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DESIGN OPTIMIZATION AND ANALYSIS OF A ONE PIECE COMPOSITE DRIVE SHAFT FOR REAR WHEEL

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Abstract - *The drive shaft in an automobile is really employed due to the transmission of exercise from the auto over the differential. A car propeller shaft, or perhaps maybe perhaps drive shaft, transmits powers of raise wheel guiding from the engine to differential device vehicle.* The impact through Transmission shaft ought becoming transmitted on the back pivot of the car. The axis on the Transmission along with the associating individual from Rear hub are really at helpful, which changes with the amount in deal that is great or perhaps maybe possibly maybe roadway quality. *Power transmission arrangement of cars include a couple of segments which now and again experience lamentable disappointments. With this particular examination, break searching of a just about all inclusive joint burden together with a drive shaft of a car control transmission framework are literally carried out. Spectroscopic investigations, metallographic examinations along with hardness estimations are in fact done for each part. For the guarantee of anxiety scenarios in the fizzled sphere, stretch exploration will be the same accomplished through the little component strategy. In current work an undertaking have been produced to organize a driveshaft for hard core guzzler grounded on almost all major torque transmitting cap, really greatest shear pressure created plus material development with various information as composite materials and lightweight aluminum amalgam as CFRP, going evaluation and industry lessening pursued by virtual pleasure and that utilizes Finite Element Analysis Software for analyzing the product execution.*

Key Words: **CFRP**, **Drive shaft**, **Static Analysis, Modal Analysis, Finite element analysis.**

1. INTRODUCTION

A driveshaft or driving shaft is a gadget that exchanges controller from the motor to the point where work is connected. On account of autos, the drive shaft exchanges motor torque to the drive pivot, which interfaces the two wheels together on inverse sides and with which they turn. The driveshaft is likewise once in a while called propeller shaft. Drive shafts are basically bearers of torque. Before they turned into a vogue, more seasoned vehicles utilized chain drive and even generators to transmit capacity to the wheels. Drive shaft today, notwithstanding, has U-joints, gadgets which assist them with moving here and there amid suspension. Some drive shafts likewise have another sort of joint, called slip joints, which enable them to change their lengths to the development of the suspension.

Changes aside, drive shafts are of various lengths relying upon their utilization. Long shafts are utilized in front-motor, raise drive vehicles while shorter ones are utilized when control must be sent from a focal differential, transmission, or transaxle. On account of the heap they Carrie, driveshaft must be solid enough to shoulder the pressure that is required in the transmission of intensity.

Drive shafts as strength transmission tubing are utilized in several applications, which include cooling towers, pumping cars, trucks, and sets, aerospace. When the length of metal drive shaft is earlier 2000 mm, it's fabricated in 2 parts to increment the fundamental regular frequency, which is alternatively corresponding to the square measurements and family member to the square foundation of particular.
In cars, trucks and advancement hardware the drive get ready is meant to send out torque through a place from the transmission on the hub (or maybe assistant transmission).The driveshaft should work through continuously altering relative tips between the transmission as well as hub. It must similarly be healthy for changing measurements while transmitting torque. This means the driveshaft should have the capability to contract, Expand as well as change working edges while heading over knocks and discouragements. This's skillful through common joints. That enable the driveshaft to have different tips, and also slip joints that give extension or withdrawal to happen. An automobile drive shaft transmits command from the engine on the differential device associated with a rear wheel drive car.

2. METHODOLOGY

2.1 Problem definition

The torque transmission capacity of the drive shaft should be greater than 7000 N-m (T_{max}) and vital typical turning resistance of the drive shaft should be higher than 4000 rpm (N_{max}) to keep away from turning vibration. Here outside expansiveness of the post is taken as 115mm and length of the drive shaft considered is 2000mm. The drive shaft of transmission system was arranged and it is assumed that the prerequisites of the drive shaft of an auto transmission are same as that of the steel drive shaft for perfect model.

