A REVIEW PAPER ON DESIGN, ANALYSIS AND WEIGHT OPTIMIZATION OF DRIVE SHAFT (LMV) BY USING COMPOSITE MATERIAL

Gavarkar Avinash Dhondiram[1], Mohite Vinod Shahaji[2], Nikam Kedar Prakash[3], Bhokare Ketan Anil[4],Salunkhe A.B[5]

UG Scholar[1], Mechanical engineering, Adarsh Institute Of Technology & Research Center Vita.
UG Scholar[2], Mechanical engineering, Adarsh Institute Of Technology & Research Center Vita.
UG Scholar[3], Mechanical engineering, Adarsh Institute Of Technology & Research Center Vita.
UG Scholar[4], Mechanical engineering, Adarsh Institute Of Technology & Research Center Vita.
Professor[5], Mechanical engineering, Adarsh Institute Of Technology & Research Center Vita.

vinodmohite039@gmail.com

Abstract- Laminated composites, with their advantage of higher specific stiffness, gained substantiality in the field of torque carrying structures through many applications. Composite drive shafts offer the potential of lighter and longer life drive train with higher critical speed. In this study, finite element analysis performed to investigate the effects of fibers winding angle and layers stacking sequence on the critical speed, critical buckling torque and fatigue resistance.

Index Terms- composite, driveshaft, ANSYS

I. INTRODUCTION

Rapid technological advances in engineering design field result in finding the alternate solution for the conventional materials. The design engineers brought to a point to finding the materials which are more reliable than conventional materials. Researchers and designers are constantly looking for the solutions to provide stronger and durable materials which will answer the needs of fellow engineers. A drive shaft, or propeller shaft (prop shaft), or Carbon shaft is a mechanical component for transmitting torque and rotation, usually used to connect other components of a drive train that cannot be connected directly because of distance or the need to allow for relative movement between them. Drive shafts are carriers of torque. They are subject to torsion and shear stress, equivalent to the diff erence between the input torque and the load. They must therefore be strong enough to bear the stress, while avoiding too much additional weight as that would in turn increase their inertia. An automotive drive shaft is a rotating shaft that transmits power from the engine to the differential gear of rear wheel drive (RWD) vehicles. 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. Moreover, a composite driveshaft can be perfectly designed to effectively meet the strength and stiffness requirements. Since composite materials generally have a lower elasticity modulus, during torque peaks in the driveline, the drive shaft can act as a shock absorber. Moreover, the breakage of composite a drive shaft (particularly in SUV's) is less -risky, since it results in splitting up of the fine fibers as compared to the scattering of broken steel parts in various directions. Composite materials have been widely used to improve the performance of various types of structures. Compared to conventional materials, the main advantages of composites are their superior stiffness to mass ratio as well as high strength to weight ratio.

Because of these advantages, composites have been increasingly incorporated in structural components bin various industrial fields. Some examples are helicopter rotor blades, aircraft wings in aerospace engineering, and bridge structures in civil engineering applications. Some of the basic concepts of composite materials are discussed in the following section to better acquaint ourselves with the behavior of composites.

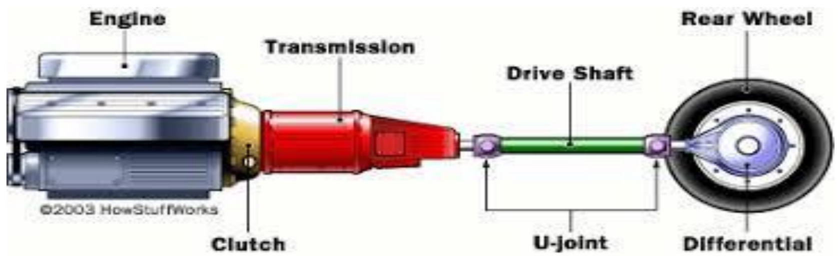

Fig.1. Layout of rear drive automotive

II. LITERATURE REVIEW

T. Rangaswamy, et al., [1] presented a paper titled, 'Optimal Design and Analysis of Automotive Composite Drive Shaft'. The overall objective of this paper was to design and analyze a composite drive shaft for power transmission applications. In this work a Genetic Algorithm (GA) has been successfully applied to minimize the weight of shaft which is subjected to the constraints such as torque transmission, torsion buckling capacities and fundamental natural frequency. The results of GA are then used to perform static and buckling analysis using Ansys software. The results have shown that the stacking sequence of shaft strongly affects buckling torque.

