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Design &Stress Analysis of double helical gear by using Ansys and its Material Optimization

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ABSTRACT

In this research Paper we have studied the deep study about the double helical gear, its details understanding of application and design and the stress generated in it, and also to find out that stresses from gear tooth with the help of fea software and try to minimizes its with replacement of new material for that we have done our study on material optimization with the help to various Materials selection .The selection of better material for double helical gear is determined out of this analysis. This Paper is the result of the analysis carried out by using ANSYS 2021 student version on a 3D model of double helical gear which was generated using catia tool. The results are then compared with the help of graphs.

Keywords— Design, Modeling, Stress, strain, deformation analysis, materials selection

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I. INTRODUCTION

In this research paper we have carried out our deep study on application of double helical gear is used in wide range of heavy torque transmission in marine ships, port cranes, mining, large processing industry, ports, cement mills and many more places, but its tooth failure occurs most probably during torque transmission, and solution for that is to do, the thing we had done the design of double helical gear and made it stress analysis of it. in that analysis we got stress, strain, deformation values, for every different material. From that we had suggested the best suitable material for it manufacturing, in the concerned with strength of materials, its mechanical properties, its thermal properties and its chemical properties also, and one more important point is that we had also thinked about the cost of material and availability of material, it should be easily available while it get to time of manufactured. The finite element method is capable to supply this information but the amount of time, a per-processor method that develops the geometry required for finite element analysis might be utilized, instruments, for example, CATIA. These tools can generate 3Dmodels of gears. The model geometry generated using CATIA is saved as an IGES file and then import it to ANSYS for analysis.

The gear in a transmission is analogous to the wheels in a pulley. The benefit of gears is that the teeth of a gear forestall slipping. At the point when two gears of unequal number of teeth are combined a mechanical advantage is produced, with both the rotational speed and the torques of the two gears contrasting in a simple relationship.

II. LITERATURE REVIEW

1. S. Vijayrangan, N. Ganeshan.

In this paper author has done his work on conventional (steel-like) material helical gears can be replaced by helical gears made of composite materials. This results in light-weight helical gears, which add to the existing list of advantages of helical gears, such as smooth and silent operation and larger load carrying capacity, while at the same time maintaining higher strengths, which is an important requirement in applications like spacecraft and aircraft. In the present work, the performance of Kevlar/epoxy and graphite/epoxy material helical gears has been compared with that of carbon steel helical gears using a three-dimensional finite element method. From the present it may be concluded that composite material helical gears behave similarly to carbon steel helical gears and graphite/epoxy helical gear behaviour is very close to that of carbon steel helical gears, except for the slightly larger displacements at the tip. The safety factor obtained based on the root stress values for the two orthotropic material helical gears is very favourable.

2.R. Mohanraj, S. Elangovan et. all,

In the perspective of exploratory analysis into the theoretical concept and performance characteristics of helical gear design, a complete relationship between the design parameters and other working parameters remains to be clearly understood because of complexity. Gears are widely used to transmit mechanical power and where helical gears are known to have smoother transmission as compared to other gears. Often the stress generated on the tooth influences various operational parameters of a gear and where subjected to stresses which lead to failure. In helical the tooth failure occurs because of root bending stress acting on the gears. In this present work, a comparative study on helical gear design and its performance characteristics were made through Finite Element Analysis (FEA) as well as numerical method. Based on American Gear Manufacturing Association (AGMA) standards, theoretical analysis for single and herringbone helical gears have been evaluated in MATLAB. The effect of tooth bending stress on single and herringbone helical gear system are studied through finite element analysis and compared with theoretical analysis. The comparison study is performed to determine the stress distribution on helical gears and it significantly increases the new variant design without considering design calculation by complex theoretical method which has scope of manual errors.

Fig.1. Double Helical gear Of Brass Alloy Material

3. J. Venkatesh, Mr. P. B. G. S. N. Murthy.

In the gear design the bending stress and surface strength of the gear tooth are considered to be one of the main contributors for the failure of the gear in a gear set. Thus, the analysis of stresses has become popular as an area of research on gears to minimize or to reduce the failures and for optimal design of gears in this paper bending and contact stresses are calculated by using analytical method as well as Finite element analysis. To estimate bending stress modified Lewis's beam strength method is used. Pro-e solid modelling software is used to generate the 3-D solid model of helical gear. Ansys software package is used to analyse the bending stress. Contact stresses are calculated by using modified AGMA contact stress method. In this also Pro-e solid modelling software is used to generate contact gear tooth model. Ansys software package is used to analyse the contact stress. Finally, these two methods bending and contact stress results are compared with each other.

