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Design and Analysis of Composite/Hybrid Drive Shaft for Automotives

Parshuram D[1], Sunil Mangsetty[2].
Pda College of Engineering Gulbarga[1].

Abstract

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 CATIA 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 FEA.

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I. Introduction

Drive shafts as power transmission tubing are used in many applications, including cooling towers, pumping sets, aerospace, trucks and automobiles. In metallic shaft design, knowing the torque and the allowable shear stress for the material, the size of the shaft's cross section can be determined. As the geometric parameter (polar moment of inertia of the cross-sectional area divided by the outer radius) equal to the torque divided by the allowable shear stress, there is unique value for the shaft inner radius when the outer radius is limited by the space under the car cabin. Metallic drive shaft has the limitations of weight, low critical speed and vibration characteristics. Composite drive shafts have solved many automotive and industrial problems accompany the usage of the conventional metal ones because the performance is limited due to lower critical speed, weight, fatigue and vibration. Numerous solutions such as flywheels, harmonic dampers, vibration shock absorbers and multiple shafts with bearings, couplings, and heavy associated hardware have shown limited success in overcoming the problems. When the length of steel drive shaft is beyond 1500 mm, it is manufactured in two pieces to increase the fundamental natural frequency, which is inversely proportional to the square length and proportional to the square root of specific modulus. A drive shaft of composites offers excellent vibration damping, cabin comfort, reduction of wear on drive train components and increasing tires traction. In addition, the use of one piece torque tube reduces assembly time, inventory cost, maintenance, and part complexity

II. Introduction To Composites

2.1. COMPOSITE MATERIALS

The advanced composite materials such as graphite, carbon, Kevlar and Glass with Suitable resins are widely used because of their high specific strength (strength/density) and high specific modulus (modulus/density). Advanced composite materials seem ideally suited for long, power driver shaft (propeller shaft) applications. Their elastic properties can be tailored to increase the torque they can carry as well as the rotational speed at which they operate. The drive shafts are used in automotive, aircraft and aerospace applications. The automotive industry is exploiting composite material technology for structural components construction in order to obtain the reduction of the weight without decrease in vehicle quality and reliability. It is known that energy conservation is one of the most important objectives in vehicle design and reduction of weight is one of the most effective measures to obtain this result. Actually, there is almost a direct proportionality between the weight of a vehicle and its fuel consumption, particularly in city driving. 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 composites, where as in alloys, constituent materials are soluble in each other and form a new material which has different properties from their constituents.

2. 2.Classification Of Composite Materials

Composite materials can be classified as

- Polymer matrix composites
- Metal matrix composites
- Ceramic Matrix

Technologically, the most important composites are those in which the dispersed phase is in the form of a fiber. The Design of fiber-reinforced composites is based on the high strength is the ratio between strength and density. Specific modulus is the ratio between strength and density. Specific modulus is the ratio between modulus and density. Fiber length has a great influence on the mechanical characteristics of a material. The fibers can be either long or short. Long continuous fibers are easy to orient and process, while short fibers cannot be controlled fully for proper orientation. Long fibers provide many benefits over short fibers. These include impact resistant, low shrinkage, improved surface finish and dimensional stability. However short fiber provide low cost are easy to work with and have fast cycle time fabrication procedures.

The principal fibers in commercial use are various types of glass, carbon, graphite, Kevlar. All these fibers can be incorporated into a matrix either in continuous lengths or in discontinuous lengths as shown in the Fig. The matrix material may be a plastic or rubber polymer, metal or ceramic. Laminate is obtained by stacking a number of thin layers of fibers and matrix consolidating them to the desired thickness. Fiber orientation in each layer can be controlled to generate a wide range of physical and mechanical properties for the composite laminate.

2. 2.Properties Of Composite Materials

The physical properties of composite materials are generally not isotropic(independent of direction of applied force or load) in nature, but rather are typically orthotropic (depends on the direction of the applied force or load). For instance, the stiffness of a composite panel will often depend upon the orientation of the applied forces and/or moments. Panel stiffness is also dependent on the design of the panel.

In contrast, isotropic materials (for example, aluminum or steel), in standard wrought forms, typically have the same stiffness regardless of the directional orientation of the applied forces and/or moments. While, composite materials exhibit different properties in different directions.

The relationship between forces/moments and strains/curvatures for an isotropic material can be described with the following material properties: Young's Modulus, the Shear Modulus and the Poisson's ratio, in relatively simple mathematical relationships. For the anisotropic material, it requires the mathematics of a second order tensor and up to 21 material property constants. For the special case of orthogonal isotropy, there are three different material property constants for each of Young's Modulus, Shear Modulus and Poisson's ratio--a total of 9 constants to describe the relationship between forces/moments and strains/curvatures.

