Design and Structural Analysis of Half Shaft by using Different Materials

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Abstract: In this study, the design and analysis of half shaft are compared with different materials.The main concept of our project is to reduce the weight of automotive half shaft with the utilization of composite material. Composite materials have been played an important rolein automotive components because of their properties such as low weight, high specific stiffness, corrosion free, ability to produce complex shapes, high specific strength and high impact energy absorption etc.As the automotive half shaft is a very important component of vehicle. A shaft has to be designed to meet the stringent design requirements for automotive. In this project,We can use different materials like Steel(AISI 1053),Titanium Alloy(ti-6al-7Nb), Aluminum Alloy(al-6061) and Carbon Epoxy hybrid Composite for the half shaft.In this, half shaft is subjected to torsion. Efforts have also been carried out for modelling of the Half shaft on Catia V5 and fem based structural behaviour of different material were studied. Ansys 14.0 is used as the analysis tool in the present work to determine the total deformation, equivalent stress and the equivalent elastic strain. Also check theloads and stresses.By getting best result we can choose that material for the half shaft.

KEYWORDS: Half Shaft, Ansys, Static Analysis.

DOI of the Article: https://doi.org/10.46501/GIETME34

Available online at: http://ijmtst.com/vol7si05.html

As per UGC guidelines an electronic bar code is provided to seure your paper

To Cite this Article: Durga Satish A; Ajay Kumar CH; Naveen B; Bhavya Teja V and Gowthami K[5]. Design and Structural Analysis of Half Shaft by using Different Materials. *International Journal for Modern Trends in Science and Technology* 2021, *7*, pp. 216-222. https://doi.org/10.46501/GIETME34

Article Info. Received: 12 June 2021; Accepted: 16 July 2021; Published: 20 July 2021

INTRODUCTION

1.1 ROLE OF HALF SHAFT

A Half Shaft is essentially a drive axle, and it's so named because it does half of the job, extending from a transaxle or differential to one of the wheels. Its twin on the other side completes the set. This half shaft is used to design by students for Formula SAE competition for the specifications. Half shaft is assembly of shalf and wheel hub. Half shafts are used as power transmission and used in many applications, like cooling towers, pumping sets, aerospace, trucks and automobiles.

1.2 ROLE OF COMPOSITE MATERIALS

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 in various industrial fields. Some examples are helicopter rotor blades, aircraft wings in aerospace engineering, and bridge structures in civil engineering applications.

A material composed of two 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.

PAPER STRUCTURE

The paper is organized as follows: In Section 1, The introduction of the paper is provided along with the structure, important terms, objectives and overall description. In Section 2, We discuss about the related works. In Section3, We havethe information about design of half shaft. Section 4,
We have discuss about different materials used in half shaft and it's properties.Section 5, Shares information about the finite element analysis. Section 6,Discusses the methodology and results. Section 7,Future Scope andConclusion.

OBJECTIVES

In this work an attempt has been made to replace the Half shaft of Steel(AISI1053) alloy with different materials like Titanium Alloy(ti-6al-7Nb), Aluminum Alloy(al-6061) and Carbon Epoxy hybrided Composite.By getting best result we can choose that material for the half shaft.

RELATED WORK

There are numerous works that have been done related to design and analysis of half shaft by comparing with different composite materials.

S Dharmadhikari J P Giri et al [1] Study deals with design and analysis of composite drive shaft using Ansys and genetic algorithm.

S Shinde et al [2]This paper deals with Design of propeller shaft For Mahindra considering torque capacity, Shear stress, and critical rpm requirement. And epoxy and aluminum material used for replacement of conventional shaft.

Bhirud P.P et al[3]This paper deals with the replacement of steel shaft with E glass resign composite drive shaft. ANSYS is used as analysis software.

Salaisivabalan T et al [4] This paper deals with propeller shaft of MARUTI OMNI to design shaft for its minimum dimension. then part can be created in NX 8.5 and after modeling Torsional bucklinganalysis and model analysis can be carried out in NX NASTRAN. Obtained results can be compared.

Parshuram D et al[5]In this work studied weight optimization of the shaft by using the composite material. design of the shaft is carried out in CATIA and analysis is carried out in ANSYS

H banker et al [6] They studied various composite materials for the composite drive shaft. This paper deals with various composite propeller shaft material like E glass/epoxy, HS carbon/Epoxy, HM Carbon/epoxy, Polystyrene etc. he compared various materials propeller shaft. And analysis is carried out in ANSYS software.