Fig.2 Heavy Equipment Application Of Gears

Fig.3. Helical Gear

4. Easwar Ram S., Apoorv Saxena, Dr. Vineet Kumar.

In this paper author has done his work is intended to focus upon the stress analysis of double helical gears for different material. Gears being one of the prime components involved in the power transmission process are subjected to failure because of the bending and surface stresses incurred at their teeth which causes a surface fatigue failure known as pitting. The specific category of gear systems selected for the work is the double helical gears, wherein the FEA analysis has been carried out to determine the stresses so induced at the time of meshing of gears with involute profile in the commonly used materials for gear which are EN24, Aluminium bronze and chromium stainless steel. 3D modelling and analysis have been performed to determine the contact stresses on finite element software packages (Ansys). The results have been then compared for different materials.

Fig.4. Double Helical Gear

III. DESIGN CALCULATIONS AND FORMULA'S

[All standard reference values are taken from V.B. Bhandari Std. Book]

Considering the module = 4mm.

Pitch Circle Diameter = 342 mm.

1. Module (m)

m=4 (reference from V.B. Bhandari text book.)

2. Number of teeth on gear

{for 20-degree full depth involute system the number of teeth on pinion is =20 from that assuming gear ratio is 4 (reference from V.B. Bhandari text book)}

i =

Zg=i×Zp= 4×20=80

Number of teeth t= 80.

Dg=342mm.

4.Addendum=1×Mn=4mm

5.Dedendum=1.25×Mn=5mm

6. Torque (T)

Let Power = 20KW

N = 900 rpm

T= 212.2065 NM.

7.. Forces applied of Gear tooth

1) Tangential component force (Pt)

$$Pt = \frac{2(Mt)}{dp}$$

Pt = 4985.23 N.

2) Thrust component force (Pa)

Pa= Pt×tanα

Pa=1814.47 N.

3) Radial component force (Pr)

$$Pr = [\frac{tan\alpha n}{cos\psi}]$$

Pr = 1930.92 N.

standard formulas for calculations

A) For stress calculation Lewis's equation

σ t =WtPt/FY

or

Standard Stress formula = (Forces acting on body part)/ (Area Under the load)

where,

Wt =the tangential Force

Pd= the diametral pitch

F= the face width

Y =Lewis's form factor

B) Standard formula for strain calculation

Strain = (δ L)/Lo

Where, δ L = Change in length

Lo= Original length

C) Standard formula for total deformation

δ total= Σi (Pi Li)/ (Ei Ai)

TABLE I
INPUT VALUES FOR MODELLING

Sr.no	Variable Name	Description	Values	units
1	Zg	Number of teeth on gear	80	_
2	Dg	Gear pitch circle diameter	342	mm
3	m	Module	4	mm
4	α	Helix angle	20	degree
5	b	Face Width	52	mm
6	D	Diameter of Shaft	50	mm
7	ψ	Pressure Angle	20	degree
8	P	Power	20	KW
9	N	Speed	900	RPM
10	A	Addendum	4	mm
11	B	Dedendum	5	mm

IV. CAD MODEL OF DOUBLE HELICAL GEAR

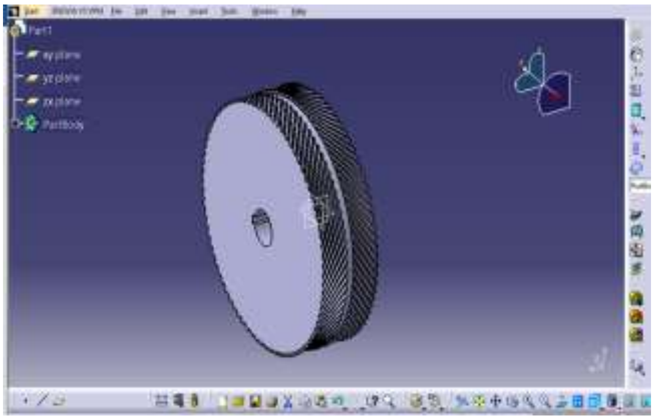

Fig.5. CAD Model of Double Helical Gear

V. STRESS ANALYSIS OF DOUBLE HELICAL GEAR

In this study we had use the Ansys software for analysing the stress inside the tooth, as well as to found strain and total deformation of gear tooth. For stress analysis of double helical gear, we have to go through certain method and their steps. Certain steps in formulating a finite element analysis of a physical problem are common to all such analyses, whether structural, heat transfer, fluid flow, or some other problem. These steps are embodied in commercial finite element software packages and are implicitly incorporated in this text, although we do not necessarily refer to the steps explicitly in the following chapters. The steps are described as follows.