2. 3.Advantages Of Composites Over The Conventional Materials

- High strength to weight ratio
- High stiffness to weight ratio
- High impact resistance
- Better fatigue resistance
- Improved corrosion resistance
- Good thermal conductivity
- Low coefficient of thermal expansion. As a result, composite structures may exhibit a better dimensional stability over a wide temperature range.
- High damping capacity.

2.4. LIMITATIONS OF COMPOSITES

- Mechanical characterization of a composite structure is more complex than that of metallic structure
- The design of fiber reinforced structure is difficult compared to a metallic structure, mainly due to the difference in properties in directions
- The fabrication cost of composites is high
- Rework and repairing are difficult
- They do not have a high combination of strength and fracture toughness as compared to metals
- They do not necessarily give higher performance in all properties used for material Selection

2.5. APPLICATIONS OF COMPOSITES

The common applications of composites are extending day by day. Nowadays they are used in medical applications too. The other fields of applications are,

- Automotive : Drive shafts, clutch plates, engine blocks, push rods, frames, Valve guides, automotive racing brakes, filament–wound fuel tanks, fiber Glass/Epoxy leaf springs for heavy trucks and trailers, rocker arm covers, suspension arms and bearings for steering system, bumpers, body panels and doors

- Aircraft: Drive shafts, rudders, elevators, bearings, landing gear doors, panels and floorings of airplanes etc.
- Space: payload bay doors, remote manipulator arm, high gain antenna, antenna ribs and struts etc.
- Marine: Propeller vanes, fans & blowers, gear cases, valves &strainers, condenser shells.
- Chemical Industries: Composite vessels for liquid natural gas for alternative fuel vehicle, racked bottles for fire service, mountain climbing, underground storage tanks, ducts and stacks etc.
- Electrical & Electronics: Structures for overhead transmission lines for railways, Power line insulators, Lighting poles, Fiber optics tensile members etc

III. Introduction To Drive Shaft

The term Drive shaft is used to refer to a shaft, which is used for the transfer of motion from one point to another. Whereas the shaft, which propel are referred to as the propeller shaft. Propellers are usually associated with ships and planes as they are propelled in water or air using a propeller shaft because apart from transmitting the rotary motion from the front end to the rear end of the vehicle forward. The shaft is the primary connection between the front and the rear end which performs both the motion and propelling the front end. Thus, the terms Drive Shaft and Propeller Shaft are used interchangeably.

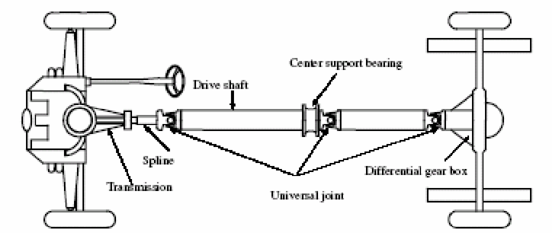


FIG.3.1. Conventional Two-Piece Drive Shaft Arrangement
For Rear Wheel Vehicle Driving System

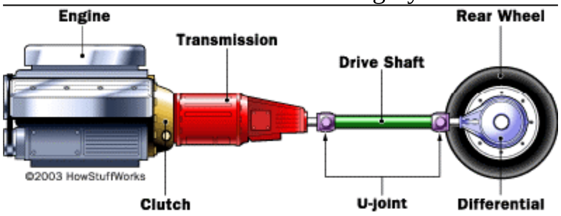


Fig.3.2 One-Piece Composite Drive Shaft

The propeller shaft is a longitudinal drive shaft used in vehicles where the engine is situated at the opposite end of the vehicle to the driven wheels. A propeller shaft is an assembly of one or more tubular shaft connected by universal, constant velocity or flexible joints. The number of tubular pieces and the joints depends on the distance between the gearbox and the axle. On some four wheel drive vehicles one propeller shaft is used to power the rear wheels as with rear wheel drive and a second propeller shaft is used to power the front wheels. In this case the second propeller shaft is replaced between a transfer gear box and the front axle. Hence, it can be observed that a drive shaft is one of the most important components, which is responsible for the actual movement of the vehicle once the motion is produced in the engine. The designing of such a critical component is usually stringent, as any fracture in this part could lead to as catastrophic failure of the vehicle when it is in motion.

