

Design and Analysis of Propeller Shaft

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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 steel drive shafts with a single-piece e-glass/ epoxy, high strength carbon/epoxy and high modulus carbon/epoxy composite drive shaft for an automotive application. The design parameters were optimized with the objective of minimizing the weight of composite drive shaft. The design optimization also showed significant potential improvement in the performance of drive shaft. The main concept of our project is to reduce the weight of automotive drive shaft with the utilization of composite material. Composite materials have been used in automotive components because of their properties such as low weight, high specific stiffness, corrosion free, ability to produce complex shapes, high specific strength and high impact energy absorption etc. As the automotive drive shaft is a very important component of vehicle. The modeling of the drive shaft assembly was done using SOLIDWORKS software. A shaft has to be designed to meet the stringent design requirements for automotives. In automobiles the drive shaft is used for the transmission of motion from the engine to the differential. An automotive propeller shaft, or drive shaft, transmits power from the engine to differential gears of rear wheel-driving vehicle. In present work an attempt has been to estimate deflection, stresses under subjected loads & natural frequencies using Ansys software.*

Keywords--- *Propeller Shaft, Design and Analysis, Composite Materials, E-glass/ Epoxy.*

I. INTRODUCTION

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.

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.

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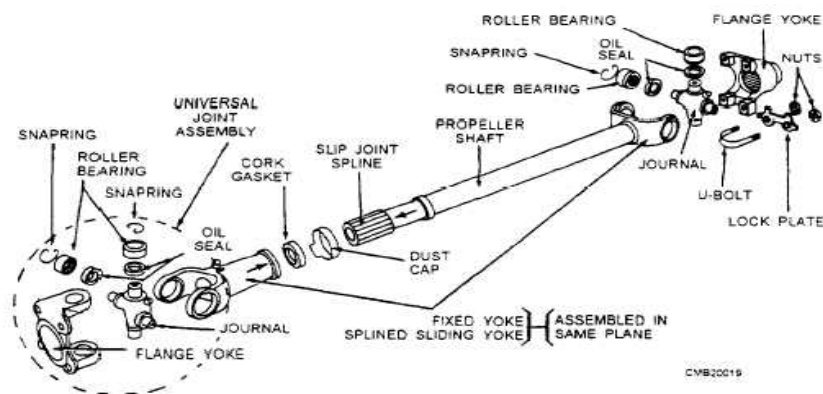
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Also, composite materials typically have a lower modulus of elasticity. As a result, when torque peaks occur in the driveline, the driveshaft can act as a shock absorber and decrease stress on part of the drive train extending life. Many researchers have been investigated about hybrid drive shafts and joining methods of the hybrid shafts to the yokes of universal joints. But this study provides the analysis of the design in many aspects.

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.



II. OBJECTIVE

Almost all automobiles (at least those which correspond to design with rear Wheel drive and front engine installation) have transmission shafts. The Weight reduction of the drive shaft can have a certain role in the general Weight reduction of the vehicle and is a highly desirable goal, if it can be Achieved without increase in cost and decrease in quality and reliability. It is possible to achieve design of composite drive shaft with less weight to Increase the first natural frequency of the shaft and to decrease the bending Stresses using various stacking sequences. By doing the same, maximize the torque transmission and torsional buckling capabilities are also maximized.

This work deals with the replacement of a conventional steel drive shaft with E-Glass/ Epoxy, High Strength Carbon/Epoxy and High Modulus Carbon/Epoxy composite drive shafts for an automobile application.

III. WORKING PRINCIPLE

The torque that is produced from the engine and transmission must be transferred to the rear wheels to push the vehicle forward and reverse. The drive shaft must provide a smooth, uninterrupted flow of power to the axles. The drive shaft and differential are used to transfer this torque. First, it must transmit torque from the transmission to the

differential gear box. During the operation, it is necessary to transmit maximum low-gear torque developed by the engine. The drive shafts must also be capable of rotating at the very fast speeds required by the vehicle.

The drive shaft must also operate through constantly changing angles between the transmission, the differential and the axles. As the rear wheels roll over bumps in the road, the differential and axles move up and down. This movement changes the angle between the transmission and the differential. The length of the drive shaft must also be capable of changing while transmitting torque. Length changes are caused by axle movement due to torque reaction, road deflections, braking loads and so on. A slip joint is used to compensate for this motion. The slip joint is usually made of an internal and external spline. It is located on the front end of the drive shaft and is connected to the transmission.