DESIGN OF HALF SHAFT

Geometry of the Half Shaft is a assembly of shaft and wheel hub and all essential information to create the model.CATIA software packages allow for modeling and simulation of 3D parametric modeling of Half shaft in Ansys. It also a good interface with Finite Element software.

We taken following specifications of the Half shaft are assuming

Design parameters for Half-shaft

- L - Length ofshaft
- D_o - Outer diameter ofshaft
- D_i - Internal diameter ofshaft
- T- Maximum Torque applied by differential on shaft
- Σ–Maximum Normal Stress onshaft
- T–Maximum Sheer Stress onshaft
- J–Polar Moment of Inertia ofshaft
- G – Modulus ofRigidity

Design parameters of Wheel Hub

- n – Number of Bolts
- b - Bolt circle diameter
- d - Flange diameter is measured between opposite holes
- S - Spoke hole diameter
- W – width centre to flange
- P - Load capacity is the amount of weigth a wheel will carry

4. MATERIALS USED FOR HALF-SHAFT AND ITS PROPERTIES

4.1 Medium carbon Steel(AISI 1053)

Medium Carbon Steel have carbon deliberations between 0.25% and 0.60%. These steels may be heat-treated by austenlizing, quenching, and then tempering to recover their mechanical properties. On a power-to-cost basis, the heat-treated medium carbon steels provide great load carrying capacity.

PROPERTIES:

PROPERTIES	STEEL
Density	7850kg/m^3
Young's Modulus	2E+05MPa
Poisson's Ratio	0.3
Tensile Yield Strength	250MPa
Compressive Yield Strength	250MPa
Tensile Ultimate Strength	460MPa

4.1 Titanium Alloy (Ti-6Al-7Nb)

Ti-6Al-7Nb (UNS designation R56700) is an alpha-beta titanium alloy first synthesized in 1977. It featuring high strength and have similar properties as the cytotoxic vanadium containing alloy Ti-6Al-4V. Ti-6Al-7Nb is used as a material for hip protheses. Ti—6Al—7Nb is one of the titanium alloys that built of hexagonal α phase (stabilised with aluminium) and regular body-centred phase β (stabilised with niobium)

PROPERTIES:

PROPERTIES	TITANIUM
Density	4500kg/m^3
Young's Modulus	116*E^3MPa
Poisson's Ratio	0.34
Tensile Yield Strength	880MPa
Compressive Yield Strength	970MPa
Tensile Ultimate Strength	950MPa

4.3Aluminium Alloy (Al 6061 Alloy)

6061 is a precipitation-hardened aluminium alloy field magnesium and silicon as its main alloying origins. First named "Alloy 61S", it was established in 1935. It has decent mechanical properties, exhibits good weldability and is very commonly extruded (second in popularity only to 6063). It is one of the most common alloys of aluminium for general-purpose use.

PROPERTIES:

PROPERTIES	ALUMINIUM ALLOY (6061)
Density	2680kg/m^3
Young's Modulus	68.3*E^3MPa
Poisson's Ratio	0.34
Tensile Yield Strength	290MPa
Compressive Yield Strength	700MPa
Tensile Ultimate Strength	310MPa

4.4 Carbon Epoxy Hybrided Composite

Composite materials are produced by combining a reinforcing fibre with a resin matrix system such as epoxy. The carbon-carbon chain has extremely strong molecular bonds and this is what gives the fibres their high strength

PROPERTIES:

PROPERTIES	CARBON EPOXY
Density	1470Kg/m^3
Longitudinal Modulus	123.6GPa
Poisson's Ratio	0.328
Transverse Modulus	7.4
Shear Modulus	4.28

FINITE ELEMENT ANALYSIS

Finite Element Method is the easy technique as compared to the theoretical methods to calculate the stress developed in half shaft. Therefore, FEM is widely used for the stress analysis of half shaft. FE analysis is done in ANSYS Workbench to determine the maximum stresses for half shaft and also the deformation is found out for the half shaft. the half shaft is created in CATIA It is imported as CATpart extension a file in ANSYS Workbench.