Finite element analysis process is divided into three main phases

a) Pre-processor,
b) Solution,
c) Postprocessor.

Fig.6. ANSYS software user interface

Case 1. Analysis of Double Helical Gear for Titanium Alloy Material

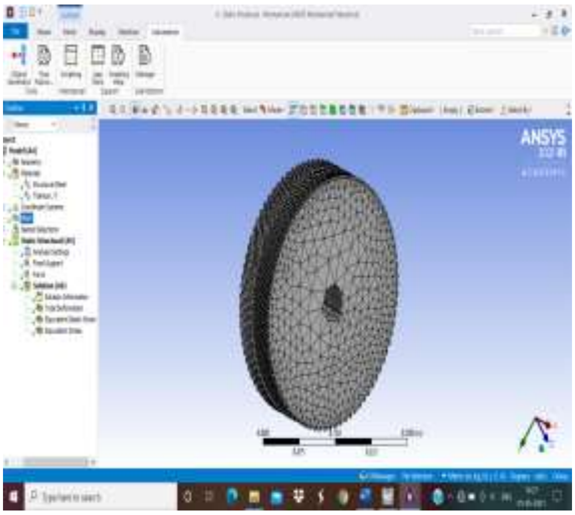

Fig.7. Mesing of Double Helical gear

Table No.2
Material Properties of Titanium Material

Properties	Metric	Imperial
Density	4.50 g/cm3	0.163 lb./in3
Melting point	1650-1670 °C	3000-3040 °F
Boiling point	3287 °C	5949 °F

TABLE NO.3

Properties	Metric	Imperial
Tensile strength	220 MPa	31900 psi
Modulus of elasticity	116 GPa	16800 ksi
Shear modulus	43.0 GPa	6240 ksi
Hardness, Brinell	70	70
Hardness, Vickers	60	60
Elongation at Break	54%	54%
Poisson's Ratio	0.34	0.34