IV. MATERIAL PROPERTIES

E-Glass Resin

A polymer is generally manufactured by Step-growth polymerization or addition polymerization. When combined with various agents to enhance or in any way alter the material properties of polymers the result is referred to as a plastic. Composite plastics refer to those types of plastics that result from bonding two or more homogeneous materials with different material properties to derive a final product with certain desired material and mechanical properties.

Fibre-reinforced plastics are a category of composite plastics that specifically use fibre materials to mechanically enhance the strength and elasticity of plastics. The original plastic material without fibre reinforcement is known as the matrix.

The matrix is a tough but relatively weak plastic that is reinforced by stronger stiffer reinforcing filaments or fibres. The extent that strength and elasticity are enhanced in a fiber-reinforced plastic depends on the mechanical properties of both the fibre and matrix, their volume relative to one another, and the fibre length and orientation within the matrix. Reinforcement of the matrix occurs by definition when the FRP material exhibits increased strength or elasticity relative to the strength and elasticity of the matrix alone.

Low-E glass works by reflecting heat back to its source. All objects and people give off varying forms of energy, affecting the temperature of a space. Long wave radiation energy is heat, and short wave radiation energy is visible light from the sun. The coating used to make low-E glass works to transmit short wave energy, allowing light in, while reflecting long wave energy to keep heat in the desired location.

Low-E glass comes in high, moderate and low gain panels. In especially cold climates, heat is preserved and reflected back into a house to keep it warm. This is accomplished with high solar gain panels. In especially hot climates, low solar gain panels work to reject excess heat by reflecting it back outside the space. Moderate solar gain panels are also available for areas with temperature fluctuations.

Low-E glass is glazed with an ultra-thin metallic coating. The manufacturing process applies this with either a hard coat or soft coat process. 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. Hard coated low-E glass is more durable and can be used in single paned windows. It can also be used in retrofit projects.

Generally low-E windows cost between 10% and 15% more than standard. The reduction in energy loss can be 30% to 50%. Low-E windows are a larger investment initially but will pay for themselves by reducing heating and cooling costs.

Visibility was a problem with some of the first low-E glass available. Original panes were said to have a brownish tint. Technology and manufacturing has continued to improve its quality resulting in a spectrally selective low-E glass that allows the best possible visibility while still filtering heat.

Mechanical Properties

DESCRIPTION	E-GLASS RESIN
Density	2100 kg m ⁻³
Young's modulus(N/mm ²)	3.4E+10
Poisson ratio	0.366

Structural Steel

- Characteristics - Structural steel differs from concrete in its attributed compressive strength as well as tensile strength.
- Strength - Having high strength, stiffness, toughness, and ductile properties, structural steel is one of the most commonly used materials in commercial and industrial building construction.
- Constructability - Structural steel can be developed into nearly any shape, which are either bolted or welded together in construction. Structural steel can be erected as soon as the materials are delivered on site, whereas concrete must be cured at least 1–2 weeks after pouring before construction can continue, making steel a schedule-friendly construction material.
- Fire resistance - Steel is inherently a noncombustible material. However, when heated to temperatures seen in a fire scenario, the strength and stiffness of the material is significantly reduced. The International Building Code requires steel be enveloped in sufficient fire-resistant materials, increasing overall cost of steel structure buildings.
- Corrosion - Steel, when in contact with water, can corrode, creating a potentially dangerous structure. Measures must be taken in structural steel construction to prevent any lifetime corrosion. The steel can be painted, providing water resistance. Also, the fire resistance material used to envelope steel is commonly water resistant.

Mechanical Properties

Mechanical properties	Symbol	Units	Steel
Young's Modulus	E	GPa	207.0
Shear modulus	G	GPa	80.0
Poisson's ratio	ν	-----	0.3
Density	ρ	Kg/m ³	7600
Yield Strength	Sy	MPa	370
Shear Strength	Ss	MPa	275

Advantages

Increased efficiency: The power is not wasted in friction (from the belt, chain, etc., and especially, gearboxes.)

Reduced noise: Being a simpler device, a direct-drive mechanism has fewer parts which could vibrate, and the overall noise emission of the system is usually lower.