1. FE approach for concentrate the pressure/strain and disfigurements

2. Using explanatory conditions, numerical displaying is created to confirm the anxieties and distortion.

3. Linear static examination and bilinear investigation of middle of the road shaft

4. Dynamic examination, model and symphonious investigation of halfway shaft
5. High weariness life assessment of middle of the road shaft

2.2 Analysation technique

1. Plan of one-piece drive shaft was done through NX CAD programming.

2. Composed one-piece drive shaft was transported in Ansys programming.

3. Limited component investigation of one-piece drive shaft was done in Ansys programming.

4. Execution investigation of drive shaft goes through Ansys programming with regular steel material and furthermore with composite Epoxy/E-glass and Epoxy materials for torsional loads.

5. A static, demonstrate examination of drive shaft is finished with the assistance of Ansys programming for various materials to compute weight, diversions, worries of the drive shaft.

6. Results acquired from the examination are analyzed and the best material is proposed in light of the weight to quality proportion.

2.3 Initial requirements of design and its specification details:

Table-1: Design specifications

SL. NO.	Name	Notation	Value
1	Torque	Tmax	7500 N-m
2	Speed of Shaft	Nmax	3000 rpm
3	Shaft Length and Shaft dia	L and D	2000mm 120mm

Steel (SM45C) is utilized for making car drive shafts. The material properties of the steel (SM45C) are given in Table underneath. The steel drive shaft ought to fulfill three plan determinations, for example, torque transmission capacity, clasping torque ability and bowing normal recurrence.

Table-2: Material Properties

Mechanical properties	Symbol	Steel
Young's Modulus	E	210000 MPa
Shear Modulus	G	80000 MPa
Poisson's Ratio	υ	0.3
Density	ρ	7600 kg/m^3
Yield Strength	σ_y	550 N/mm^2
Shear Strength	σ_s	710 N/mm^2

2.4 Torque Transmission Capacity

1. Starting Torque (N-m) = Gear Ratio Max. Torque x 1
Starting Torque is to raise pivot drive.
In 1st Gear Ratio of apparatus box torque sustained by propeller shaft. This Max.Torque is taken for Maximum shear stretch.

2. I-M.I., mm^4 = Moment Of Inertia
$= (\pi/64)\ (D_o^4-D_i^4)$

3. J-POLAR M.I., mm^4
$= (\pi/32) \times (D_o^4-D_i^4)$

4. Z-Section Modulus, mm^3
$= (\pi/16) \times((D_o^4-D_i^4/D_o)$

5. Torsional Shear Stress/mm
= (Torque x D)/ (2J)

2.5 Design Criteria for material selection

Next value of Shaft Diameter is chosen if torsional shear stress is exceeding shear strength of material.

2.6 Critical Speed Calculation

Critical Speed, RPM= $(30/\pi) \times \text{sqt}\ (g/\delta_{max})$

Where, δ_{max} is maximum static deflectionof drive shaft.

Max. Deflection, δ, mm= $(5Mg^*\text{Cos}\ \theta \times L^3) / (384 \times EJ)$by Rayleigh Reitz Method Where M is mass of tube.

For safe design, to avoid vibration, and thereby deflection of shaft should be minimized by reducing weight or length of the shaft.

