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Analysis of Propeller Shaft for Composite Materials

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Abstract

Fuel efficiency and weight of automobile are the two important parameters to be considered. The most suitable way to increase the efficiency of automobile without sacrificing the safety of passengers is by using composite materials. Most of the automobile industries are using composite materials for manufacturing components of an automobile to reduce the weight without compromising quality and reliability. The main objective of this paper is to reduce the weight of an automobile drive shaft assembly by using the composite materials such as Epoxy/E-glass and Epoxy carbon. Conventional Drive shaft has having less strength, less specific modulus and increased weight. Composite materials are having advantages like high strength, free corrosion resistance, high specific modulus, high impact energy and reduced weight. Pro-E wildfire 4.0 is used to model the drive shaft assembly and ANSYS 11.0 is the analysis package used to carry out analysis.

Keywords: Drive shaft assembly, composite materials, finite element analysis.

Introduction

The main purpose of the diving shaft or propeller shaft is to transmit torque from the gear box to differential gear box, it has to withstand high rotational speeds required by the vehicle and the drive shaft has to change its length while transmitting the torque.

Propeller shaft consists mainly of three parts those are shaft, universal joint and a slip joint. The shaft has to withstand mainly torsional loads. It has to be well balanced to avoid whirling at high speeds. Depending upon the rear axle drive the number of universal joints may be varied as one or two. When the vehicle is running the universal joint accounts for up and down moment of rear axle. The slip joint serves to adjust the length of the propeller shaft when demanded by the rear axle moments.

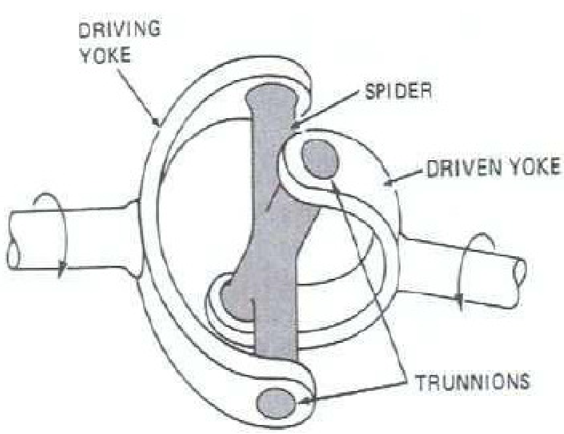

Figure-1
Universal joint

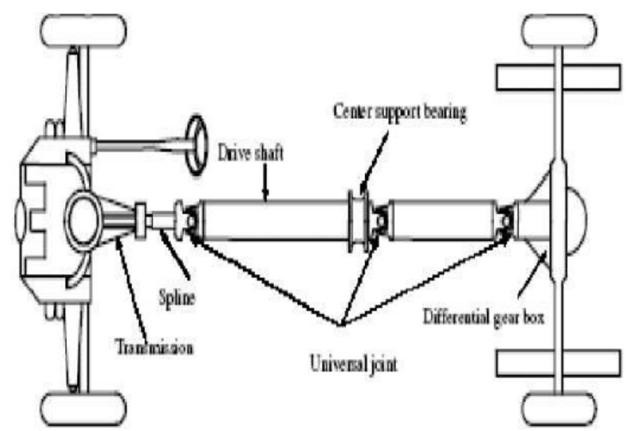

Figure-2
Propeller shaft for drive line system

The universal joint or hooks joint is used to connect two shafts which are inclined to each other. Main parts of universal joint are driving yoke, driven yoke, spider and trunnions.

Power transmission system of vehicle consists of Flywheel, clutch, gearbox, propeller shaft, differential, final drive etc. The power produced from an engine of automobile can be transferred to the drive wheel by means of power transmission system. The Drive shaft is used for the transfer of motion from one point to another. Whereas the shafts, which propel (push the object ahead) are referred to as the propeller shafts. However the drive shaft of the automobile is also referred to as the propeller shaft because apart from transmitting the rotary motion from the front end to the rear end of the vehicle, these shafts also propel the vehicle forward. The shaft is the primary connection between the front and the rear end (engine and differential) which performs both the jobs of transmitting the motion and propelling the front end[1].

Composite drive shaft is having more advantages than that of conventional drive shaft. The composite drive shaft is having high strength and specific modulus. By using composite shaft the overall weight can be redused[2].

