

Comparative Study of Different Types of Shaft

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ABSTRACT: This study is focused on the shaft which is used in industry for transferring the torque from one end to another. While transferring the torque there is sever damages occurred on shaft. Stainless steel was mainly used because of its high strength. But this stainless steel shaft has less specific strength and less specific modulus. Stainless steel has less damping capacity. Because of its higher density of molecules of stainless steel, its weight is very high. Also creping occurs on the surface of shaft and after creping on the surface and due to that continuous deformation is done on the shaft and after some time shaft will get break. Due to that lots of accidents are happened in industry. Due to the failure of shaft the machine will unable to work and so that will directly effects on the production of company. So need is arises to avoid or minimize accidents and increase pre notice time to change shaft before it will fail. Also we focused on to minimize the weight of shaft so that it will give more efficiency that older ones.

KEYWORDS: ANSYS, Composite Material, Drive Shaft

I. INTRODUCTION

Nowadays, composite materials are used in large volume in various engineering structures including spacecrafts, airplanes, automobiles, boats, sports' equipments, bridges and buildings. The widespread use of composite materials in industry is due to the excellent characteristics such as, specific strength and specific hardness or strength-weight ratio and hardness-weight ratio. The application of composite materials started first at the aerospace industry in 1970s, but nowadays after only three decades, it has been developed in most industries. Meanwhile, the automotive industry, considered as a pioneer in every country, has been benefited from the properties and characteristics of these advanced materials. Along with progress in technology, metallic automotive parts have been replaced by composite ones. Power transmission drive shafts are used in many applications, including cooling towers, pumping sets, aerospace, structures, and automobiles.

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. Drive shafts are utilized as force transmission tubing in numerous applications, including cooling towers, siphoning sets, aviation, trucks and autos. In the structure of metallic shaft, knowing the force and the reasonable shear worry for the material, the size of the pole's cross segment can be resolved. The conventional steel material is replaceable by advanced composite materials. In metallic shaft configuration, knowing the force and the passable help shear worry for the material permits the size of the pole's cross-segment to be resolved. The composite drive shaft has favorable circumstances like impressive weight decrease, symmetric composite guaranteed the dynamic equalization of speeding up, electrically non conductive, custom end fitting contemplations, vibrations and cruelty, long weariness life and furthermore it diminish the bearing and diary wear. The materials typically have a lower modulus of versatility which brings about when force tops are happened the drive shaft may fills in as a safeguard.

Composites have just demonstrated their value as weight-sparing materials, the current test is to make them financially savvy. Definition expressed by Jartiz "Composites are multifunctional material frameworks that give attributes not realistic from any discrete material. They are durable structures made by truly joining at least two good materials, distinctive in creation and qualities and in some cases in structure". They have high explicit modulus and quality, diminished loads. Because of the weight decrease, fuel utilization will be diminished. They have high damping limit thus they produce less vibration and clamor. They have great consumption opposition. More noteworthy force limits than steel or aluminum shaft. The key regular recurrence of the carbon fiber composite drive shaft can be twice as high as that of steel or aluminum in light of the fact that the carbon fiber composite material has multiple occasions the particular solidness of steel or aluminum, which makes it conceivable to make the drive shaft of traveler vehicles in a single piece.

Composite materials have been regarded as potential candidates for manufacturing drive shafts because of their high specific stiffness and strength. Previous studies on this topic have dealt mainly with composite shaft design in the subcritical case that is when the first critical speed is never exceeded. However, when a long driveline is required (in the case of helicopters, tilt-rotors, tailless aircraft with twin turboprops, etc.), an additional means of increasing the drive shaft length consists in operating above the first critical speed, in the so-called supercritical regime. The main advantage of long shafts is that they reduce the number of bearing supports required, and thus greatly decrease the maintenance costs and the weight of the driveline. The design process is more complex, however, because the shaft has to cross a critical speed, and dynamic instabilities due to rotating damping can occur in this regime. Aeronautic applications lend themselves well to operating in the supercritical regime because the driveline always rotates at the nominal speed during flight, since they undergo acceleration and deceleration processes on the ground.

