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Composites as Drive Shaft using FEA

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ABSTRACT: Material science is a field in which many researches are being conducted in the recent years. This is because to avoid the scarcity of raw materials needed for production. In engineering field, the availability of raw material and cost of raw material are the main factors for selecting of product to be manufactured. On the other side, the physical and mechanical properties of the material is also to be analysed before proceeding to production, this is because to withstand the design life and to keep up the product life promises. Also automobile is a field in which, new innovations and technologies takes birth day to day. In this work, a split type propeller shaft is modelled and analysed using under FE analysis using ANSYS software. Then the geometry of the shaft is modified accordingly for the application of composite material replacement. This new geometry is analysed same as the previous one under various material conditions. This analysis is carried out using ANSYS software. For the comparison of materials, the materials used in this work are, SM45C, E Glass composite, HM and HS Copper composites and Kevlar composite. The results are obtained by applying appropriate boundary conditions and the tabulated and the better material for replacement purpose is suggested finally and stating the application of composite materials and the role of ANSYS for the analysis of composite material.

KEYWORDS: Driver shaft, Design modification, Material optimization, Composite materials, ANSYS workbench

I. INTRODUCTION

Mohammad Reza Khoshravan et al.[1] presents made up of high modulus carbon and epoxy multilayered composites. 72 % of weight reduction is achieved by replacement of composite materials.

T.Rangaswamy et al.[3] Presents The overall objective of this paper is to design and analyze a composite drive shaft for power transmission applications. A single piece drive shaft was designed using High modulus (HM) Carbon/Epoxy and E Glass/Epoxy composites. Genetic Algorithm (GA) has been applied to minimize the weight of shaft. The static and buckling analysis are performed in ANSYS with the results of GA.

Naik Shashank Giridhar et al.[4] said that analysis of the yoke clearly shows that by a small modification in the existing design the strength of the part can be increased significantly. Also with the same changes we obtain a small amount of weight reduction in the design. The maximum stress values generated are significantly reduced and the stress is evenly distributed over the entire part.

D.Dinesh and F.Anand raju [5] says that optimization of carbon/epoxy composite drive shaft were analyzed. It improves the performance of drive shaft and weight reduction.

Raffi et al. [6] deals that carbon fibre epoxy composite surface protected by aluminium tube to prevent absorption of moisture and increase the reliability.

II. PROBLEM DEFINITION AND OBJECTIVE OF THE WORK

The connecting rods are made of general steel grade of SM45 group and other grades. The recent trends in the innovations of composite materials have made the researchers to adopt the new materials in all the fields of engineering. In this project the same have been followed. Here, the propeller shaft is selected for the material replacement analysis.

The statement of the problem is, to analyse a propeller shaft used in automobile under various composite materials. Also, for the implementation of composite material's layer lapping angle, the design of the shaft is to be changed from

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split shaft to single tube shaft. The tube is to be of 5mm thickness, which implies, the composite layer should be of 2 nos., and each layer should be of 2.5mm thickness. The angle of lap of the layers is taken as +45 and -45 degrees. The main objective of this work is to analyse an existing split type propeller shaft under static structural and buckling conditions to find the amount of stress and to determine the load carrying capacity of the assembly. Then the propeller shaft design is revised accordingly to a single shaft. This new design is also to be analysed for the same conditions same as the split type shaft, but under various material conditions. Then the results will be compared to select a suitable composite material.