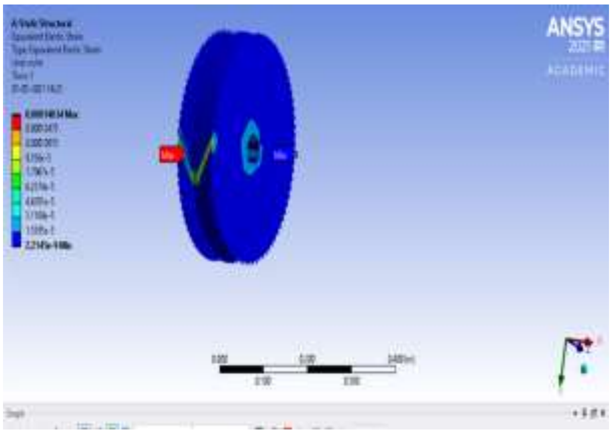

Fig.8.Equivalent Elastic Strain Analysis for Titanium alloy

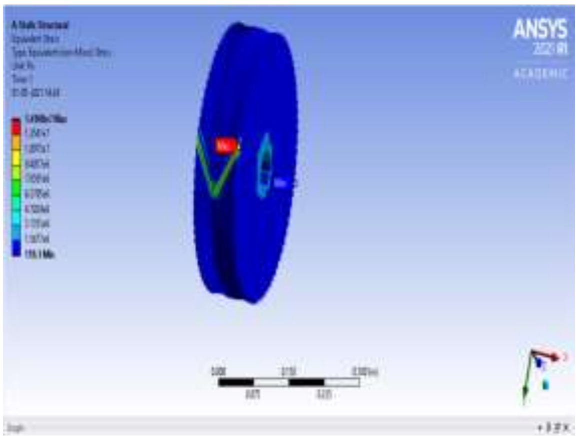

Fig.9.Equivalent (Von-Mises) Stress Analysis for Titanium alloy

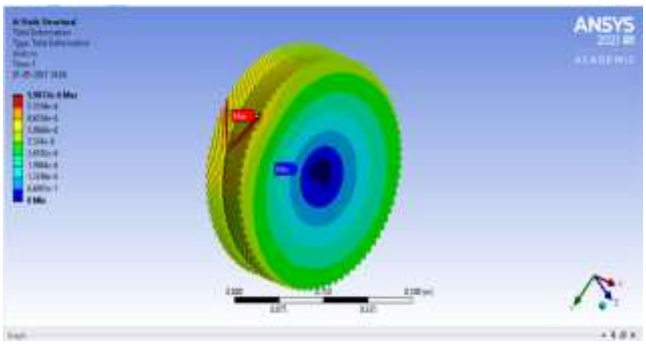

Fig.10.Total Deformation for Titanium alloy

Case-2. Analysis of Double Helical Gear for Brass

Table No.4
Material Properties

Density	8267kg/m3
Youngs Modulus	9.995e+10pa
Poisson's Ratio	0.345
Bulk Modulus	1.0747e+11 pa
Shear Modulus	3.7156e+10 pa
Isotropic Scent coefficient of thermal expansion	1.999e-05 1/^0c
Ultimate Tensile Strength	5.02e+08 pa
Tensile yield Strength	3.674e + 08 Pa

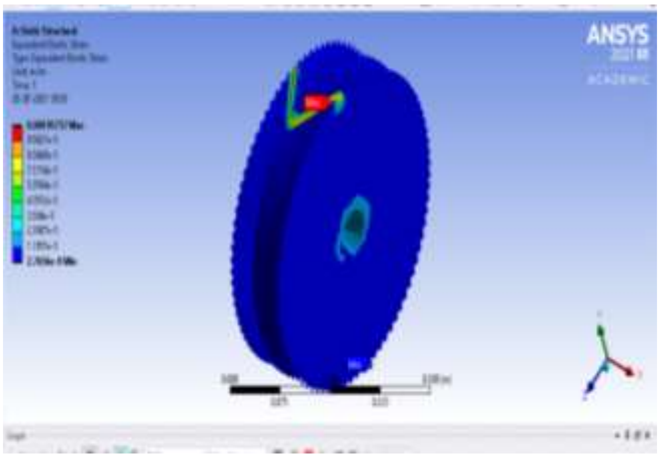

Fig.11. Equivalent Elastic Strain Analysis for Brass alloy

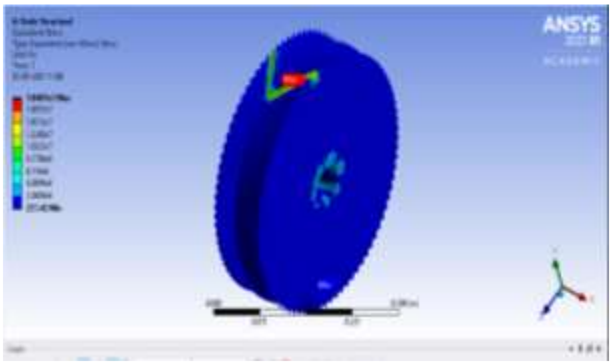

Fig.12.Equivalent (Von-Mises) Stress Analysis for Brass alloy

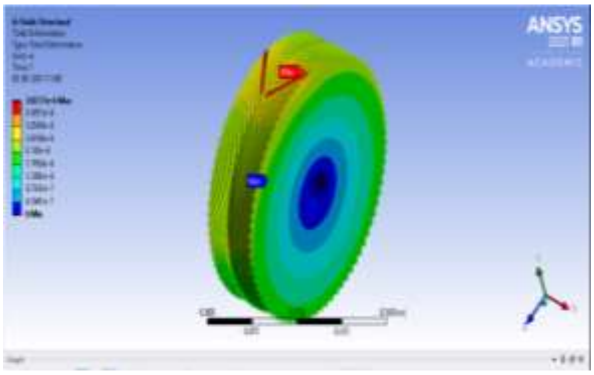

Fig.13. Total Deformation for Brass Alloy

VI. RESULTS

Sr. No.	Parameter	Titanium alloy	Brass Alloy
1	Equivalent Strain (mm/mm) ×10^5	14.03	10.57
2	Equivalent von-mises Stress (MPa)	14.410	18.4
3	Total Deformation(m) 10^-6	5.983	3.92

