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Research Paper

FAILURE ANALYSIS AND EVALUATION OF A COMPOSITE MATERIAL AUTOMOTIVE DRIVESHAFT BY USING FEM—A REVIEW

Amol B Rindhe[1]* and S R Wagh[2]

*Corresponding Author: Amol B Rindhe, ✉ rindhe.amol120@gmail.com

In heavy duty vehicles driveshaft is one of the important components. Generally a two-piece alloy steel drive shaft is used in automotive which can be replaced by a single piece of composite material driveshaft. Our main aim is to study its design procedure along with finite element analysis some important parameter will be obtained. 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. Also, the dynamic characteristics of the composite shafts must be analyzing well.

Keywords: Drive shaft, Failure analysis, Composite material, FEM

INTRODUCTION

Drive Shaft 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. Automotive drive Shaft is a very important component of vehicle. The present project focuses on the design of such an automotive driveshaft by composite materials. Now a day's two pieces steel shaft are used as drive shaft. However, the main advantages of the present design are; only one piece of composite driveshaft is possible that fulfil all the requirements of drive shaft. The basic requirements considered here are torsion strength, torsional buckling and bending natural frequency. An optimum design of the draft shaft is done, which is cheapest and lightest but meets all of the above load requirements. Progressive failure analysis of the selected design is also done.

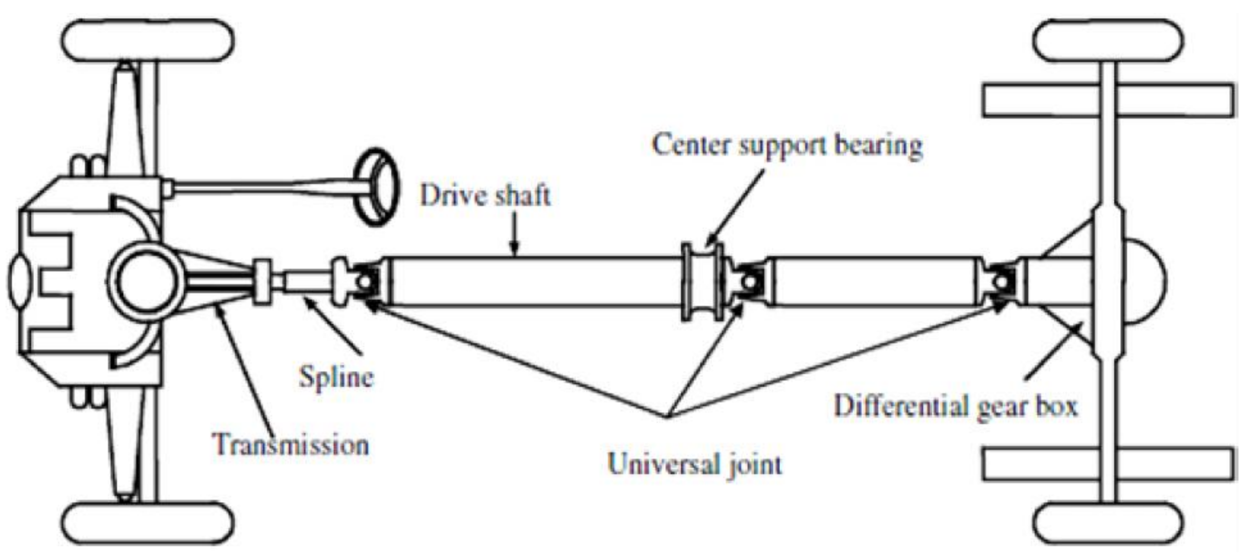
AIM AND OBJECTIVE

- To create a CAD model of existing driveshaft.

[1] Advance Manufacturing & Mech. System Design, SSGMCE, Shegaon, India.

[2] Mechanical Engineering Department, SSGMCE, Shegaon, India.

Figure 1: Conventional Two-Piece Steel Drive Shaft



- To check the CAD model by using FEM with existing material and at normal operating conditions.
- To study the behavior of composite material.
- To suggest new and improved material for the same driveshaft.

LITERATURE REVIEW

Thimmegowda Rangaswamy and Sabapathyvijayarangan (2005)

In this work an attempt has been made for design optimization of composite drive shafts for power transmission applications. The one-piece composite drive shaft is designed to replace conventional steel drive shaft of an automobile using E-glass/epoxy and High Modulus (HM) carbon/epoxy composites. A formulation and solution technique using Genetic Algorithms (GAs) for design optimization of composite drive shafts is presented here. The purpose of using GA is to minimize the weight of shaft that is subjected to the constraints such as torque transmission, torsional buckling capacities and fundamental lateral natural frequency (Mohammad Reza Khoshravan, 2011).