3.1. Purpose of the Drive Shaft (Or Propeller Shaft)

- It must transmit torque from the transmission to the differential gear box
- The drive shaft must also be capable of rotating at the very fast speed required by the vehicle.
- The drives shaft must also operate through constantly changing the angles between the transmission, the differential and the axels.
- The length of the drive shaft must also be capable of changing while transmitting torque.
- The drive shaft should provide a smooth, uninterrupted flow of power to the axles.

3.2. Functions Of The Drive Shaft

- 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 shaft must also be capable of rotation 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 the axle 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 movement5 due to torque reaction, road deflections, braking load and so on. A slip joint is used to composite for this motion. The slip joint is usually made of an internal and external spline. It is located on front end of the drive shaft and is connected to the transmission.

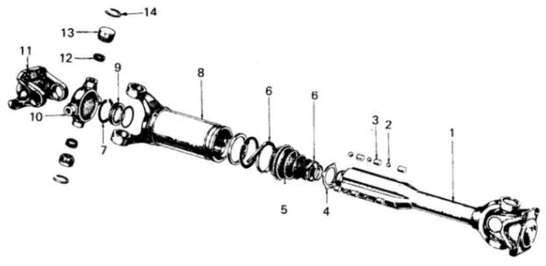
3.4. Different Types Of Shafts

- Transmission shaft: These shaft transmit power between the source and the machines absorbing power. The counter shafts, line shafts, overhead shafts and all factory shafts .Since these shafts carry machine parts such as pulleys, gears etc., therefore they are subjected to bending movement in addition to twisting.
- Machine Shaft: These shaft forms an integral part of the machine itself. For example crank shaft is an internal part of I.C. engine slider-crank mechanism.
- Axle: A shaft is called "an axle", if it is a stationary machine element and is used for the transmission of tending moment only. Iit simply act as a support for rotating bodies.
  Application: To support hoisting drum, a car wheel or a rope sheave.
- Spindle: A shaft is called "a spindle", if it is a short shaft that imparts motion either to a cutting tool or to a work-piece.
  Applications:
  1. Drill press spindles-impart motion to cutting tool (drill).
  2. Lath spindles-impart motion to work piece.

Apart from, an axle and spindle, shafts are used at so many places and almost everywhere wherever power transmission is required. Some of them are:

1. Automobile Drive Shaft: Transmits power from main gear box to differential gear box.
2. Ship Propeller Shaft: Transmits power from gear box to propeller attached on it.
3. Helicopter Tail Rotor Shaft: Transmits power to rail rotor fan, etc.

3.5. Parts Of Drive Shaft Assembly



1	Drive shaft	6	Boot band	11	Flange yoke
2	Drive shaft ball	7	Snap ring	12	Oil seal
3	Ball spacer	8	Sleeve yoke	13	Needle bearing
4	Drive shaft stopper	9	Sleeve yoke plug	14	Snap ring
5	Rubber boot	10	Spider journal		

Figure.3.3. Parts of Drive Shaft.

3.6. Demerits Of A Conventional Drive Shaft

- They have less specific modulus and strength
- Increased weight
- Conventional 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. Therefore the steel drive shaft is made in two sections connected by a support structure, bearings and U-joints and hence overall weight of assembly will be more.
- Its corrosion resistance is less as compared with composite materials.
- Steel drive shafts have less damping capacity.

3.7. Merits Of Composite Drive Shaft

- They have high specific modulus and strength
- Reduced weight
- The fundamental natural frequency of the carbon fiber composite drive shaft can be twice as high as that of the steel or aluminum because the carbon fiber composite material has more than 4times the specific stiffness of , which makes it possible to manufacture the drive shaft of passenger cars in one piece. A one-piece composite shaft can be manufactures so as to satisfy the vibration requirements. This eliminates all the assembly, connecting the two piece steel shafts and thus minimizes the overall weight, vibrations and cost.
- Due to weight reduction, fuel consumption will be reduced.

- They have high damping capacity and hence they produce less vibration and noise.

- They have good corrosion resistance
- Greater torque capacity than steel and aluminum shaft
- Longer fatigue life than steel and aluminum shaft
- Lower rotating weight transmits more of available power.

Introduction To Catia

4.1. CATIA

Computer aided three dimensional interactive applications as high end CAD/CAE/CAM tool used worldwide.

Catia v5 is developed by Dassault Systems. France is a completely re-engineered next generation family of CAD/CAM/CAE software solutions for product lifecycle management. Through its exceptionally easy to use state of the art user interface CATIA V5 delivers innovative technologies for maximum productivity and creativity from concept to the final product. CATIA V reduces the learning curve as it allows the flexibility of using feature based and parametric designs.

