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Review Paper on Design and Analysis of Composite Drive Shaft

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Abstract- In automobile in day to day running number of components were worn out or failed due to some material physical and mechanical properties or their compositions. This project deals with the design and material optimization of an automobile component. For this purpose, the drive shaft is selected in which both material and design optimization is being conducted. In this firstly prepare the Creo software based model of propeller shaft and then will be import in ANSYS for FE analysis. Then the design of this shaft is altered and analyzed under same material and boundary conditions. Now this modified shaft analyzed with composite material under same boundary conditions.

Keywords- material optimization, drive shaft, composite materials.

I. INTRODUCTION

Universal joint (1) in the propeller shaft assembly drive transfers engine torque to the rear axle through one or more universal joints, sleeve (2) and sliding shaft (3) the splines on the ends at the propeller shaft fit perfectly into the splines in the sleeve. This allows a length variation between the driving and the driven unit to vary slightly without damaging the output and input bearings. Main bearing (4) the main bearing support and guide the propeller shaft. Flange (5) the flanges connect the propeller shaft to the gearbox. (See Figure:-1)

The drive shaft, or propeller shaft, connects the transmission output shaft to the differential pinion shaft. Since all roads are not perfectly smooth, and the transmission is fixed, the drive shaft has to be flexible to absorb the shock of bumps in the road. Universal, or "U-joints" allow the drive shaft to flex (and stop it from breaking) when the drive angle changes.

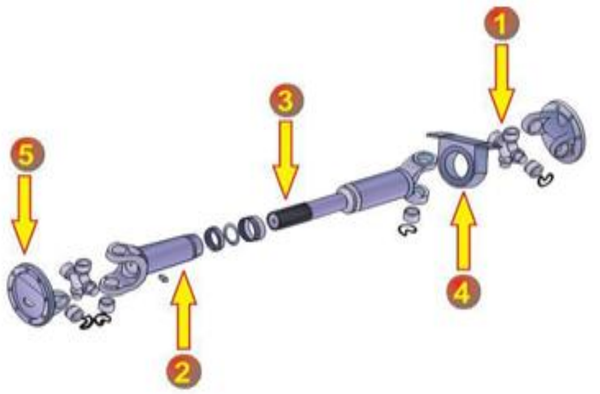

Fig 1. Components of Propeller shaft.

1. Requirements of Propeller Shaft:

For achieving efficient functions, the following are expected in a propeller shaft

- High torsional strength
- Toughened and hardened
- Efficiently jointed
- Dynamically balanced

2. Propeller Shaft Trouble Shooting:

Following are the major troubles that may develop in the propeller shaft unit.

2.1 Vibration:

The vibration may develop in the propeller shaft due to the following reason

- Bent propeller shaft, remedy is to straighten it.
- Broken or worn universal joint crosses and bearings, remedy is to replace them.
- Loose propeller shaft supporting mounting, remedy is totight it.
- Loose universal joint bolt nuts, remedy are to tighten them.
- Splines not properly aligned at sliding joint, remedy is to align them with the help of arrows.

2.2 Lubricant loss at the joints:

This may be due to worn out joint seals, worn out universal joint cross as well bearings, and the bearings not seated property in the yokes or flanges.

3. Materials Science

Material science involves the discovery and design of new materials, with an emphasis on solids. Materials science is also an important part of forensic engineering and failure analysis - investigating materials, products, structures or components which fail or which do not operate or function as intended, causing personal injury or damage to

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property. Such investigations are key to understanding, for example, the causes of various aviation accidents. The material of choice of a given era is often a defining point.

II. METHODOLOGY

1. Geometry Selection:
As stated above, the geometries of split type propeller shaft and single cylinder propeller shaft are modelled accordingly using the solid works package. The following are the images of the existing and proposed shafts.

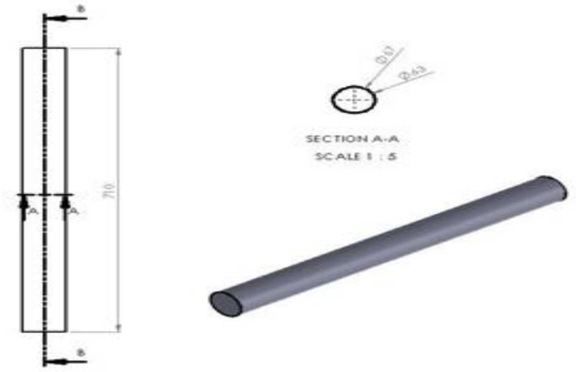

Fig 2. Propeller shaft.