ANALYSIS OF TOTAL DEFORMATION OF STEEL(AISI 1053)

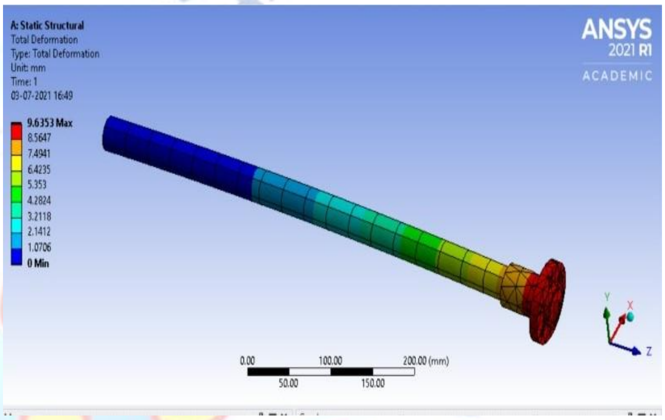

Figure 5.1

The Total Deformation of the Steel are 9.6353 are results obtained by the after analysis

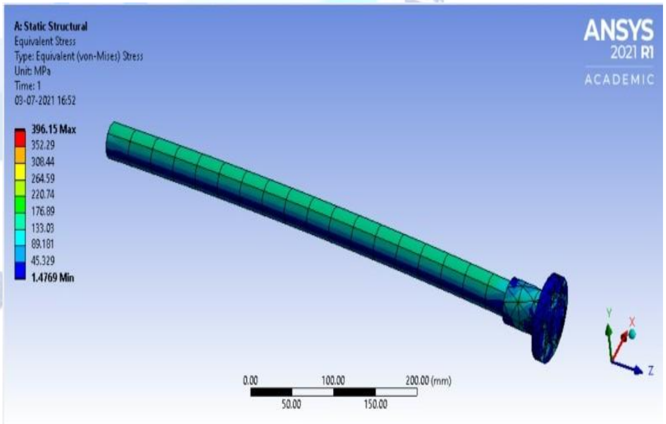

Figure 5.2

The Equivalent Stress of the Steel are 396.15Mpa are results obtained by the after analysis

ANALYSIS OF EQUIVALENT STRESSES OF DIFFERENT MATERIALS

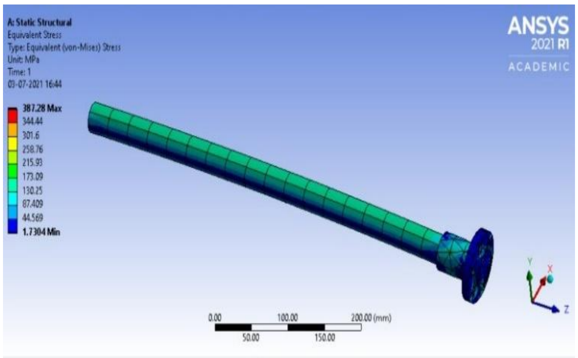

Figure 5.3

The Equivalent Stress of the Titanium alloy are 387.28Mpa are results obtained by the after analysis

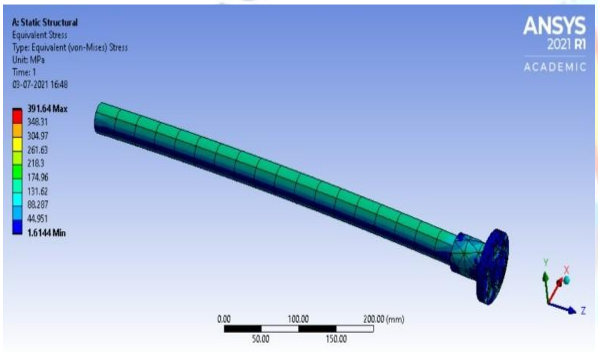

Figure 5.4

The Equivalent Stress of the Aluminium alloy(6061) are 391.64Mpa are results obtained by the after analysis

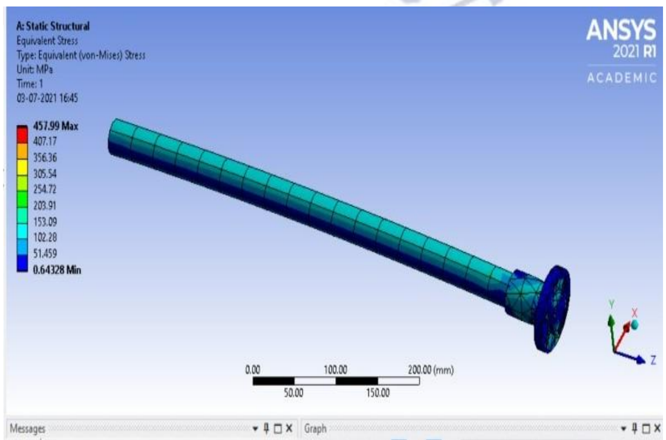

Figure 5.5

The Equivalent Stress of the Carbon Epoxy Composite are 457.99Mpa are results obtained by the after analysis

The Carbon Epoxy Composite material of half shaft has high Equivalent Stress compared to other materials. The conventional steel alloy used for the gear material have disadvantages such as low specific stiffness and strength and high weight. Substituting the composite material for the half shaft have advantage of higher specific strength, less weight, high damping capacity, longer life, high critical speed and greater torque carrying capacity and can results in considerable amount of weight reduction as compared to steel .