CATIA V5 provides three basic platforms – P1, P2 and P3. P1 is for small and medium sized process oriented companies which wish to grow towards the large scale digitized product definition. P2 is for the advanced design engineering companies that require product, process and resources modeling. P3 is for the high-end design application and is basically for automotive and aerospace industry where high equality surfacing or Class-A surfacing is used for designing.

The subject of interpretability offered by CATIA V5 includes receiving legacy data from the other CAD systems and even between its own product data management modules. The real benefit is that the links remain associative. As a result any changes made to this external data are notified and the model can be updated quickly.

CATIA V5 serves the basic tasks by providing different workbenches. A workbench is defined as a specific environment consisting of a set of tools which allows the user to perform specific design tasks in a particular area.

5. Introduction To Finite Element Analsys

5.1. FEA

The finite element analysis (finite element method) is a numerical technique for finding approximate solutions of partial differential equations as well as of integral equations. The solution approach is based on either eliminating the differential equation completely (steady state problems) or rendering the partial differential equation into an approximating system of ordinary differential equations, which are then numerically integrated using standard techniques such as Euler's method, Runge-Kutta method etc.

In the finite element method, a structure is broken down into many small simple blocks or elements. The behavior of an individual element can be described with a relatively simple set of equations. Just as the set of elements would be joined together to build the whole structure, the equations describing the behaviors of the individual elements are joined into an extremely large set of equations that describe the behavior of the whole structure.

5.2. GENERAL PROCEDURE OF FEA

The following steps summarize the general procedure for finite element analysis.

- STEP 1 - The continuum is a physical body, structure or solid being analyzed. Discretization may be simply described as process by which the given body is subdivided into equivalent system of finite elements.
- STEP 2 - The selection of displacement or temperature models or shape functions representing approximately the actual distribution of the displacement or temperature.

The three factors which influence the selection of shape functions are

a. The type and degree of displacement model
b. Displacement magnitudes
c. The requirements to be satisfied which ensuring correct solution.

- STEP 3 - The derivation of the stiffness matrix which consists of the coefficients of the equilibrium equations derived from the geometric and material properties of the element. The stiffness relates the displacement at nodal points to applied forces at nodal points.
- STEP 4 - Assembly of the algebraic equations for the overall discredited continuum includes the assembly of overall stiffness matrix for the entire body from individual element stiffness matrices and the overall global load vector from the elemental load vectors.
- STEP 5 - The algebraic equations assembled in step 4 are solved for unknown displacements by imposing the boundary conditions. In linear equilibrium

problems, this is a relatively straightforward application of matrix algebra techniques.

- STEP 6 - In this step, the element strains and stresses are computed from the nodal displacements that are already calculated from step 5.

5.3. Advantages and Limitations Of Fea

Planning the analysis is arguably the most important part of any analysis, as it helps to ensure the success of the simulation. Oddly enough, it is usually the one analysis leave out.

The purpose of an FEA is to model the behavior of a structure under a system of loads. In order to do so, all influencing factors must be considered and determined whether their effects are considerable or negligible on the much dependent on the level of planning that has been carried out.

FEA is an approximate way of simulation the system behavior. But the results can be quite close to actual testing values. FEA can never replace actual physical testing all the times. This is due to fact, the information required for FEA simulations like material properties emanates from physical testing.

FEA results by themselves can never be taken as complete solution. Usually at least one prototype testing is necessary before the design guided/validated through FEA can be certified.

But when effectively used FEA can predict the results/behavior quite close to reality and can reduce the design lead times as well as number of prototypes to be tested. Also there are some situations like gears in contact, which cannot be simulated exactly using FEA techniques. Under such conditions some work around such as simulating the worst conditions that can happen can be followed. Especially in situations like studying the behavior of a component by changing material, FEA can be highly handy as it is amounts to changing few numbers and re-running the analysis to know the component/system behavior.

5.4. APPLICATIONS OF FEA

- Structural engineering (analysis of frames, trusses, bridges etc).
- Aircraft engineering (analysis of aero plane wings, different parts of missiles and rockets).
- Heat engineering (analysis on temperature distribution, heat flux etc).
- Hydraulic and hydrodynamic engineering (analysis of viscous flow, potential and boundary layer flows).

5.5 POPULAR FEA SOFTWARES

There are varieties of commercial FEA software available over the market. No single software is supposed to have all the capabilities that can meet the complete simulation requirements of a design. Hence based upon the requirements, some of the firms use one or more FEA software. While some other firms develop their own customized versions of software. Some of the popular commercially available FEA software are as follows.