II. RELATED WORK

M.A. Badie, et al. (2011) This paper examines the effect of fiber orientation angles and stacking sequence on the torsional stiffness, natural frequency, buckling strength, fatigue life and failure modes of composite tubes. Finite element analysis (FEA) has been used to predict the fatigue life of composite drive shaft (CDS) using linear dynamic analysis for different stacking sequence. Experimental program on scaled woven fabric composite models was carried out to investigate the torsional stiffness. FEA results showed that the natural frequency increases with decreasing fiber orientation angles. The CDS has a reduction equal to 54.3% of its frequency when the orientation angle of carbon fibers at one layer, among other three glass ones, transformed from 0 to 90. On the other hand, the critical buckling torque has a peak value at 90 and lowest at a range of 20–40 when the angle of one or two layers in a hybrid or all layers in non-hybrid changed similarly. Experimentally, composite tubes of fiber orientation angles of ± 45 experience higher load carrying capacity and higher torsional stiffness. Specimens of carbon/epoxy or glass/epoxy composites with fiber orientation angles of ± 45 show catastrophic failure mode. In a hybrid of both materials, $[\pm 45]$ configuration influenced the failure mode.

Y.A. Khalid, et al. (2007) Throughout this experimental study, a bending fatigue analysis was carried out for hybrid aluminum/composite drive shafts. The hybrid shafts used were fabricated using filament winding technique. 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 $[\pm 45]$.

Z. Pater, et al. (2015) This paper presents the numerical and experimental results of producing hollow parts by a new method of rotary compression. First, the most popular methods for producing axisymmetric hollow parts are described. Next, the paper examines the forming of such parts by rotary compression. With the method, a hollow billet is shaped by tools that both rotate and translate relative to the axis of the billet. In order to estimate the technological viability of rotary compression, we numerically model the rotary compression process for a drive shaft by the finite element method. The 3D FEM simulations are performed using the Simufact Forming software suit. Thermal phenomena are investigated. The numerical results are then verified under laboratory conditions. The experimental results show a good agreement with the FEM results, which confirms that hollow parts such as stepped axes and shafts can be produced by rotary compression.

S.A. Mutasher, et al. (2018) A hybrid aluminum/composite is an advanced composite material that consists of aluminum tube wound onto outside by layers of composite material. The result from this combination is a hybrid shaft that has a higher torque transmission capability, a higher fundamental natural bending frequency and less noise and vibration. This paper investigates the maximum torsion capacity of the hybrid aluminum/composite shaft for different winding angle, number of layers and stacking sequences. The hybrid shaft consists of aluminum tube wound outside by E-glass and carbon fibers/epoxy composite. The finite element method has been 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 show that the static torque capacity is significantly affected by changing the winding angle, stacking sequences and number of layers. The maximum static torsion capacity of aluminum tube wound outside

