Design and Analysis of Composite Propeller Shaft

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***Abstract* - A composite material made up of two or more elements/materials with extensive different physical or chemical properties. When they combined together, this possesses unique characteristics. In an automobile, propeller shaft must be more durable and able to transfer more power. And withstand twisting and bending effect. Also the weight of shaft must be lesser to overcome inertia and bending moment. In general propeller shafts made up of steel. So in this paper we replaced steel with composite materials to enhance the required properties and to overcome the problems occurred in conventional steel shafts. Also we optimize the size of the shaft to reduce the overall weight without affecting the strength of the shaft. Basically the interchanged materials are composites like Carbon Epoxy, E glass Epoxy. Also we compared the results of steel material to composite shaft though manual calculations and ANSYS results. The design is done by CATIA v5 software and post processing is done by ANSYS 15.0.**

***Index Terms* - composite materials, propeller shaft, shape, CATIA v5, ANSYS 15.0.**

I.INTRODUCTION

Propeller shaft which imparts power from the gearbox to the back centre with the help of far and wide joints. The power that is formed using the engine and power transmission must be moved to the back tires to drive the vehicle progress and adjust. The drive shaft must give a smooth, relentless development of capacity to the axles. The driving shaft and differential are utilize to move this force. In any case, it must give power from the transmission to the differential. During the power transmission most of twisting and bending moments applied on the propeller shaft, so that material for propeller shaft will play key roll. So we concentred on interchange the existing material to enhance the properties to withstand, more twisting and bending loads. Also we optimize the size of the shaft to reduce the overall weight without affecting the strength of the shaft. Basically the interchanged materials are composites like Carbon Epoxy, E glass Epoxy.

II LITERATURE SURVEY

In the year 2004, T. Rangaswamy, S. Vijayarangan, R.A. ChandraSkhar, T.K. Venkatesh and K. Anantharaman proposed a paper on “OPTIMAL DESIGN AND ANALYSIS OF AUTOMOBILE COMPOSITE DRIVE SHAFT” and they stated that their shaft made of E-Glass Epoxy and HS Carbon Epoxy multilayered composites were designed. They optimised using GA and analyzed by using ANSYS software for optimum/better stacking sequence, torque transmission capacity etc. Also improves the vibration characteristics during bending. Due to the composites they optimized the considerable amount of weight up to 48% to 86% while compared with steel. These results are propose that GA can be used efficiently in other complex and sensible designs often useful for real time engineering applications[1].

V.S. BHAJANTRI, S.C. BAJANTRI, S.S AMARAPURE, A.M. SHINDOLKAR, has proposed a paper on “DESIGN AND ANALYSIS OF COMPOSITE DRIVE SHAFT” and they stated that the high strength Carob Epoxy and High elastic module Carbon Epoxy composite shafts have designed instead of steel /Aluminium driving shaft for an automobile. They compared the results of composite shafts with steel. And they concluded that composite shafts have more strength to weight ratio [2].

Dr. K. Rambabu and R.P. Kumar Rompicharla were proposing a paper “Design and Optimization of Drive Shaft with Composite Materials” and they stated that the usage of the composite materials has resulted to considerable weight reduction of shaft up to 28% while compared with the materials of conventional driving shaft. Due to this deformation, shear stresses were induced and also resonant frequencies. It is evident that Kevalar Epoxy composite has most encouraging properties to act as replacement for conventional material like steel [3].

III DESIGN AND CALCULATIONS

DESCRIPTION OF PROBLEM:

Presently a-days each vehicle has transmission shafts. The weight decrease of propeller/driving shaft of a vehicle have a specific part in autos, on the off chance that it can accomplish without increment in cost and decline in quality and reliability. It is possible to accomplish the plan of propeller shaft with optimized weight by utilizing of composite materials and which thus, it additionally increment the normal recurrence of the pole. This undertaking manages supplanting of regular drive shaft with high quality composite materials (carbon epoxy and e-glass epoxy)propeller shafts for a vehicle

MANUAL CALCULATIONS:

P = 103 KN

T = 320 N-m

Case – i : d_o = 50mm; d_i = 42.5 ≈ 42mm

<u>For Steel:</u>

- $T/J = \tau /r$

$(320*10^3)/(\pi/32 * (50^4-42^4)) = \tau /(50/2)$

$\tau = 25.97\ N/mm^2$

So Shear stress is within limits and hence design is safe.