Two solution methods are available in solving structural problems they are p-method and h-method. The h-method can be used for any type of analysis but the p-method can be used only for linear structural static analysis. The h-method requires fine mesh than p-method[3].

Now a days the main important parameters to be considering in automobile are fuel efficiency and the weight of the vehicle. The best way of achieving these by replacing the conventional materials with fiber reinforced composite materials[4]. The finite element analysis is used because it is cost effective, time saving, easy modification and accurate[5]. Composite materials such as Graphite, Carbon and Glass with suitable resins are widely used because of their high specific strength (strength/density) and high specific modulus (modulus/ density) [6].

Methodology

Composite materials selection: The different composite material likes, Epoxy glass, Epoxy carbon resin are going to analyzed and studied. The various characteristics and properties of composite material are as below:

A. Characteristics of composite material: They have high strength and specific modulus. Reduced weight. Due to reduction in weight, fuel consumption will be reduced. The damping capacity is high and hence vibration and noise are low. Corrosion resistance is high. Torque capacity is greater than steel and aluminum shaft. Transmit higher amount of available power due to its lower weight.

Materials used in analysis and their properties: The material used in the analysis is structural steel, E-glass and E-carbon.

Table-1
Properties of Structural Steel

Young's modulus	**2.07e+011pa**
Poisson ratio	0.3
Density	7600 kg/m3
Allowable Stress	370e+006pa
Shear modulus	77.9 e+009pa

Results and Discussion

The analysis of composite materials and structural steel are done and it is compared with structural steel.

Table-2
Properties of E-glass

Young's modulus	5.e+010
Poisson ratio	0.3
Density	2000 kgm3
Allowable Stress	400e+006 pa
Shear modulus	5.6e+009pa

Table-3
Properties of E-carbon

Young's modulus	1.9e+011pa
Poisson ratio	0.3
Density	1600kg/m3
Allowable stress	440e+066pa
Shear modulus	4.2e+009pa

Table-4

Material/property		**Structural steel**	**E -glass**	**E- carbon**
Weight		75.8	19.3	15.4
% Reduction in weight		-	75%	80%
Maximum principal stress (pa)		1.57e008	4.01e007	3.21e007
%Reduction of maximum principal stress		-	75%	79%
Maximum shear stress (pa)		8.35e007	2.12e007	1.70e007
%Reduction of maximum shear stress		-	74%	79%
Deformation (mm)	Max	0.20055	0.2044	0.0430

Conclusion

By performing analysis on two different composite materials E-GLASS has 75% reduction in Von Mises stress and 74% reduction in weight than Structural Steel as shown in table 4.

E-CARBON has 79% reduction in Von Mises stress and 80% reduction in weight than structural steel as shown in table 4.

By comparing above two results with structural steel it can be concluded that all stress induced in the materials are within the allowable limits. It can be concluded that the E-CARBON composite material can be used as drive shaft material instated of conventional steel. So that weight and stress induced in propeller shaft can be reduced.

