MODELING AND ANALYSIS OF PROPELLER SHAFT WITH UNIVERSAL JOINTS

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Abstract— **A drive shaft, also known as a propeller shaft or cardan shaft, it is a mechanical part that transmits the torque generated by a vehicle's engine into usable motive force to propel the vehicle. Now a day's two piece steel shaft are mostly used as a drive shaft. The two-piece steel drive shaft consists of three universal joints, a center supporting bearing and a bracket, which increases the total weight of an automotive vehicle and decreases fuel efficiency, This work deals with the replacement of conventional two piece steel drive shafts with a one piece Eglass/epoxy composite drive shaft for an automotive application. The basic requirements considered here are torsional strength, torsional buckling and bending natural frequency. The E-glass/epoxy as in which the steel has a role to transmit the required torque, while the E-Glass epoxy composite increases the bending natural frequency. An experimental study was carried out to study the static torsion capability. Four cases were studied using steel tube wounded by different layers of composite materials. Results obtained from this study show that increasing the number of layers would enhance the maximum static torsion approximately 66% for {+45/-45}3s laminates higher than the pure aluminium and mass reduction of 42% compared with of steel drive shaft. A one-piece hybrid composite full drive shaft is optimally analysed using Finite Element Analysis Software and results were compared with the existing steel drive shaft.**

Keywords — E-Glass Resin and Structural Steel for Stress Analysis, Strain Analysis and Deformation.

1. INTRODUCTION

A driveshaft is a rotating shaft that drives power from the front axle to the differential gear of a rear axle. Driveshaft must operate through constantly changing angles between the transmission and axle. High quality steel is a common used material for propeller shaft. Steel drive shafts are usually manufactured in two pieces which is used 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.

The steel drive shaft consists of three universal joints, a center supporting bearing and a bracket, which will increase the total weight of a vehicle. To improve power transmission by reduction of inertial mass and light weight.

It has higher specific stiffness and higher specific strength of composite materials for conventional metallic structures has many advantages.

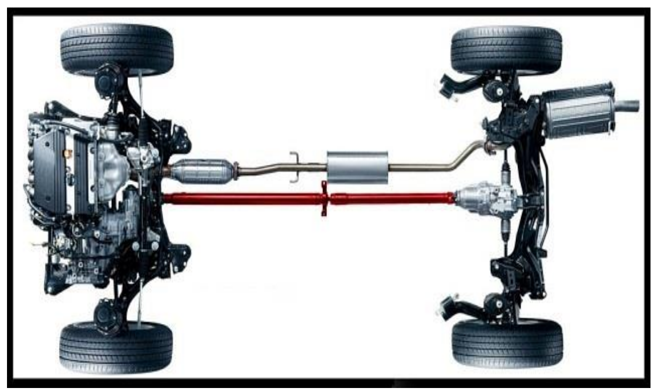

Fig.1. Schematic arrangement of under body of automobile

Composite materials can be used to get efficient design requirements of strength, stiffness and composite drive shafts weight less than steel or aluminium 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.

2. FUNCTION OF PROPELLER SHAFT

Propeller shaft must transmit torque from the engine to the differential gear box. During the operation, it is necessary to transmit maximum low-gear torque developed by the engine. It should provide a smooth, uninterrupted flow of power to the axles.The drive shafts must also be capable of rotating at the very fast speeds required by the vehicle.

The drive shaft should operate constantly changing the angles between the transmission, the differential and axles which moves up and down.

The length of propeller shaft should be capable of changing while transmitting torque. Changes of length are caused by axle movement due to torque reaction, road deflection, braking loads and so on. A slip joint is used to compensate for this motion.

3. MATERIAL PROPERTIES

3.1 E-GLASS RESIN

A polymer is generally manufactured by step-growth polymerization. When added with various agents to increase or alter the material properties of polymers, the result is referred to as a plastic. Fibre-reinforced plastics are a type of composite plastics that used for specifically to mechanically increase the strength and elasticity of plastics. The original plastic material without fibre reinforcement is known as a matrix.