Longer lifetime: Having fewer moving parts also means having fewer parts prone to failure. Failures in other systems are usually produced by aging of the component (such as a stretched belt), or stress.

High torque at low rpm.

Faster and precise positioning: High torque and low inertia allows faster positioning times on permanent magnet synchronous servo drives. Feedback sensor directly on rotary part allows precise angular position sensing.

Drive stiffness: Mechanical backlash, hysteresis and elasticity is removed avoiding use of gearbox or ball screw mechanisms.

Applications

High Speed

Medium or Variable

Very low rotational Speed.

V. DESIGN TOOL (SOLIDWORKS)

Solid Works is a Para solid-based solid modeler, and utilizes 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, such as line lengths or circle diameters, or geometric parameters, such as tangent, parallel, concentric, horizontal or vertical, etc. Numeric parameters can be associated with each other through the use of relations, which allow them to capture design intent.

Building a model in Solid Works usually starts with a 2D sketch (although 3D sketches are available for power users). The sketch consists of geometry such as points, lines, arcs, conics (except the hyperbola), and splines.

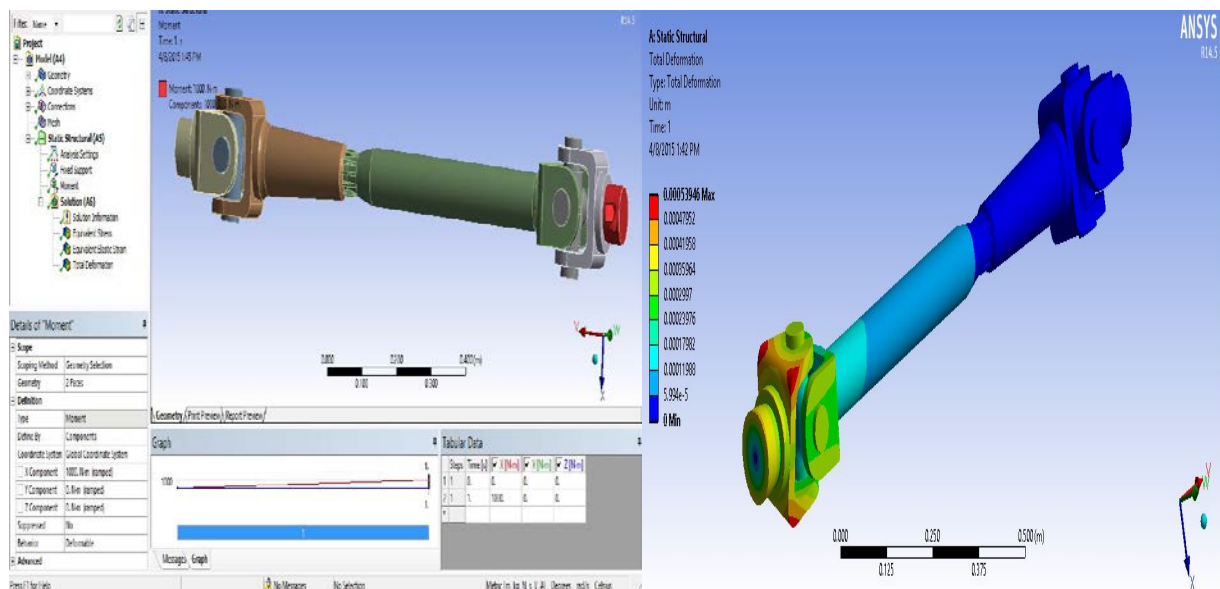
Dimensions are added to the sketch to define the size and location of the geometry. Relations are used to define attributes such as tangency, parallelism, perpendicularity, and concentricity.