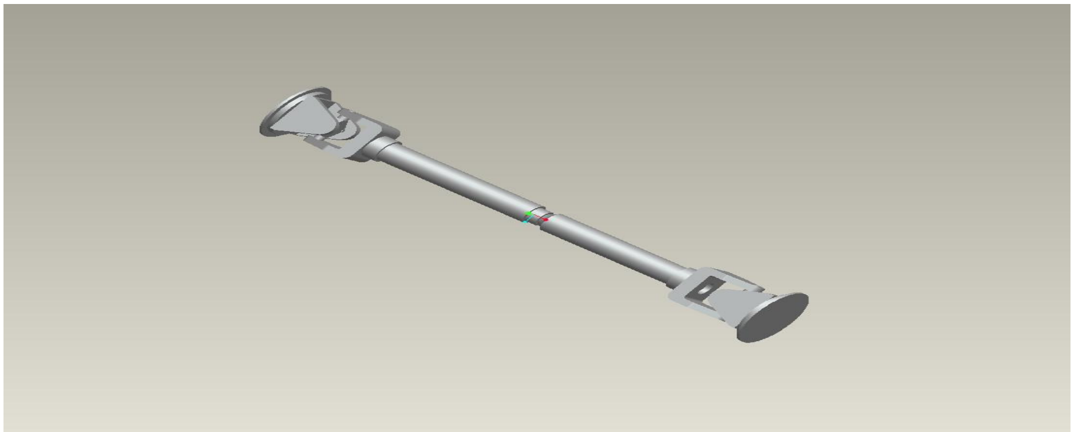

Figure-3
Modeling of propeller shaft in Pro-E

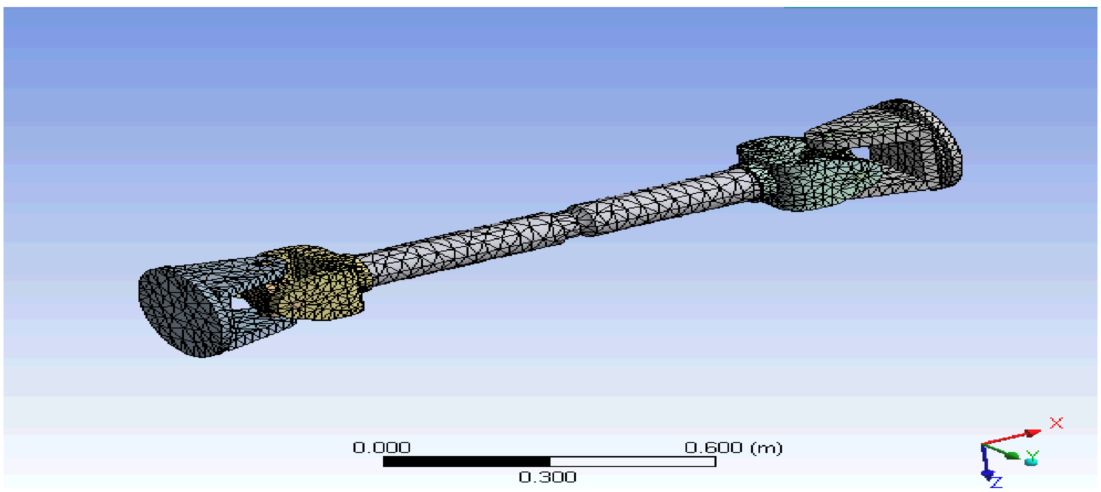

Figure-4
Meshing of Propeller shaft

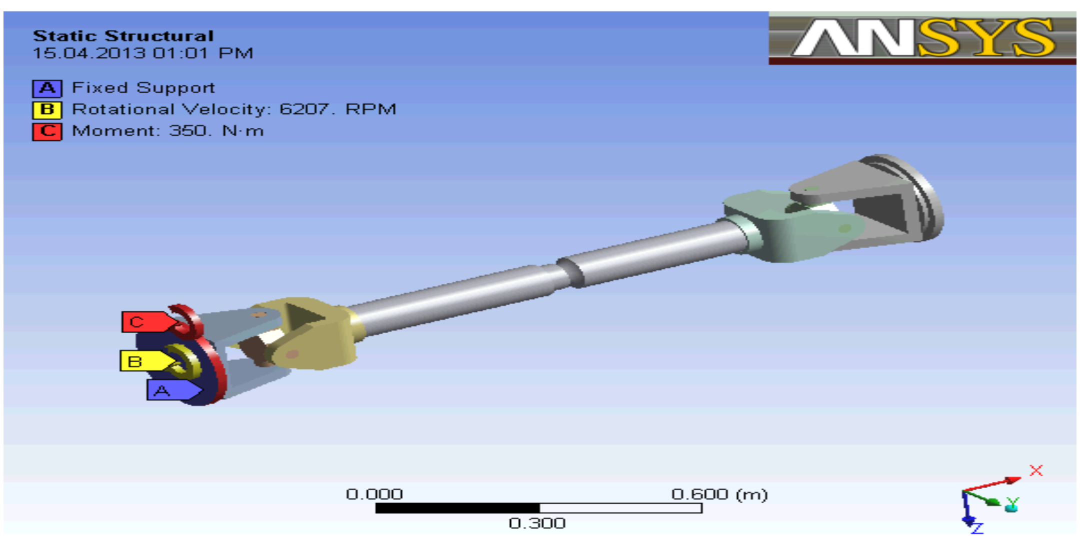

