Design and Stress Analysis of Composite Helical Gear Using Finite Element Method

Venkatesulu Ch1 | Siva Kumar A2 | Dhanunjaya Naidu A[3] | Jaswanth B[4] | Sreenivasa Reddy K[5]

[1,2,3,4,5]Department of Mechanical Engineering, Godavari Institute of Engineering and Technology (A), Rajahmundry.

Abstract: In this study, the design and stress analysis of composite helical gear are investigated numerically. In recent years it is required to operate machines at varying load and speed. Gear teeth normally fail when load is increased above certain limit. Therefore, it is required to explore alternate materials for gear manufacturing. Composite materials provide adequate strength with weight reduction and they have emerged as a better alternative for replacing metallic gears. In this work an attempt has been made to replace the metallic gears of steel alloy with the composites. The composites consider were the Carbon fiber epoxy composites and carbon fiber silicon carbide composites. Efforts have also been carried out for modelling of the Helical gear 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 bending moment. Composite gears offer improved properties over steel alloys and these can be used as better alternative for replacing metallic gears.

KEYWORDS: Composite helical gear, Carbon fibre epoxy composites, Equivalent stress.

DOI of the Article: https://doi.org/10.46501/GIETME24

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: Venkatesulu Ch; Siva Kumar A; Dhanunjaya Naidu A; Jaswanth B and Sreenivasa Reddy K. Design and Stress Analysis of Composite Helical Gear Using Finite Element Method. *International Journal for Modern Trends in Science and Technology* 2021, *7*, pp. 145-149. https://doi.org/10.46501/GIETME24

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

INTRODUCTION:

Composite material (also called a composition material or shortened to composite) is a material made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure. The new material may be preferred for many reasons: common examples include materials which are stronger, lighter, or less expensive when compared to traditional materials. More recently, researchers have also begun to actively include sensing, actuation, computation and communication into composites, which are known as robotic Materials. In the present work an attempt has been made to replace the conventional steel alloy gear material with composite material having an application in high power transmission system.

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 the related work. In Section3, we have the complete information about design of helical gear. Section 4 shares information about the finite element analysis with meshing of the gear. Section 5 discusses the methodology and results. Section 6 discusses the future scope.

OBJECTIVES

The Composite materials provide adequate strength with weight reduction and they have emerged as a better alternative for replacing metallic gears.

In this work an attempt has been made to replace the metallic gears of steel alloy with the composites. The composites consider were the Carbon fiber epoxy composites and carbon fiber silicon carbide composites.

II.RELATED WORK

There are great deal of researchers and number literatures on gear analysis that has been published. Generally, their major concerns are on the analysis of gear stresses, transmission errors, dynamic loads, noise, and failure of gear tooth, which are very useful for optimal design of gear set. They have used various approaches and means to attain their main intention. The first systematic studies in gear dynamics started in the 1920s by A. A Ross and E. Buckingham [1]. The basic concern in their studies was the prediction of tooth dynamic loads for designing gears at higher speeds.

Vljayaragan and Ganesan [2] presented a static analysis of composite helical gears system using three dimensional finite element methods to study the equivalent stresses at a helical gear tooth. The validity of their results of the FEM was tested by the stress for composite material helical gear and comparing the result with obtained from conventional gear. The paper presented also the evaluation of the performance of composite helical gears by companion of with that of the conventional metallic gear. It is observed from the result that composite materials can be used safely for it is high durability and low Maintenance.

R. Yakut et al.[3] The purpose of the paper is to examine the load capacity of composite helical gears and investigation of gear damage. Further the usability of composite material as helical gear was also investigated.The helical gears were tested by applying different loading at two different numbers of revolutions on the Ansys. The result shows that the usage of Composite materials brings an advantage in many industrial areas because such materials are durability and high load carrying capacity.

Vijayaragan and Ganesan [4] obtained results by static investigation of composite of helical gear using three dimensional finite element approaches. Performance of two orthotropic substances helical gears were given and compared with cast steel gear. Form the result it was presumed that composite materials could be considered as material for power transmission helical gears however the strength is more compared to metalic gears.

Bharat Gupta [5] studied that the helical gear tooth failure take place if Equivalent stresses in the gear are higher than the wear strength of the gear. For research purpose selecting composite helical gear for Equivalent stress analysis. The Equivalent stresses can be calculated by FEA method. The model of gear is formed in the Catia v5 software and imported in the ANSYS for calculates the Equivalent stresses. The result found by two gears (cast steel helical gear and Composite helical

gear) are compared and concluded that difference is within reasonable limit.

Putti Srinivasa Rao [6] studied that The Equivalent stress in the helical gears is the key parameter in gear design. Deformation of the gear is also another key parameter which is to be considered. The study in this paper shows that the complex design problem of helical gear which requires fine software skill for modeling and also for analyzing. The project aims at the minimization of both Equivalent stress as well as Total deformation to arrive at the best possible combination of helical gear. In this process of helical gears,two different materials were selected and the software programme to use analysis. The use of different materials in gear manufacturing provides a range of Equivalentstresses. This range of stresses and deformation is useful in the selection of material in different applications.