3. RESULTS AND DISCUSSION

3.1 Static analysis of drive shaft

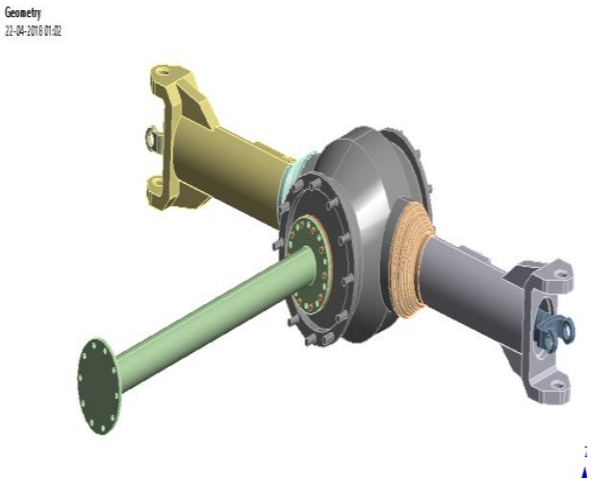

Fig -1: Isometric view of intermediate shaft

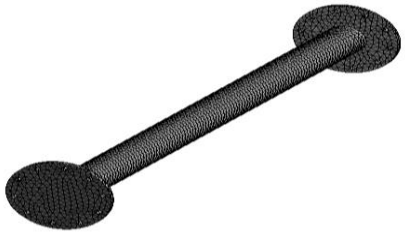

Fig -2: Meshing of Intermediate shaft

Meshing 3d model of intermediate shaft is made up of hexa element of 22000 element and 31540 nodes. ANSYS Meshing is a broadly useful, insightful, computerized elite item. It delivers the most proper work for exact, proficient multiphysics arrangements.