Low-E glass is one of the most popular and versatile building materials used today it works by reflecting heat back to its source. Long wave radiation energy is heat, and short wave radiation energy is visible light from the sun. Low-e coatings have been developed to minimize the amount of ultraviolet and infrared light that can pass through glass without compromising the amount of visible light that is transmitted. When heat or light energy is absorbed by glass it is either shifted away by moving air or reradiated by the glass surface. The ability of a material to radiate energy is known as emissivity.

In general, highly reflective materials have a low emissivity and dull darker coloured materials have a high emissivity. All materials, including windows, radiate heat in the form of long-wave, infrared energy depending on the emissivity and temperature of their surfaces

There are two types of low-e coatings: passive low-e coatings and solar control low-e coatings. Soft coated low-E glass is more delicate and easily damaged so it is used in insulated windows where it can be in between two other pieces of glass. Here's how the coatings measure up by minimizing the amount of ultra-violet and infrared light that can pass through glass without compromising the amount of visible light that is transmitted. It can also be used in retrofit projects.

The Mechanical property of the E-Glass Resin material is tabulated in Table 1.

Description	**E-Glass Resin**
Density	2100 kg m^{-3}
Young's modulus (N/mm^2)	3.4E+10
Poisson ratio	0.366

Table 1 "Mechanical properties of the E-Glass Resin"

3.2 STRUCTURAL STEEL

Structural steel is a type of steel used as a construction material. Structural steel shapes, sizes, composition, strengths, storage practices, etc., are regulated by standards in the most countries.

Structural steel shapes available are I-beam, Z-Shape, Hollow structural section, Angle, C-beam, T-shaped cross-section, asymmetrical I-beam etc. Most Structural steel shapes are made by hot or cold rolling, others are made by welding together flat or bent plates.

3.2.1 Strength

Structural steel should have high strength, high stiffness, high toughness, and high ductile properties

3.2.1 Constructability

Structural steel can be made into any shape, which are either bolted or welded together in construction. Structural steel can set as soon as the materials are delivered on site, whereas concrete should be cured for 1-2 weeks after pouring it.

3.2.3 Fire resistance

Steel is a non-combustible material. However, when it is heated to temperatures seen in a fire scenario, the strength and stiffness properties of the material are significantly decreased. The International Building Code requires steel can be developed as sufficient fire-resistant materials, increasing overall cost of steel structure buildings.

The properties of the Structural steel material are tabulated in Table 2.

Mechanical properties	**Symbol**	**units**	**Value**
Young's modulus	E	GPa	207.0
Shear modulus	G	GPa	80.0
Poisson's ratio	V	---	0.3
Density	□	Kg/m^3	7600
Yield strength	Sy	MPa	370
Shear strength	Ss	Mpa	--

Table 2: "Properties of the Structural steel"

3.2.4 Characteristics

Structural steel is different from concrete. It is attributed compressive strength as well as tensile strength

3.2.5 Corrosion

Steel is made contact with water and air, it can corrode the steel, forming a potentially dangerous structure. Measurement should be taken in structural steel construction to prevent corrosion. To reduce corrosion, steel can be painted and provide water resistance.

4. DESIGN TOOLS (SOLID WORKS)

SolidWorks is a solid modeller, and utilized by a parametric feature-based approach to create models and assemblies. Parameters refer to constraints whose values determine the shape or geometry of the model or assembly. Parameters can be either numeric parameters or geometric parameters. Numeric parameters can be associated with each other through the use of relations, which allow them to capture design intent. SolidWorks allows the user to specify that the hole is a feature on the top surface, and will then honour their design intent no matter what height they later assign to the can. Building a model in Solid Works usually starts with a 2D sketch. The sketch consists of geometry such as points, lines, arcs, conics (except the hyperbola), and splines. Dimensions are added to the sketch to define the size and location of the geometry. Relations are used to define attributes such as tangency, parallelism, perpendicularity and concentricity.

