-2

9.1.3 Displacements and Stresses at load step-3:



9.3Fig: Total displacement and von misses observed on drive shaft at load step-3

9.1.4 Displacements and Stresses at load step-4:



9.4Fig: Total displacement and von misses observed on drive shaft at load step-4

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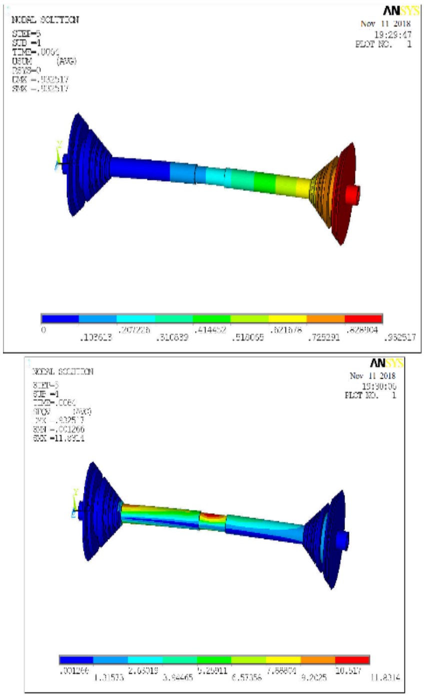
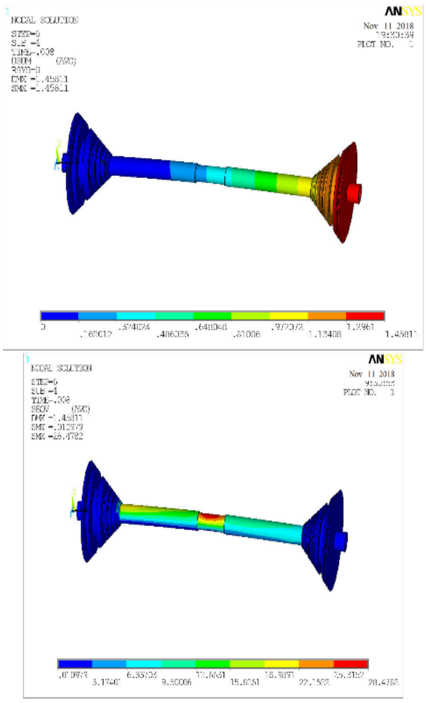
9.1.5 Displacements and Stresses at load step-5:



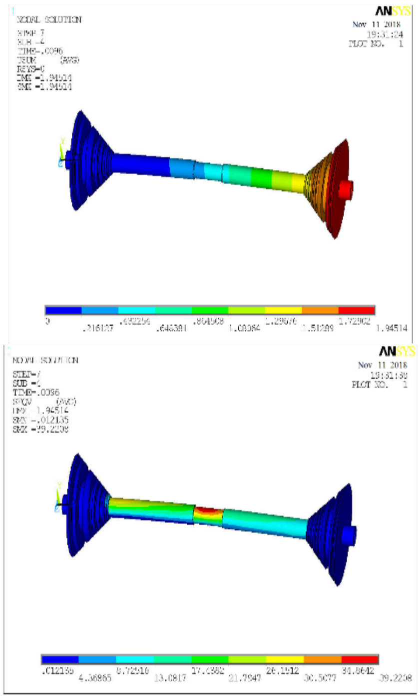
9.5Fig: Total displacement and von misses observed on modified chassis at load step-5

9.1.6 Displacements and Stresses at load step-6:



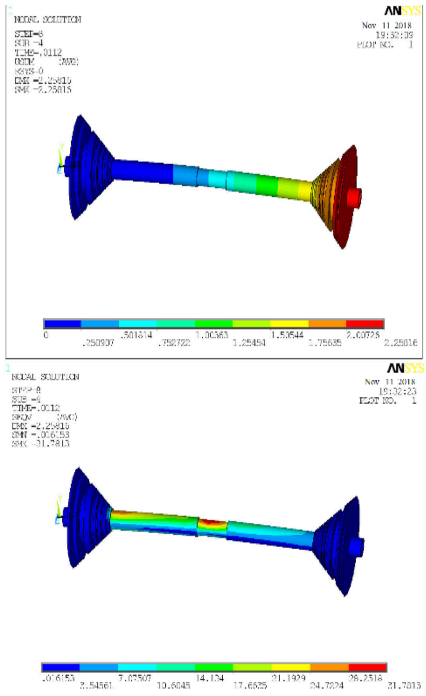
9.6Fig: Total displacement and von misses observed on drive shaft at load step-6

