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Finite Element Analysis of Drive Shaft Aluminium Based Metal Matrix Composite Reinforced with Sic and Al_2o_3

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ABSTRACT

The composite material is mainly used to reduce the weight and increase the strength, stiffness etc… Stir casting process is mainly used to manufacturing of reinforced with metal matrix composite. The manufacturing of aluminum alloy based on stir casting method its used to one of the most economical method of processing MMC. The main project the operating parameter of the composite as its control the properties of the composite material. The drive shaft is increases the length of the shaft because to reduce the whirling vibration. This paper present overview of stir casting process, parameter & preparation of MMC study on mechanical behavior of metal matrix composite with varies composition of reinforcement particles of graphite or Nano particle Sic and Al_2O_3 composite produced by the stir casting technique. The shaft is modeled using CERIO modeling, finite element analysis is done for same model utilizing ANSYS 15.0 software for Aluminum (Al-SiC), and the results were discussed.

Keywords : Stir-casting; process; MMC; Reinforcement; Alumina; drive shaft; Static analysis; Nano composite

I. INTRODUCTION

Drive shaft is most important part contrasted with different parts in an automobile division. In recent papers 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.[1] The two piece steel drive shaft consists of three universal joints, a center supporting bearing and a bracket, which increase the total weight of a vehicle. Power transmission can be improved through the reduction of inertial mass and light weight. Substituting composite structures for conventional metallic structures has many advantages because of higher specific stiffness and higher specific strength of composite materials. Composite materials can be tailored to efficiently meet the design requirements of strength, stiffness and composite drive shafts weight less than steel or aluminum of similar strength. It is possible to manufacture one piece of composite. Drive shaft to eliminate all of the assembly connecting two piece steel drive shaft. In addition, composite materials typically have a lower modulus of elasticity. As a result, when torque peaks occur in the driveline, the driveshaft can act as a shock absorber and decrease stress on part of the drive train extending life. Many researchers have been investigated about MMCs drive shafts and joining methods of the MMCs shafts to the yokes of universal joints.

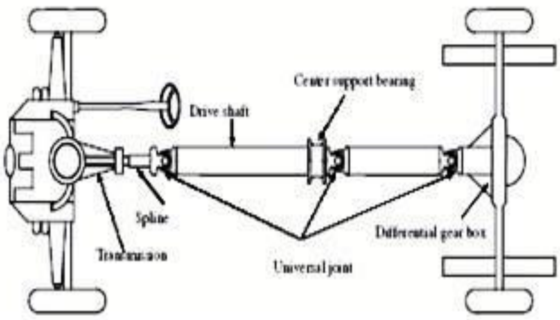

Figure 1 : Schematic arrangement of underbody of an automobile.

II. METHODS AND MATERIAL

2. Design of Composite Drive Shaft

2.1 Identification of Problem

- ✓ The passenger cars, trucks and vans should have the torque transmission capacity more than 3500Nm and the natural frequency must be higher than 6500 rpm to avoid whirling vibration.
- ✓ In that the critical speed of shaft is inversely proportional to the square of the length.so that the vibration problem could be solve by increasing the length of shaft but it's not permitted due to space limitations.
- ✓ So that it's only for manufacturers and manufacture the shaft in two pieces.

2.2. Assumptions

The shaft rotates at a constant speed about its longitudinal axis. The shaft has a uniform, circular cross section.

The shaft is perfectly balanced, all damping and nonlinear effects are excluded. The stress-strain relationship for composite material is linear and elastic; hence, Hook's law is applicable for composite materials. Since lamina is thin and no out-of-plane loads are applied, it is considered as under the plane stress.

2.3. Merits of Composite Drive Shaft

1. They have high specific modulus and strength.
2. Reduced weight.
3. Due to the weight reduction, fuel consumption will be reduced.
4. They have high damping capacity hence they produce less vibration and noise.
5. They have good corrosion resistance.
6. Greater torque capacity than steel or aluminum shaft.
7. Longer fatigue life than steel or aluminum shaft.

3. Theory

3.1. Composite Material

A material composed of two or more constituents is called composite material. Composites consist of two or more materials or material phases that are combined to produce a material that has superior properties to those of its individual constituents. The constituents are combined at a macroscopic level and or not soluble in each other. The main difference between composite and an alloy are constituent materials which are insoluble in each other and the individual constituents retain those properties in the case of composites, whereas in alloys, constituent materials are soluble in each other and forms a new material which has different properties from their constituents. Classification of Composites

- ✓ Polymer matrix composites
- ✓ Metal matrix composites
- ✓ Ceramic Matrix composites

3.2. Material Selections

(A6061)-LM6 Aluminum alloy having density of 2.72 gm/ and prominent properties like weight, toughness etc. was chosen as the base material due to its usage of drive shafts.