· Adina
· Abaqus
· Ansys
· MSC/Nastran
· Cosmos
· NISA
· Marc
· Ls-Dyna
· MSC/Dytran
· Star-CD

6. Introduction to Ansys

6.1. ANSYS

ANSYS is a general-purpose finite element-modeling package for numerically solving a wide variety of mechanical problems. These problems include: static/dynamic structural analysis (both linear and non-linear), heat transfer and fluid problems, as well as acoustic and electro-magnetic problems. It enables engineers to perform the following tasks -
build computer models or transfer cad models of structures, products, components or system, apply operating loads or other design performance conditions, study physical responses such as stress levels, temperature distributions or electromagnetic fields, optimize a design early in the development process to reduce production costs, carryout prototype testing in
environment where it otherwise would be undesirable or impossible.

6.2. HISTORICAL DEVELOPMENT

Development of the finite element method closely parallels the timetable of the Development of the digital computer. Prior to the advent of the digital computer, work during the 1940’s involved the approximation of continuous solids as a collection of line elements (bars and beams). However, due to the lack of computation tools, the number of line elements had to be kept to a minimum. The first appearance of two-dimensional elements appeared in a paper published in 1956 by

Turner, Clough, Martin, and Top [1]. However, Clough did not use the term finite element until 1960 in a paper. The 1960's were an era in which most large corporations began installing mainframe computers. However, most finite element analysis work was done as a research exercise, rather than being part of the normal product design cycle. During the 1970's, several large general purpose finite element programs running on mainframe computers began to appear. However, due to the dependence on large computing facilities, finite element Analysis was generally used by only large corporations. Computer graphic displays were not prevalent until the late 1970's. This forced the pre- and postprocessing steps to rely on hardcopy graphical displays produced on plotters. This greatly increased the time required to perform the steps required in pre- and post-processing phases.

During the 1980's, many finite element software packages were running on minicomputers along with highly interactive graphically oriented pre-and post-processors. The late 1980's and 1990's found many of these finite element packages being moved onto personal computers. However, even today, some finite element analysis is still done on large scale computers for problems which involve very large models, such as fluid flow computations, casting solidification and some non-linear Structural analysis.

6.3. ADVANTAGES OF ANSYS

ANSYS provides a cost-effective way to explore the performance of products or processes in a virtual environment. This type of product development is termed virtual prototyping.

With virtual prototyping techniques, users can iterate various scenarios to optimize the product life before the manufacturing is started. This enables a reduction in the level of risk, and in the cost of ineffective designs. The multifaceted nature of ANSYS also provides a means to ensure that users are able to see the effect of design on the whole behavior of the product, be it electromagnetic, thermal, mechanical etc.

6.4. Assembly Of Drive Shaft Arrangement

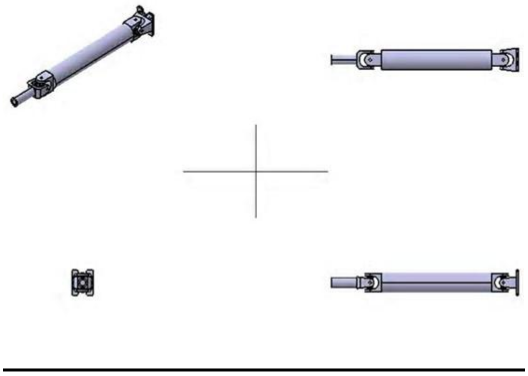


Figure.6.1. Assembly of drive shaft

7. Analysis Of Drive Shaft

Since the domain for analysis is a complex assembly of a number of parts, ANSYS 12.1 Workbench has chosen for performing the analysis. The proper connection between each part of the assembly and the subsequent connectivity of is the key criteria for getting proper load transfer throughout the assembly. The workbench module of ANSYS 12.1 does not require the explicit specification of element 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 easier to manufacture, the composite material were applied.

7.1. Description Of The Problem

The fundamental natural bending frequency of drive shaft for passenger cars, small trucks, and vans should be higher than 6,500 rpm to avoid whirling vibration and the torque transmission capability of the drive shaft should be larger than 3,500 Nm. The drive shaft outer diameter should not exceed100 mm due to space limitations.

SL.NO	NAME	Notations	Units	Value
1	Ultimate Torque	T_{max}	Nm	3500
2	Maximum Speed of Shaft	N_{max}	rpm	6500
3	Maximum Diameter of The Shaft	D	mm	100

Table 7.1.Problem Specifications

7.2. Hallow Shaft Subjected To Loads

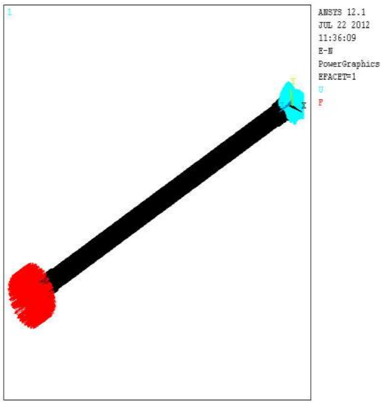


Figure.7.2 Hallow Shaft subjected to loads.