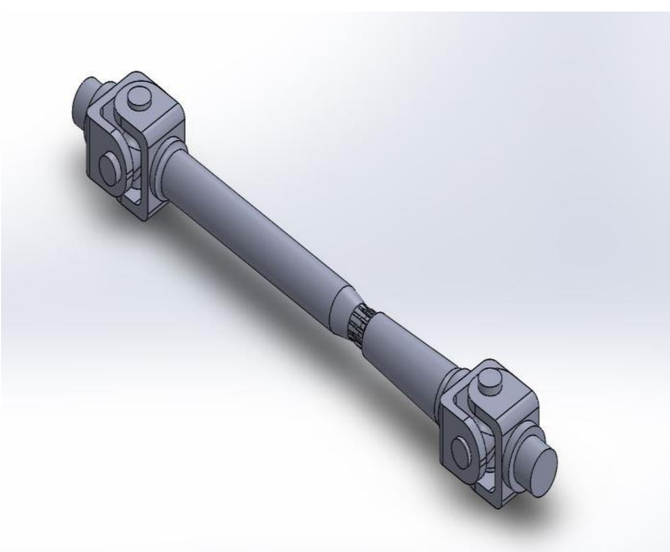

Fig.2 Model of propeller shaft with universal joints

In an assembly, the analog to sketch relations are mates. Just as sketch relations define conditions such as tangency, parallelism, and concentricity with respect to sketch geometry, assembly mates define equivalent relations with respect to the individual parts or components, allowing the easy construction of assemblies

5. ANALYSIS TOOL (ANSYS WORKBENCH)

ANSYS is an engineering simulation software (computer-aided engineering) developer that is headquartered south of Pittsburgh in the South pointe business park in Cecil Township, Pennsylvania, and United States. ANSYS Mechanical is a finite element analysis tool for structural analysis, including linear, nonlinear and dynamic studies. An innovative project schematic view ties together the entire simulation process, guiding the user through even complex multi physics analyses with drag-and-drop simplicity..