The aim of increasing the wear resistance, strength, stiffness, hardness etc. of this drive shaft alloy, SiC particles of 23micron size was selected as reinforcement. This SiC has higher density 3.22 gm/cm3 , higher hardness relative to B4C, and the excellent

Table 1. Aluminium alloy series

Alloy Series	Features	Application
Al2024	Good corrosion resistance & High strength	High strength structural (aircraft), automotive parts, screws and rivets.
Al6061	Good formability, weld ability, corrosion resistance and strength.	Marine, aircraft's and automobile parts
Al7075	High strength alloy	Aircraft and structure, recreation equipment's.

III. RESULTS AND DISCUSSION

Finite Element Analysis

4.1. Design Analysis

Finite element analysis is a computer based analysis technique for calculating the strength and behavior of structural engineering. In the structure is represented as finite element. These elements are jointed at particular points which are called as nodes. The FEA is used to calculate the deflection, stress, strain, buckling behavior of the member.

In our project FEA is carried out by using ANSYS 15.0. Initially we don't know the displacement and other quantities like stress, strain, deflection which are the then calculated from nodal displacement.

Figure 2. Cerio modeling

In present work, we have used FEA for the structural analysis of Aluminium/SiC drive shaft. The CERIO software is used to prepare the drive shaft. After completing CERIO modeling, the model is saved in STP, IGES file then STP, or IGES file is import to ANSYS 15.0 software for the finite element analysis.

4.2. Boundary Condition

The finite element model of Al-SiC shaft is shown in figure. One end is fixed and torque is applied at other end.

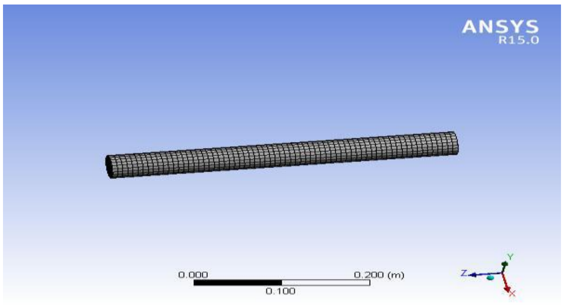

Figure 3. Finite element model of Al-SiC

Ansys Simulation

Static Analysis

A static analysis is used to determine the displacement, strain, von mises stress and force in structure or compounds caused by load that do not significant inertia and damping effects. The static analysis of drive shaft is done by ANSYS software 15.0.

Static Analysis of Al-SiC

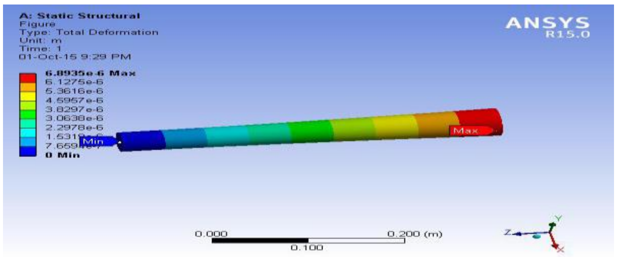

Figure 4. Total deformation of Al-SiC

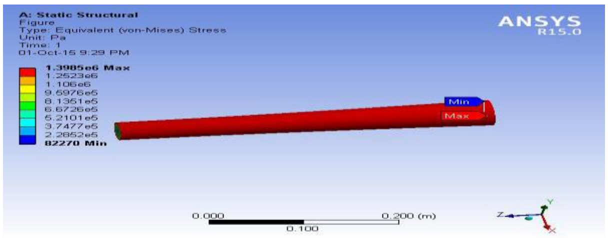

Figure 5. Von mises stress of Al-SiC

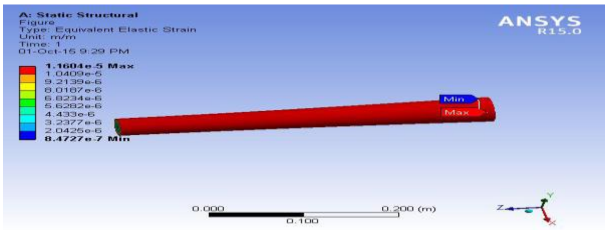

Figure 6. Strain of Al- SiC

Table 2. Static analysis of drive shaft

Material	Totaldeformation mm	Vonmisestress pa	Strain
Aluminium alloy	**$1.1927e^{-5}$**	**$1.3985e^{6}$**	**$1.9765e^{-5}$**
Al- SiC	**$6.8935e^{-6}$**	**$1.3985e^{6}$**	**$1.1604e^{-5}$**

4.3 Dynamic Analysis

Modal Analysis: The modal analysis is one of the important analysis for drive shaft as we are eliminating two piece drive shaft and using single piece. Single piece not allowing any axial adjustment movement of drive shaft. The modal analysis is required as the 1st mode frequency of vibration must be less than shaft operating frequency to avoid failure of drive shaft. The boundary condition applied is as shown is fig.

