International Journal of Scientific Research & Engineering Trends
Volume 5, Issue 6, Nov-Dec-2019, ISSN (Online): 2395-566X

A Review Article of Composite Drive Shaft Vibration Effects and Methodology

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Abstract **- 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 tensional buckling capabilities are also maximized. This work deals with the replacement of a conventional steel drive shaft with High Strength Carbon drive shafts for an automobile application.**

Keywords **- Propeller shaft, Composites, Carbon Fibre High strength, Structural Steel.**

I. INTRODUCTION

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.

II. DESCRIPTION OF THE PROBLEM

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.

1. Aim and Scope of the Work:

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. OPTIMUM DESIGN USING GENETIC ALGORITHM

The design parameters are to be optimized for E-Glass/ Epoxy, High Strength Carbon/Epoxy and High Modulus Carbon/Epoxy composite drive shafts of an automobile using Genetic Algorithm. The purpose of using Genetic Algorithm is to minimize the weight of the shaft, which is subjected to the constraints such as torque transmission, torsional buckling capacities and fundamental lateral natural frequency.

The design parameters to be optimized are,

1. Ply thickness
2. Number of plies required
3. Stacking sequence of Laminate

1. Analysis:

1. Modelling of the High Strength Carbon/Epoxy composite drive shaft using ANSYS.
2. Static, Modal and Buckling analysis are to be carried out on the finite element model of the High Strength Carbon/Epoxy composite drive shaft using ANSYS.
3. To investigate

- The stress and strain distributions in E-Glass/ Epoxy, High Strength Carbon/Epoxy and High Modulus Carbon/Epoxy

composite drive shafts using classical lamination theory (CLT).

- The effect of centrifugal forces on the torque transmission capacity of the composite drive shafts.
- The effect of transverse shear and rotary inertia on the fundamental lateral natural frequency of the shaft.

3. Background

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, where as in alloys, constituent materials are soluble in each other and forms a new material which has different properties from their constituents.

4. Classification of Composites

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 and stiffness on a weight basis. Specific strength 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 resistance, low shrinkage, improved surface finish, and dimensional stability. However, short fibers provide low cost, are easy to work with, and have fast cycle time fabrication procedures. The characteristics of the fiber-reinforced composites depend not only on the properties of the fiber, but also on the degree to which an applied load is transmitted to the fibers by the matrix phase.

The principal fibers in commercial use are various types of glass, carbon, graphite and Kevlar. All these fibers can be incorporated into a matrix either in continuous lengths or in discontinuous lengths as shown in the Fig 3.1. 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.

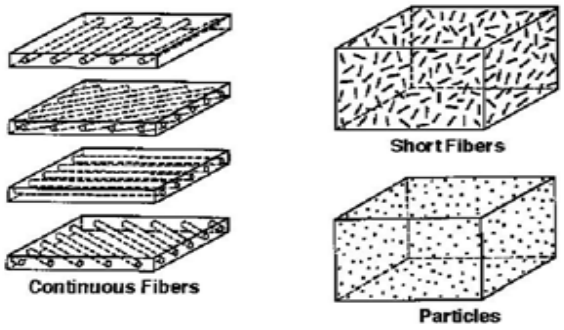

Fig.1. Types of fiber.

IV. ADVANTAGES OF FIBER REINFORCED COMPOSITES

The advantages of composites over the conventional materials are [1, 2]

1. High strength to weight ratio
2. High stiffness to weight ratio
3. High impact resistance
4. Better fatigue resistance
5. Improved corrosion resistance
6. Good thermal conductivity
7. Low Coefficient of thermal expansion. As a result, composite
8. Structures may exhibit a better dimensional stability over a wide.
9. Temperature range.
10. High damping capacity.

1. Limitations of composites:

The limitations of composites are [1, 2],

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

2. 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,

1. **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
2. **Aircraft:** Drive shafts, rudders, elevators, bearings, landing gear doors,panels and floorings of airplanes etc.

3. **Space:** payload bay doors, remote manipulator arm, high gain antenna, antenna ribs and struts etc.
4. Marine: Propeller vanes, fans & blowers, gear cases, valves &strainers, condenser shells.
5. **Chemical Industries:** Composite vessels for liquid natural gas for alternative fuel vehicle, racked bottles for fire service, mountain climbing, under ground storage tanks, ducts and stacks etc.
6. **Electrical & Electronics:** Structures for overhead transmission lines for railways, Power line insulators, Lighting poles, Fiber optics tensile members etc.
7. **Sports Goods:** Tennis rackets, Golf club shafts, Fishing rods, Bicycle frame work, Hockey sticks, Surfboards, Helmets and others.