III.DESIGN OF HELICAL GEAR

geometry of the helical gear and all essential information to create the model.CATIA software packages allow for modeling and simulation of 3D parametric modeling of helical gear in Ansys. It also a good interface with Finite Element software.

We taken following specifications of the Helical Gear are assumingthe composite helical gear teeth (z) are 18. pressure angle is 20°, module of the composite helical gear is (m) 18mm... the remaining specifications are tabulated below,

Number of Teeth (z)	18
pitch(p)mm	5
Facewidth mm	42
Dedenddumn mm	1.25mn
helix angle	20°
Module mm	18
Pressure Angle	20°

TABLE 3.1

The formula of module is

Module, $m = \frac{d}{Z}$,

diametric pitch=$\frac{Z}{d}$

were Z=Number of teeth

d= diameter of the gear

we are taking into gear material properties given below.the cast steel metal properties are

Density = 7870 kg/m3

Young modulus = 200 GPa

Poisson's ratio = 0.29

Tensile strength = 518.8 MPa

Ultimate Tensile Strength = 540 MPa

Yield Tensile Strength = 415 MPa

Bulk modulus = 140 GPa

The properties of the composite materials are taken by, (50% Carbon Fibers in Epoxy Resin Matrix)

Density = 1800 kg/m3

Young modulus = 450 GPa

Poisson's ratio = 0.30

Tensile strength = 52 MPa

Compressive strength = 600 MPa

Figure 3.1

IV.FINITE ELEMENT ANALYSIS

Finite Element Method is the easy technique as compared to the theoretical methods to calculate the stress developed in teeth of gears. Therefore, FEM is widely used for the stress analysis of helical gears. FE analysis is done in ANSYS Workbench to determine the maximum stresses for steel and composite material. Also the deformation is found out for the gears. the helical model gear is created in CATIA It is imported as CATpart extension a file in ANSYS Workbench.

MESHING

Meshing is done using Tetrahedron mesh with number of elements of 499900 and number of nodes of 2125654. The element size is 0.8 mm. This mesh is used as it is fine and gives least number of elements with good results. This mesh is used as it is fine and gives least number of elements with good results. So the calculation time is reduced.

In this Anlasys we are using Meshing withtetrahedron, if the analysis of the the each and element.doing the meshing operation every element in the gear are clearly analyzed.

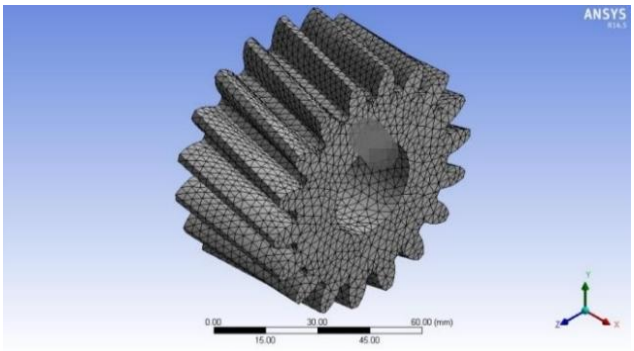

Figure 4.1

BOUNDARY CONDITION OF HELICAL GEAR

The frictional support is less added to the gear to evaluate and model the actual situation as well as the frictionless support on the internal gear is added to facilitate its tangential rotation but to limit the radial transition. applied in clockwise direction as a moving location on the gear.

STATIC STRUCTURAL ANALYSIS

To order to study the action of the system under the constant load pressures, static structural research has been performed thus considering inertia and damping effects as well as load-variable loads. All non-linearity forms, such as large deformations, plasticity, creeping, stress rigidity, contact elements etc. The FEA-based analysis method has been used in this project to investigate the structural behavior, for each composite material, of various compositing materials under the defined boundary conditions, by evaluating overall deformation, equivalent of lost stress for each composite material and then the relation.

V METHODOLOGY

The Equivalent stress and Total Deformation are the crucial parameters during the analysis of helical gears. When the total repetitive load acting on the gear tooth is greater than its strength then the gear tooth will fail .then the metalic gears are failure in more load condition.So as we Stress Analysis the metalic gear as compare with Composite Helical gears.if we are following procedure to the design and Analysis of the Helical Gears.a Cast Steel Helical Gear and Composite Helical Gear are designed in Catia v5.And Analysis in AnsysSoftware.after analysis the composite helical gear results are Equivalent stress, Total Deformation and Max shear stresses are More than the Metalic Cast Steel Helical Gear.Then the composite Helical Gear Much more Better than Cast Steel Helical Gear.if the following formulas are analysing the Stress in the Helical Gears.

$$\sigma_e = \frac{F_t}{b \times m \times j} \times K_V \times K_0 (0.93 \times K_m)$$

$$\sigma_b = \frac{F_t}{b \times m \times Y}$$

were,

K_V=velocity factor,

K_0=over load factor,

m= module,

b=face width,

σ_e=Equivalent Stress,

σ_b=Bending Stress.

