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DESIGN, ANALYSIS AND WEIGHT OPTIMIZATION OF DRIVE SHAFT (LMV) BY USING COMPOSITE MATERIAL –II

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ABSTRACT:- 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 should be moved to the back tires to push the vehicle forward and turn around. The drive shaft should give a smooth, continuous progression of capacity to the axles.

Composite materials have been broadly used to improve the exhibition of different sorts of designs. Contrasted with ordinary materials, the principle benefits of composites are their better firmness than mass proportion just as high strength to weight ratio. Because of these advantages, composites have been increasingly incorporated in structural components in various industrial fields. Some examples are helicopter rotor blades, aircraft wings in aerospace engineering, and bridge structures in civil engineering applications.
Key ward :- Drive Shaft, Composite Material,

I. INTRODUCTION

Drive shaft is been used in the automobiles. They are mainly used in the commercial vehicles such as vans, trucks, SUV's etc. There should be a medium from where the motion from engine is been transferred to the rare wheels. To transfer this motion from the engine to the rare wheels, drive shaft plays an important role. At whatever point the distance between the motor and uncommon wheels is more than 1.5m utilization of two-piece drive shaft is been utilized. Jump shaft is one of the significant pieces of the vehicle, without which we can't move movement from motor to the uncommon wheel easily.

A composite material is characterized as a material made out of at least two constituents joined on a naturally visible scale by mechanical and substance bonds. Numerous composite materials offer a mix of solidarity and modulus that are either tantamount to or better than any customary metallic materials. As a result of their low explicit gravities, better solidarity to weight-proportion and modulus weight-proportions, these composite materials are better than those of metallic materials. The exhaustion strength weight proportions also as fatigue damage tolerances of composite laminates are very excellent. Because of these reasons, fiber composite have developed as a major class of structural material and are good choice for metals in many weight-critical components in aerospace, automotive and other industries.

In order to conserve natural resources and to reduce energy 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.

II. LITERATURE REVIEW

In the recent days a lot of research has been taken up by various people on the concept of the use of composite materials for power transmitting members. Works taken up by the following people are significant in connection with the present work.

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.

M. A. Badie, et al.,[2] presented in a paper titled, 'Automotive composite drive shaft's investigation of the design variables effects', finite element analysis was performed to investigate the effects of fibers winding angle and layers stacking sequence on the critical speed, critical buckling torque and fatigue resistance. A configuration of a hybrid of one layer of carbon epoxy(0º) and three layers of glass-epoxy (±45º, 90º) was used. The results have shown that, in changing carbon fibers winding angle from 0º to 90º, the loss in natural frequency is 44.5% and shifting from the best to the worst stacking sequence the drive shaft loses 46.07% of its buckling strength, which gain the major concern over shear strength in drive shaft design. Inferences drawn by the authors indicate that the layers of ±45º angles are to be located far at inner side and that of cross-ply configuration located at top face with the 90º layer exposed to outside to increase the fatigue resistance, meaning that the stacking sequence has an effect on fatigue properties.

Y.A. Khalid et al., [3] in paper titled, 'Bending fatigue behavior of hybrid aluminum/composite drive shafts' throws light on the experimental study of a bending fatigue analysis carried out on hybrid aluminum/composite drive shafts. Glass fiber with a matrix of epoxy resin and hardener were used to construct the external composite layers needed. Four cases were studied using aluminum tube wounded by different layers of composite materials and different stacking sequence or fiber orientation angles. The failure mode for all the hybrid shafts was identified. The macroscopic level tests indicate that the cracks initiating in the zones free of fibers or in the outer skin of resin and increase with increasing number of cycles until the failure of specimen. It has also been noticed that there is no fiber breakage from the rotating bending fatigue test. Results obtained from this study show that increasing the number of layers would enhance the fatigue strength of aluminum tube up to 40%, for [±45]3s.

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 major concern 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.