Figure-5
Boundary Conditions of propeller shaft

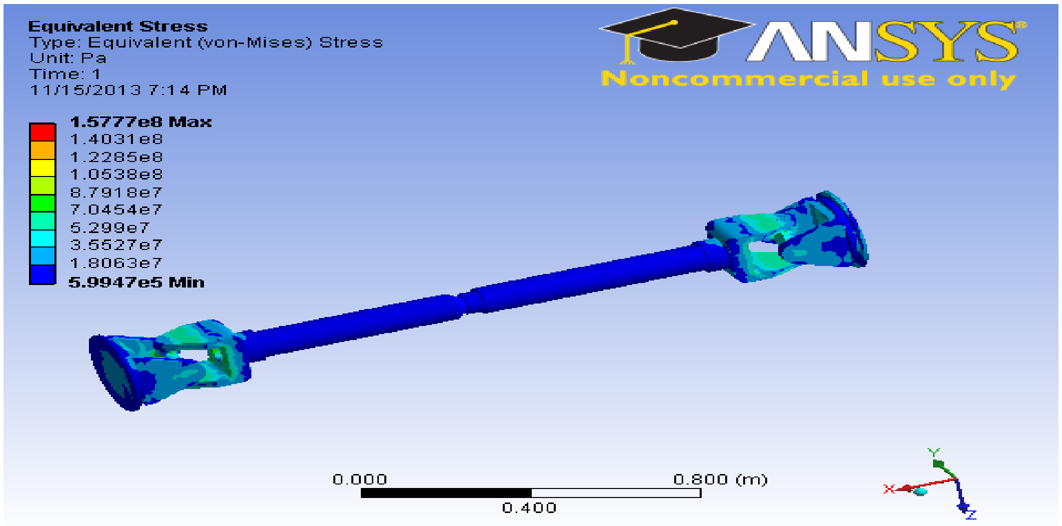

Figure-6
Von misses Stresses

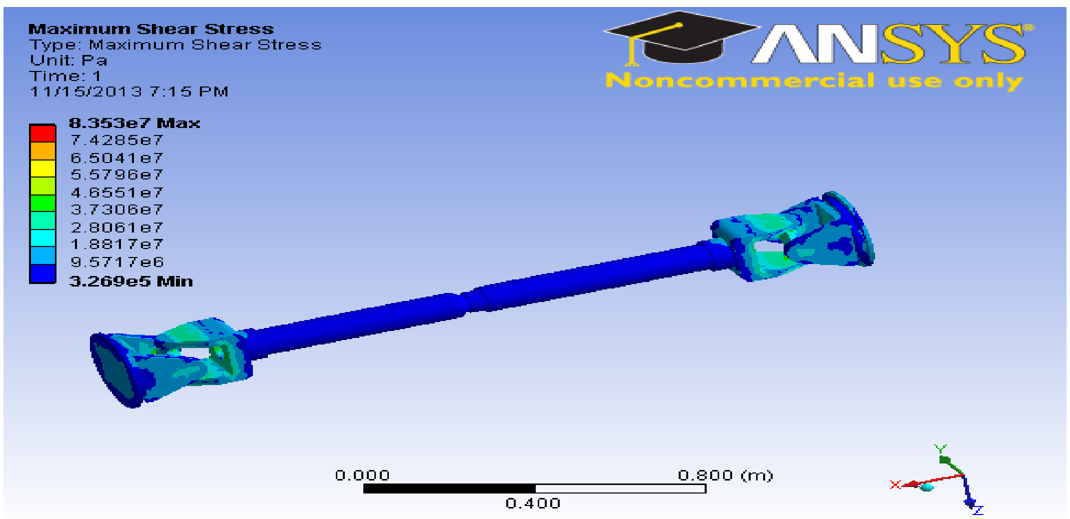

Figure-7