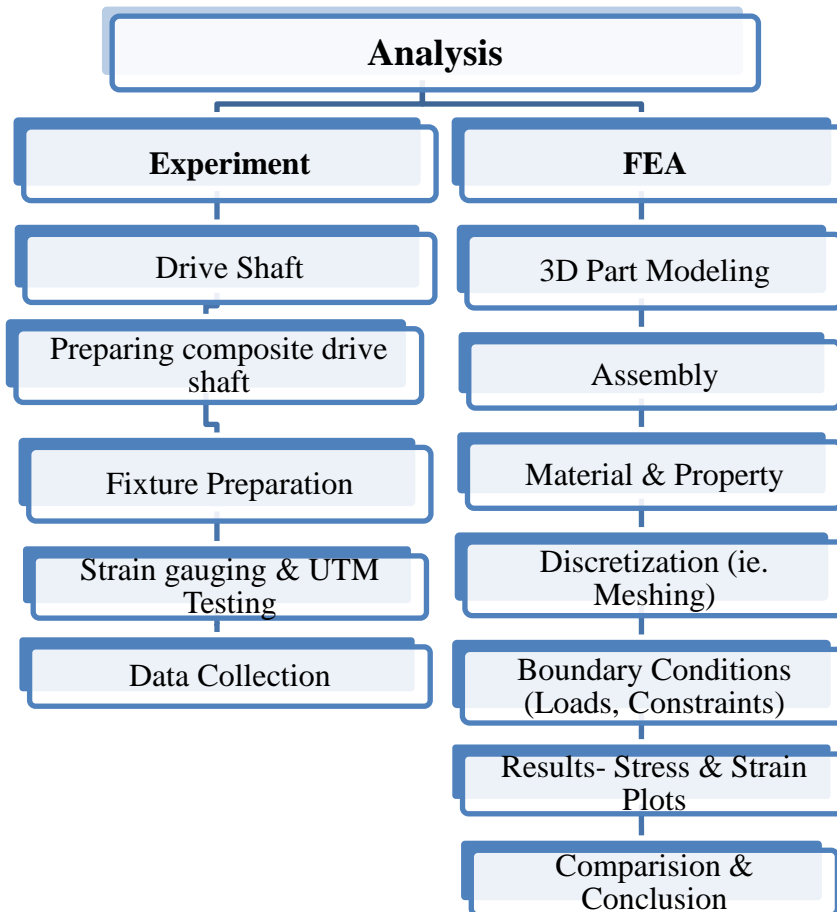
by six layers of carbon fiber/epoxy composite at winding angle of 45 was 295 Nm. Good agreement was obtained between the finite element predictions and experimental results..

III. METHODOLOGY

Modeling of steel shaft.

- a) Analyzing for stresses, deformation and reaction moments.
- b) Preparing epoxy reinforced steel shaft.
- c) Analyzing for stresses, deformation and reaction moments on composite shaft.
- d) Experimental testing on Torsion Testing Machine and correlating results.

In order to achieve the objective stated above, methodology comprised design and analysis techniques, was adopted in the study. The study of shaft can be achieved through the literature review and discussed in chapter one. The designing and analysis methodology of the regular shaft and modified composite shaft has discussed in chapter three and four. The modeling and designed has carried by Catia software and analysis carried by the FEA software. Analysis was carried for stresses, deformation and reaction moments. Based on the analysis composite shaft was prepared and experimental testing has been carried on Torsional testing machine.



IV. EXPERIMENTAL RESULTS

CAD modeling

CAD modeling of rotor tool has created by using the design software.CATIA has sound establishment programming that permits clients to extend further usefulness with every segment. CATIA has the core modeling strengths and satisfies the need of design engineer. We carried four cases for designing of shaft namely:

- a) Regular SS Shaft
- b) Composite shaft with 5mm epoxy glass material
- c) Composite shaft with 7mm epoxy glass material

- d) Composite shaft with 10mm epoxy glass material

The details of designing are given below

Regular SS Shaft

Mostly regular shaft is made up of Structural Steel. We designed shaft in CATIA V5 by using dimensions of 70mm in diameter and 1000mm in length. Drafting is also done by using CATIA V5.

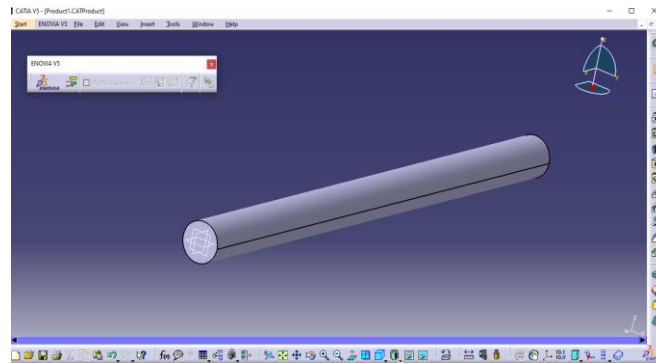


Fig.1. CAD model of SS shaft

Composite shaft with 5mm epoxy glass material

Composite shaft is made up of epoxy glass material and Structural Steel. In this case we took dimension of shafts are 65 mm diameter of SS shaft with the coating of 5mm epoxy glass material and with the length of 1000 mm. Designing and drafting is done in CATIA v5

