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Finite Element Analysis of Shaft Using Composite Materials Without and With Damping

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Abstract:

High-technology structures often have stringent requirements for structural dynamics. Suppressing vibrations is crucial to their performance. Passive damping is used to suppress vibrations by reducing peak resonant response. Viscoelastic damping materials add passive damping to structures by dissipating vibration strain energy in the form of heat energy. The incorporation of damping materials in advanced composite materials offers the possibility of highly damped, light-weight structural components that are vibration-resistant. The aim of the project is to analyze the shaft without damping material and with damping material. The present used material for shaft is steel. In this thesis, the composite materials considered are HM Carbon Epoxy and HS Carbon Epoxy. The material for damping is rubber. The structural analysis is done to verify the strength of the shaft and compare the results for three materials. Modal analysis is done on the shaft to determine mode shapes.

Analysis is done in Ansys.

KEYWORDS: ***Modelling, Analysis, Ansys***

1. INTODUCTION

A driveshaft is a rotating shaft that transmits power from the engine to the differential gear of a rear wheel drive vehicles Driveshaft must operate through constantly changing angles between the transmission and axle. High quality steel (Steel SM45) is a common material for construction. 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 beam length and proportional to the square root of specific modulus.

The drive shaft is generally composed by the main gear box, differential, wheels, transmission and drive shaft shell. Its role is cardan transmission power coming folded over an angle of 90 ° to change the direction of transmission of force by the main reducer to reduce the speed, to increase the torque, after differential assigned to the left and right axle and drive round.

1.1: A truck propeller shaft

METHADOLOGY

The 2D model of shaft reinforcement is made in PROE. After that is imported into wokbench for analysis. Stress and deformation is observed. We are applied force on shaft for calculating deformations. Now by using Newton's second law, we calculated force value according to respected speeds for

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respective materials. This point force applied centrally on Shaft.

MATERIAL SELECTION

Three types of material are selected for shaft mainly following specification:

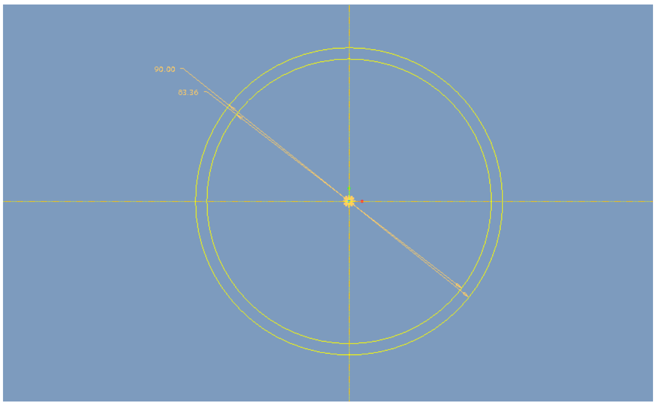
	STEEL SM 45 C	HS-CARBON FIBER	HM-CARBON FIBER
DENSITY (Kg/m^3)	7600	1600	1650
YOUNG'S MODULUS (MPa)	20700	134000	195000
POISSON'S RATIO	0.3	0.3	0.3
STRENGTH (MPa)	335	5000	4900