V. S. Bhajantri, et al [2] The High Strength Carbon/Epoxy and High Modulus Carbon/Epoxy Composite drive shafts have been designed to replace the steel drive shaft of an automobile. The weight savings of the High strength carbon/epoxy and high modulus carbon/epoxy shafts wer e equal to 50 % approximately of the steel shaft. Optimum fiber angle orientation will play important role in composite shaft which depends on requirement of composite shaft. The design procedure is studied and along with finite element analysis some important parameter are obtained. The composite drive shaft made up of HM carbon / epoxy multilayered composites has been designed. The results reveal that the orientation of
fibers has great influence on the static characteristics of the composite shafts and offers advantages such as:

1. Lower weight
2. Higher strength
3. Progressive failure mechanism (offers warning before failure)
4. Lower power consumption

The present finite element analysis of the design variables provide an insight of their effects on the drive shaft's critical mechanical characteristics and fatigue resistance. A model of hybridized layers was generated incorporating carbon-epoxy. The buckling, which dominates the failure mode, have a value which not increases regularly with increasing the winding angle. Regression Analysis was done to obtain relations between fiber angle orientation andparameters like stresses induced in each layer, deflection in each layer and natural frequencies of the composite shaft. This relation helps in finding the above mentioned parameters at any fiber orientation; which will help to optimize the design of a composite shaft and hence will reduce the cost of manufacturing.

Bhushan K. Suryawanshi, et al [3] The hybrid aluminum/composite drive shafts have been designed to replace the steel drive shaft of an automobile. A one-piece hybrid aluminum/composite drive shaft for rear wheel drive automobile has been designed with the objective of minimization of weight of the shaft which was subjected to the constraints such as torque transmission, tensional buckling capacities and natural bending frequency. The mass of the hybrid aluminum/composite drive shaft will be very less compared to the conventional steel drive shaft. The static torque capability and the fundamental natural frequency were 4320 Nm and 9390 rpm, which exceeded the design requirements. A press fit joining method between the steel yoke with protrusions on its surface and the aluminum tube was developed to increase the reliability of joining and to reduce manufacturing cost.

A. R. Abu Talib et al., [4] presented their work 'Developing a hybrid, carbon/glass fiber- reinforced, epoxy composite automotive drive shaft'. In this study a finite element analysis was used to design composite drive shaft incorporating carbon and glass fibers with an epoxy matrix. A configuration of one layer of carbon-epoxy and three layer of glass-epoxy with 00, 450 and 900. The results shown that in changing the fibers winding angle from 00 to 900, the loss in the natural frequency of the shaft. While shifting from best to worst stacking sequence, the drive shaft causes a loss in its buckling strength, which represents a majorconcern over the shear strength in the drive shaft design.

A. Gebresilassie [5] presented the paper 'Design and analysis of Composite Drive Shaft for Rear-Wheel Drive Engine', aimed at evaluation of the suitability of composite material such as E-Glass/Epoxy for the purpose of automotive drive shaft application. A one-piece composite shaft was optimally analyzed using Finite Element Analysis Software for E- Glass/Epoxy composites with the objective of minimizing the weight of the shaft, which is subjected to the constraints such as torque transmission, critical buckling torque capacity and bending natural frequency.

M.R. Khoshravan, et al [6] In this paper a two-piece steel drive shaft was considered to be replaced by a one-piece composite drive shaft. Its design procedure was studied and along with finite element analysis some important parameter wer e obtained. The composite drive shaft made of high modulus carbon/epoxy multilayered composites has been designed. Modal analysis was conducted to obtain natural frequencies of the composite shaft. The effect of changing the carbon fiber orientation angle on natural frequency was also studied. The replacement of composite materials has resulted in considerable amount of weight reduction about 72% when compared to conventional steel shaft. Also, the results showed that the orientation of fibers has great influence on the dynamic char acteristics of the composite shafts.

Arun Ravi , et al [7] The High Strength Carbon composite drive shafts have been designed to replace the steel drive shaft of an automobile. A one-piece composite drive shaft for rear wheel drive automobile has been designed with High Strength Carbon composites with the objective of minimization of weight of the shaft which was subjected to the constraints such as torque transmission, torsional buckling capacities and natural bending frequency. The High Strength Carbon composite drive shafts have been analysed to replace the steel drive shaft of an automobile. The weight savings of the HS Carbon is 24 % (100-50 & Solid) compared to same dimensions of steel shaft.

S.A. Mutasher [8] in this work titled 'Prediction of the torsional strength of the hybrid aluminum/composite drive shaft' investigated the maximum torsion capacity of the hybrid aluminum/composite shaft for different winding angle, number of layers and stacking sequences. This hybrid shaft consisted of aluminum tube wound outside by E- glass and carbon fibers/epoxy composite.

The finite element method was used to analyze the hybrid shaft under static torsion. Ansys finite element software was used to perform the numerical analysis for the hybrid shaft. Full scale hybrid specimen was analyzed. Elasto-plastic properties were used for aluminum tube and linear elastic for composite materials. The results showed that the static torque capacity is significantly affected by changing the winding angle, stacking sequences and number of layers.