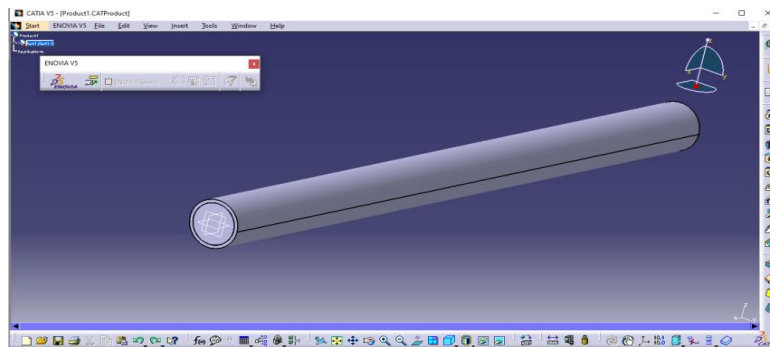


Fig.2. CAD model of Composite shaft with 5mm epoxy glass material

Composite shaft with 7mm epoxy glass material

Composite shaft is made up of epoxy glass material and Structural Steel. In this case we took dimension of shafts are 63mm diameter of SS shaft with the coating of 7mm epoxy glass material and with the length of 1000 mm. Designing and drafting is done in CATIA v5

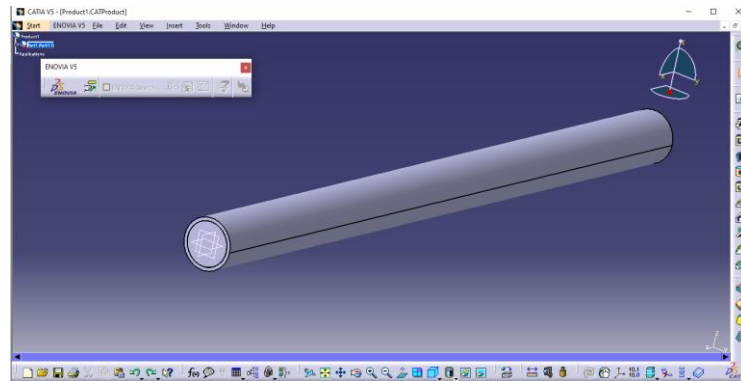


Fig.3. CAD model of Composite shaft with 7mm epoxy glass material

Composite shaft with 10mm epoxy glass material

Composite shaft is made up of epoxy glass material and Structural Steel. In this case we took dimension of shafts are 60mm diameter of SS shaft with the coating of 10mm epoxy glass material and with the length of 1000 mm. Designing and drafting is done in CATIA v5

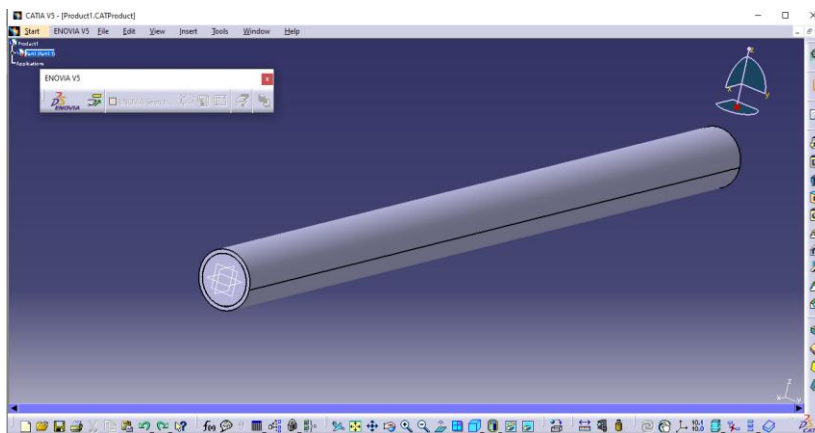


Fig.4. CAD model of Composite shaft with 10 mm epoxy glass material

Finite element study analysis of rotor tool has carried by analysis software i. E. ANSYS. ANSYS used to simulate engineering problems. The software creates simulated CAD models of machine components i.e. Rotor tool to simulate strength, toughness, stress and deformation.