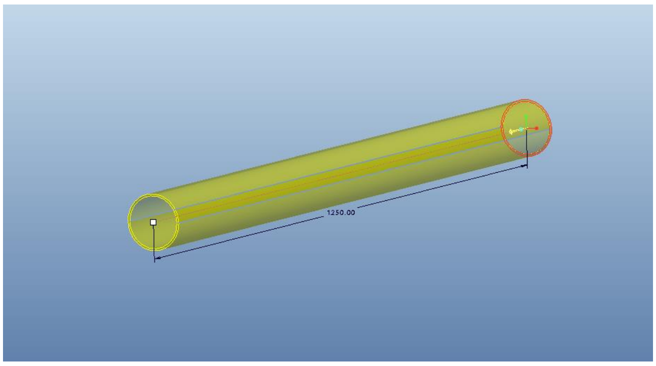
Table 3.1: Material properties

MODELLING OF SHAFT

DIFFERENT MODULES IN PRO/ENGINEER

- PART DESIGN
- ASSEMBLY
- DRAWING
- SHEETMETAL
- MANUFACTURING



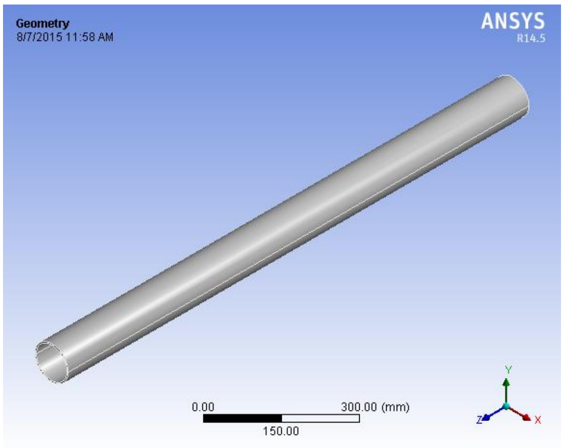


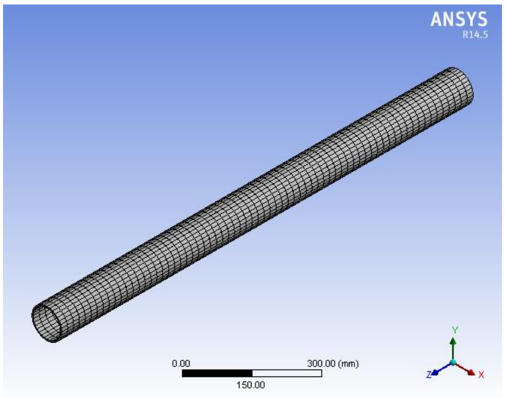
EXPERIMENTAL PROCEDURE

4.3 SHELL ELEMENT - STRUCTURAL ANALYSIS

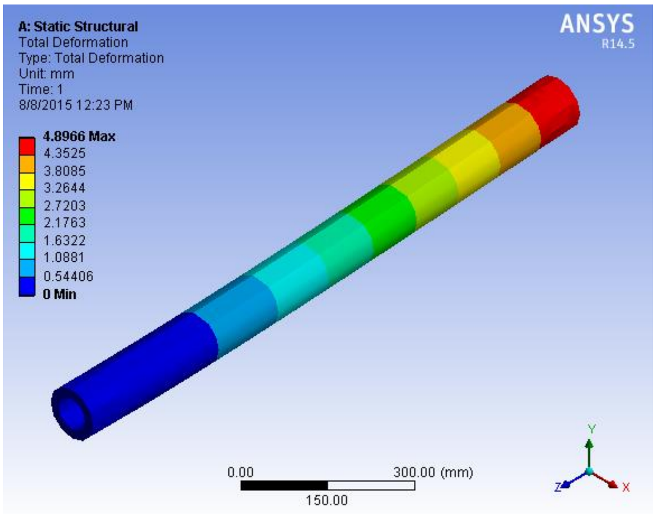
4.3.1 WITH DAMPING MATERIAL (RUBBER)

MATERIAL – STEEL (SM 45 C)





TOTAL DEFORMATION



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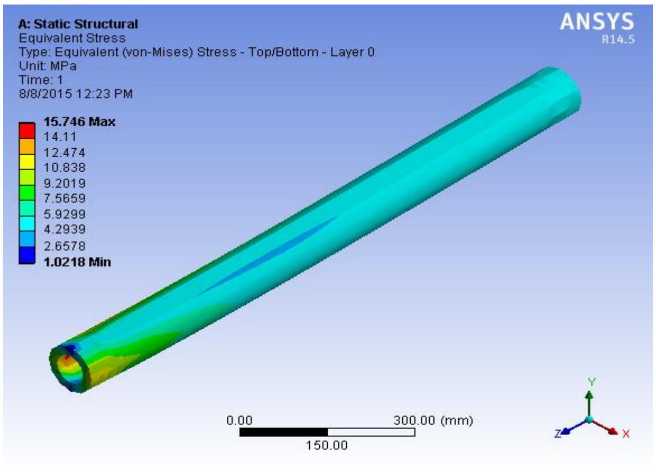
VON-MISES STRESS