Sagar R Dharmadhikari, et al [9] Many methods are used for the design optimization that assumes all the design variables are continuous. But in actual structural optimization almost all the variables are discrete. The GA is a stochastic global search method that mimics the metaphor of natural biological evolution. GA operates on a population of potential solutions applying the principle of survival of the fittest to produce (hopefully) better and better approximations to a solution. At each generation, a new set of approximations is created by the process of selecting individuals according to their level of fitness in the problem domain and breeding them together using operators borrowed from natural genetics. This process leads to the evolution of populations of individuals that are better suited to their environment than the individuals that they were created from, just as in natural adaptation. The replacement of conventional drive shaft results in reduction in weight of automobile. The finite element analysis is used in this work to predict the deformation of shaft. The deflection of steel, HS Carbon / Epoxy and HM Carbon / Epoxy shafts was 0.00016618, 0.00032761 and 0.0003261 mm respectively. Natural frequency using Bernoulli – Euler and Timoshenko beam theories was compared. The frequency calculated by Bernoulli – Euler theory is high because it neglects the effect of rotary inertia & transverse shear. Hence the single piece High Strength Carbon / Epoxy composite drive shaft has been proposed to design to replace the two piece conventional steel drive shaft of an automobile.

R. Srinivasa Moorthy et al [10] Precisely, for the specifications chosen, using Carbon/Epoxy driveshaft in the place of conventional driveshaft will lead to an appreciable mass saving of 89.756% with barely half of the wall thickness of conventional steel shaft. Though the mass saving is substantial in both the composites considered, making either of the composites a better choice for the conventional high quality SM45C steel, using Carbon/Epoxy for making automotive driveshaft has multiple advantages as mentioned above. This work relies purely upon analytical calculations and use of ply distribution tables/graphs pertaining to 60% volume fraction and 0.13 mm ply thickness. The approach can be extended to other widely used composites like Glass/Epoxy and Boron/Epoxy to check their suitability. This approach throws light upon ply distribution in standard orientations of 0º, 90º, +45º and -45º for the composite considered. The effect of varying ply staking sequence on the performance of composites can be found by using computational software’s. Moreover, considering the material and manufacturing cost will give better grounds to compare the overall efficacy, thus resulting in an appropriate selection of the best fiber/matrix combination for making automotive drive shafts.

III. PROBLEM DEFINITION

In order to conserve natural resources and to reduce fuel consumption, weight reduction of vehicle has been the main aim of automobile manufacturer. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes .The drive shaft is one of the key items for weight reduction in automobile. In working condition, torque is been applied on the drive shaft due to which stress is been induced. Hence, the stress of the material becomes a major factor in designing the drive shaft. The introduction of composite materials made it possible to reduce the weight of the drive shaft without any reduction on load carrying capacity. Composite Materials have high strength-to-weight ratio as compared to those of steel.

3.1 OBJECTIVES

The objectives of this project are
1) To reduce the weight of the drive shaft in vehicle to increase the fuel efficiency.
2) Static analysis of standard Steel drive shaft, composite Glass fiber and Carbon fiber drive shaft using FEA. Determining effects of stress.
3) Manufacturing and Testing of Composite drive shaft.
4) Comparison and Validation of results by Theoretical calculations and Testing
5) Modal analysis of drive shaft.

IV. METHODOLOGY

After referring to multiple references it was understood that how composite drive shaft having optimum weight can be selected using the exact methodology.
For this process we use CATIA V5 R20 and ANSYS workbench 14.5 software
1. CAD model of conventional drive shaft is prepared in CATIA V5 R20 as per actual dimension. Then this model is imported to ANSYS workbench 14.5 software. For
pre-processing and to derive a final solution results are derived from ANSYS software.
2. CAD model of composite drive shaft is prepared in CATIA V5 R20 as per actual dimension. Then this model is imported in ANSYS workbench 14.5. For pre- processing and to derive a final solution results are derived from ANSYS software.
3. Compare conventional drive shaft and composite drive shaft results
4. For validation, we require the results derived from theoretical and experimental calculations.
5. To perform the experiment, we manufacture the sample composite material and conventional drive shaft. Testing of these two shafts is been done in torsion test machine and the results are been derived.
6. Later CAD model for these two shafts having same dimensions was been generated and was imported in ANSYS. Results were derived after this process and were compared with the experimental results.
7. Theoretical calculations for sample conventional and composite drive shaft were calculated.
8. Lastly ANSYS, theoretical and experimental results were compared and preferable shaft was selected in automobile.

V. CONCLUSION

One piece composite drive shaft was considered to replace the two piece conventional steel drive shaft by using composite materials about 81% of weight savings and reduces the vehicle weight when compared to steel shaft Fiber angle orientation and stacking sequence has a great influence on buckling torque and also on the dynamic characteristics and offers advantages such as lower weight, higher strength, lower power consumption and progressive failure mechanism (offers warning before failure)

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