Maximum Shear Stresses

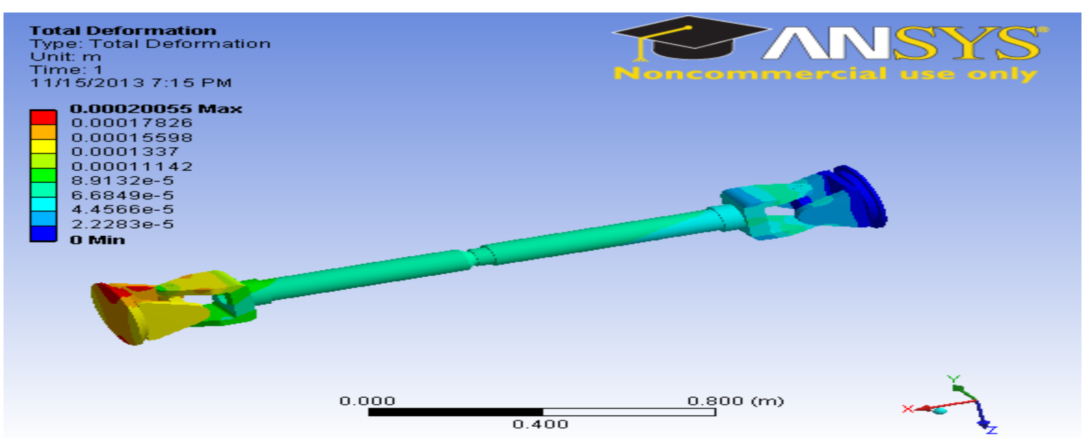

Figure-8
Maximum deflection

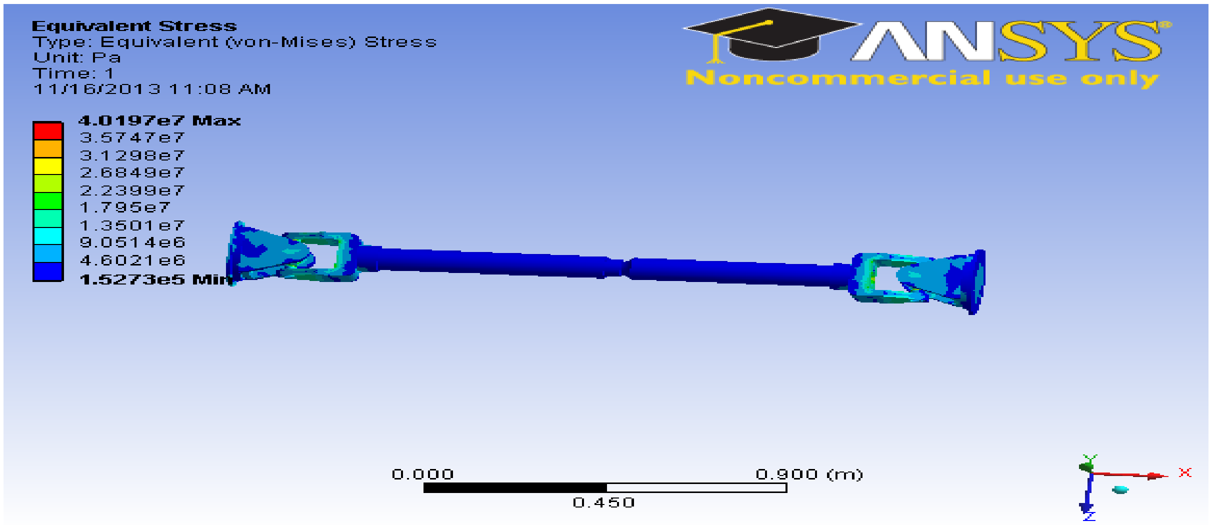

Figure-9
Von misses Stresses

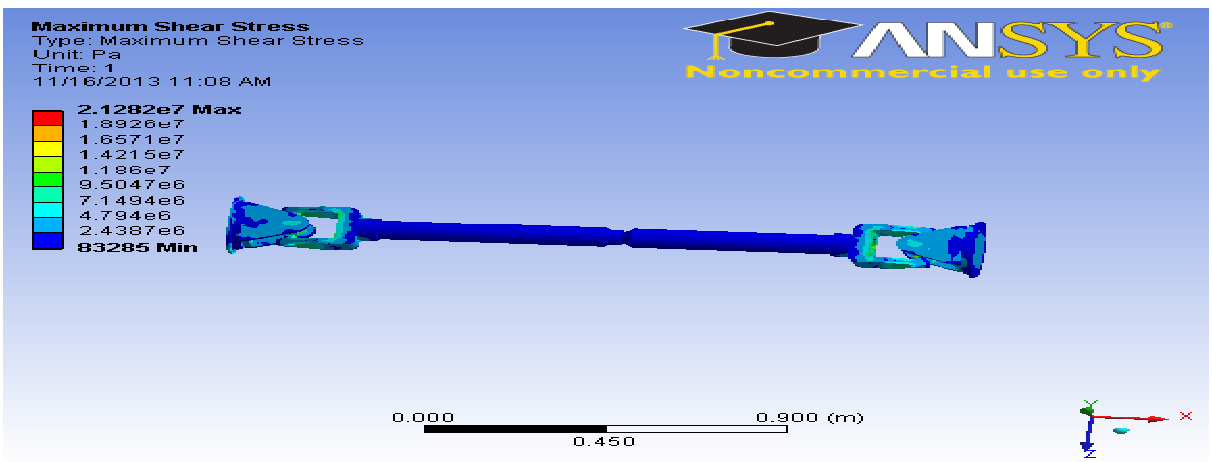