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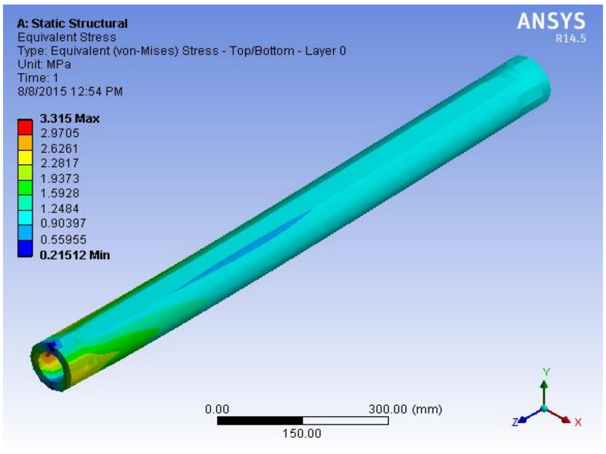
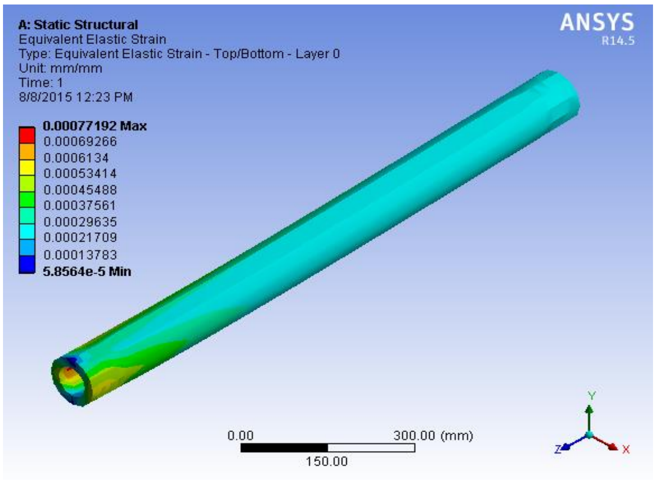


VON-MISES STRAIN



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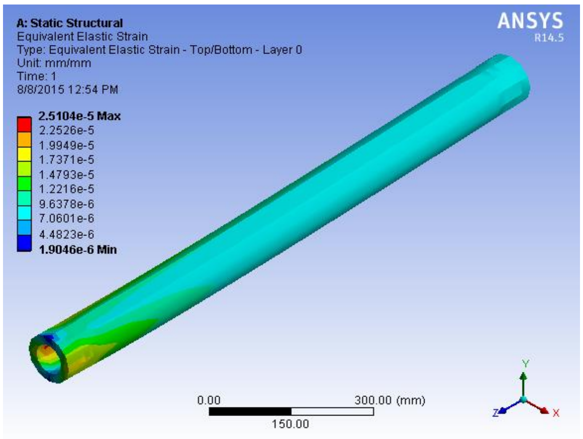
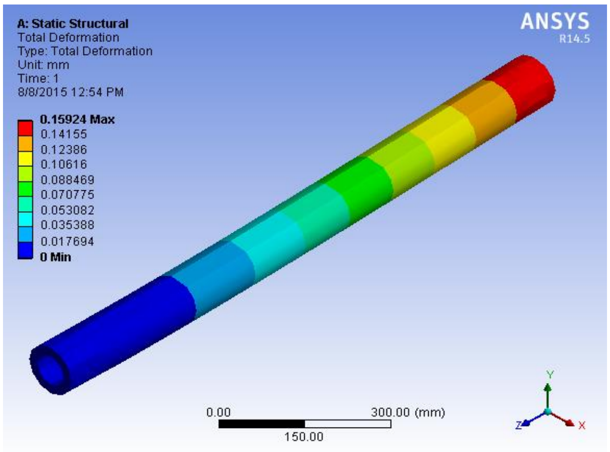
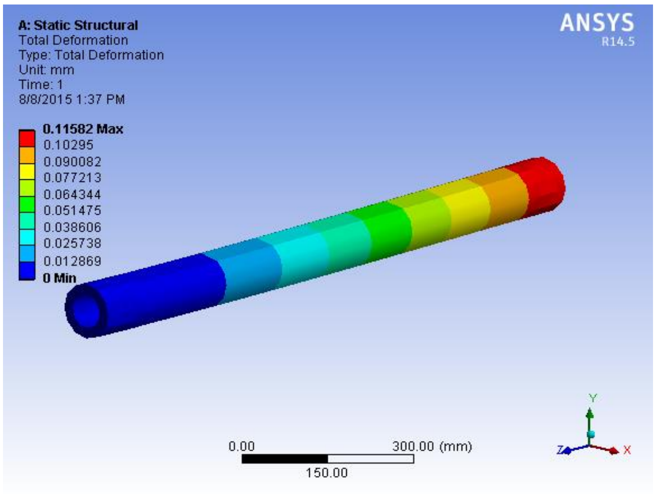