We carried four cases for FEA of shaft namely:

- a. Regular SS Shaft

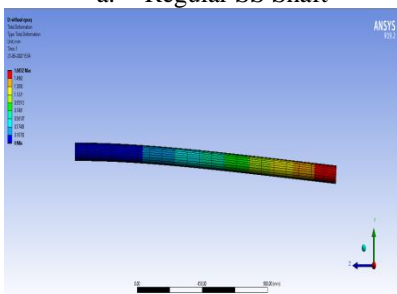


Fig.5.Total Deformation

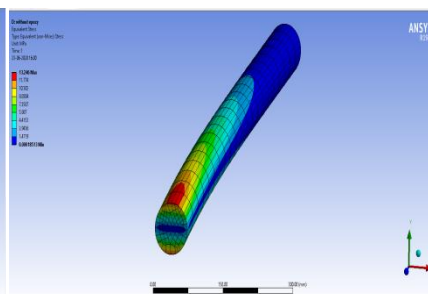


Fig.6. Equivalent Stress

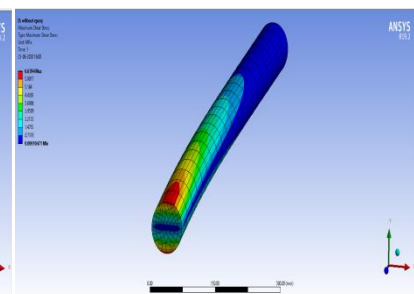


Fig.7. Shear Stress

b. Composite shaft with 5mm epoxy glass material

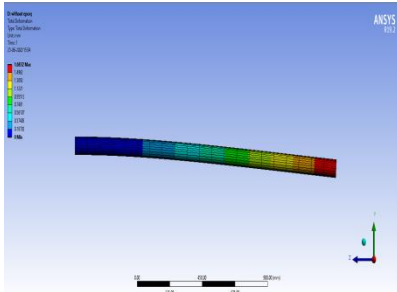


Fig.8.Total Deformation

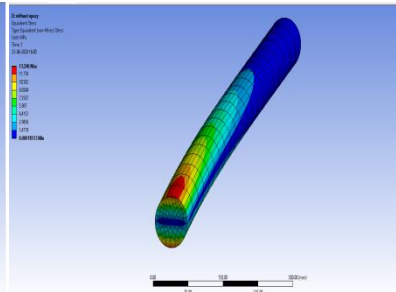


Fig.9. Equivalent Stress

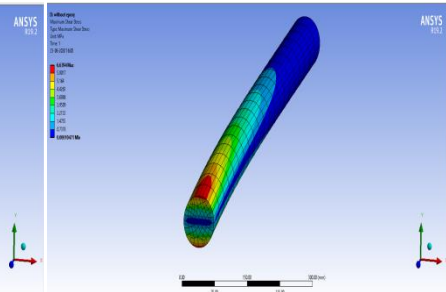


Fig.10. Shear Stress

c. Composite shaft with 7mm epoxy glass material

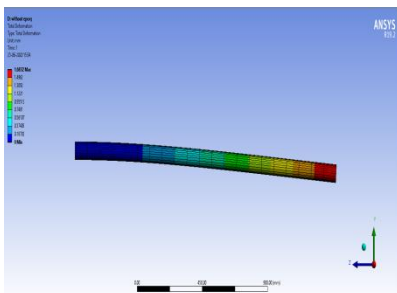


Fig.11.Total Deformation

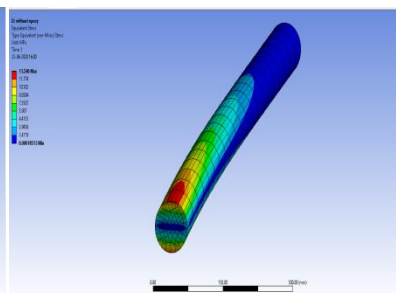


Fig.12. Equivalent Stress

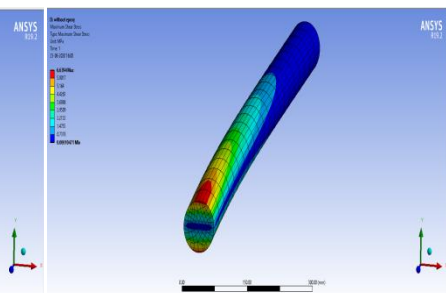


Fig.13. Shear Stress

d. Composite shaft with 10mm epoxy glass material

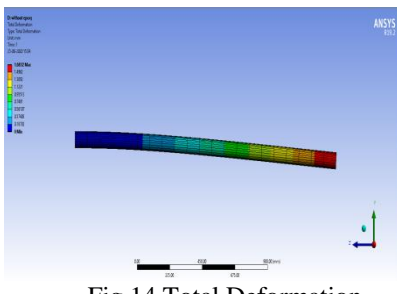


Fig.14.Total Deformation