Fig -3: Boundary Conditions

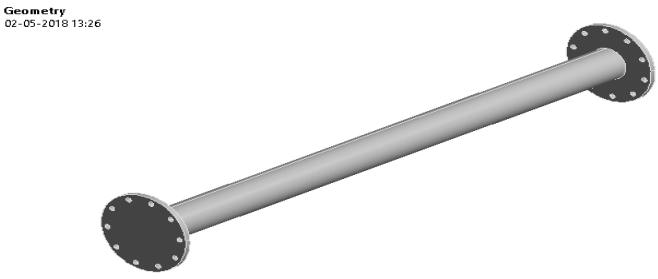

Fig -4: Isometric view 3d model of CRFP intermediate shaft

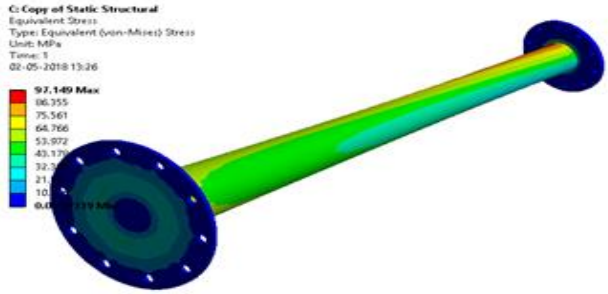

Fig -5: Von Mises equivalent stress is 97.149 MPa of CRFP shaft

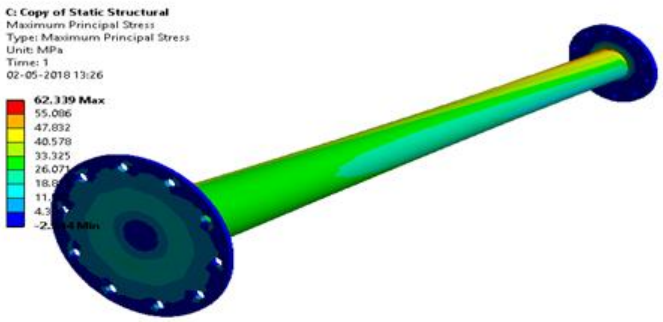

Fig -6: Maximum principal stress is 62.339 MPa of CRFP shaft

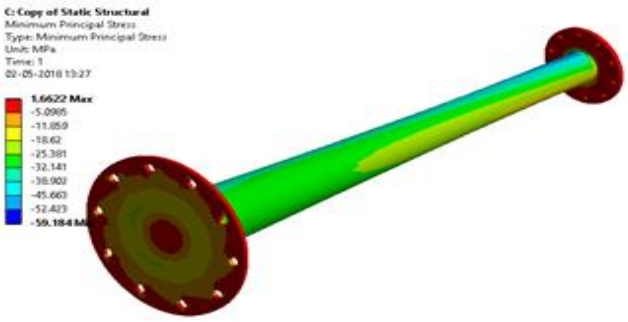

Fig -7: Minimum principal stress is 1.662 MPa of CRFP shaft

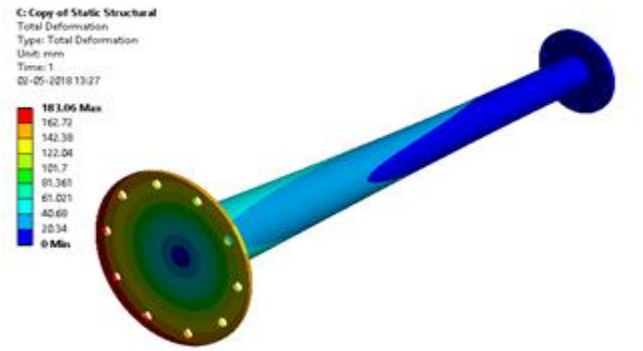

Fig -8: Max total deformation is 0.183 mm of CRFP shaft

3.2 Modal Analysis and Fatigue Life estimation

An analysis of measured information is a procedure in which the measured recurrence response functions are broke down to locate a theoretical model that most nearly resembles the dynamic behaviour of the structure under test. This piece of the modal test is called experimental modal analysis.

