Design And Analysis Of Drive Shaft Using Composite Materials And Ansys

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***Abstract*—** Substituting composite structures for conventional metallic structures has many advantages because of higher specific stiffness and strength of composite materials. This work deals with the replacement of conventional two piece shaft with a single piece composite shaft for an automotive application. The advanced composite materials such as Boron, Carbon, and Kevlar with suitable resins are widely used now a days for automotive and other industrial applications especially for rotor applications because of their high specific strength (strength/density) and high specific modulus (modulus/density). Polymer matrix composites were proposed for light weight shafts in drivelines for automotive, industries. Present work is conducted to analyze the composite drive shaft model of Toyota Qualis, which is used for four wheel rear drive passenger cars. Boron/Epoxy, Kevlar/Epoxy, Aluminium-Boron/Epoxy and Carbon-Kevlar/Epoxy drive shafts are analyzed taking into consideration of the dimensional proportionality. Finally, considering the Density, Maximum Shear stress, Total Deformation from the analysis, Kevlar/Epoxy is acceptable to use instead of steel for the Toyota Qualis driveshaft.

Keywords*—*Boron/Epoxy; Kevlar/Epoxy;Aluminium-Boron/Epoxy; Carbon-Kevlar/Epoxy

1. INTRODUCTION

In the process of designing a vehicle, one of the most important objectives is the conservation of energy and the most effective way to obtain this goal is the reduction of weight of the vehicle. There is almost a direct proportionality between the weight of the vehicle and its fuel consumption, particularly in city driving. The automotive industry is exploiting composite material technology for structural component construction in order to obtain reduction of weight, without decrease in vehicle quality and reliability. The advanced composite materials seem ideally suitable for long power drive shaft (propeller shaft) applications as their elastic properties can be tailored to increase the torque they carry as well as the rotational speed at which they operate. In this project, the conventional drive shaft material has been replaced with advanced composites and hybrid materials to carry out a comparative analysis, thus determining the most suitable replaceable material.

2. METHODOLOGY

A. Pre-processing

The pre-processor stage in ANSYS package involves the following:

Specify the title, which is the name of the problem. Set the type of the analysis to be used, i.e., structural, thermal, fluid, or electro-magnetic, etc., Create the model - The model is drawn in ID, 2D, or 3D space in the appropriate units (m, mm, in, etc). The model may be created in preprocessor, or it can be imported from another CAD drafting package through a neutral file format like IGES, STEP, ACIS, Para solid, DFX, etc.,. The same units should be applied in all directions, otherwise results will be difficult to interpret, or in extreme cases the result will not show up mistakes made during loading and restraining of the model. Define the element type, this may be 1D, 2D or 3D, and specify the analysis type being carried out. Apply mesh - Mesh generation is the process of dividing the analysis continuum in to a number of discrete parts or finite elements. The finer mesh, the better result, but the longer the analysis time. Therefore, the compromise between accuracy and solution speed is usually made. Assign the properties - Material properties (Young's Modulus, Poisson's ratio, density, and if applicable coefficient of expansion, friction, thermal conductivity, damping effect, specific heat, etc.,) have to be defined.

B.Meshing

In manual meshing the elements are smaller at joint. This known as mesh refinement, and it enables the stress to be captured at the geometric discontinuity. Manual meshing is long and tedious process for models with any degree of geometric complication, but with useful tool emerging in pre-processes, the task is becoming easier.

C. Post-Processor:

In this module, the results of the analysis are read and interpret. All postprocessor include the calculation of stress and strain in all of the X, Y, Z directions or indeed in the direction at an angle to the co-ordinate axes. The principle stress and strain may also be plotted.