7.3. Material Properties Of Steel (SM45)

The standard material properties of steel are given in table

SL.NO	Mechanical properties	Symbol	Units	Value
1	Young's modulus	E	GPa	207.0
2	Shear modulus	G	GPa	80.0
3	Poisson's ratio	υ	----	0.3
4	Density	ρ	Kg/m^3	7600
5	Yield strength	S_y	MPa	370
6	Shear strength	S_x	MPa	275

Table.7.3. Material Properties of Steel (SM45C)

SL.NO	PROPERTY	Symbol	UNITS	VALUES
1	Longitudinal Modulus	E11	GPa	190
2	Transverse Modulus	E22	GPa	7.7
3	Shear Modulus	G12	GPa	4.2
4	Poisson's Ratio	υ	-----	0.3
5	Density	ρ	Kg/m^3	1600

7.3.1. Analysis of Steel Shaft

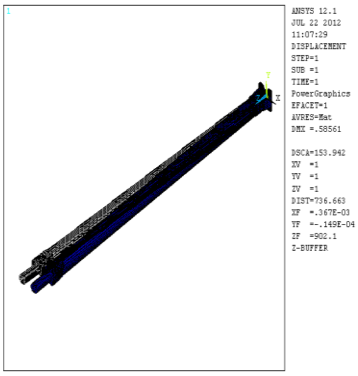


Figure.7.3.1. Deformation in Drive Shaft made of Steel

Figure.7.3.2. Shear Stress of Steel

Figure.7.3.3. Natural Frequency of Steel

7.4. Material Properties Of Carbon/Epoxy
Table 7.4. Material Properties of Carbon/Epoxy

7.4.1. Analysis Of Carbon/Epoxy Composite Shaft

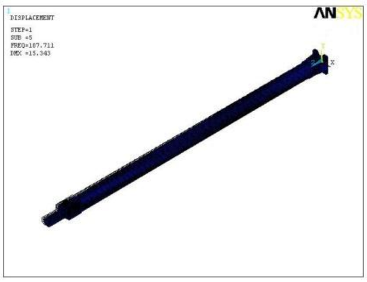


Figure.7.4.1. Modal analysis of Drive Shaft made of Carbon/Epoxy

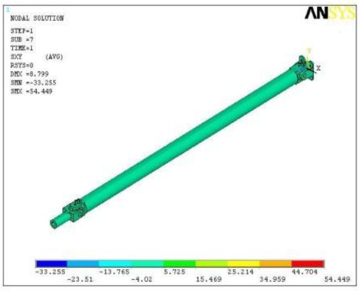


Figure.7.4.2 Shear Stress of Carbon /Epoxy Shaft

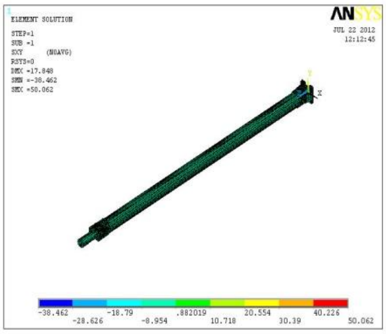


Figure.7.4.3. Vonmisess Stress of Carbon /Epoxy Shaft

7.5. Material Properties Of Boron/Epoxy

Table 7.5. Material Properties of Boron/Epoxy

7.5.1. Analysis of Boron/Epoxy Composite Shaft

Figure.7.5.1. Modal analysis of Drive Shaft made of Boron/Epoxy

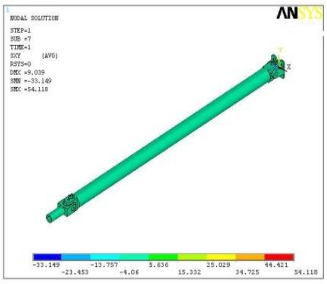


Figure.7.5.2. Shear Stress of Boron /Epoxy Shaft

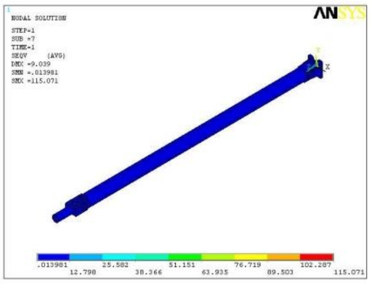


Figure.7.5.3. Vonmisess Stress of Boron /Epoxy Shaft

7.6. MATERIAL PROPERTIES OF KEVLAR /EPOXY

SL.NO	PROPERTY	Symbol	UNITS	VALUES
1	Longitudinal Modulus	E11	GPa	79.2
2	Transverse Modulus	E22	GPa	7.25
3	Shear Modulus	G12	GPa	4.25
4	Poisson's Ratio	υ	-----	0.34
5	Density	ρ	Kg/m^3	1384