Table No.5

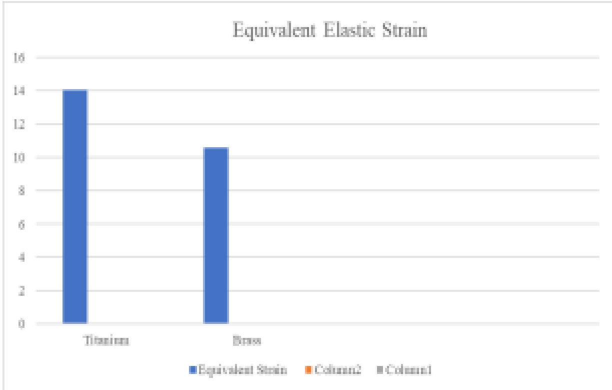

Fig.14. Graph of Result for Equivalent Strain

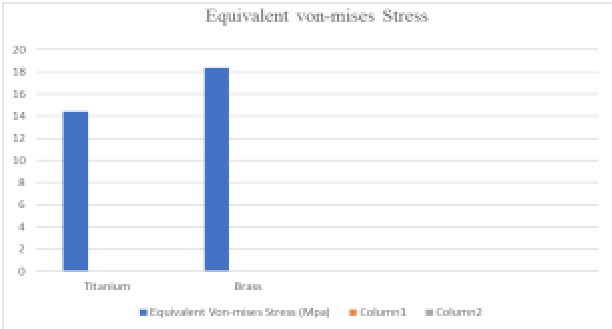

Fig. No.15. Graph of Results for Equivalent Stress

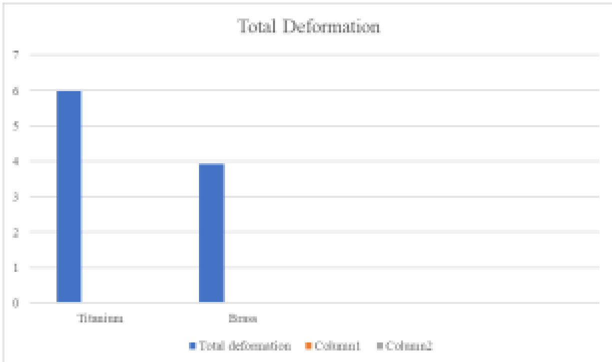

Fig. No.16. Graph of Results for Total deformation

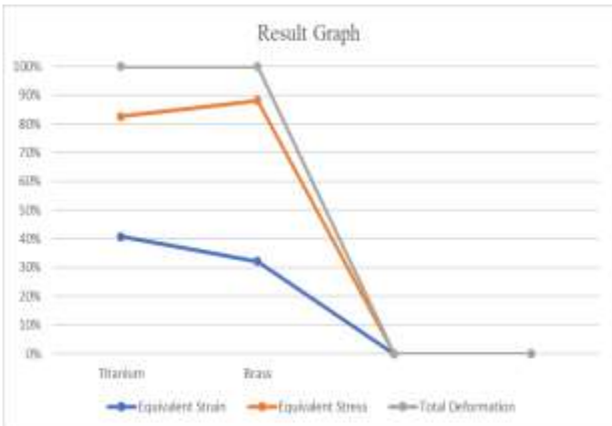

Fig.17. Graph of all values in the form of percentage

VII. CONCLUSION

In this research paper all the above results obtained from Ansys software, we have came to point of make our conclusion. If we compared all the material on the aspects of Equivalent elastic strain, equivalent von-mises stress and total deformation in it, it has been seemed that, if we talk in percentage, the material of titanium having 40% of strain and material brass having 32% of strains well as the Equivalent von-mises Stress developed is 82% and 89% respectively. And in case of total deformation there is small version of percentage of deformation in between this two.

Also, the added advantages are obtained from brass material i.e.; brass is a non-ferrous material so it gives more corrosion resistance as compared to other, also brass is having low cost compared to titanium. It also gives us high workability and durability. Brass is also easily available in market compared to titanium. The process of gear manufacturing of brass material is quietly easier than titanium, the cutting tools required for titanium is get very difficult to obtained. Titanium is very costly material as well as is not easily get available as required quantity. So, from above analysis it can learned that brass having low strain and deformation as compared to titanium, so here we can recommend the brass can be the best suitable material for manufacturing of double helical gear. For the application of heavy torque transmission. Additionally, to increase its life and resistance to wear and to avoid pitting failure of gear tooth we can apply a coating of special suitable material on the tooth of double helical gear.

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