MATERIAL – HS-CARBON/EPOXY
TOTAL DEFORMATION



MATERIAL – HM-CARBON/EPOXY
TOTAL DEFORMATION



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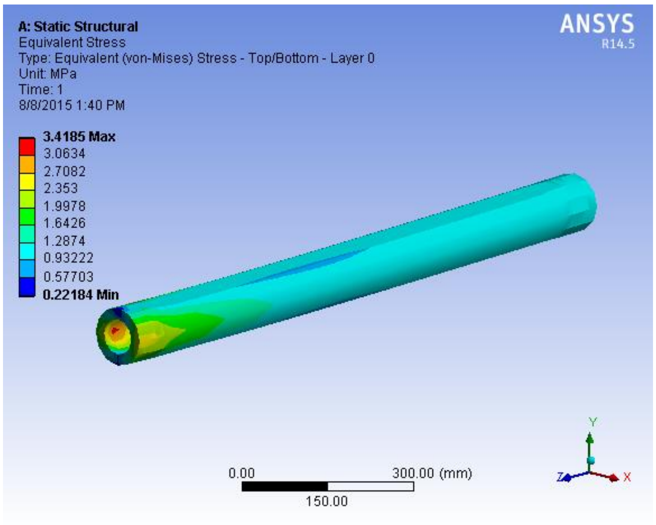

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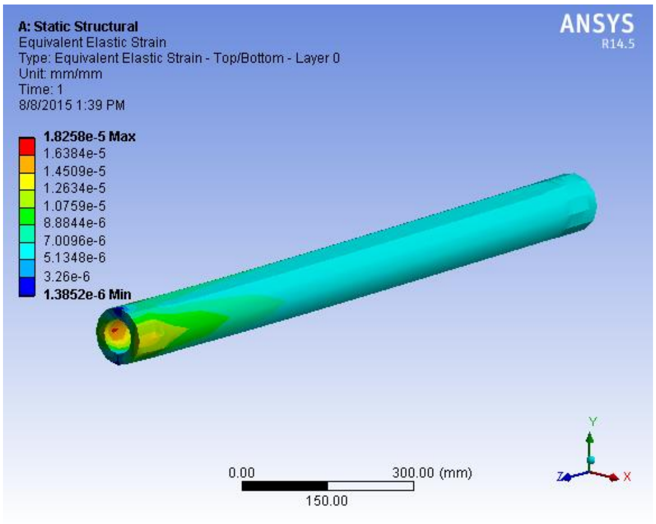