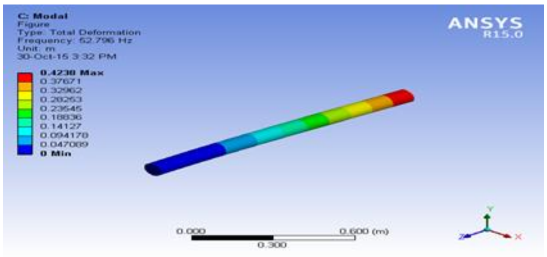

Figure 7. Mode shape 1

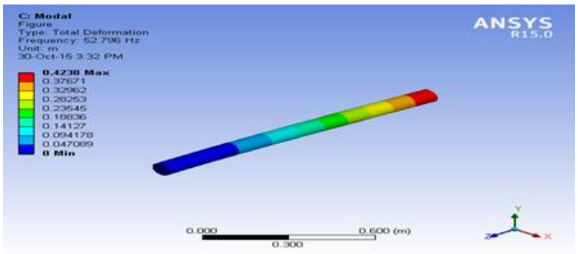

Figure 8. Mode shape 2

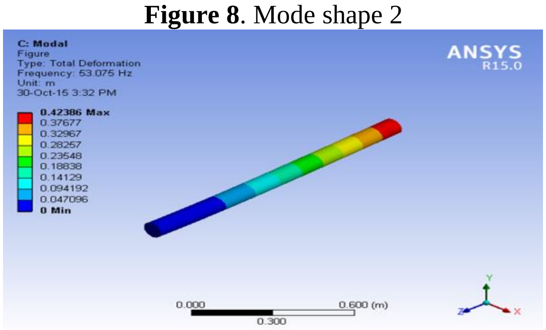

Figure 9. Mode shape 3

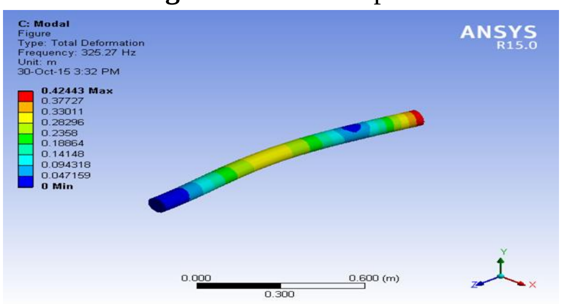

Figure 10. Mode shape 4

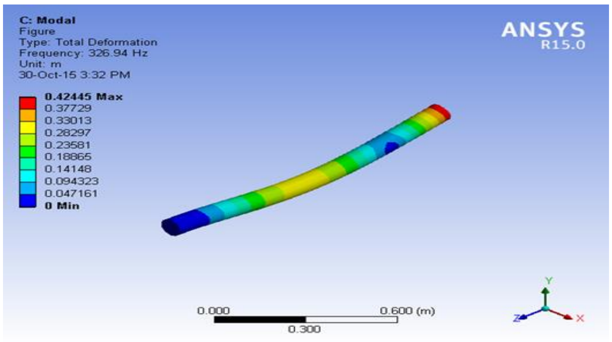

Figure 11. Mode shape 5

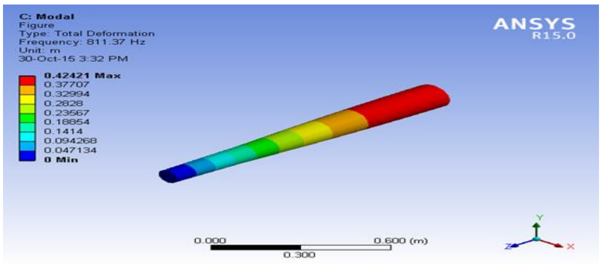

Figure 12. Mode shape 6

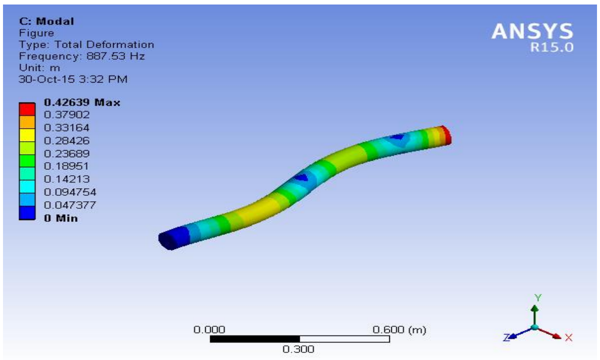

Figure 13. Mode shape 7

IV. CONCLUSION

- ✓ The high strength Al-SiC composite drive shaft have been designed to replace the steel, aluminium alloy drive shaft of an automobile. .
- ✓ The replacement of conventional drive shaft results in reduction in weight of automobile.
- ✓ The finite element analysis is used in this work to predict the deformation of shaft.
- ✓ Hence, the single piece high strength Al-SiC drive shaft has been proposed to design to replace the two-piece conventional steel, aluminium alloy drive shaft of an automobile.
- ✓ The design of drive shaft is critical as it is subjected to combined loads. The designer has two options for designing the drive shaft whether to select solid or hollow shaft.
- ✓ The solid shaft gives a maximum value of torque transmission but at same time due to increase in weight of shaft the 1st mode frequency decreases.

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