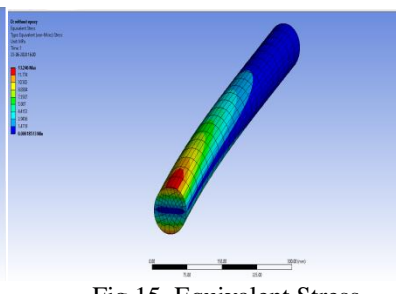


Fig.15. Equivalent Stress

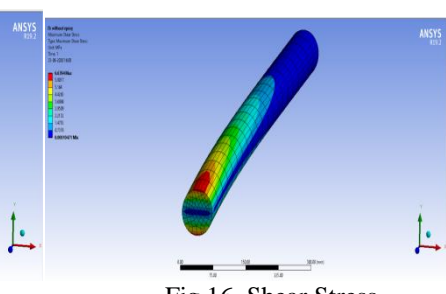


Fig.16. Shear Stress

V. CONCLUSION

In last chapter by using analysis we get the values of all four cases. By comparing it we are able to decide how much thickness we should use to make our composite shaft. Data of last chapter is given in Table 1.

Table 1. Result comparison of all types of shaft

Type of shaft	Weight (kg)	Total deformation(mm)	Equivalent Stress(MPa)	Shear Stress(MPa)
SS Shaft	117	1.6832	13.246	6.6394
Composite shaft with 5mm epoxy glass material	105	2.3759	15.97	8.031
Composite shaft with 7mm epoxy glass material	101	2.7732	17.447	8.746
Composite shaft with 10mm epoxy glass material	94	3.5745	19.934	10.33

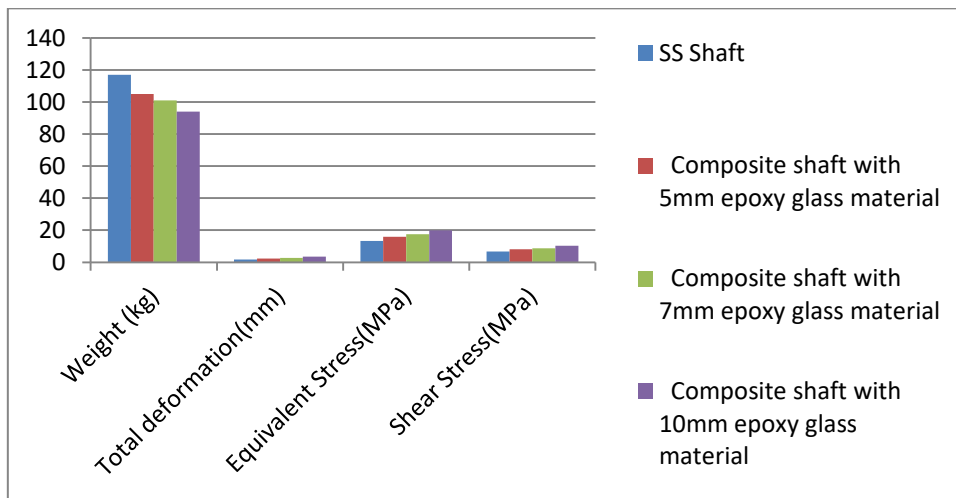


Fig.16. Result comparison of all types of shaft

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