VI. ANALYSIS TOOL (ANSYS WORKBENCH)

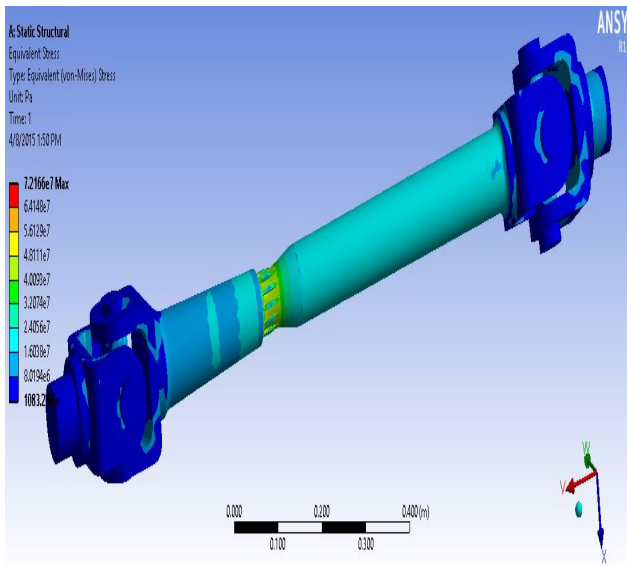
The ANSYS Workbench platform is the framework upon which the industry's broadest and deepest suite of advanced engineering simulation technology is built. An innovative project schematic view ties together the entire simulation process, guiding the user through even complex multiphysics analyses with drag-and-drop simplicity. With bidirectional CAD connectivity, powerful highly-automated meshing, a project-level update mechanism, pervasive parameter management and integrated optimization tools, the ANSYS Workbench platform delivers unprecedented productivity, enabling Simulation-Driven Product Development.

VII. ANALYSIS OF PROPELLER SHAFT FOR E-GLASS RESIN

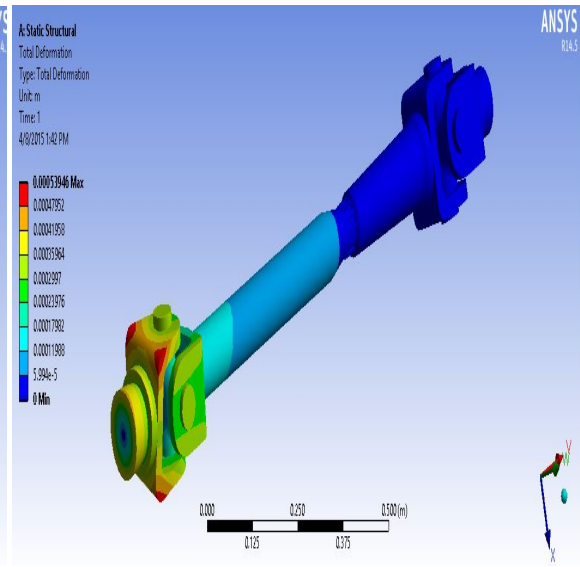


Structural Moment (Torsional Loading Condition)