Table 7.6. Material Properties of Kevlar/Epoxy

SL.NO	PROPERTY	Symbol	UNITS	VALUES
1	Longitudinal Modulus	E11	GPa	232.2
2	Transverse Modulus	E22	GPa	7.413
3	Shear Modulus	G12	GPa	4.05
4	Poisson's Ratio	υ	-----	0.262
5	Density	ρ	Kg/m^3	2080

7.6.1. Analysis Of Kevlar /Epoxy Composite Shaft

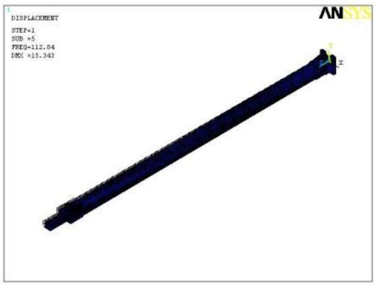


Figure.7.6.1. Modal analysis of Kevlar/Epoxy Drive Shaft

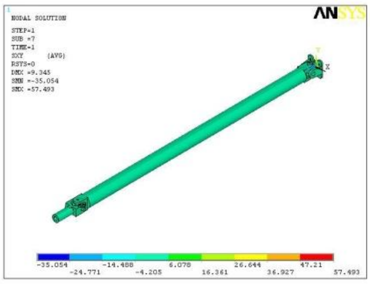


Figure.7.6.2. Shear Stress of Kevlar/Epoxy Drive Shaft

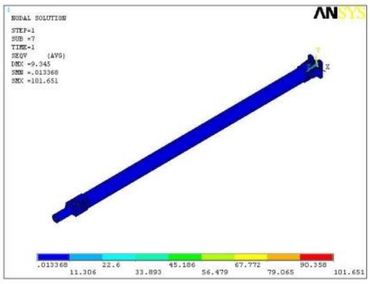


Figure.7.6.3.Vonmisess Stress of Kevlar/Epoxy Drive Shaft

7.7. Material Properties of Carbon-Kevlar/Epoxy Hybried Composite

SL.NO	PROPERTY	Symbol	UNITS	VALUES
1	Longitudinal Modulus	E11	GPa	123.6
2	Transverse Modulus	E22	GPa	7.4
3	Shear Modulus	G12	GPa	4.28
4	Poisson's Ratio	υ	-----	0.328
5	Density	ρ	Kg/m^3	1470

Table 7.7. Material Properties of Carbon-Kevlar/Epoxy

7.7.1. Analysis Of Carbon-Kevlar/Epoxy Hybried Composite

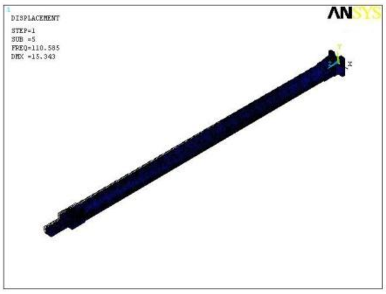


Figure.7.7.1. Modal analysis of Carbon-Kevlar/Epoxy Drive Shaft

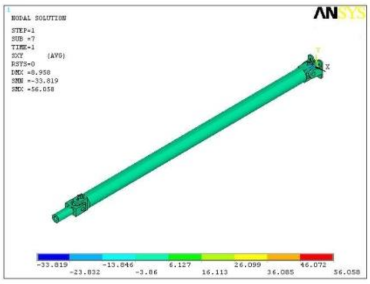


Figure.7.7.2. Shear Stress of Carbon-Kevlar/Epoxy Drive Shaft

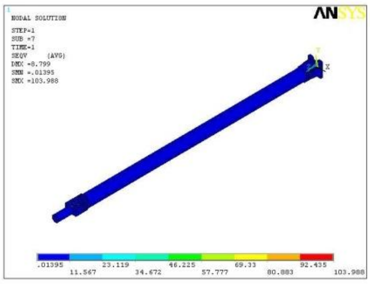


Figure.7.7.3.Vonmisess Stress of Carbon-Kevlar/Epoxy Drive Shaft

7.8. Material Properties Of Aluminum-Boron/Epoxy Hybried Composite

SL.NO	PROPERTY	Symbol	UNITS	VALUES
1	Longitudinal Modulus	E11	GPa	169.6
2	Transverse Modulus	E22	GPa	7.29
3	Shear Modulus	G12	GPa	4.625
4	Poisson's Ratio	υ	-----	0.29
5	Density	ρ	Kg/m^3	2100