III. GEOMETRY AND MATERIAL SELECTION

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

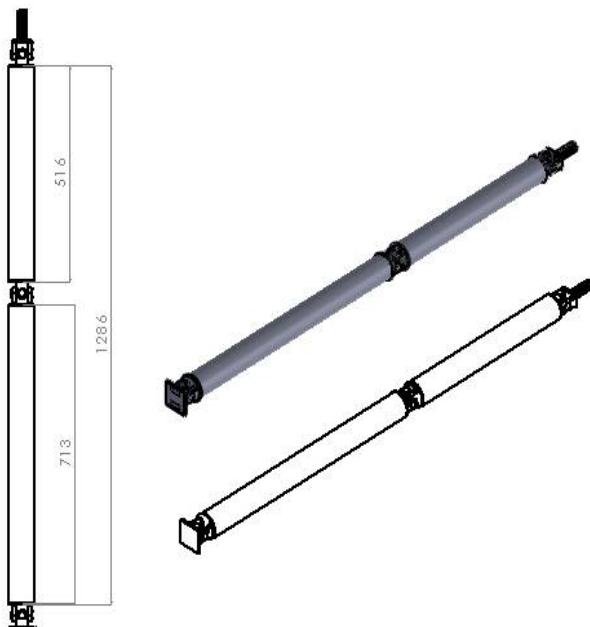


Fig. 1. Details of Existing Propeller Shaft

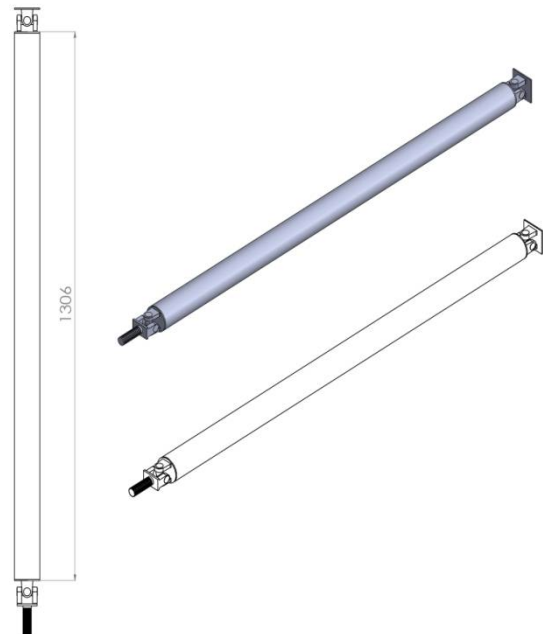


Fig 2. Details of Proposed Propeller Shaft

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.

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, Kevlar composites and so on. Out of the listed composites, in this project the composite materials used are E-Glass, HM Carbon, HS Carbon and Kevlar. The following are the detailed properties of the selected materials. Out of these, the Kevlar and SM45C have isotropic properties whereas others have orthotropic properties.

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TABLE I. MATERIAL PROPERTIES OF EXISTING AND PROPOSED MATERIALS

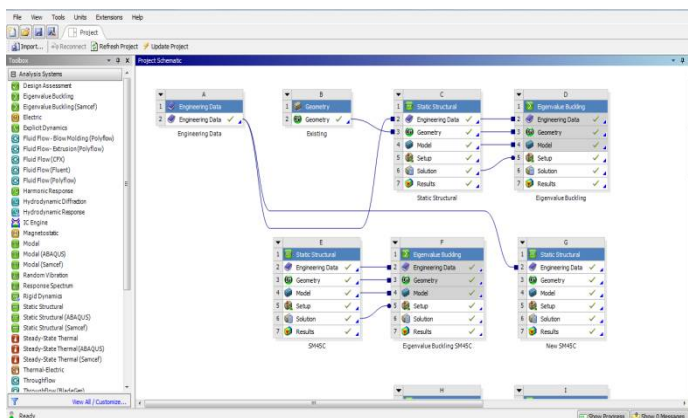
PROPERTY	UNITS	E-GLASS	HM CARBON	HS CARBON	KELVAR	SM45C
Density	Kg/mm ³	0.000002	0.0000016	0.0000016	0.0000014	0.0000076
Youngs modulus in X	MPa	50000	190000	134000	11390	207000
Youngs modulus in Y	MPa	120000	7700	7000		
Youngs modulus in Z	MPa	120000	7700	7000		
Poissons Ratio in XY		0.3	0.3	0.3	0.34	0.3
Poissons Ratio in YZ		0.3	0.3	0.3		
Poissons Ratio in XZ		0.3	0.3	0.3		
Shear modulus in XY	MPa	5600	4200	5800	4250	79615
Shear modulus in YZ	MPa	5600	4200	5800		
Shear modulus in XZ	MPa	5600	4200	5800		

IV. SELECTION OF ANALYSIS TYPE, TOOL AND BOUNDARY CONDITIONS

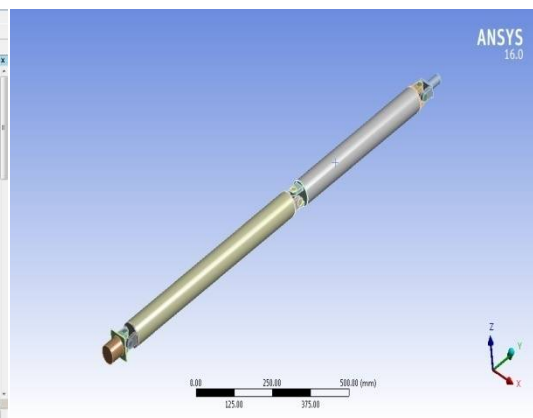
The propeller shafts have to be analysed to determine the stress and deformation that occur because of the applied load. Also the proposed shaft has to be analysed under two layer conditions using layer overlap conditions. Also, the buckling loads have to be determined to find the load carrying capacity. 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 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].