D. Jebakani and T. Paul Robert, [6] in their work 'Particle Swarm Optimization for RBDO of Composite Drive Shaft', considered the effect of variations in material and geometric properties by applying the structural reliability theory. Here in this reliability based composite drive shaft design optimization which incorporates uncertainties in engineering design is presented. The effect of the uncertainties in material and geometric properties is considered to quantify the probability of failure. Particle Swarm Optimization (PSO), an evolutionary algorithm is applied to determine the optimal values of the critical design parameters of the composite drive shaft. Monte-Carlo reliability estimation method is used to evaluate various designs in order to obtain the optimal stacking sequence for specific target reliability.

M. R. Khoshravan et al., [7] presented 'Design Method and Vibration Analysis of Composite Propeller Shafts'. In this paper, they aimed to replace a metallic drive shaft by a two-piece composite drive shaft. Parameters such as critical speed, static torque and adhesive joints are studied as a prerequisite to composite shaft design; the behavior of materials is considered nonlinear isotropic for adhesive, linear isotropic for metal and orthotropic for composite shaft. Along with the design all the analyses were performed using finiteelement software (ANSYS). The results show significant points about optimum design of composite drive shafts.

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.

M .S. Qatu and J. Iqbal [9] in their work 'Transverse vibration of two-segment cross-ply composite shafts with a lumped mass' discuss about the advantages of having higher stiffness to weight ratio and strength to weight ratio that composite materials have resulted in. Positive impacts on attributes like fuel economy, performance and possibly noise, vibration and harshness (NVH) that weight savings has in automotive engineering is also discussed. This paper presents an exact solution for the vibration of a cross-ply laminated composite driveshaft with an intermediate joint as the design of the driveshaft of an automotive system is primarily driven by its natural frequency. The joint is modeled as a frictionless internal hinge. The Euler Bernoulli beam theory is used. Lumped masses are placed on each side of the joint to represent the joint mass. Equations ofmotion are developed using the appropriate boundary conditions and then solved exactly.

R. A. Oza, and S. P. Patel [10] presented their work 'Analysis and Optimization of Drive Shaft in Eccentric Mechanical Press'. In this paper, first the model is prepared on pro/Engineer software and after that the analysis work on Ansys is carried out for comparing the different parameters such as bending stress, shear stress and deflection of the shaft for existing condition as well as the new design developed for this condition. Then weight reduction is checked by using E-Glass/Epoxy and HM-Carbon / Epoxy materials.