ANALYSIS OF PROPELLER SHAFT WITH UNIVERSAL COUPLING FOR STRUCTURAL STEEL

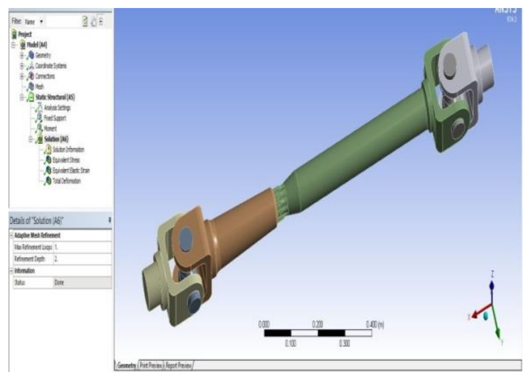

Fig.3 Geometry view of propeller shaft with universal coupling

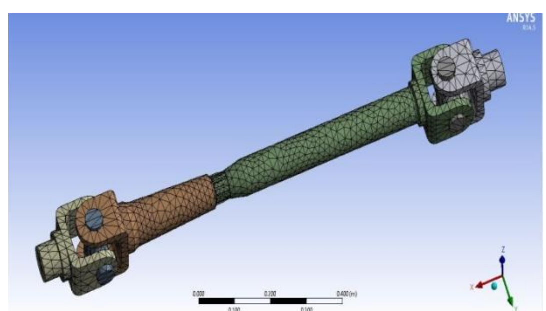

Fig. 4 Meshing view of propeller shaft with universal coupling

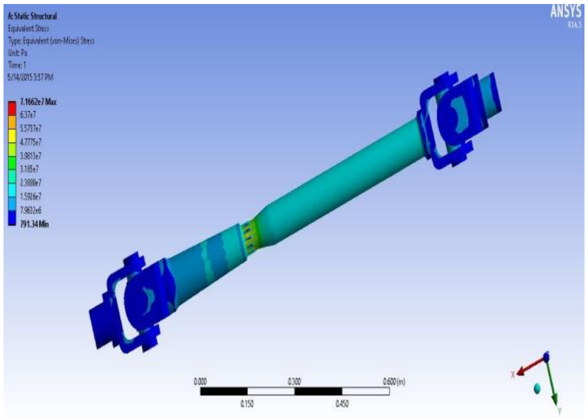

Fig.5 Stress Analysis

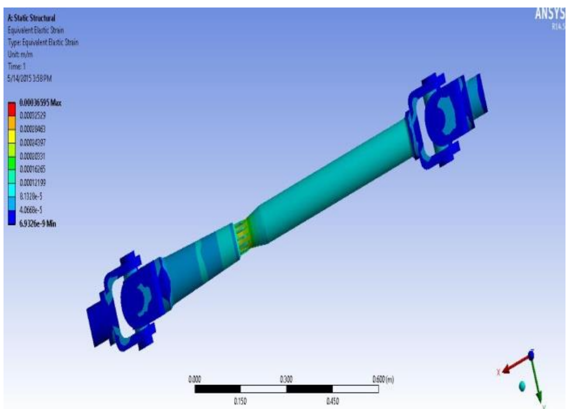

Fig. 6 Strain Analysis

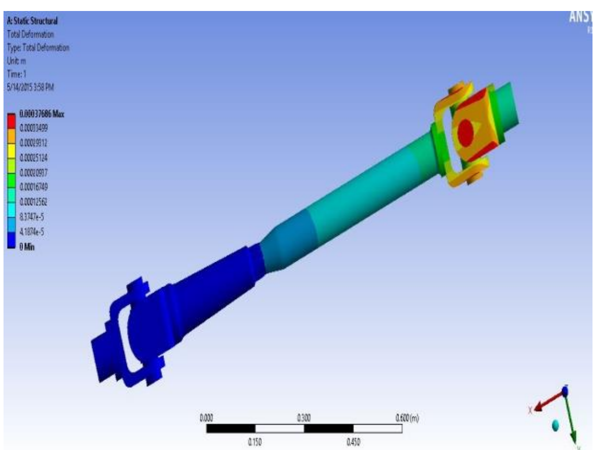

Fig. 7 Deformation

RESULT FOR STRUCTURAL STEEL

Descriptions	Steel
Max. Stress	5.7087e7
Min. Stress	1096
Max. Strain	0.00029716
Min. Strain	1.3661e-8
Deformation	0.00033251