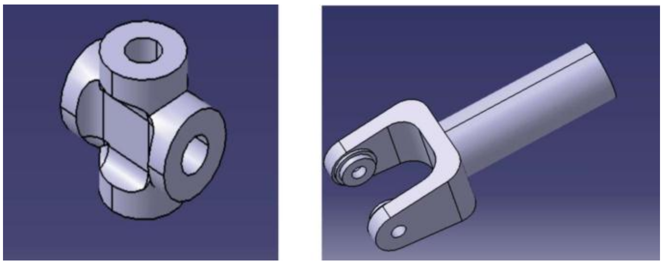
D. Structural Analysis:

Structural analysis is probably the most common-application of FEM. The term structural implies not only civil engineering structures such as bridges and buildings, but also naval, aeronautical, mechanical components such as axles, pistons, machine parts and tools. The primary unknowns (nodal degree of freedom) calculated in a structural analysis are displacements other qualities such as strains, stresses and reaction forces are derived from the nodal displacements.

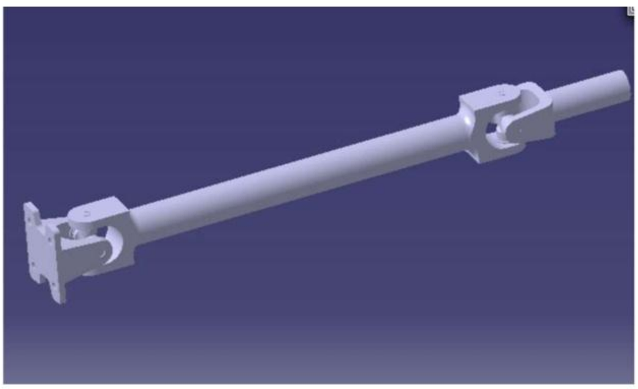
E. Modal Analysis:

We use Modal Analysis to determine the vibrations characteristics (Natural frequencies and mode shapes) of a structure of machine component while it is be designed. It also can be a starting point for another, more detailed, Dynamics Analysis, such as a transient dynamics, a harmonic response analysis, or a spectrum analysis. The natural frequencies and mode shapes are important parameters in the design of structure for dynamic loading conditions. They are also required if you want to do a spectrum analysis or a mode superposition harmonic or transient analysis.

Drive shaft components in CATIA



Drive shaft assembly in CATIA



The Toyata quails drive shaft assembly was created in CATIA software shown in above figure.

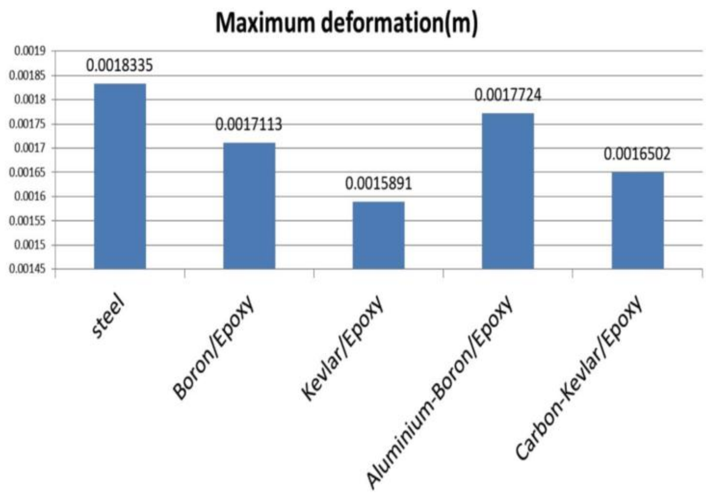
3. ANALYSIS OF DRIVE SHAFT :

The Assembly thus created in CATIA is used in ANSYS 14.5 Workbench to carry out the torsional analysis. Since the domain for analysis is a complex assembly of a number of parts, ANSYS 14.5 Workbench was chosen for performing the analysis. The proper connection between each part of the assembly and the subsequent connectivity of mesh is the key criteria for getting proper load transfers throughout the assembly. The Workbench module of ANSYS 14.5 does not require the explicit specification of element types by the user, depending upon the assembly, the element types are chosen by the solver to get the best possible results. For the intricate parts of the assembly which cannot be manufactured using composite materials, conventional steel material was chosen, but for the dominating major portion of the assembly which is relatively easier to manufacture, the composite material were applied.