The usage of composite materials and optimization techniques has resulted in considerable amount of weight saving in the range of 48 to 86% when compared to conventional steel shaft.

Mohammad Reza Khoshravan and Amin Paykani (2011)

This paper presents design method and vibrational analysis of composite propeller shafts.in this paper, the aim is to replace a metallic drive shaft by a two-piece composite drive shaft. The replacement of composite materials has resulted in considerable amount of weight reduction about 72% when compared to conventional steel shaft (Chowdhuri *et al.*, 2010).

Kumar Rompicharla and Rambabu (2012)

The objective of this paper is to design and analyze a composite drive shaft for power transmission. The design optimization also showed significant potential improvement in the performance of drive shaft. The drive shaft of Toyota Qualis was chosen. 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 Kevlar/Epoxy (Dinesh, 2012).

Chowdhuri and Hossain (2010)

The present paper focuses on the design of such an automotive drive shaft by composite materials. Now a day's two pieces steel shaft are used as drive shaft. However, the main advantage of the present design is; only one piece of composite drive shaft is possible that fulfil all the requirements of drive shaft. At the end it may be concluded, the proposed drive shaft can serve all the requirements and from the progressive failure analysis its failure load is also calculated. The successful application of the present design can make a huge improvement in automotive industry (Gay *et al.*, 2004).

Bhushan et al. (2013)

In this, a carbon fibre epoxy composite layer was co-cured on the inner surface of an aluminium tube rather than wrapping on the outer surface to prevent the composite layer from being damaged by external impact and absorption of moisture. A press fit joining method between the steel yoke with protections on its surface and the aluminium tube was developed to increase the reliability of joining and to reduce manufacturing cost (Pollard, 1999).

Manjunath and Mohan Kumar (2011)

In this paper an attempt has been made to optimize ply stacking sequence of single piece E-Glass/Epoxy and Born/Epoxy composite driveshaft using Particle Swarm Algorithm (PSA). The weight saving of two material shafts using PSA are compared with GA results and found that the PSA have better results than GA (Rangaswamy and Vijayrangan, 2005).

Poul and Ruzicka (2006)

This paper deals with the design of the carbon fibre composite driveshaft .Three different versions of driveshaft were designed and produced. Version 1.Completely made of Al alloy. Version 2.is a hybrid design where the central part is made up of high strength carbon composite and flanges are made of Al alloy (Rastogi, 2004).

Gummadi Sanjay and AkulaJagadesh Kumar (2007)

This work deals with the replacement of conventional two-piece steel driveshaft with a single piece E-Glass/Epoxy, High strength carbon/Epoxy and High modulus carbon/ Epoxy composite driveshaft for an automobile application. Design parameters were optimized with the objective of minimizing the weight of composite driveshaft weight of saving of the E-Glass/Epoxy, High strength carbon/Epoxy and High modulus carbon/poxy shafts were equal to 48.36%, 86.90% and 86.90% of the weight of steel shaft respectively (Lee *et al.*, 2004).

Chandrashekhar and Venkatesh (2002-04)

The overall objective of this paper is to design and analyze a composite driveshaft for power transmission applications. A one piece driveshaft for rear wheel drive automobile was designed optimally using E-Glass/Epoxy and HM carbon/Epoxy composites. In this paper a GA has been successfully applied to minimize the weight of shaft which is subjected to the constraints such as torque transmission, torsional buckling capacities and fundamental natural frequency. These results are encouraging and suggest that GA can be used effectively in other complex and realistic, design often encountered in engineering applications (Pappada and Rametto, 2002).

PROCEDURE / METHODOLOGY

Composite Material

A material composed of 2 or more constituents is called composite material. 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, whereas in alloys, constituent materials are soluble in each other and forms a new material which has different properties from their constituents.

Classification of Composites

- Polymer matrix composites
- Metal matrix composites
- Ceramic Matrix

Advantages of Composites

The advantages of composites over the conventional materials are: 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.