The proposed shaft is again modified accordingly based on the requirements of the analysis type. For analysing under composite material with multiple layers, solid shafts are not applicable, and because of this reason, the model is revised. As shown in fig.3

2. Material Properties:

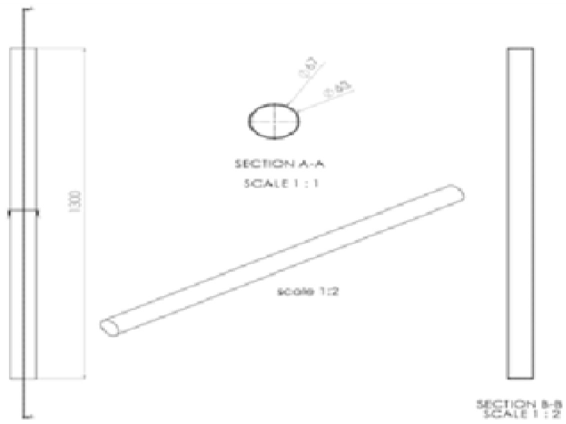

Fig 3. Modified proposed propeller shaft.

It has been found that, the existing material for the propeller shaft is SM45C grade steel. On the analysis of journals, the composite materials used as material replacements are E Glass fibre, Epoxy fibres, Boron carbides, Aluminium composites, HM and HC carbon composites, Silicon composites, Kelva composites and so on. Out of the listed composites, in this project the composite materials used are E-Glass, HM Carbon, HS Carbon and Kelvar. The following are the detailed properties of the selected materials. Out of these, the Kelvar and SM45C have isotropic properties whereas others have orthotropic properties.

III. BOUNDARY CONDITIONS

The boundary conditions are the details which give the details about the loads acting on the system and the supports applied to the system. In this project, the boundary conditions used are torque and displacement support. The load is taken as 3000 Nm (torque transmission capacity of drive shaft). This value is taken from IJEST paper.

1. Analysis Type and Tool Selection:

Table 1. Data of materials used.

Property	Units	E-Glass	Hm Carbon	Hs Carbon	Kelvar	Sm45c
Density	Kg/mm^3	0.000002	0.0000016	0.0000016	0.0000014	0.0000076
Youngs modulus in X	MPa	50000	190000	134000		
Youngs modulus in Y	MPa	120000	7700	7000	11390	207000
Youngs modulus in Z	MPa	120000	7700	7000		
Poissons Ratio in XY		0.3	0.3	0.3		
Poissons Ratio in YZ		0.3	0.3	0.3	0.34	0.3
Poissons Ratio in XZ		0.3	0.3	0.3		
Shear modulus in XY	MPa	5600	4200	5800		
Shear modulus in YZ	MPa	5600	4200	5800	4250	79615
Shear modulus in XZ	MPa	5600	4200	5800		

The propeller shafts have to be analysed to determine the stress and deformation that occur because of the applied load. Also the proposed shaft has to be analysed under two layer conditions using layer overlap conditions.

Also, the buckling loads have to be determined to find the load carrying capacity. Based on these conditions, the analysis tool selected is ANSYS Workbench and the mode of analysis is Static Structural and Eigen value buckling analysis.

The analysis in ANSYS workbench for the above mentioned modes is comprised of the following processes and those have been pictured accordingly.

Importing the geometry | Material assignment | Meshing | Applying Boundary Conditions | Integrating the Structural and Buckling analysis | Solving the analysis.

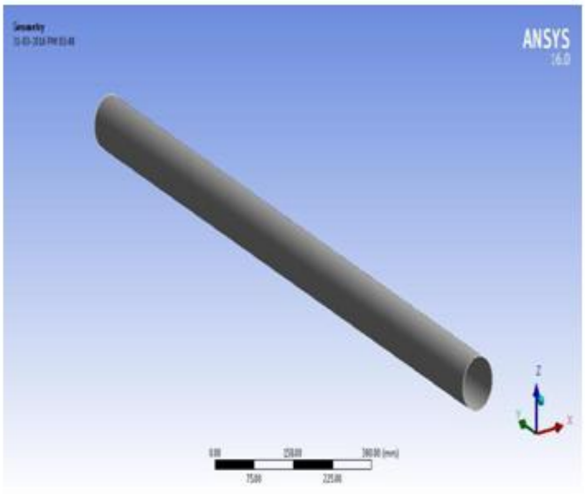

Fig 4. Geometry imported in ANSYS Workbench – Proposed geometry.

