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DESIGN, SIMULATION AND ANALYSIS OF HELICAL GEAR

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ABSTRACT

The Paper presents the simulation of Helical Gear under Bending Stress. Gears are one of the most important parts in mechanical power transmission system. Gears have wide variety of application. Gears generally fail when the tooth stress exceeds the maximum permissible stress .The bending and Surface stresses of the gear tooth are main causes for the failure of the gear. Thus, analysis of stresses has become popular as an part of research on gears to reduce the failures and for best possible design of gears .The study in this thesis show that the characteristics of an involute helical gear system mainly concentrate on bending stresses .in this thesis we modeled a helical gear on solid work .The FEM simulation is carried out using standard commercial available software that is ANSYS 15.0 is used.

The analytical investigation is based on AGMA bending stress formula. Stress distribution and deformation on the gear is simulated and presented .The study in this thesis investigates that complex design problem of helical gear required superior software skill for modeling and analysis.

Face width and helix angle are important geometrical parameters in determining the state of stresses. In this thesis Simulation is conducted by varying the face width and helix angle and stress distribution pattern has been observed. The bending stress found from Ansys results are compared with AGMA Procedures.

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For the effective power transmission, Gear design and analysis is very crucial because when a gear fails it becomes dangerous and affects the power transmission.

Key words – Helical Gear, Design, Modeling, Bending Stress, Finite Element Analysis, AGMA Equation

I. INTRODUCTION

A gear may be defined rotating mechanical device used in transmission system that allows rotational force to be transmitted or received to another toothed member or device. Motion through helical gears might be transmitted between parallel shafts and non crossing shafts. Geared devices are utilized to change the speed or control power between two stages (input and output). Depending on their configuration and arrangement, forces are often transmitted at completely different speeds, torques and even in a very completely different direction, from the power source. In helical gears gradual engagement between the teeth provides quiet operation with higher efficiency in comparison of spur gears. Gears are the most crucial devices in a mechanical power transmission, and in most commercial rotating machinery. Throughout the mechanical industry, diverse sorts of gears exist with every kind of gear possessing specific benefits for its supposed applications. In future it is attainable that gear can predominate as basically the most widely recognized method of transmitting power as a result of their high measure of reliability and compactness. Additionally, the advancement of technology, the rapid shift in the industry from heavy industries which include shipbuilding to industries which include automobile manufacture and workplace automation tools would require a advanced application of gear technology. .

The bending stress and contact stresses are considered to be some of the main contributions for the failure of the gear teeth within the gear set. Thus, to reduce the probabilities of failures and additionally for the best design of gears, analysis of stresses has become widespread as an area of analysis on gears. **B.Venkatesh etc**. (1) presented that the stresses were calculated for helical gear by using different materials. **Pushpendra Kumar** etc. (2) explained about the bending stress for different face width of helical gear calculated by using MATLAB Simulink. **Khalish.C** (3) focused on Lewis beam strength equation was used to finding out bending strength of a helical gear. **Yi-Cheng Chen** et al.(4) in their study stress analysis of a helical gear set with localized bearing contact have investigated the contact and the bending stresses of helical gear set with localized bearing contact by using finite element analysis.***Tribhuwan Singh, Mohd.***

***Parvez** (5)* Face width and helix angle are important geometrical parameters in determining the state of stresses during the design of gears. Thus, in this work a parametric study is conducted by varying the face width and helix angle to study their effect on the bending stress of helical gear. The strength of the gear tooth is a crucial parameter to prevent failure. In this study, it is shown that the effective method to estimate the root bending stresses using three dimensional model of the gear and to verify the accuracy of this method the results with different number of teeth are compared with the standard formula. Based on the result. from the contact stress analysis the hardness of the gear tooth profile can be improved to resist pitting failure: a phenomena in which a small particle are removed from the surface of the tooth that is because of the high contact stresses that are present between mating teeth. As it is expected, in this work the maximum bending stress decreases with increasing face width and it will be higher on gear of lower face width with higher helix angle. As a result, based on this finding if the material strength value is Criterion then a gear with any desired helix angle with relatively larger face width is preferred**.Vljayaragan and Ganesan** (6) obtained results by static investigation of composite of helical gear using three dimensional finite element approaches. Performance of two orthotropic substances gears were given and compared with mild steel gear. Form the result it was presumed that composite materials could be considered as material for power transmission helical gears however the face width must be surely increased.**Rao and Muthuveerappa** (7) clarified about the geometry of helical gears by way of easy mathematical equation. This project deals with stress analysis of helical gears using finite element approach of helical gear in different load conditions for distinct points of the contact line. They developed a computer program .With the help of this program the impact of design parameters on root stress is investigated. Root stresses had been calculated for special positions of the contact line when it moves from the root to the tip. To verify the legitimacy of the created program, the changes in the estimation of the most extreme root stress values at different points on the tooth along the face width have been compared with the experimental outcome. The aim was to perform a parametric analysis by changing the estimation of face width and helix angle to study their influence on the root stresses stress of helical gear. Based on their outcome, the influence of design parameters on the root stresses of helical gears used to be clarified for distinct points on the contact line.