- $f_n = \pi/2 *\sqrt{(EI/Ml^4)}$

$M = P(\pi/4)(d_0^2- d_i^2)$

$= 7600*(\pi/4)*(0.05^2-0.042^2)$

= 2.63 kgs

$I = (\pi/64)*(0.05^2-0.042^2)$

$= 1.57 * 10^{-7}\ m^4$

$f_n = \pi/2 *\sqrt{((207*10^9*1.57*10^{-7})/(4.39*1))}$

= 133 Hz

<u>For Carbon Epoxy:</u>

- $T/J = \tau /r$

$(320*10^3)/(\pi/32 * (50^4-42^4)) = \_/(50/2)$

$\tau = 25.97\ N/mm^2$

So Shear stress is within limits and hence design is safe.

- $f_n = \pi/2 *\sqrt{(EI/Ml^4)}$

$M = P(\pi/4)(d_0^2- d_i^2)$

$= 1550*(\pi/4)*(0.05^2-0.042^2)$

= 0.896 kgs

$I = (\pi/64)*(0.05^2-0.042^2)$

$= 1.57 * 10^{-7}\ m^4$

$f_n = \pi/2 *\sqrt{((136.6*10^9*1.57*10^{-7})/0.896)}$

= 238.53 Hz

<u>For E glass Epoxy:</u>

- $T/J = \tau /r$

$(320*10^3)/(\pi/32 * (50^4-42^4)) = \_/(50/2)$

$\tau = 25.97\ N/mm^2$

So Shear stress is within limits and hence design is safe.

- $f_n = \pi/2 *\sqrt{(EI/Ml^4)}$

$M = P(\pi/4)(d_0^2- d_i^2)$

$= 2100*(\pi/4)*(0.05^2-0.042^2)$

= 1.21 kgs

$I = (\pi/64)*(0.05^2-0.042^2)$

$= 1.57 * 10^{-7}\ m^4$

$f_n = \pi/2 *\sqrt{((43.3*10^9*1.57*10^{-7})/1.21)}$

= 117.55 Hz

Similarly,

Case – ii : d_o = 55mm; d_i = 46.75 ≈ 46mm

Case – iii : d_o = 60mm; d_i = 51mm

PROPERTIES	UNITS	CASE 1 (AT 50 MM DIA)			CASE2 (AT 55 MM DIA)			CASE3 (AT 60 MM DIA)		
		S S	C E	E E	S S	C E	E E	S S	C E	E E
Outer Diameter	mm	50	50	50	55	55	55	60	60	60
Inner Diameter	mm	42	42	42	46	46	46	51	51	51
Length	mm	1000	1000	1000	1000	1000	1000	1000	1000	1000
Torque	Nm	320	320	320	320	320	320	320	320	320
Max.Shear stress	Mpa	29.14	40	65	30	42	66	31	43	66
Weight	N	43.06	8.79	11.87	53.17	10.89	14.7	58.46	11.87	16.18
Bending Natural Frequency	Hz	133	239	117.55	146.9	258.1	127.74	161.36	284.9	140.4

Table.1 manual calculation results

NOTE: S S – STRUCTURAL STEEL, C E – CARBON EPOXY, EE – E GLASS EPOXY

CREATING THE 3D MODEL:

In this step, I was generated a 3d model of propeller shaft by using CATIA v5 software according to the requirements.

CREATION OF VARIOUS PARTS OF PROPELLER SHAFT:

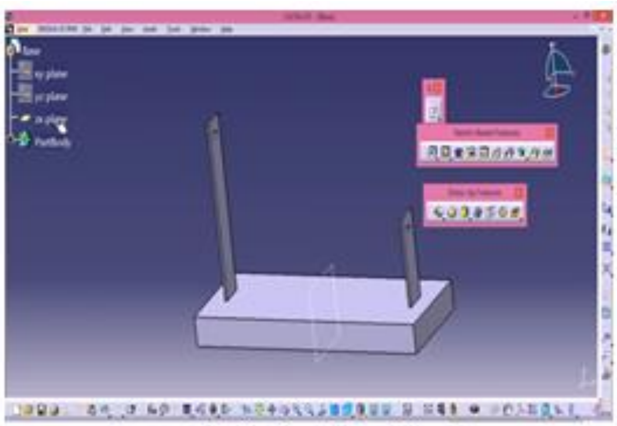


Fig1. Creation of stand

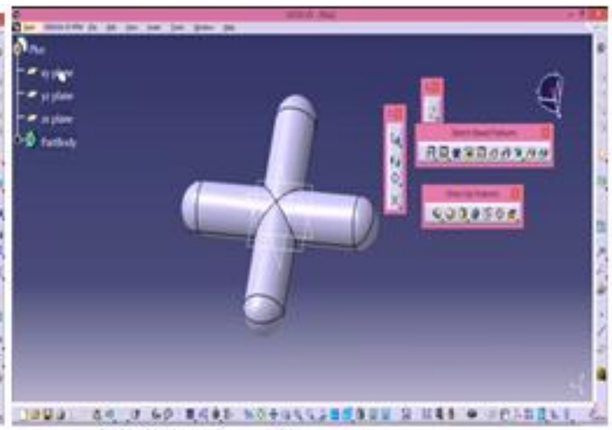


Fig2.Creation of cross

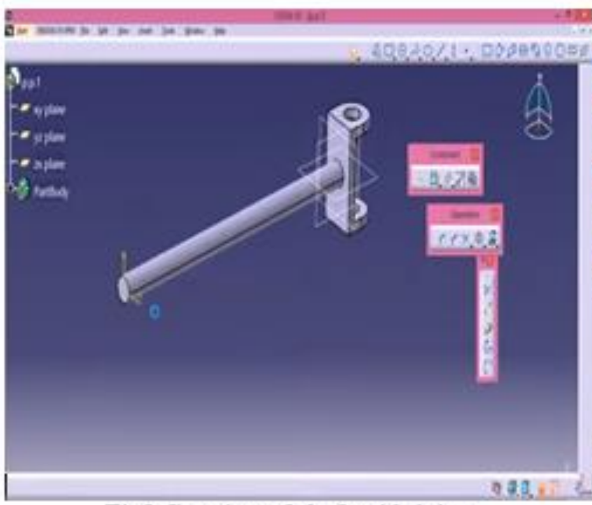


Fig3.Creation of shaft with joint

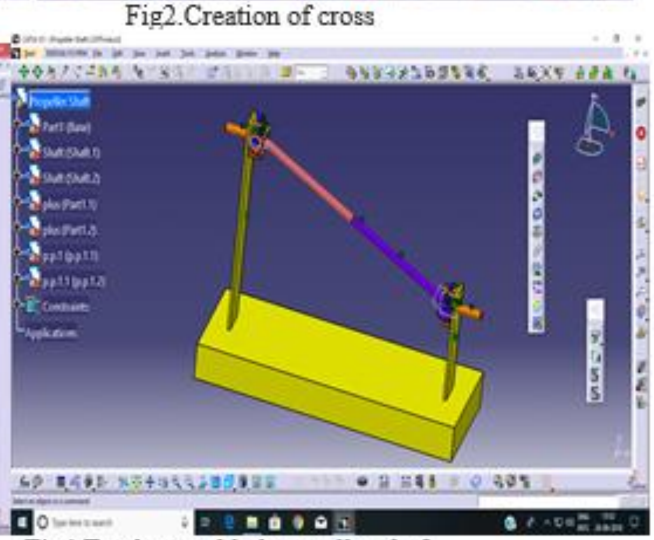


Fig4.Total assembled propeller shaft

SIMULATION USING ANSYS 15.0:

BOUNDARY CONDITIONS

Total deformation for steel

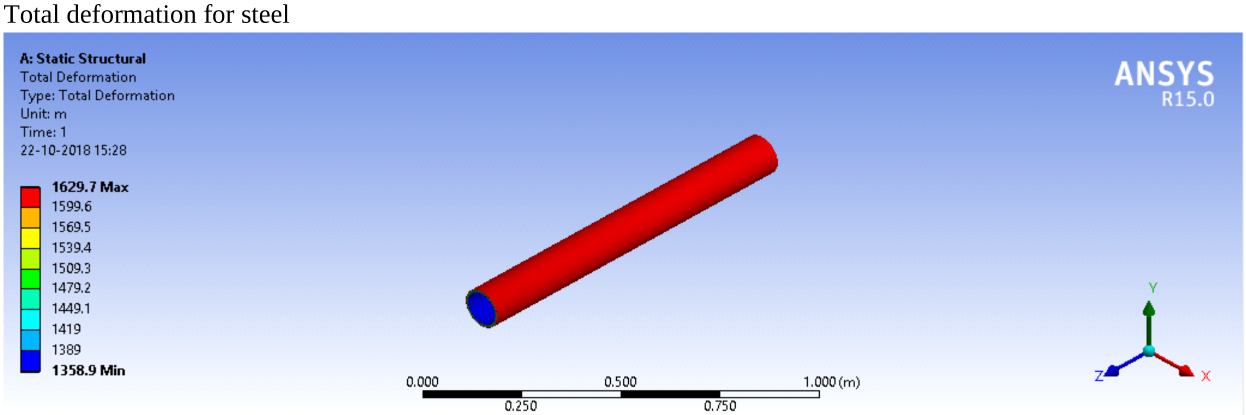


Fig5.Total deformation

Equivalent stress for steel

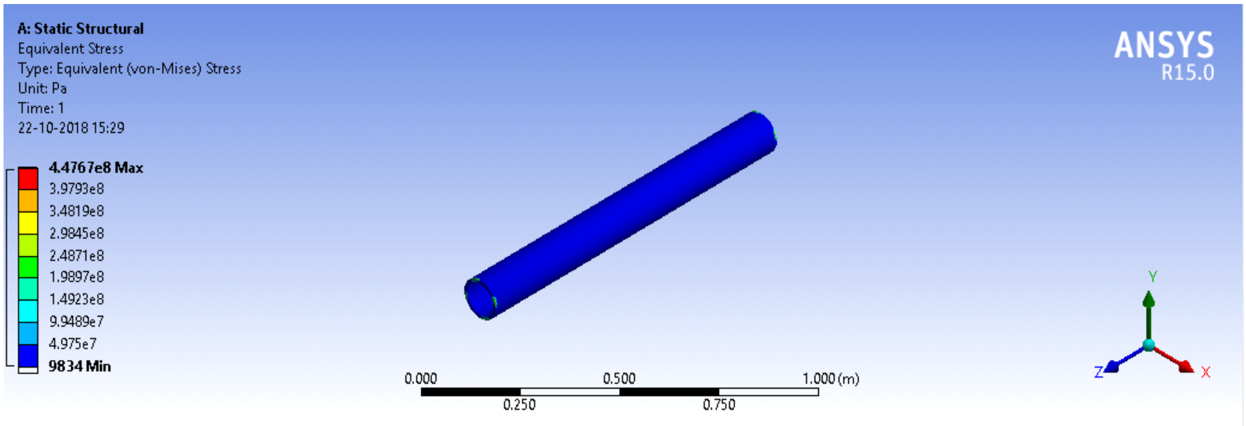


Fig6.EQUIVALENT STRESS

- Now change the material property to carbon epoxy and apply boundary conditions and generate / plot results.
- Total deformation for carbon epoxy composite material