III. CAD Drawing of Testing Shaft Sample

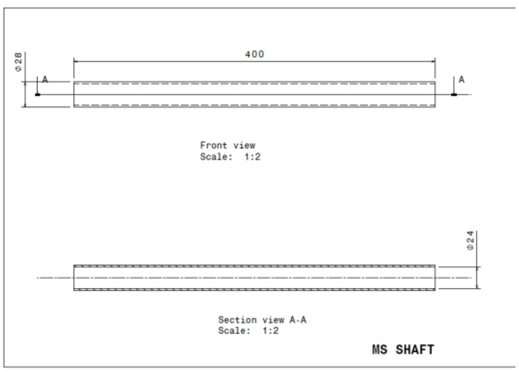

Fig 1.- Drawing of MS Shaft for Analysis

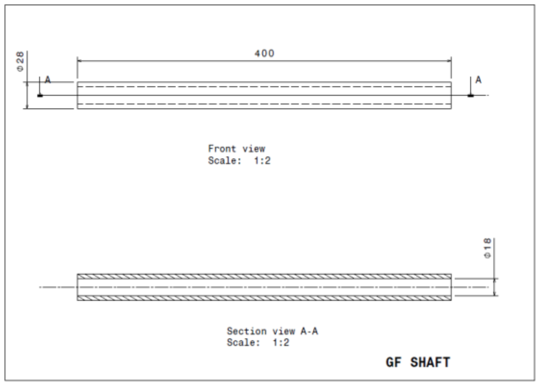

Fig 2.- Drawing of GF Shaft for Analysis

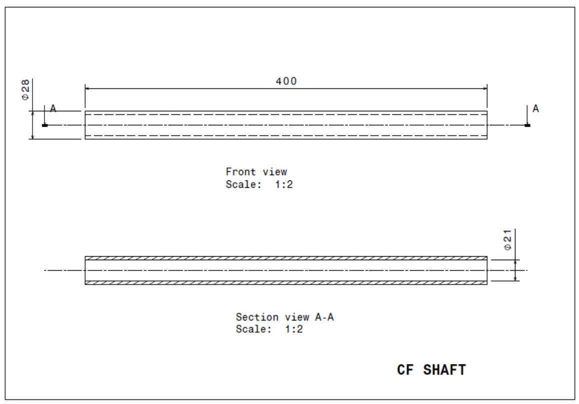

Fig 3.- Drawing of CF Shaft for Analysis

IV. ANALYSIS

Boundary Condition

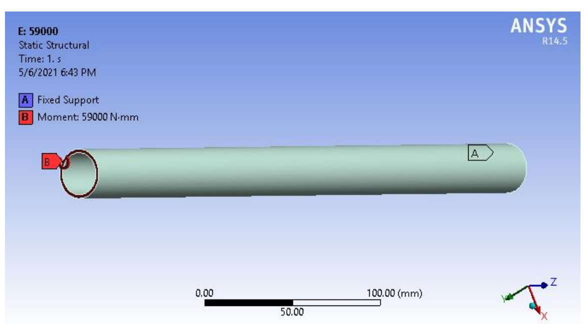

Fig 4. Boundary analysis MS Shaft for Analysis

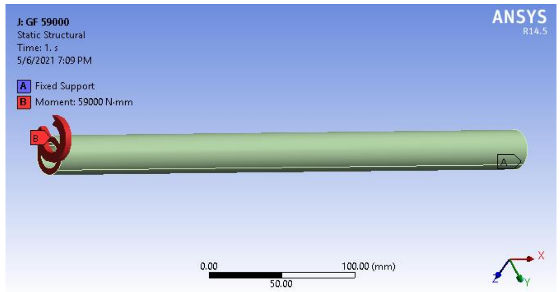

Fig 5. Boundary analysis GF Shaft for Analysis.