RESULT TABLE

1 STRUCTURAL ANALYSIS – SOLID ELEMENT

	Deformation (mm)	Stress(N/mm²)	Strain
STEEL(SM45C)	0.11996	8.1713	0.00039709
HS-CARBON/EPOXY	0.0039014	1.7203	1.2914e-5
HM-CARBON/EPOXY	0.0027515	1.7203	9.1078e-5

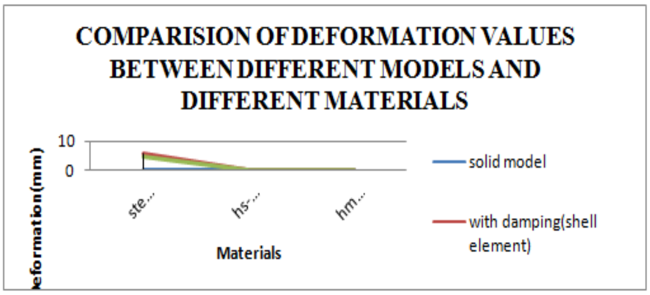
SHELL ELEMENT WITH DAMPING

	Deformation (mm)	Stress(N/mm²)	Strain
STEEL(SM45C)	5.731	23.187	0.001136
HS-CARBON/EPOXY	0.19236	8.028	4.2739e-5
HM-CARBON/EPOXY	0.26085	7.5174	5.6768e-5

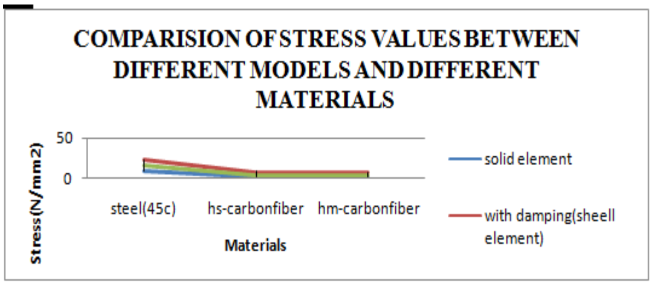
SHELL ELEMENT WITHOUT DAMPING

	Deformation (mm)	Stress(N/mm²)	strain
STEEL(SM45C)	4.8966	15.746	0.00077192
HS-CARBON/EPOXY	0.159424	3.315	2.510e-5
HM-CARBON/EPOXY	0.11582	3.4185	1.8258e-5

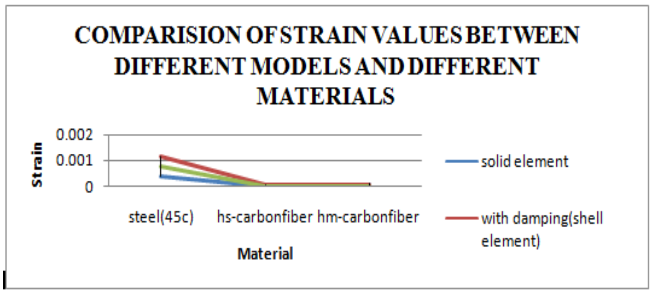
DEFORMATION



STRESS



STRAIN



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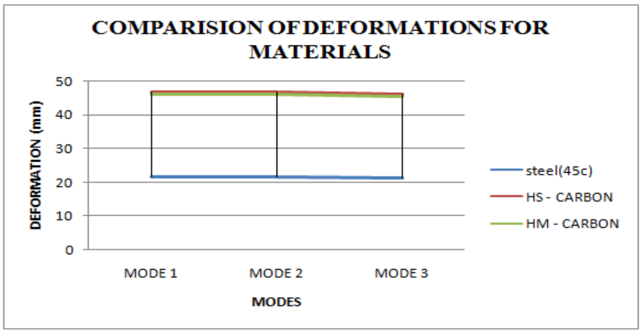
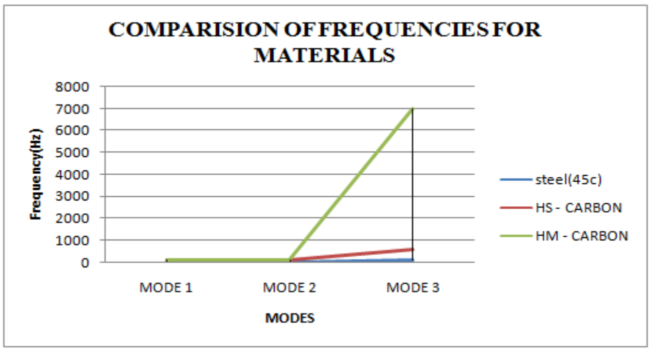
MODAL ANALYSIS – SOLID ELEMENT