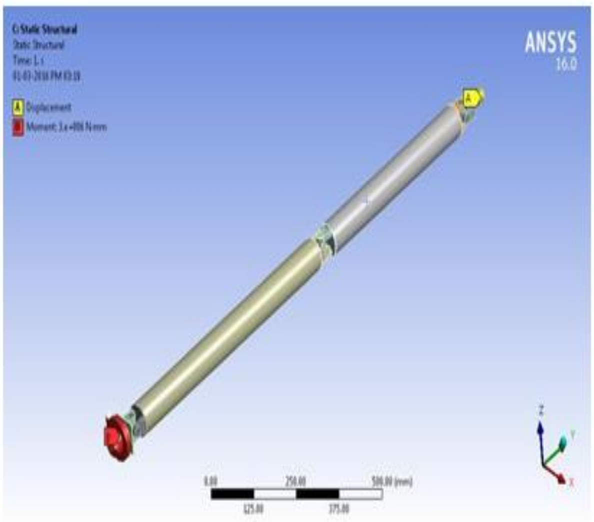

Fig 5. Boundary conditions of existing shaft.

The above are the pre-processing steps that have to be implemented before solving the problem. ANSYS package will solve the problem accordingly and the results have been explained in the next chapter.

The following are the post-processing steps of the analysis process. The results are explained in the form of coloured contours and tabulated values accordingly. The results that have been derived from the analysis are deformation, stress, stain and buckling deformation and load carrying capacity. The following are the contour plots of the analysed models.

IV. RESULTS & DISCUSSION

1. Results of Existing Model – Sm45c Shaft

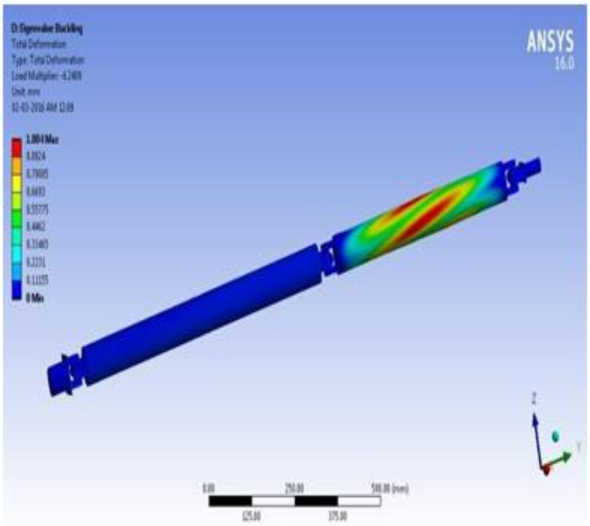

Fig 6. Buckling deformation of the existing shaft.

Table 2. Structural results of existing propeller shaft.

Object Name	Total Deformation (mm)			
Minimum	0	3.5631e-008	1.0016e-003	14.98
Maximum	9.8913	1.7749e-002	3576.2	742.64

Table 3. Buckling results of existing propeller shaft.

Mode	Load Multiplier
1	-6.2409
2	-6.2287
3	4.1662
4	4.1966
5	4.227
6	4.2606

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2. Results of Propsed Shaft- Sm45c Material:

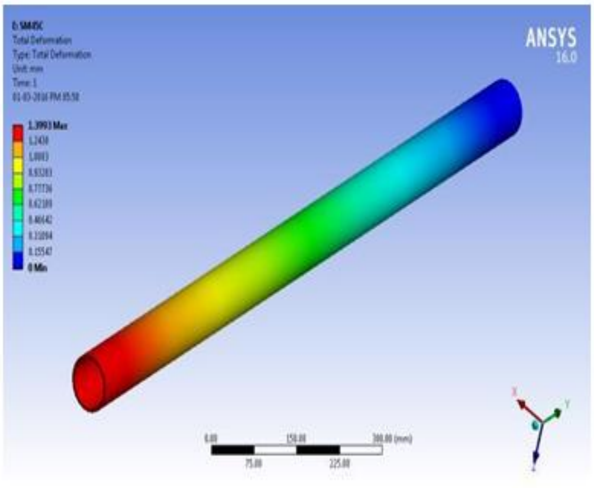

Fig 7. Total deformation of proposed shaft SM45C material.

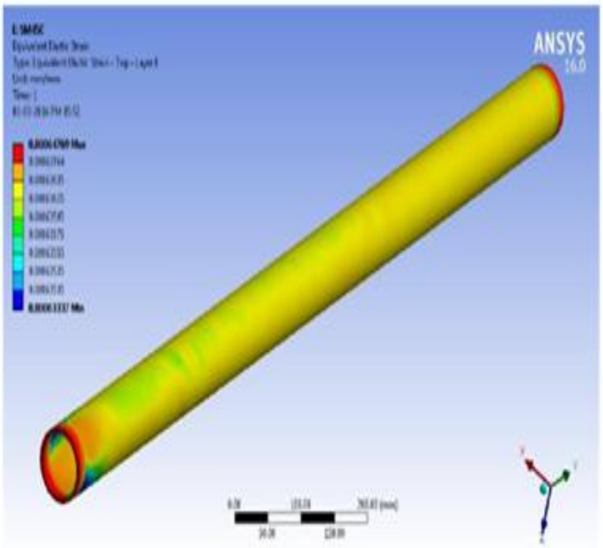

Fig 8. Strain plots of proposed shaft SM45C material.