ANALYSIS OF PROPELLER SHAFT WITH UNIVERSAL COUPLING FOR E-GLASS RESIN

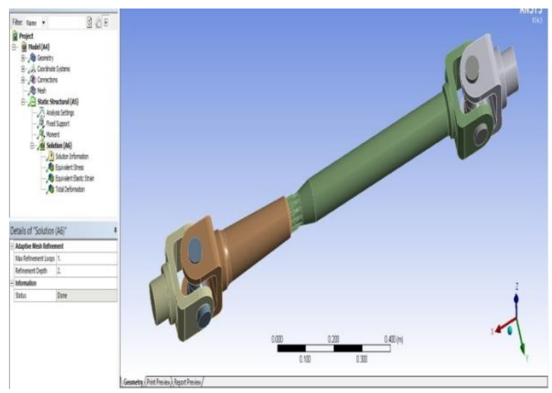

Fig.8 Geometry view of propeller shaft with universal coupling

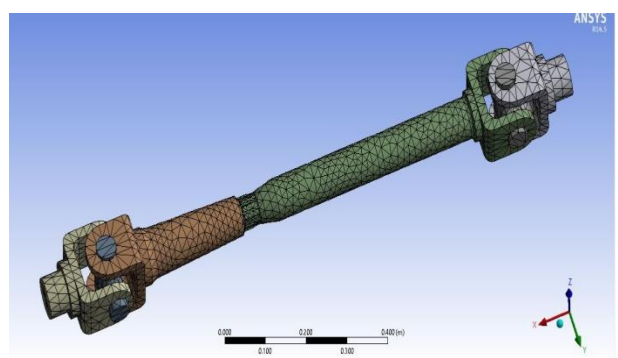

Fig. 9 Meshing view of propeller shaft with universal coupling

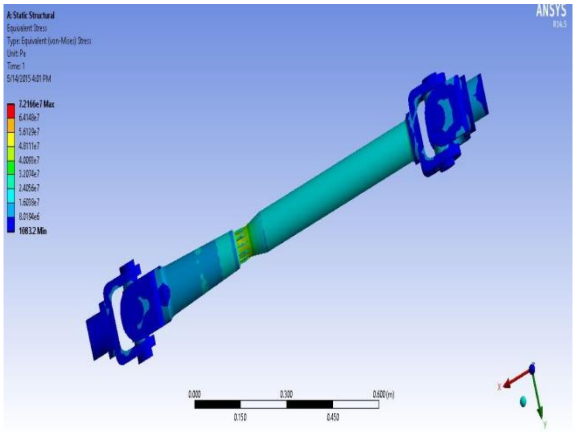

Fig. 10 Stress Analysis

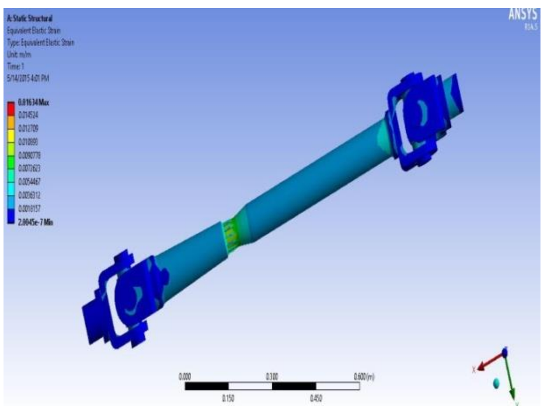

Fig. 11 Strain Analysis

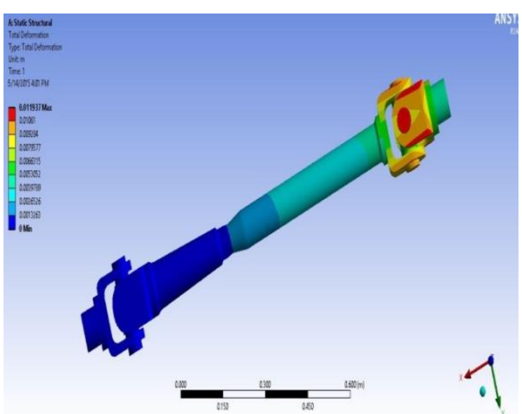

Fig. 12 Deformation

RESULT FOR E-GLASS RESIN

Description	E-Glass
Max. Stress	7.1684e7
Min. Stress	791.37
Max. Strain	0.0044705
Min. Strain	609379e-9
Deformation	0.00053946

6. ADVANTAGES

The power loss due to friction (from the belt, chain, etc., and especially, gearboxes) is neglected. It is simple in construction. It has fewer parts which reduce vibrate and the overall noise emission of the system. It transmits higher torque at low rpm. Due to high torque and low inertia which allows faster positioning times on permanent magnet synchronous servo drives.

It neglected Mechanical backlash, hysteresis and elasticity.

7. APPLICATION

High speed

Medium or variable

Very low rotational speed.

8. CONCLUSION

By using composite materials, weight is reduced upto 30% when compared to structural steel. It is clearly shown that E-Glass/Epoxy composite has good weight saving, deformation, shear stress induced and resonant frequencies properties compared to steel.

This paperwork was aimed to reduce the fuel consumption of the automobile which employs drive shafts, in general it is achieved by using light weight composites like E-Glass resin. This paperwork also deals with design optimization i.e. converting two piece drive shaft into single piece light weighted composite drive shaft.

The material properties of composites were ensured by limiting the include values within the permissible range in ANSYS workbench 14.5r. The results are satisfactory.

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