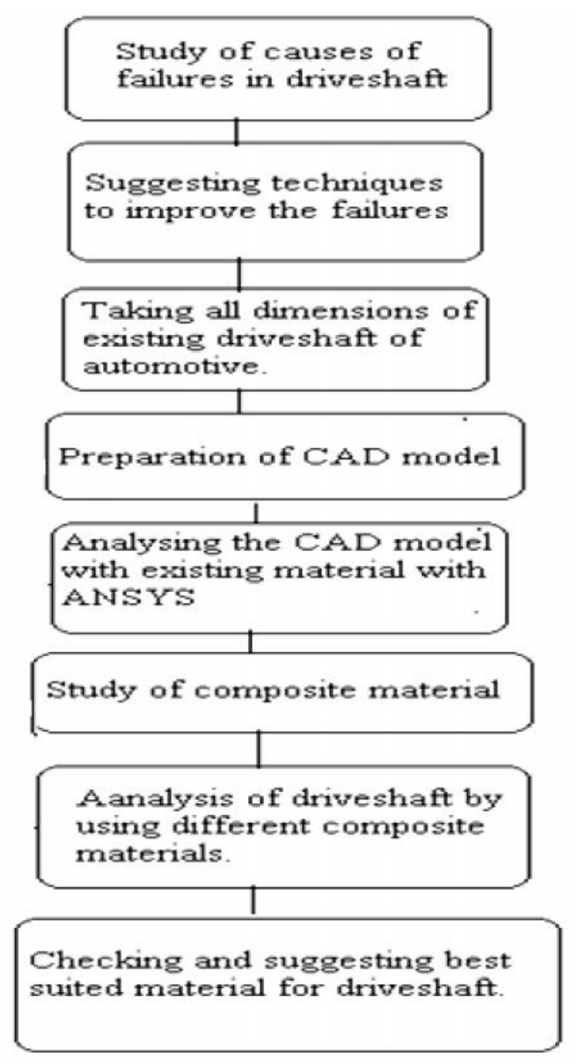
Limitations of Composites

The limitations of composites are: Mechanical characterization of a composite structure is more complex than that of a 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 and they do not necessarily give higher performance in all properties used for material selection.

Applications of Composites

The common applications of composites are extending day by day. Now a day they are used in medical applications too. The other fields of applications are (Lee *et al.*, 2002): Automotive: Drive shafts, clutch plates, engine blocks, push rods, frames, valve guides, automotive racing brakes, filament–wound fuel tanks, fibre Glass/Epoxy leaf springs for heavy trucks and trailers, rocker arm covers, suspension arms and bearings for steering system, bumpers, body panels and doors. Space: payload bay doors, remote manipulator arm, high gain antenna, antenna

Figure 2: Procedure/Methodology



ribs and struts, etc. Marine: Propeller vanes, fans and blowers, gear cases, valves and 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. Aircraft: Drive shafts, rudders, elevators, bearings, landing gear doors, panels and floorings of airplanes, etc. Electrical and Electronics: Structures for overhead transmission lines for railways, Power line insulators, Lighting poles, Fiber optics tensile members, etc. Sports Goods: Tennis rackets, Golf club shafts, Fishing rods, Bicycle framework, etc.

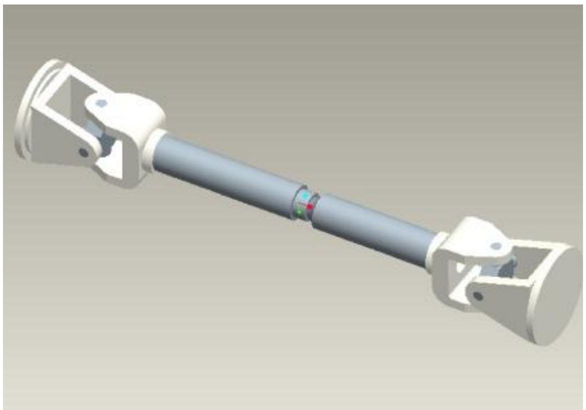
DEMERITS OF A CONVENTIONAL DRIVE SHAFT

They have less specific modulus and strength and have 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 over all weight of assembly will be more. Its corrosion resistance is less as compared with composite materials and steel drive shafts have less damping capacity.

Merits of Hybrid Aluminium / Composite Drive Shaft

They have high specific modulus and strength and reduced weight. A one-piece composite shaft can be manufactured 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 the total cost. Due to the weight reduction, fuel consumption will be reduced. They have h igh damping capacity hence they produce less vibration and noise. They have good corrosion resistance and greater torque capacity than steel shaft. Longer fatigue life than steel shaft. Lower rotating weight transmits more of available power.

Figure 3: CAD Model of Drive Shaft



CONCLUSION

The wide research has been carried out in the field of design of driveshaft for automotive. The main objective of this work is studied and to taken an account of previous work carried out by Researcher on Drive Shaft. From the review it can be noted that there are various forces, torque, angles of inclination, materials affect on components of Drive Shaft and trying to make it better by changing some parameter or material to composite material and test the same. The FEM softwares will be used for the same purpose.

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