Table 4. Structural results of proposed shaft SM45C material.

Object Name	Total Deformation in mm	Equivalent Elastic strain	Equivalent Stress (Mpa)
Minimum	0	6.3337e-004	129.78
Maximum	1.399	6.4769e-004	132.71

3. Results of Proposed Shaft – All Materials:

The following are the typical coloured plots of total deformation, strain, stress and buckling deformation of composite material. Since the contour plots for the entire composite material are same, one typical contour for each output have been pictured below.

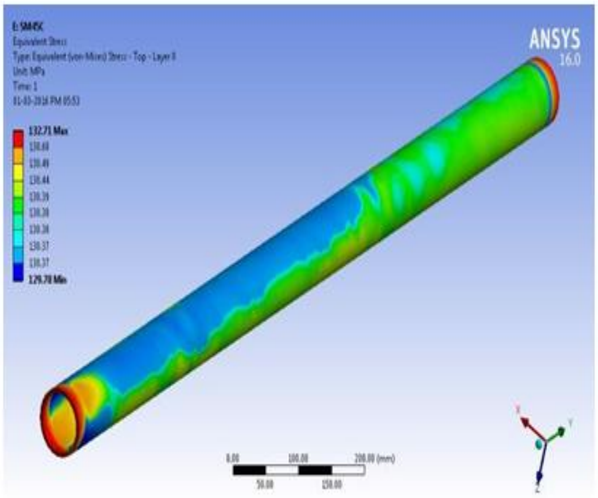

Fig 9. Stress plots of proposed shaft SM45C material.

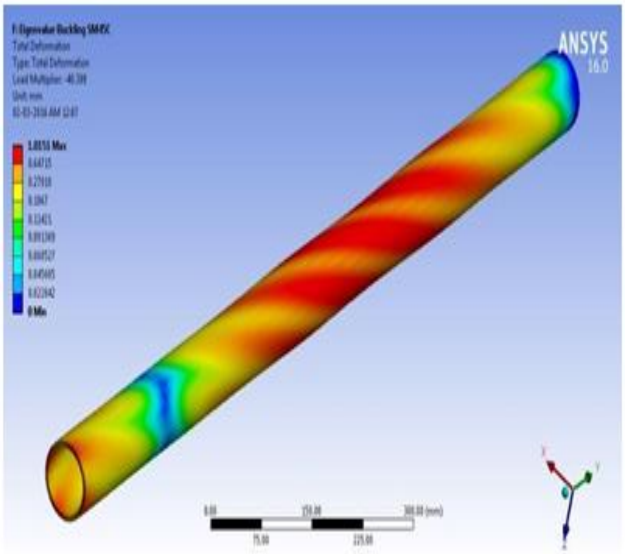

Fig 10. Buckling deformation of proposed shaft SM45C material.

Table 5. Buckling results of proposed shaft SM45C material.

Mode	Load Multiplier
1	-40.399
2	-37.026
3	-37.017
4	37.025
5	37.032
6	40.399

The respective values in the numeric form will be listed in detail.