Figure-10
Maximum Shear Stresses

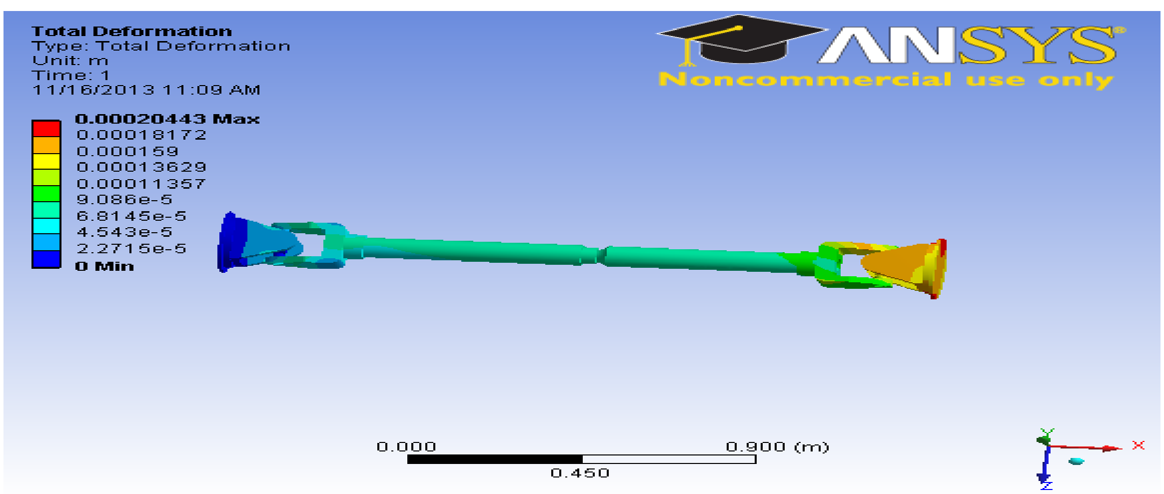

Figure-11
Maximum deflection

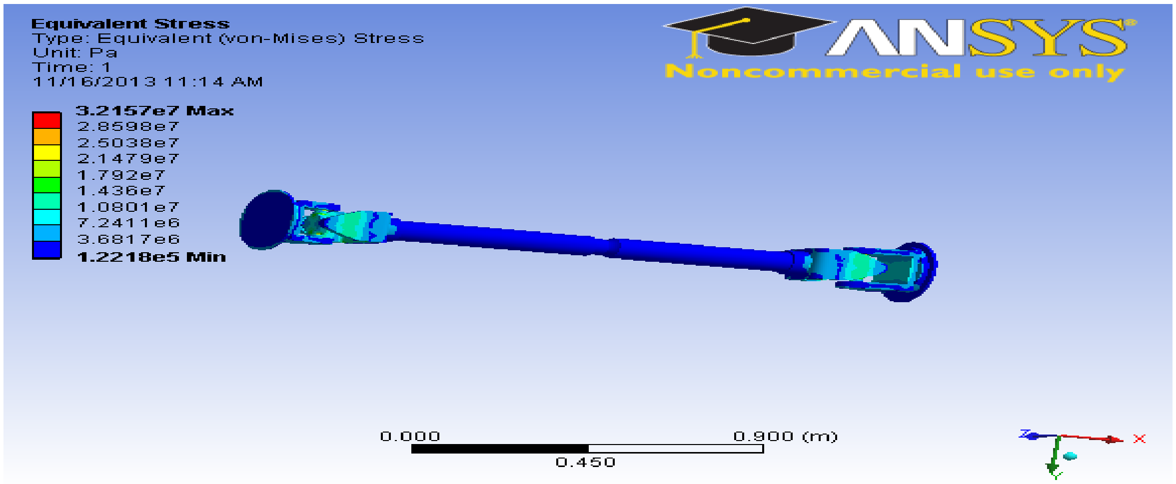

Figure-12
Von misses Stresses