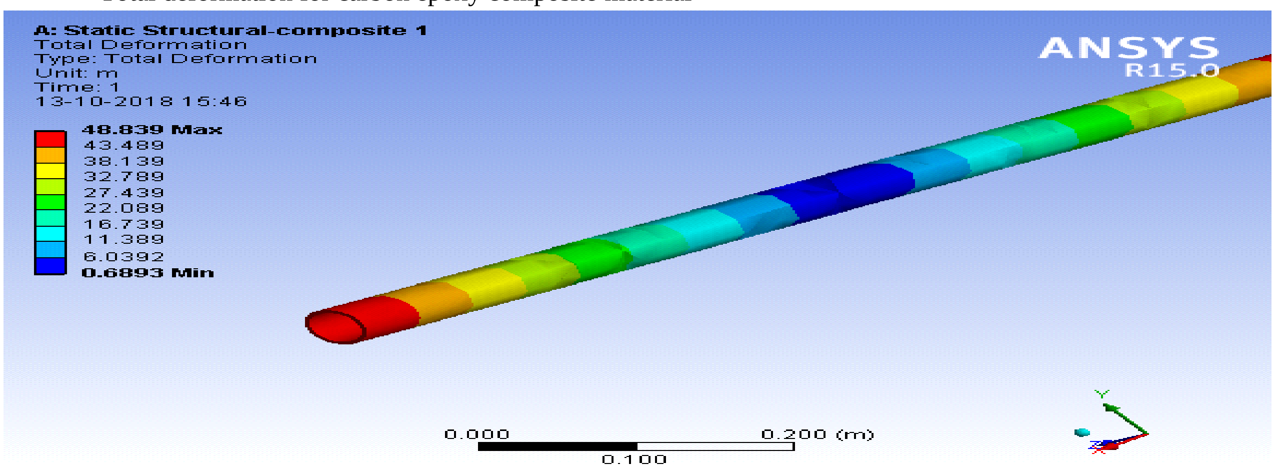


Fig7.TOTAL DEFORMATION

- maximum shear stress for carbon epoxy composite material

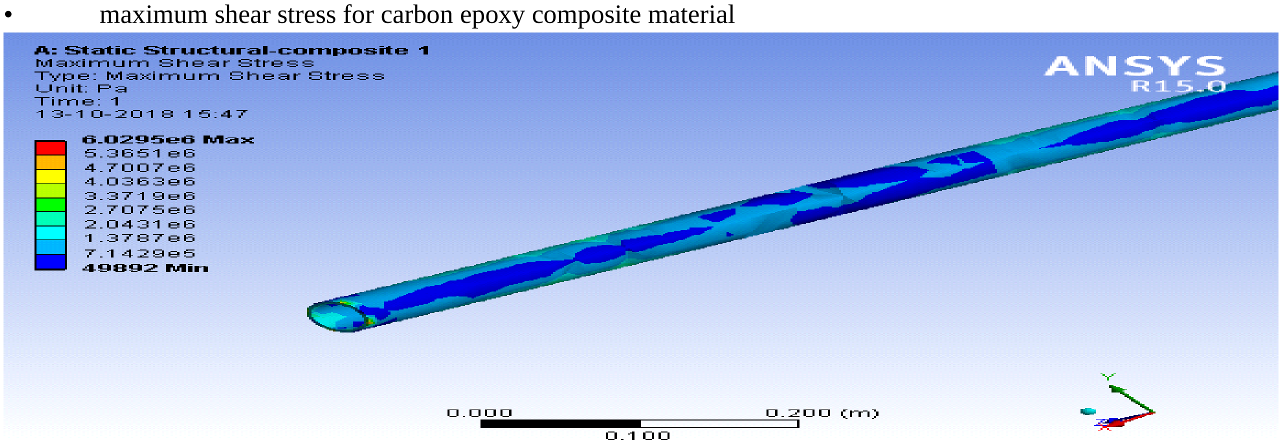


Fig8. MAXIMUM SHEAR STRESS

- Equivalent stress for carbon epoxy composite material

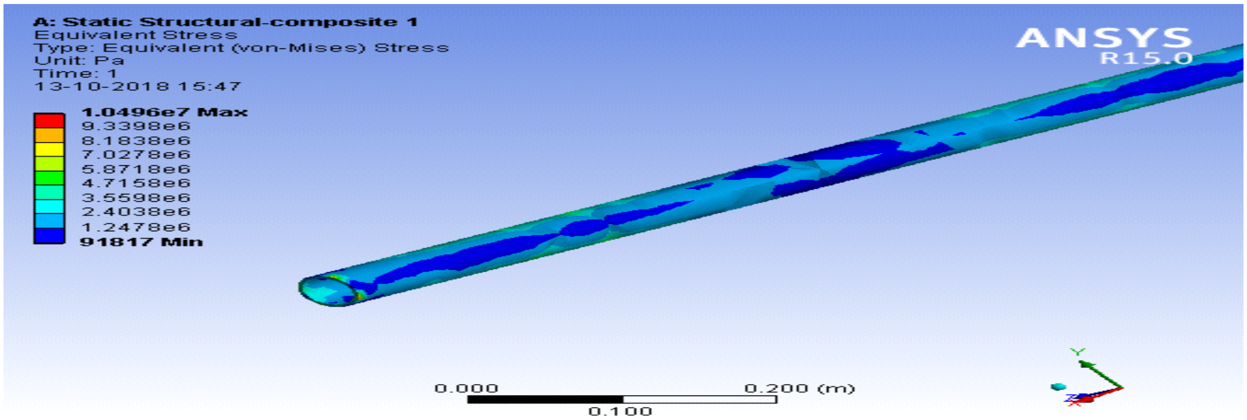


Fig9. EQUIVALENT STRESS

- Now again change the material to *E-GLASS EPOXY* and apply boundary conditions to it and generate results.
- Total deformation for E-GLASS EPOXY composite material