Table-3: Mode & Frequency Value

	Mode	Frequency(Hz)
1	1.	537.68
2	2.	673.87

3	3.	673.93
4	4.	1709.8
5	5.	2021.8
6	6.	2021.8

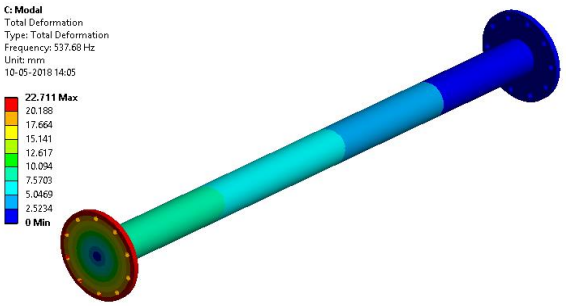

Fig -9: First mode and natural frequency is 537.68 Hz

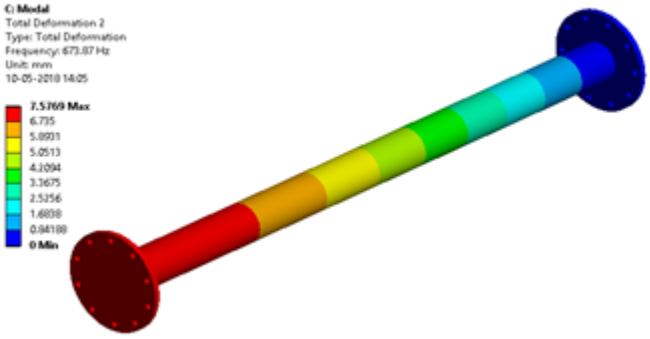

Fig -10: Second mode and natural frequency is 673.87 Hz

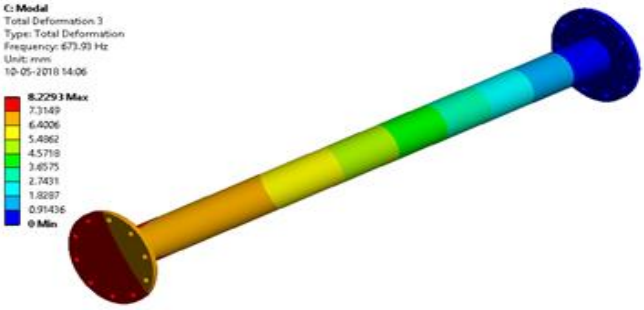

Fig -11: Third mode and natural frequency is 673.93 Hz

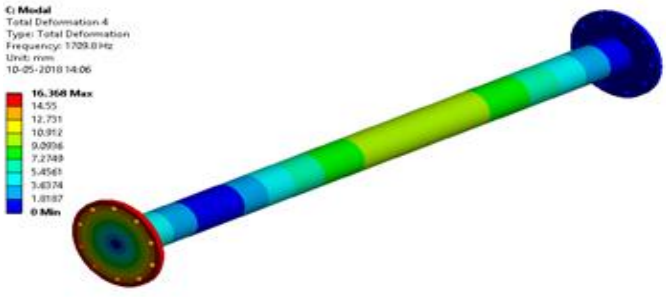

Fig -12: Fourth mode and natural frequency is 1709.8 Hz

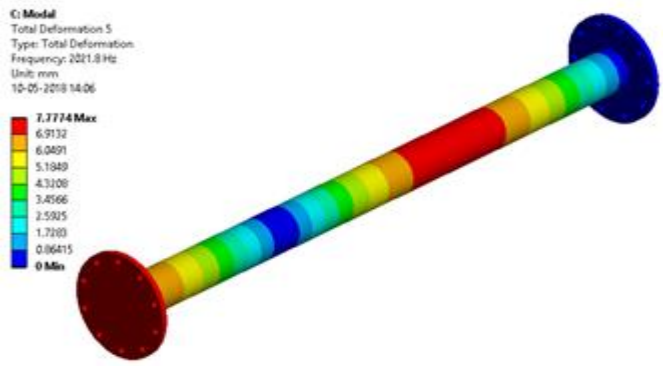

Fig -13: Fifth mode and natural frequency is 2021.6 Hz

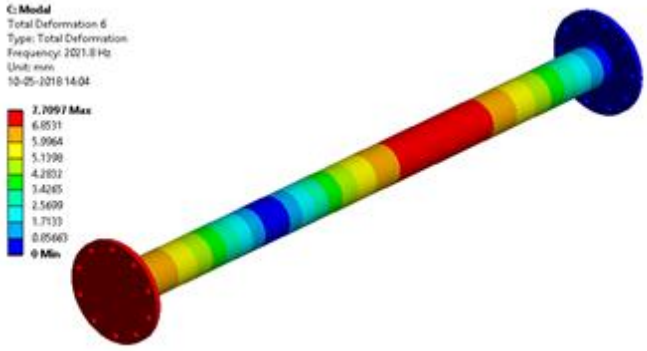

Fig -14: Sixth mode and natural frequency is 2021.6 Hz

3.3 Goodman diagram

Mean Stress can be calculated from,

$$\sigma_{mean} = \frac{\sigma_{von}}{2}$$

Where

σ_{von} = Equivalent von-Mises Stress

or $\sigma_{mean} = \frac{\sigma_1 + \sigma_2}{2}$ = (268 .31+0.0028) / 2 = 27 MPa

Alternate stress

$\sigma_{alt} = \frac{\sigma_1 - \sigma_2}{2}$ = (268 .31- 0.0028) / 2 = 134 MPa

$N_f = \left\{ \frac{[\sigma_{ult} - \sigma_{ult}(\frac{1}{fos} - \frac{\sigma_e}{\sigma_a})]}{\sigma_a} \right\}^{\frac{1}{0.08}}$ = after substituting the values we get =

N_f =1.12*e6 cycles

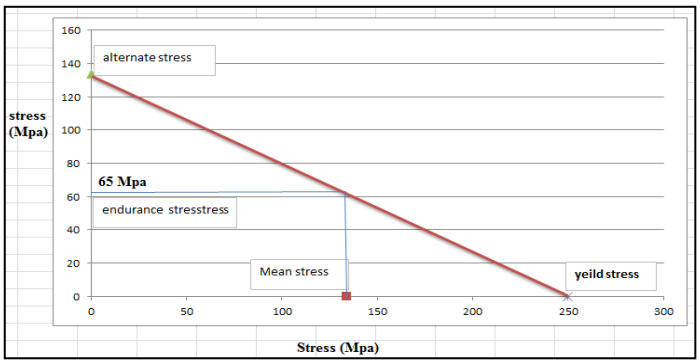

Fig- 15: Stress strain diagram

4. CONCLUSION:

Custom made methodology for the structural integrity of the shaft in a power Transmission system of a truck for different materials has been done. Here we have considered steel, aluminium and CFRP i.e. composite material for the analysis and similarly we have calculated the equivalent Von Mises stress, maximum and minimum principal stress and maximum total deformation. Here from the analysis of different materials we can conclude that aluminium is better and lighter than that compared with steel and similarly CFRP is still lighter and better than aluminium and hence better performance is obtained in CFRP material. Hence CFRP material is the best among steel and aluminium which has less weight than steel and aluminium and which in turn produces less stress and improves the overall efficiency and performance. But in this project we have not considered about the cost for which CFRP is more costly than aluminium and steel. Except the cost drawback no other parameters are there in selecting CFRP material.

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