V. ANALYSIS IN ANSYS WORKBENCH



a



b

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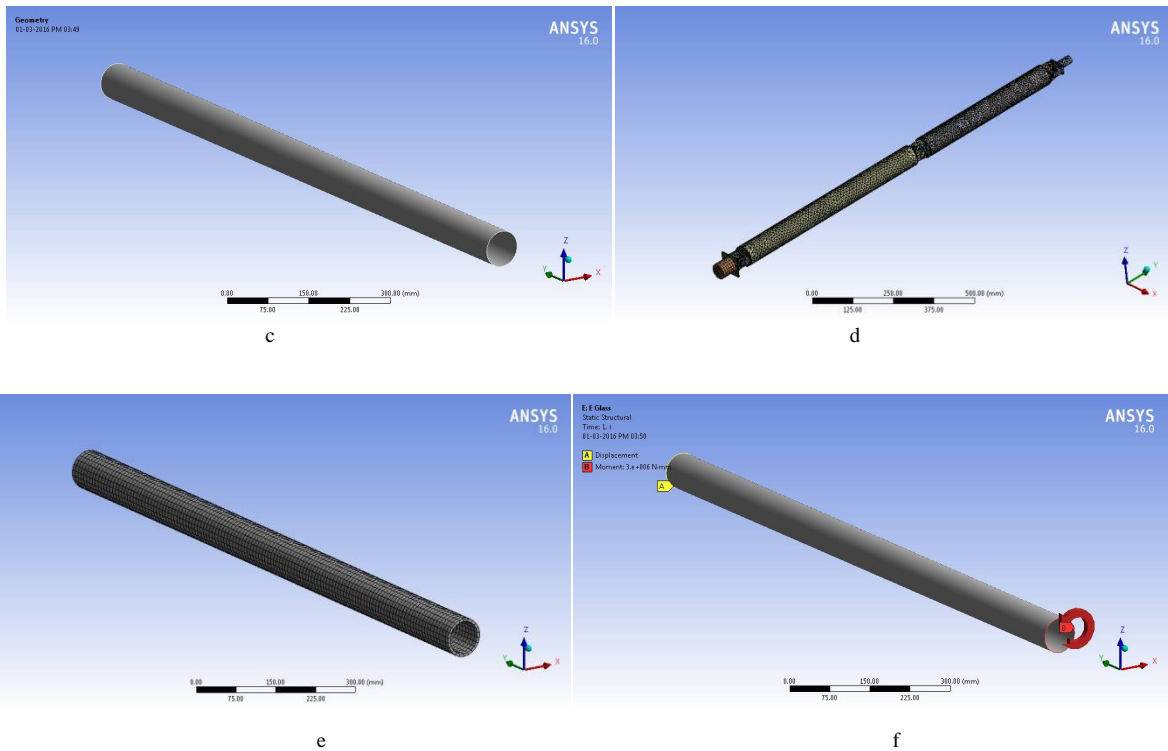


Fig.3. Details of Pre-Processing in ANSYS Workbench (a – Project Screen, b – Importing Existing Model, c – Importing proposed Model, d – Meshing Existing Model, e – Meshing Proposed Model, f – Boundary Conditions of Proposed mode.

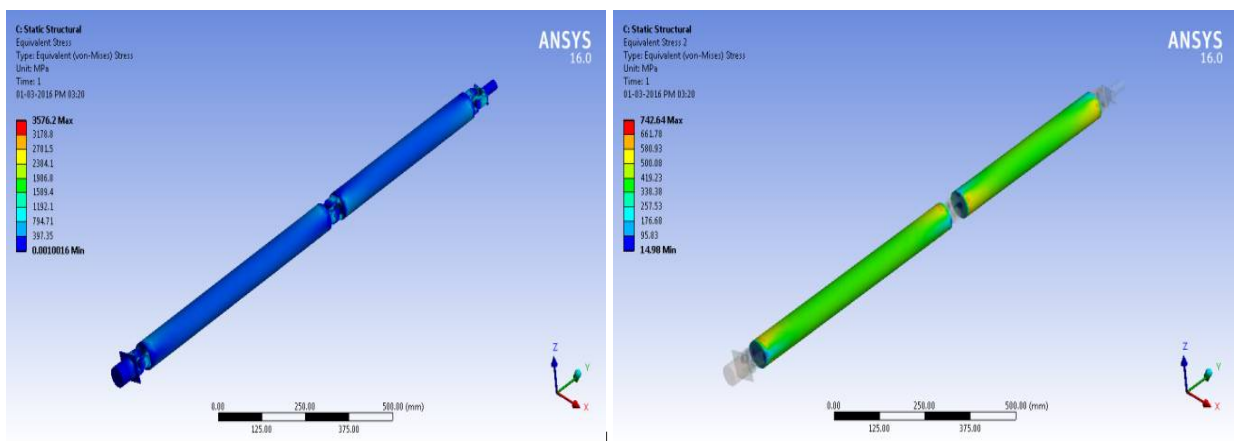


Fig.4. Stress results of Existing Model (a – Entire assembly, b – On two cylinders)