Table 7.8. Material Properties of Aluminum-Boron /Epoxy

7.8.1. Analysis Of Aluminum-Boron /Epoxy Hybried Composite

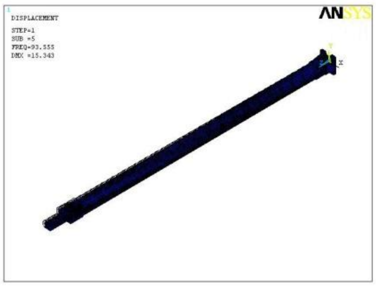


Figure.7.8.1. Modal analysis of Aluminum-Boron /Epoxy Drive Shaft

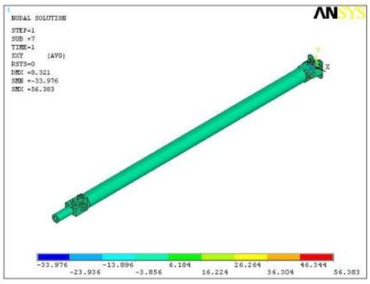


Figure.7.8.2. Shear Stress of Aluminum-Boron /Epoxy Drive Shaft

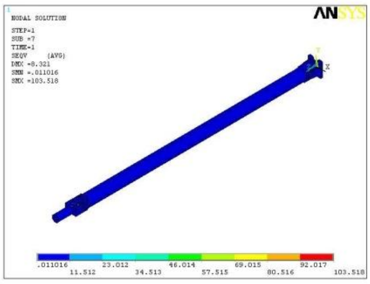


Figure.7.8.3.Vonmisess Stress of Aluminum-Boron /Epoxy Drive Shaft

8. Result and Discussions

The following results are observed by the analysis and are shown in Table 8.1.

SL. NO	Material Property	No of Layers	Angle of Orientation of Ply	Deformation in mm	Natural Frequency in H_Z	Torsional Stress value in N/mm^2
1	Steel	-------	-------	0.5856	227	53.8
2	Carbon/ Epoxy	2	±45	8.799	107.7	54.449
3	Boron/Epoxy	2	±45	9.039	92.72	54.118
4	Kevlar/ Epoxy	2	±45	9.345	112.8	57.493
5	Carbon-Kevlar/ Epoxy	2	±45	8.958	110.5	56.058
6	Aluminum - Boron/Epoxy	2	±45	8.312	93.55	56.383

Table 8.1.The Stress, Deformation, Natural Frequency

9. The Weight Coparesion Between Composite And Steel Drive Shaft

The weight of Kevlar drive shaft is less as compared to other material such as steel, boron/epoxy, and Carbon/epoxy is shown in figure below.

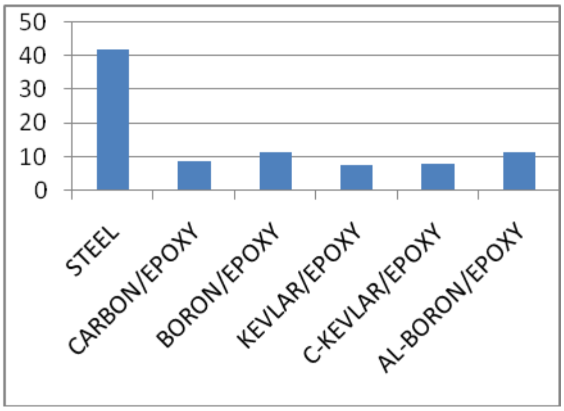


Figure.9.1. Weight comparison between steel and Composite Shaft

Conclusion

The usage of composite materials has resulted in considerable amount of weight saving in the range of 81% to 72% when compared to conventional steel drive shaft.

Taking into account the weight saving, deformation, shear stress induced and resultant frequency it is evident that Kevlar/epoxy composite has the most encouraging properties to act as replacement to steel

The present work was aimed at reducing the fuel consumption of the automobiles in particular or any machine, which employs drive shaft, in general. This was achieved by reducing the weight of the drive shaft with the use of composite materials.

By using advanced composite materials, the weight of the drive shaft assembly can be tremendously reduced.

This also allows the use of a single drive shaft (instead of a two piece drive shaft) for transmission of power to the differential parts of the assembly.

Apart from being lightweight, the use of composites also ensures less noise and vibration

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