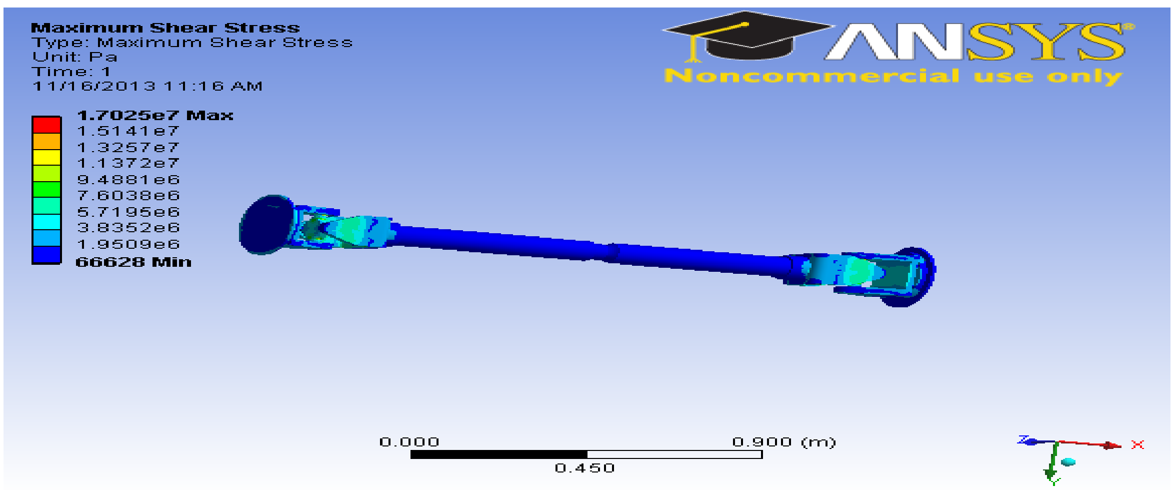

Figure-13
Maximum Shear Stresses

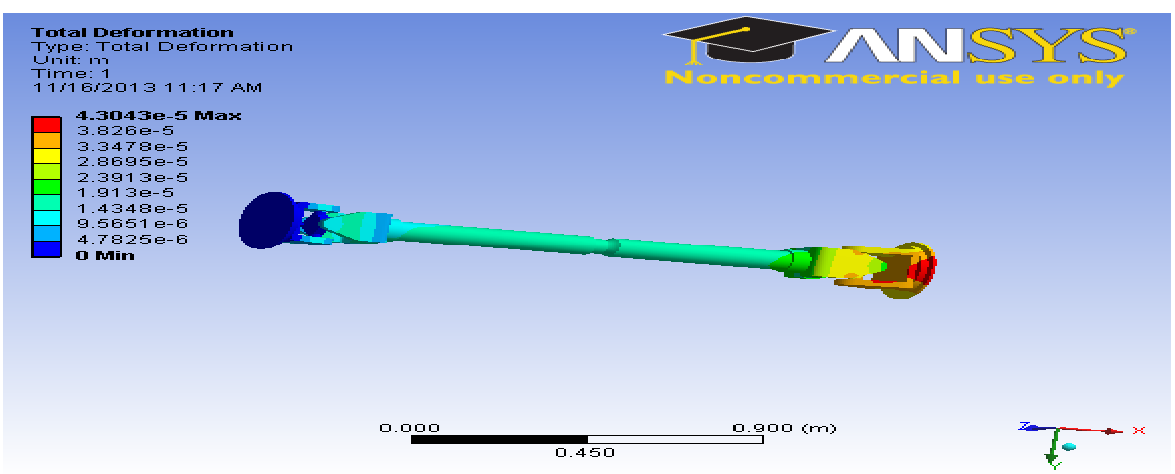

Figure-14
Maximum deflection

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