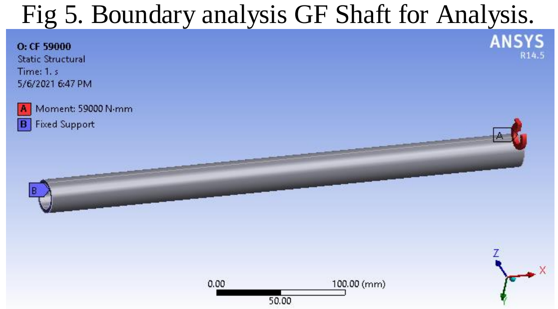

Fig 6. Boundary analysis CF Shaft for Analysis

V. Result in ANSYS

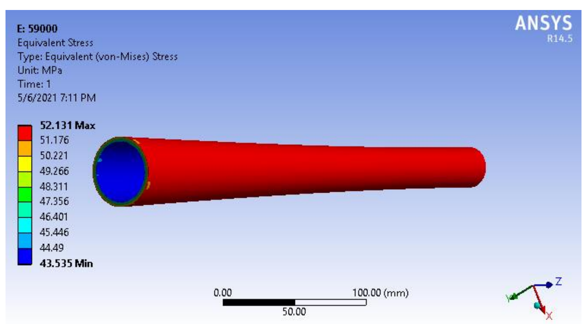

Fig. 7. Stress result in MS Shaft

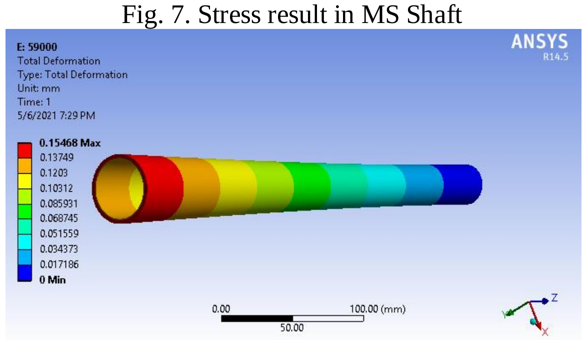

Fig.8.Deformation result in MS Shaft

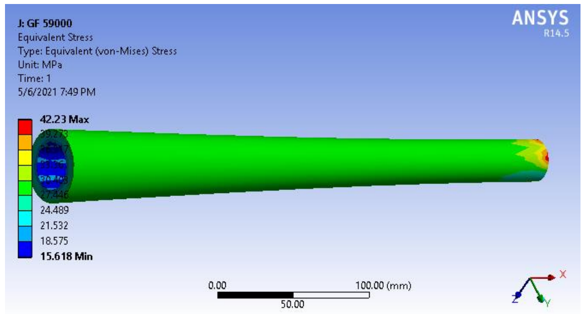

Fig.9.Stress result in GF Shaft

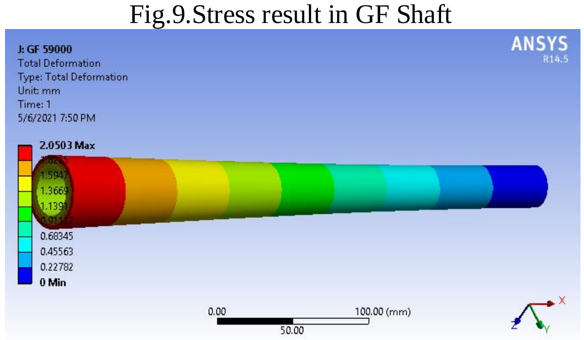

Fig.10.Deformation result in GF Shaft

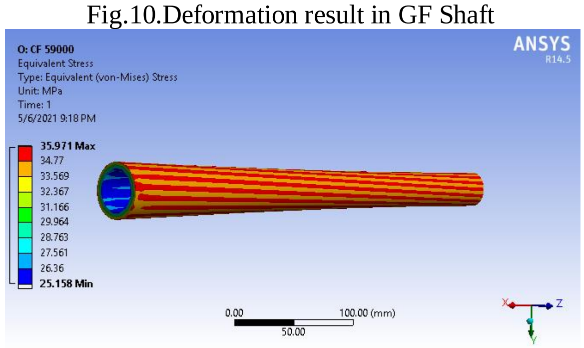

Fig.11.Stress result in CF Shaft

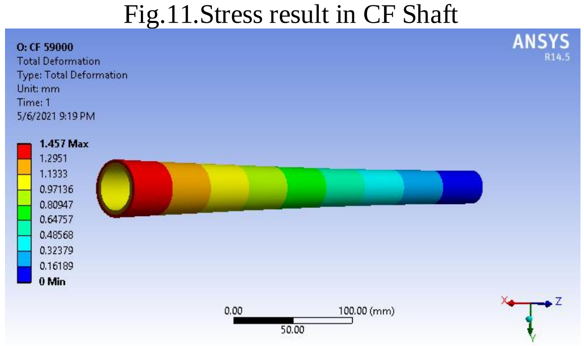

Fig.12.Deformation result in CF Shaft

5.1 RESULT TABLE

Result table shows all result of shaft after applied a force of 59000Nmm

Table 1. Result of all shaft by using ANSYS

Sr.No.	Material	Stress (MPa)	Deformation (mm)
1	MS	52.13	0.15
2	GF	42.23	2.05
3	CF	35.97	1.45

VI. CONCLUSION

Reducing weight and increasing strength of products have high demands in the automobile world. Composite materials can satisfy these demands significantly. The current work includes the static investigation of ordinary steel shaft and composite shaft. From the outcomes acquired it is reasoned that, Comparison of the outcomes shows that the Carbon fiber composite shaft having good result than other shaft. Also we concluded that the deformation in carbon fiber 1.45mm is under the maximum limit. So it's also safe for drive shaft application.

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