9.1.7 Displacements and Stresses at load step-7:



9.7Fig: Total displacement and von misses observed on drive shaft at load step-7

9.1.8 Displacements and Stresses at load step-8:



9.8Fig: Total displacement and von misses observed on drive shaft at load step-8

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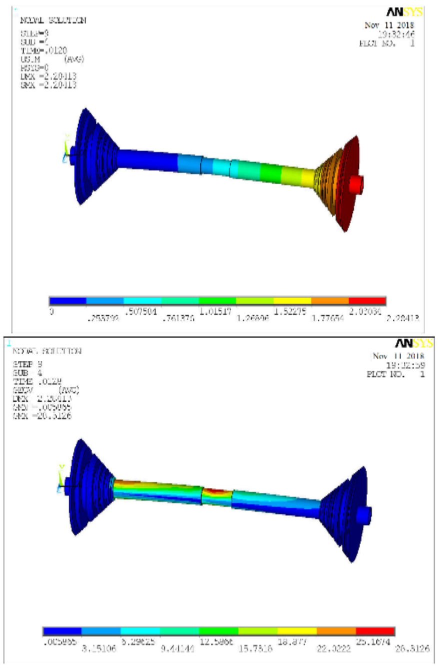
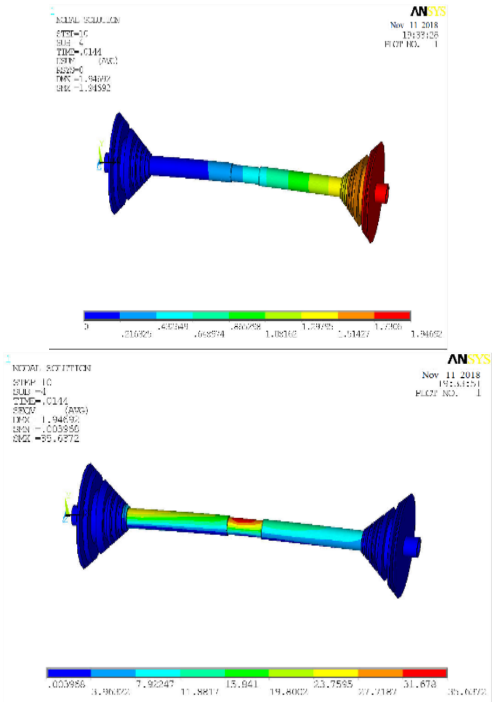
9.1.9 Displacements and Stresses at load step-9:



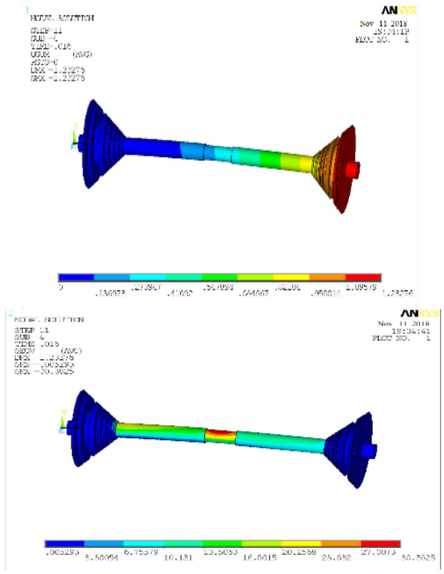
9.9Fig: Total displacement and von misses observe on drive shaft at load step-9

9.1.10 Displacements and Stresses at load step-10:



9.10Fig: Total displacement and von misses observed on drive shaft at load step-10

9.1.11 Displacements and Stresses at load step-11:



	STEEL MATERIAL	
Frequency (Hz)	**Deflection (mm)**	**Von misses stress(Mpa)**
48.2	0.0122	13.75
553.7	0.0159	17.54
	E-GLASS/EPOXY	
Frequency (Hz)	**Deflection (mm)**	**Von mises stress (Mpa)**
47.39	0.0472	10.194
527.36	0.0578	12.52
	KEVLAR/EPOXY	
Frequency (Hz)	**Deflection (mm)**	**Von misses stress (Mpa)**
68.43	**0.03051**	**10.38**
723.45	**0.0361**	**12.32**

Von misses stress formed on drive shaft using steel material at critical Frequencies

Von misses stress formed on drive shaft using steel material at critical frequencies (48.2Hz and 553.7 Hz) i.e. (95.4% and 94.15%) are less than yield strength of steel material(300 Mpa). Also Von misses strength at that frequencies 48.2Hz is less than yield strength of material but 553.7 Hz greater than yield strength of material.

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Von misses stress formed on drive shaft using E-Glass/Epoxy material at critical frequencies
(47.39Hz and 527.36 Hz) i.e (98.8% and 96.4%) are less than yield strength of E-Glass/epoxy (850Mpa) material. Also Von mises strength at that frequencies 47.39Hz and 527.36 Hz are less than yield strength of material.

Von misses stress formed on drive shaft using Kevlar/Epoxy material at criticalfrequencies
(68.43Hz and 723.45 Hz) i.e (96.5% and 98.4%) are less than yield strength of Kevlar/epoxy (800Mpa) material. Also Von mises strength at that frequencies 68.43 Hz and 723.45 Hz are less than yield strength of material.

RESULTS AND CONCLUSION

For estimated torque transmission in one piece drive shaft, all types of materials are supported. But Glass/Epoxy materials have frequency values more than their properties. And steel material have more ratio of von misses strength to yield strength value also this material have huge amount of weight compared to composite materials. Kevlar/Epoxy material have less ratio of von misses stress to yield strength value.

This material have frequency values less than yield strength. Kevlar/Epoxy material have less weight compare to remaining composites. At each shocking loads Kevlar/Epoxy have less ratio of von misses stress to yield stress values compare to remaining materials. So, From Analysis results, Kevlar/Epoxy material is suitable to above one-piece drive shaft.

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