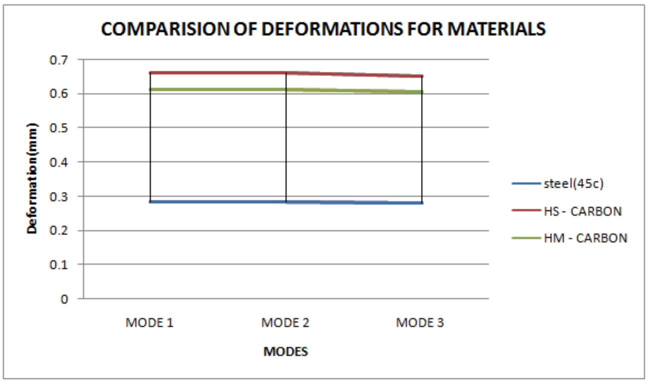
		STEEL (SM45C)	HS-CARBON/EPOXY	HM-CARBON/EPOXY
MODE 1	Frequency (Hz)	17.997	99.795	117.05
	Displacement (mm)	21.51	46.88	46.164
MODE 2	Frequency (Hz)	17.997	99.795	117.05
	Displacement (mm)	21.51	46.88	46.164
MODE 3	Frequency (Hz)	107.72	597.34	6999.99
	Displacement (mm)	21.184	46.17	45.446

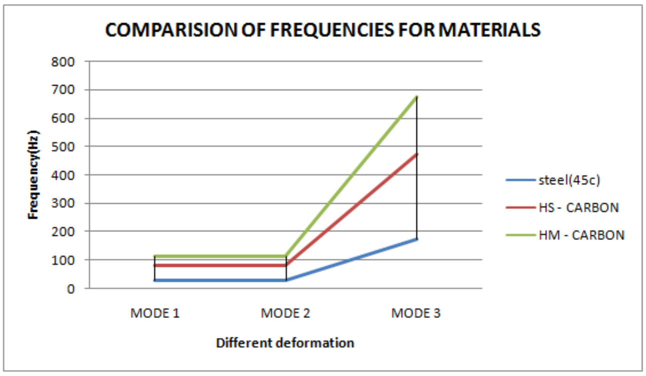




SHELL ELEMENT WITHOUT DAMPING RESULTS

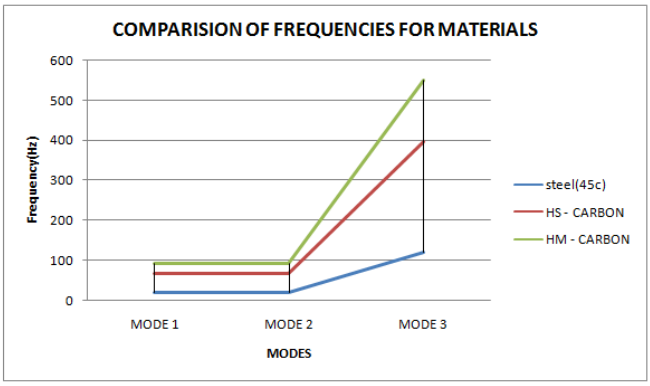
		STEEL (SM45C)	HS-CARBON/EPOXY	HM-CARBON/EPOXY
MODE 1	Frequency (Hz)	29.167	78.531	111.93
	Displacement (mm)	0.28358	0.66097	0.61236
MODE 2	Frequency (Hz)	29.536	79.351	113.05
	Displacement (mm)	0.28321	0.66034	0.61184
MODE 3	Frequency (Hz)	174.24	473	674.45
	Displacement (mm)	0.27872	0.65214	0.60429