VI.RESULTS AND DISCUSSION

Equivalent stress and Total Deformation for Cast steel and Composite Material (Carbon epoxy, Carbonfibre Composites) is calculated in ANSYS. Figure 5.1 shows the Equivalent stress for Composite Gear which gives a stress of 12.8912 MPa. Figure 5.2 shows Total Deformation for composite gear which gives a stress value of 8.021e-3mm.

Table 5.1 is the analysis of Cast Steel Helical Gear and Composite Helical Gear Stress are tabulated below.

	Cast Steel	**Composite Material**
Equilent Stress(Mpa)	12.960	12.8912
Total Deformation	18.073e-3	8.021e-3
MaxShear Stress Mpa	7.376	7.342

Table 5.1

ANALYSIS OF EQUIVALENT STRESSES

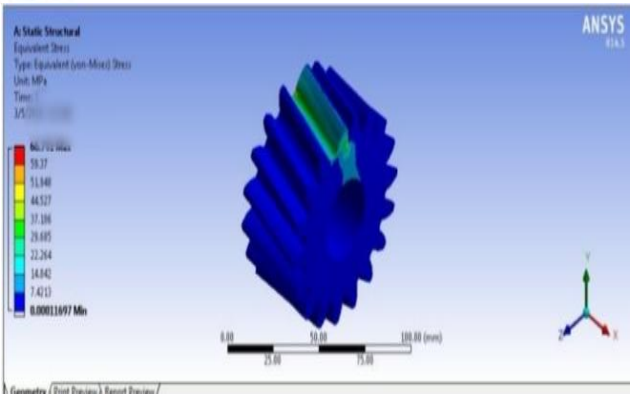

Figure 5.1

The Equivalent Stress of the composite gear are12.891Mpa are results obtained by the after analysis

ANALYSIS OF TOTAL DEFORMATION

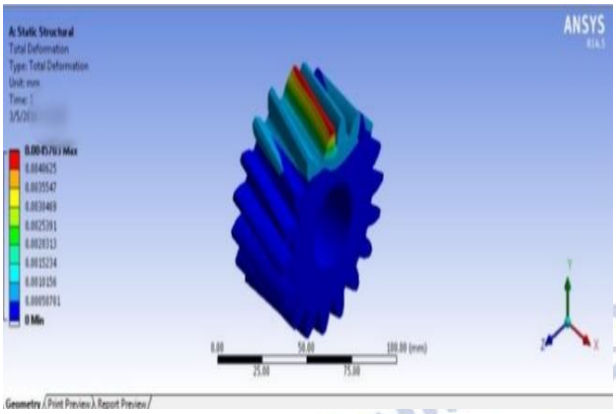

Figure 5.2

The total Deformation of the composite gear is 8.021e-3mm results obtained by the after analysis the composite material helical gear with the matrix material with 18% SiC reinforcement materials, 50% carbon fibre reinforcement in epoxy resin and carbon fibre reinforcement in silicon carbide matrix. 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 gear 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 caststeel.

VI.FUTURE SCOPE AND CONCLUSION

On the basis of that study, the analysis of both cast steel and composite materials (carbon fibre, carbon epoxy composites) are analyzed in the application of gear box drives etc. which is used in automobile vehicles. From these analyses it can be found that stress values for composite materials is less as compared to the cast steel helical gear. So from these analysis results, it can be concluded that, the stress induced, deformation and weight of the composite helical gear is less as compared to the cast steel helical gear. Composite gears offer improved properties over steel alloys and these can be used as better alternative for replacing metallic gears.

The future work is to perform same experiment for different type of gears, find out the effect of varying face width of tooth, and perform thermal analysis for same gear.

REFERENCES

1. A Design of machine element, V.B. Bhandari, third edition, chapter 17-18, page no.646-710
2. VivekKaraveerÅ*, Ashish MogrekarÅ and T. Preman Reynold JosephÅ, " Modelling and Finite Element Analysis of Helical Gear", Dec 2013, International Journal of Current.
3. M. Patil, S. Herakal, S. B. Kerur, "Dynamic Analysis of Composite Helical gear", May- 2014, Proceeedings of 3rd IRF International Conference.
4. Prof. K. Gopinath& Prof. M.M. Mayuram of IIT madras, lecture is given on helical gear of Design of machine element part 2
5. Chawathe D.D, "Handbook of Gear Technology", New Age International Publication, (2011) pp 26-89,305-536, 579-706.
6. ChabraPankaj, Bhatia Amit, "Design and Analysis of Composite Material", International Journal of Mechanical and Civil Engineering, Vol.1(2012), Issue1, pp 15-25.
7. GulaxeaPratik,AwateN.P., "Design, Modelling & Analysis of Gear for Material Handling Trolley: A Review", Mechanica Confab, Vol 2, Issue1, (2013), pp63-70.
8. Hashim J., Looney L Hashmi M.S.J., Metal Matrix Composites: Production by the Stir Casting Method, Journal of Material Processing and Technology, (1999), pp. 17.
9. Shanavas S., "Stress Analysis of Composite Helical Gear", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 2 Issue 12, December – 2013
10. Composites", International Journal of Mechanical and Materials Engineering (IJMME), Vol. 4, Issue No. 2, (2009), 109-11