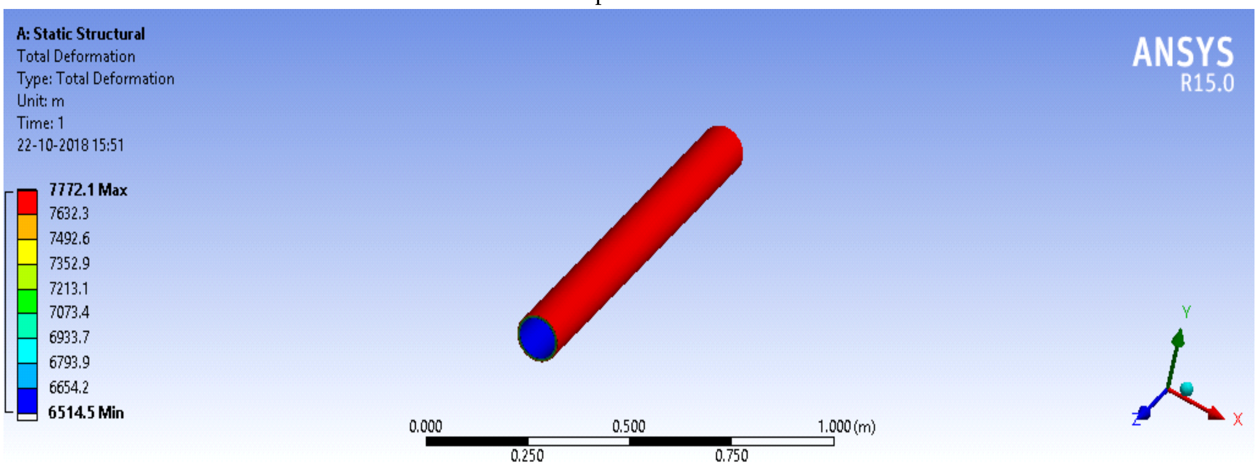


Fig13. TOTAL DEFORMATION

- Equivalent stress for E-GLASS EPOXY composite material

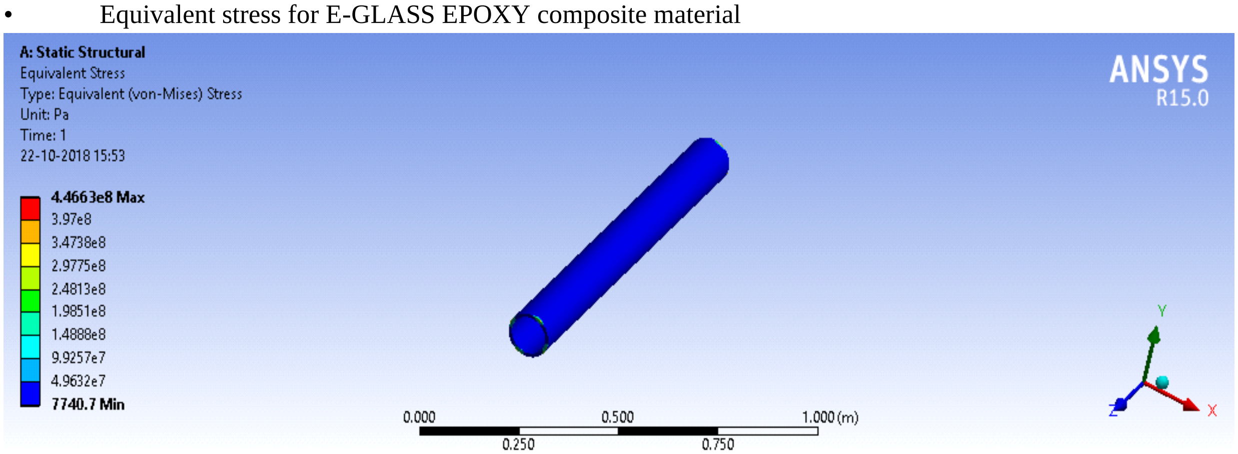


Fig14. EQUIVALENT STRESS

- Maximum shear stress for E-GLASS EPOXY composite material