SHELL ELEMENT WITH DAMPING

		STEEL (SM45C)	HS-CARBON/EPOXY	HM-CARBON/EPOXY
MODE 1	Frequency (Hz)	19.752	65.539	91.391
	Displacement (mm)	0.35128	0.40997	0.65404
MODE 2	Frequency (Hz)	19.951	66.222	92.347
	Displacement (mm)	0.35096	0.40958	0.65341
MODE 3	Frequency (Hz)	119.01	395.56	550.36
	Displacement (mm)	0.3467	0.40584	0.64525



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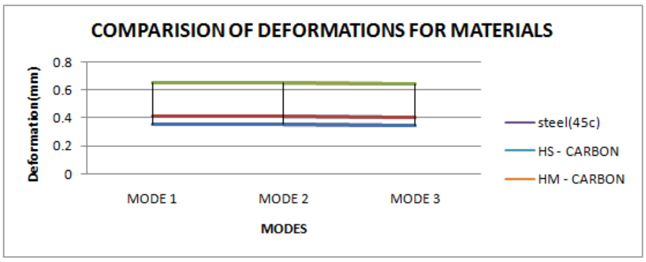

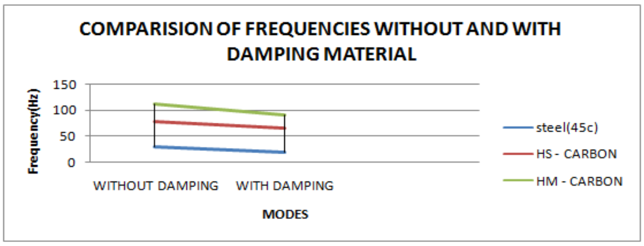

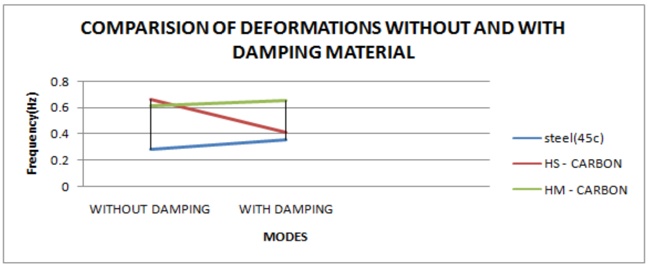

CONCLUSION

In this thesis shaft is analyzed without damping material and with damping material. The present used material for shaft is steel. In this thesis, the composite materials considered are HM Carbon Epoxy and HS Carbon Epoxy. The composite materials are considered due to their high strength to weight ratio. The material for damping is rubber.

The structural analysis is done to verify the strength of the shaft and compare the results for three materials. By observing the analysis results, the stress values are less when composite material Carbon Epoxy is used when compared with that of Steel.

Structural analysis is also done on the shaft using shell element without damping material and with damping material rubber. The stresses are more when damping material is used than without damping material but the stresses are within the range. By using damping material strength increases in the shaft thereby decreasing vibrations.

Modal analysis is done to determine the frequencies and deformations. By observing the analysis results for solid element, the frequencies are more when HS – Carbon and HM – Carbon than steel are used so vibrations will be more.

By observing the modal analysis results for shell element, when comparing the results without damping material and with damping material rubber, the frequencies are less when damping material is used, so vibrations will be less.

FUTURE SCOPE

The following recommendations are made for future work in this thesis:
The use of composite material Carbon Epoxy is better than steel when structural analysis is considered since stresses are less and also strength to weight ratio is more for composite when compared with that of steel.

But when the composite materials are used the vibrations in the shaft are more since the frequencies are higher. So more experiments will have to be performed to improve the performance of the shaft by reducing the vibrations also, since reducing the vibrations in the shaft increases the life.

This work can further be extended by analyzing the buckling failures also.

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