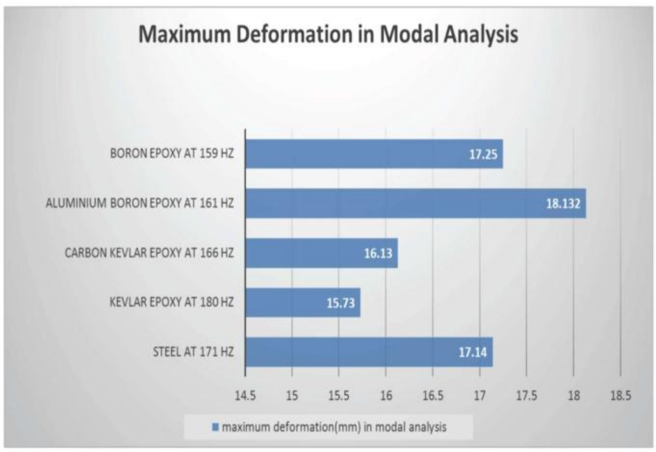
Maximum Deformation, shear stress and Density of steel and composites

S. No	Material	Maximum deformation(m)	Maximum shear stress(Mpa)	Density (Kg/m3)
1	Steel(SM45C)	0.0018335	0.31847	7600
2	Boron/Epoxy	0.0017113	0.29724	2249
3	Kevlar/Epoxy	0.0015891	0.27601	1402
4	Aluminium-Boron/ Epoxy	0.0017724	0.30786	2100
5	Carbon-Kevlar/Epoxy	0.0016502	0.28663	1470

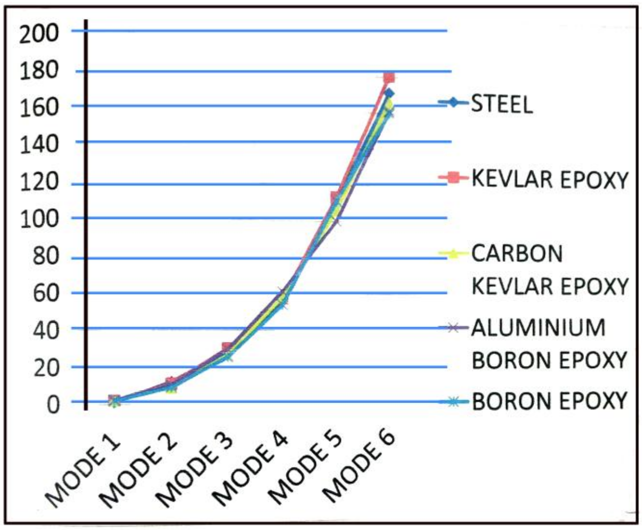
4. MAXIMUM DEFORMATION IN STATIC ANALYSIS



5. MAXIMUM DEFORMATION IN MODAL ANALYSIS



6. COMPARATIVE GRAPH BETWEEN MODES AND ITS CORRESPONDING FREQUENCIES IN MODAL ANALYSIS:



This graph shows the difference in maximum frequencies of the composite materials and steel at different modes in modal analysis, (Kevlar Epoxy) material has high frequency withstand values in modal analysis compared to another materials.

7. CONCLUSION

The presented work was aimed at reducing the fuel consumption of the automobiles, which employs drive shafts. This was achieved by reducing the weight of the drive shaft with the use of composite materials. The Drive shaft of a Toyota Qualis was chosen and the model is created in CATIA V5R17. Being a complex assembly of a number of parts, it had to be analyzed in ANSYS 14.5 Workbench. A total of five materials were chosen for the comparative analysis, including steel, which was used for reference, these 4 materials were analyzed. The analysis shows that, considerable amount of weight can be saved when composite materials are used compared to conventional steel shaft. Taking into consideration of the weight saving, deformation, shear stress induced, maximum deformation in modal analysis, it is evident that Kevlar/Epoxy composite (Kevlar of 73% and Epoxy of 23%) has the most encouraging properties to act as the replacement for steel out of the considered

8. REFERENCES

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