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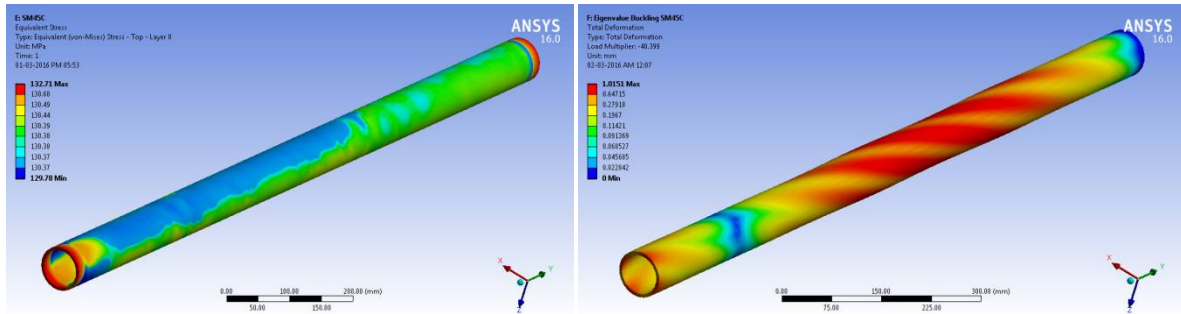


Fig.5. Typical Stress Plots of Proposed Model under Composite Material Conditions (a – Stress, b – Stress due to Buckling)

TABLE II. Results of Existing Propeller Shaft

Object Name	Total Deformation (mm)	Equivalent Elastic Strain	Equivalent Stress full assembly (MPa)	Equivalent Stress two cylinders (MPa)
Minimum	0	3.5631e-008	1.0016e-003	14.98
Maximum	9.8913	1.7749e-002	3576.2	742.64

TABLE III. RESULTS OF PROPOSED PROPELLER SHAFT UNDER VARIOUS MATERIAL CONDITIONS

MATERIAL	TYPE	Total Deformation (mm)	Equivalent Elastic Strain	Equivalent Stress (MPa)
SM45C	Min	0	6.3337e-004	129.78
	Max	1.399	6.4769e-004	132.71
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
KEVLAR	Min	0	1.15E-02	129.79
	Max	26.212	1.46E-02	164.07

TABLE IV. RESULTS OF LOAD MULTIPLIER CAPACITY OF EXISTING AND PROPOSED SHAFTS FOR ALL MATERIAL CONDITIONS

MODE	SM45C		E GLASS	HM CARBON	HS CARBON	KEVLAR
	Existing	Proposed				
1	-6.2409	-40.399	-9.0922	-2.6885	-2.9504	-2.2694
2	-6.2287	-37.026	-9.0916	-2.6763	-2.9343	-2.0749
3	4.1662	-37.017	-8.0004	2.4843	2.6759	-2.0744
4	4.1966	37.025	-7.9813	2.489	2.6807	2.0749
5	4.227	37.032	8.1062	2.7343	2.8939	2.0753
6	4.2606	40.399	8.1402	2.735	2.8952	2.2694

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From the above results and graphs, 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 HC carbon materials are having considerably good results than Kevlar material.

VI. CONCLUSION

The analysis of the existing and proposed propeller shafts have been conducted using ANSYS workbench under the static structural and eigenvalue buckling analysis. The replacement of the materials has also been implemented for the proposed shaft and the same have been analyzed under the same conditions.

The results of the analysis have been tabulated and also compared under graphical method. The comparison of the results states that the proposed design have better life in terms of stress under same material conditions and also in terms of load carrying capacity. The existing shaft of SM45C material is having maximum stress of 742 MPa and whereas in proposed shaft of same material, the stress induced is 132 MPa.

On comparing the results of proposed material under various composite conditions, it can be said that, E Glass composite is having considerably low impact in terms of stress. But the other materials also have low stress compared to the existing design and material. The values of stress induced in various composite materials are approximately nearer to each other. Based on this, the E Glass composite material can be suggested as a material for replacement. Also, this work has made an impact on the application of FEA and ANSYS workbench for analysis and selection of composite materials.

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