Strain Analysis

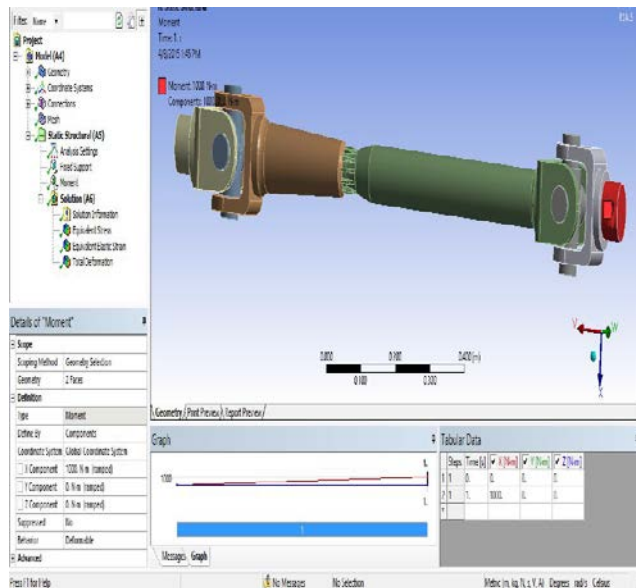


Stress Analysis

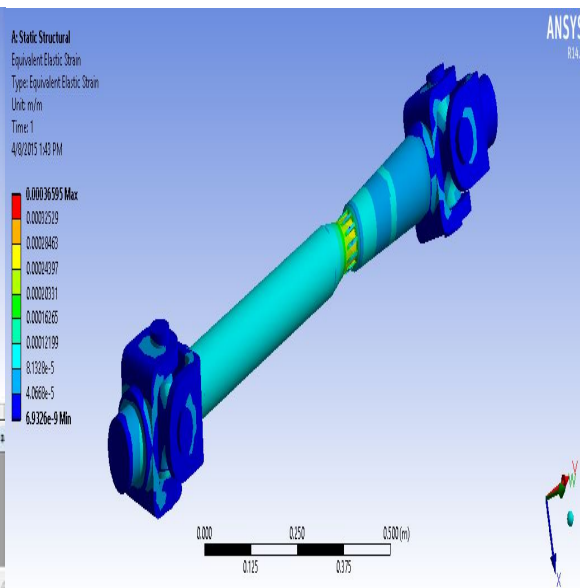


Deformation

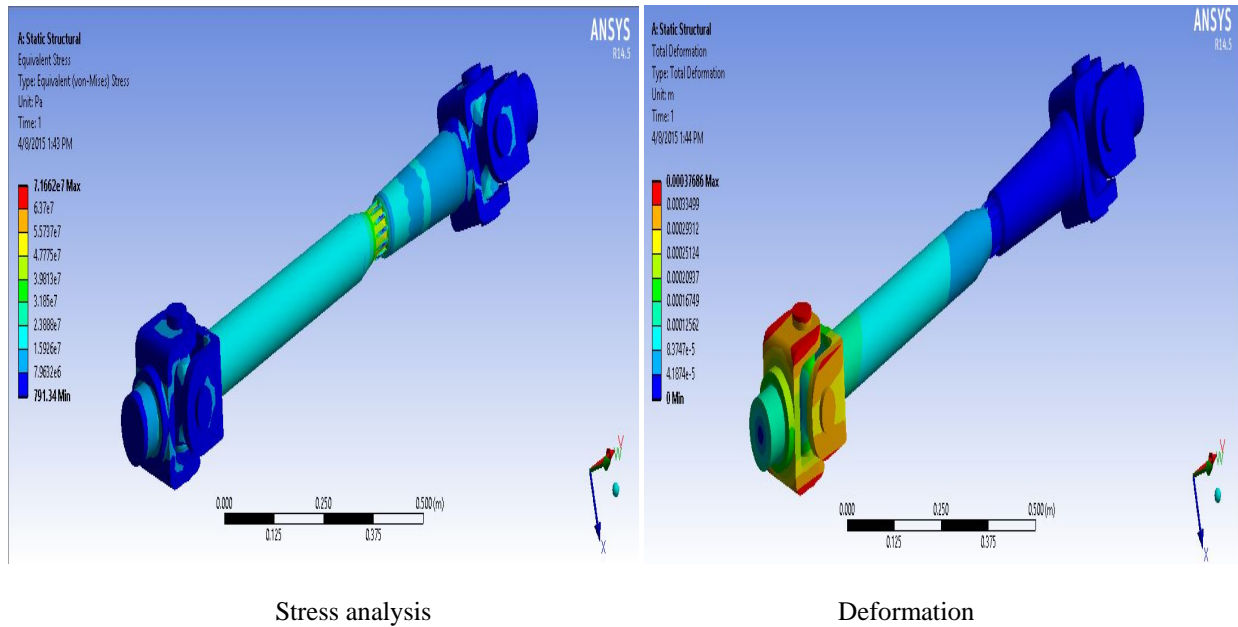
VIII. ANALYSIS OF PROPELLER SHAFT FOR STRUCTURAL STEEL



Moment (Torsional Loading Condition)



Strain analysis



IX. CONCLUSION

- 1) The usage of composite material has resulted to inconsiderable amount of weight saving in the range of 28 % when compared to Structural steel shaft.
- 2) Taking into considerations the weight saving, deformation, shear stress induced and resonant frequencies it is evident that E-Glass/Epoxy composite has the most encouraging properties to act as replacement for steel out of the considered two materials .
- 3) The presented work was aimed to reduce the fuel consumption of the automobile in the particular or any machine, which employs drive shafts ,in general it is achieved by using light weight composites like E-Glass resin.
- 4) The presented work also deals with design optimization i.e converting two piece drive shaft (Structural steel shaft) in to single piece light weighted composite drive shaft.
- 5) The drive shaft of the dimensions, which were used then used for the material properties of composites were used the stability of drive shaft is ensured by limiting the include values within the permissible range in Ansys workbench 14.5r.

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