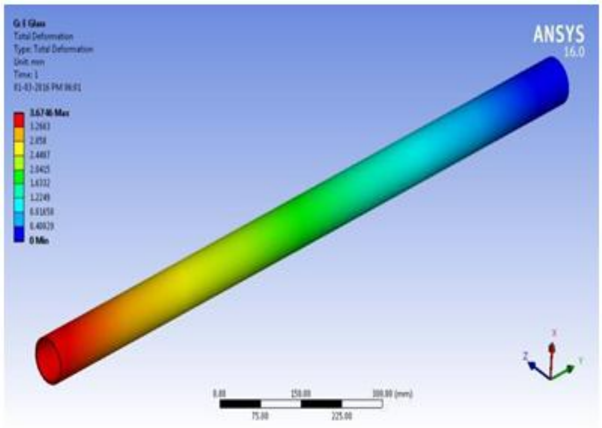

Fig 11. Typical total deformation of proposed composite shaft

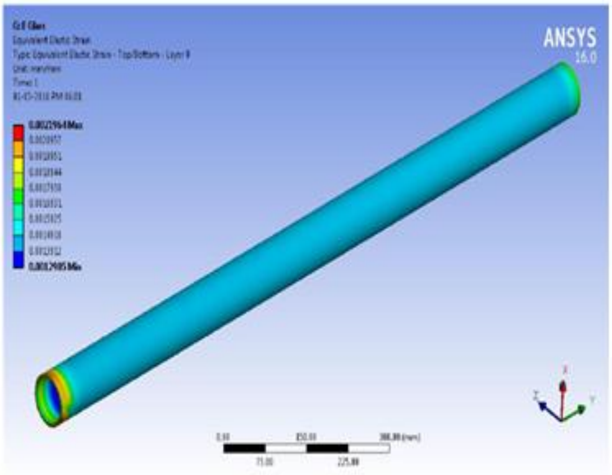

Fig 12. Typical strain plots of proposed composite shaft

Table 6. Structural results of proposed shafts under various materials.

Material	Type	Total Deformation (mm)	Equivalent Elastic Strain	Equivalent Stress (MPa)
E Glass	min	0	1.29E-03	110.89
	max	3.6746	2.20E-03	152.12
Hm Carbon	min	0	1.47E-03	36.742
	max	2.5308	8.23E-03	167.01
Hs Carbon	min	0	1.99E-03	17.791
	max	3.4347	9.11E-03	175.85
Kelvar	min	0	1.15E-02	129.79
	max	26.212	1.46E-02	164.07

V. CONCLUSION

From the above results and charts, it is evident that, next to the existing SM45C material, the E glass is having considerable less stress induced in it and among the other Composite materials, the E glass material is having the maximum load carrying capacity at modes 5 and 6. Next to the E glass material, the HM and HS carbon materials are havig considerably good result than Kelvar material.

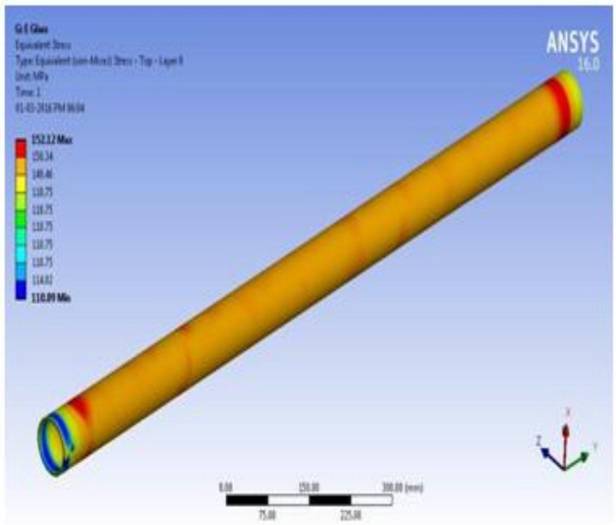

Fig 13. Typical stress plots of proposed composite shaft.

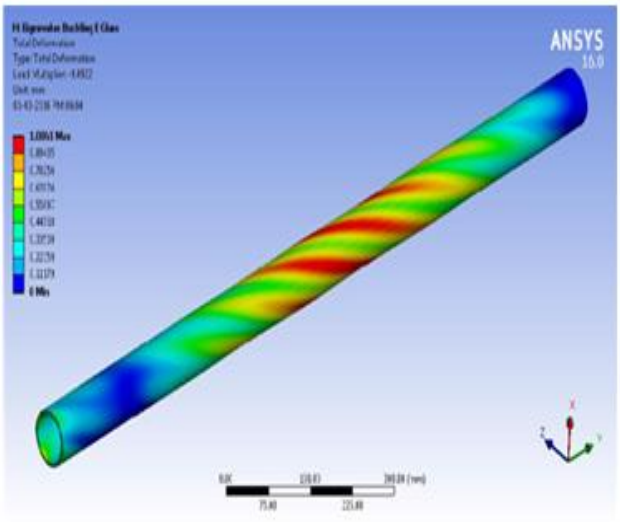

Fig 14. Typical buckling deformation of proposed composite shaft.

Table 7. Buckling load carrying results of proposed shaft under various materials.

Mode	E Glass	Hm Carbon	Hs Carbon	Kelvar
1	-9.0922	-2.6885	-2.9504	-2.2694
2	-9.0916	-2.6763	-2.9343	-2.0749
3	-8.0004	2.4843	2.6759	-2.0744
4	-7.9813	2.489	2.6807	2.0749
5	8.1062	2.7343	2.8939	2.0753
6	8.1402	2.735	2.8952	2.2694

VI. ACKNOWLEDGMENT

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