METHODOLOGY

The Equivalent stress and Total Deformation is the crucial parameters during the analysis of half shaft,When the torsion is applied in the shaft.Due to momentum the carbon steel has occurs failures so we compare design and analysisof half shaft with different materials

Torsion can be solved using the following formula:

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G \times \theta}{L}$$

where:

- T = torque or twisting moment, [N×m, lb×in]
- J = polar moment of inertia or polar second moment of area about shaft axis, [m^4, in^4]
- τ = shear stress at outer fibre, [Pa, psi]
- r = radius of the shaft, [m, in]
- G = modulus of rigidity (PanGlobal and Reed's) or shear modulus (everybody else), [Pa, psi]
- θ = angle of twist, [rad]
- L = length of the shaft, [m, in]

RESULTS AND DISCUSSION

Equivalent stress and Total Deformation for carbon steel and different materials like (TitaniumAlloy(ti-6al-7Nb),AluminumAlloy(al-6061, Carbon epoxy hybrid Composite), is calculated in ANSYS

Table 6.0 is the analysis of Carbon Steel Half shaft and different materials are tabulated below

MATERIALS	TOTAL DEFORMATION(MM)	EQUIVALENT STRESS(MPA)	EQUIVALENT ELASTIC STRAIN(MM/MM)
STEEL	9.6353	396.15	0.0024614
TITANIUM (Ti-6al-7 Nb)	16.586	387.28	0.0041509
ALUMINIUM (6061)	27.51	391.64	0.0069533
CARBON EPOXY	39.77	457.99	0.068106

Table 6.1

6.2The Weight Comparision Between Steel Half Shaft with different materials

The weight of Carbon Epoxy composite Half shaft is less as compared to other material such as steel, Aluminium (6061)alloy and Titanium (ti-6al-7Nb) is shown in figure below.

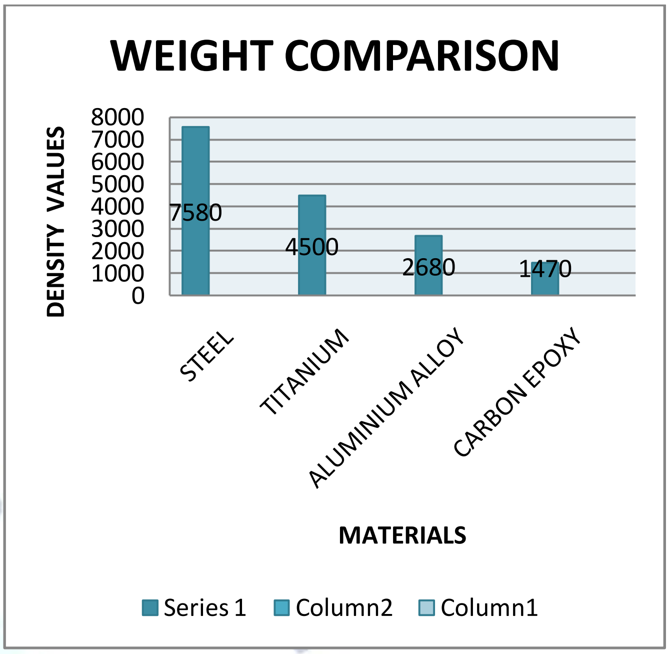

Table 6.2.1

FUTURE SCOPE AND CONCLUSION

The replacement of steel drive shaft results in a reduction of weight of automobile vehicle. FEA analysis is used to predict deformation of the shaft.Here we compared with different materials among them Titanium material for designing of the drive shaft is excluding the cost of the material. When incuding the cost of the material the titanium is not so preferable material then the other two material.

It concluded that Aluminium alloy and Carbon epoxy composite material is used as shaft material. The composite material is free from corrosion apart from the lightweight use of composite also ensure less noise and vibration. The weight savings of the High strength carbon/epoxy and high modulus carbon/epoxy shafts were equal to 50 % approximately of the steel shaft. The composite material is recyclable hence able to reuse. Less Fuel consumption because of the light in weight composite shaft than steel shaft.

The future work is to perform same experiment in various components in automotives, It helps in reduction in weight and increase in physical properties. The competetions like SAE AND Formula 1 are used compositehalf shafts in rear wheel driven due to their desired specifications.It has various applications in Automotives

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