V. ISSUES OF OLD ARTICLES

1. Gummadi Sanjay,AkulaJagadeesh Kumar, "Optimum Design and Analysis of a Composite Drive Shaft for an Automobile" 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.

2. D.dinesh, F.Anandraju, "Optimum Design And Analysis Of A Composite Drive Shaft For An Automobile By Using Genetic Algorithm And Ansys" 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. Keywords:-Torque transmission, Torsional buckling capacities, Fundamental lateral Natural frequency, Bernoulli Euler theory, Timoshenko beam theory, Static analysis, Modal analysis, Buckling analysis, Ansys.

3. Pankaj K. Hatwar, Dr. R.S. Dalu, "Design and Analysis of Composite Drive Shaft" Polymeric materials reinforced with synthetic fibres such as glass, carbon, and aramid provide advantages of high stiffness and strength to weight ratio as compared to conventional construction materials, i.e. wood, concrete, and steel. Despite these advantages, the widespread use of synthetic fibre-reinforced polymer composite has a tendency to decline because of their high-initial costs, their use in non-efficient structural forms and most importantly their adverse environmental impact. In the recent days, there is a huge demand for a light weight material such as fiber reinforced polymer composites seems to be a promising solution to this arising demand. These materials have gained attention due to their applications in the field of automotive, aerospace, sports goods, medicines and household appliances. The overall objective of this work is to analyze a composite drive shaft for power transmission. This work deals with the replacement of conventional steel drive shafts composite drive shaft for an automotive application.

4. G. Kaviprakash, "Design and Analysis of Composite Drive Shaft for Automotive Application" This paper examines the result of fiber orientation angles and stacking sequence on the torsional stiffness, natural frequency and buckling strength of composite drive shaft. 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. Substituting composite structures for conventional metallic structures has many advantages because of higher specific stiffness and strength of composite materials. The advanced composite materials such as graphite, carbon, Kevlar and Glass fibers with suitable resins are widely used because of their high specific strength and high specific modulus. 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 functional 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. In the present work an attempt is made to evaluate the suitability of composite material for the purpose of automotive transmission applications. A composite drive shaft is optimally analyzed using ANSYS for hybrid of high strength carbon fiber, high modulus carbon fiber and Kevlar fiber with Epoxy resin composites with the objective of minimization of weight of the shaft which is subjected to the constraints such as torque transmission, tensional and buckling strength capabilities. The present work includes analysis on drive shaft of Indian car with composite material and concludes that the use of composite materials for drive shaft would induce less amount of stress which additionally reduces the weight of the shaft.

5. A.sridhar1, Dr. R. Mohan2 ,R.Vinoth kumar3, "design and analysis of composite drive shaft" Almost all automobiles which correspond to design with Rear wheel

drive and front engine installation have transmission shafts. In heavy duty vehicles driveshaft is one of the important components. 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,

It can be achieved without increase in cost and decrease in quality and reliability. The aim of this work is to replace the conventional steel driveshaft of automobiles with an appropriate composite driveshaft. The conventional drive shafts are made in two pieces for reducing the bending natural frequency, whereas the composite shafts can be made as single-piece shafts, thus reducing the overall weight. The design parameters were optimized with the objective of minimizing the weight of composite drive shaft. The composite drive shaft made up of high modulus material is designed by using CAD software and tested in ANSYS for optimization of design or material check and providing a best material. The replacement of composite materials can results in considerable amount of weight reduction if compared to conventional steel shaft.

VI.CONCLUSION

Polymeric materials reinforced with synthetic fibres such as glass, carbon, and aramid provide advantages of high stiffness and strength to weight ratio as compared to conventional construction materials, i.e. wood, concrete, and steel. Despite these advantages, the widespread use of synthetic fibre-reinforced polymer composite has a tendency to decline because of their high-initial costs, their use in non-efficient structural forms and most importantly their adverse environmental impact. In the recent days, there is a huge demand for a light weight material such as fiber reinforced polymer composites seems to be a promising solution to this arising demand. These materials have gained attention due to their applications in the field of automotive, aerospace, sports goods, medicines and household appliances. The overall objective of this work is to analyze a composite drive shaft for power transmission. This work deals with the replacement of conventional steel drive shafts composite drive shaft for an automotive application.

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