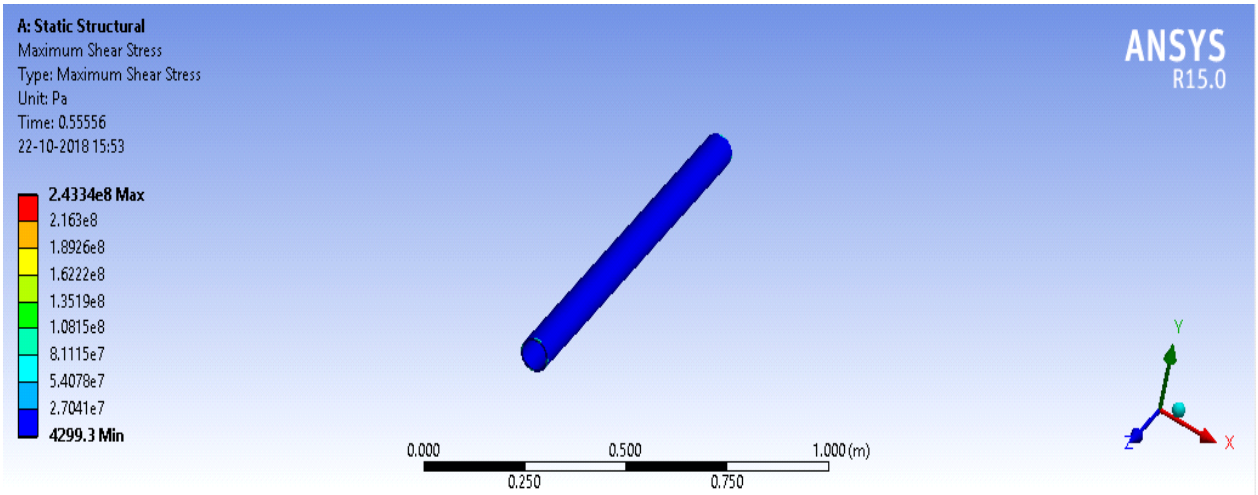
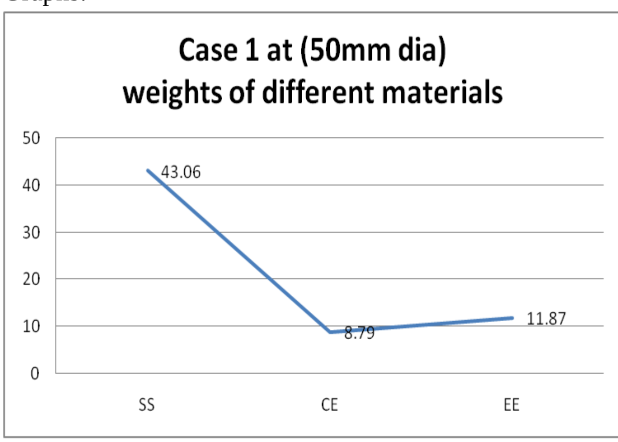
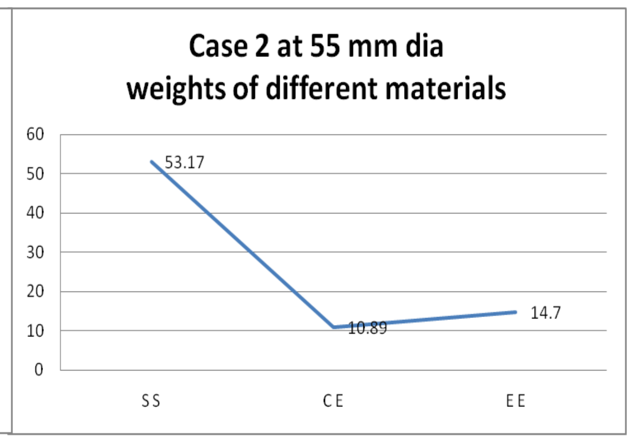


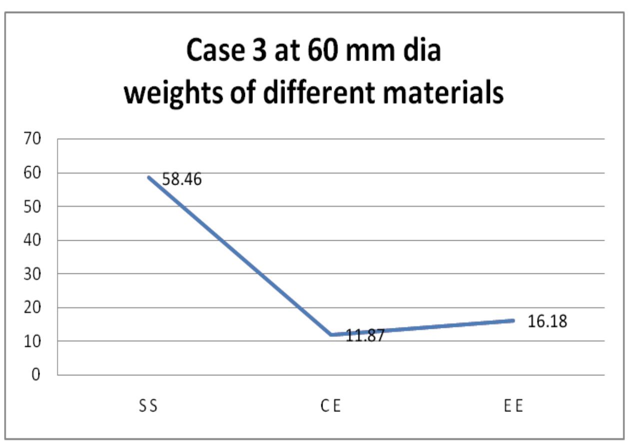
Fig15. Maximum shear stress

RESULTS AND GRAPHS

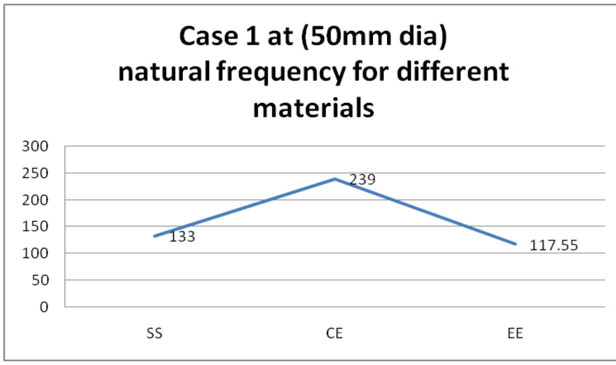
Graphs:

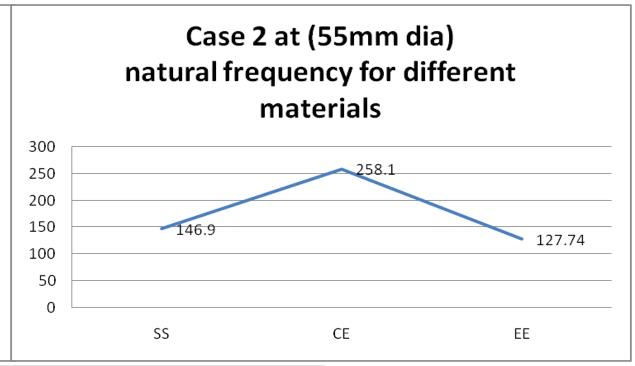


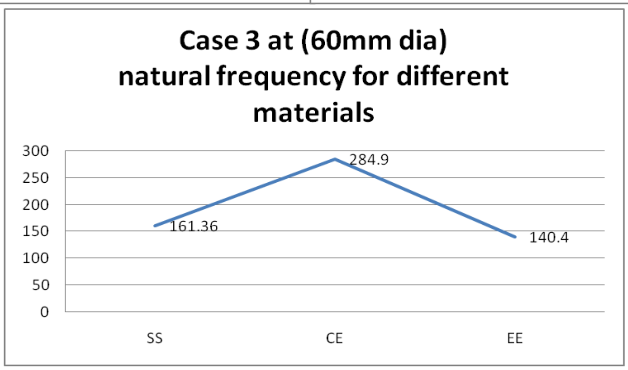




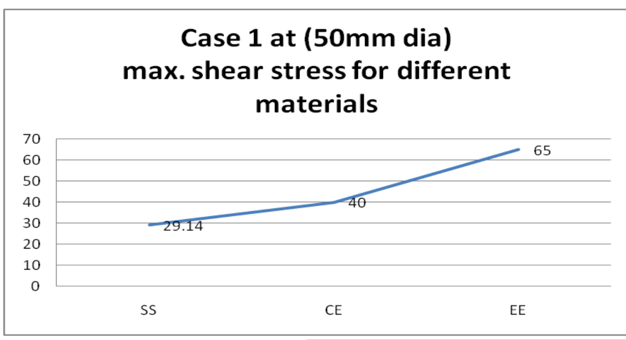
weights of different materials at different

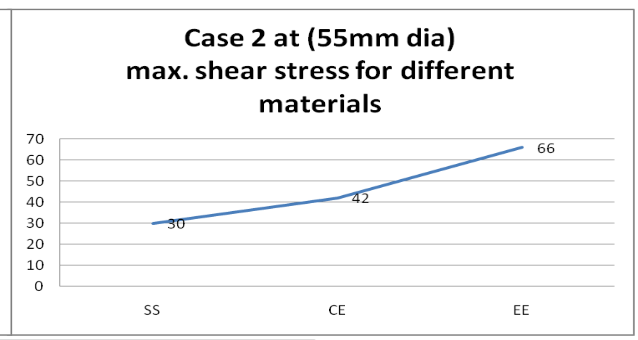


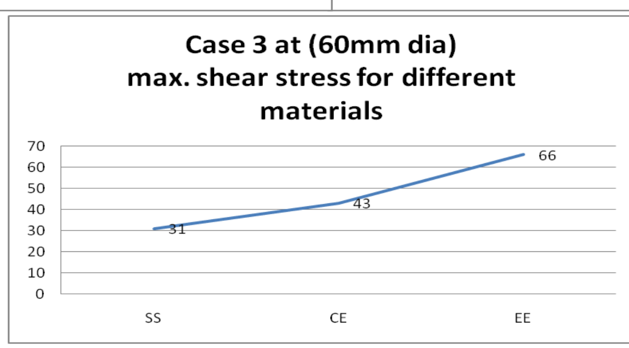




Natural bending frequency for different







Max. Shear stress valuesfordifferent

IV CONCLUSION

By choosing of appropriate propeller shaft by shifting its organizations, we improved the mechanical properties. In this task distinctive propeller shafts are chosen however among one shaft fulfills the outcomes and by contrasting them likewise and auxiliary steel.

- The Carbon/Epoxy and Glass/Epoxy composite propeller shafts are intended to meet safe plan prerequisites as the ordinary steel shaft.
- The utilization of composite material diminishes the heaviness of shaft fundamentally as the composite having lower thickness.
- By contrasting above outcomes carbon epoxy and e glass epoxy are in less weight when contrasted and steel. From the two composites we reason that carbon epoxy is less in weight and has great properties analyzed different materials.

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