II. DESIGNING OF GEAR

A. General Design of gears for power transmission for a particular application is a function of (a) the expected transmitted power, (b) the driving gear's speed, (c) the driven gear's speed or speed

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ratio and (d) the centre distance. In this we are designing helical according bending strength condition and the tooth bending stress equation for helical gear teeth is given as

$\sigma_b = \frac{Ft}{bmj} K_v K_o (0.93 K_m)$ 1

Introduction of constant 0.93 with the mounting factors reflects slightly lower sensitivity of helical gears to mounting condition. All the calculation are carried out on the basis of eq.4.1 recommended by AGMA.

From which the pitch circle diameter of pinion gear was derived to be given as

$D \geq 2T \frac{2T}{bmj[\sigma b]} K_v K_o (0.93 K_m)$

Where,

Force transmitted (F_t) = 3979 N
Face width (b) = 20 mm
Normal module = 2 mm
Geometry factor (J) = 0.594

Dynamic Factor (Kv) = 1.18

Overload factor (K_o) = 2

B. **Tangential force calculation**:

In order to design the gear according to bending strength condition the parameter are following:

Power (P) = 20 kw
Speed = 1200 r.p.m

$Torque(Tp) = \frac{9549.3 \times (kw)}{speed\ (RPM)}$ = 159.16N.m

$$TangentialForce(Ft) = \frac{2000\ Tp}{pitchdiametr} = 3979N$$

c. After the tangential force calculation , the AGMA bending stress calculation is carried out using equation { 1} for five different faces wide (b = 20mm , 30 mm , 40 mm , 50 mm , 60 mm) as follows:

$$(\sigma_{bAGMA1}) = \frac{3979}{20 \times 2 \times 0.594} 1.18 \times 2 \times (0.93 \times 1.2) = 441.83\text{MPa}$$

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$$(\sigma_{bAGMA2}) = \frac{3978.875}{30\times2\times0.594} 1.18\times2\times(0.93\times1.2) = 294.56MPa$$

$$(\sigma_{bAGMA3}) = \frac{3978.875}{40\times2\times0.594} 1.18\times2\times(0.93\times1.2) = 220.92MPa$$

$$(\sigma_{bAGMa4}) = \frac{3978.875}{50\times2\times0.56} 1.18\times2\times(0.93\times1.2) = 176.73MPa$$

$$\sigma_{bAGMA5}) = \frac{3978.875}{60\times2\times0.56} 1.18\times1\times(0.93\times1.2) = 147.28MPa$$

III. Modeling of Gear

Table -1 Parameter involved in modeling varying the Face width

No. of Teeth (Z)	40	
Module (M)	2	mm
Pitch diameter (D)	80	mm
Pressure angle (PHI)	20	Degree
Helix angle (β)	20	Degree
Face width (b)	20,30,40,50,60	mm
Addendum (Radius) (A)	42	mm
Dedendum (Radius) (B)	37.5	mm
Modulus of Elasticity (E)	200	Gpa
Poission's ratio (V)	0.3	
Power (P)	20	KW
Speed (N)	1200	Rev/min

Parametric modeling allows the design engineer to let the characteristic parameters of a product drive the design of that product. During the gear design, the main parameters that would describe the designed gear such as module, pressure angle, and root radius, and tooth thickness, number of teeth could be used as the parameters to define the gear as shown in Table 1.

In this paper work, module, pressure angle, numbers of teeth of both the gears are taken as input parameters. Solid Work uses these parameters, in combination with its features to generate the

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geometry of the helical gear and all essential information to create the model.CAD software packages allow for modeling and simulation of 3D parametric modeling of helical gear. It also a good interface with Finite Element software. Solid Work has model the involute profile helical gear geometry perfectly.

Figure 1 3D Helical Gear Model

Figure 2 Final Assembly of Gear

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IV. FINITE ELEMENT ANALYSIS

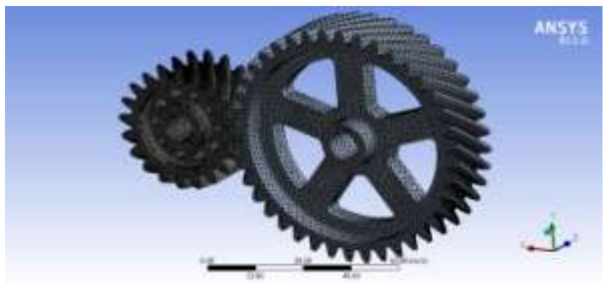

Figure- 3 Meshing

Finite Element Method is the easy technique as compared to the theoretical methods to find out the stress developed in a pair of gears. Therefore FEM is widely used for the stress analysis of mating gears. In this paper, finite element analysis is carried out in ANSYS Workbench 15.0 to determine the maximum Bending stresses .Also deformation is found out for both the gears.

4.1 Meshing

Fine meshing is done to get the accurate results of bending stress.

4.2 Boundary Condition

Cylindrical support is applied on inner rim of the pinion gear. Frictionless support is applied on the inner rim of gear to allow its tangential rotation but restrict from radial translation. Moment of 1.32e+005 N.mm is applied on the inner rim of gear in clockwise direction as a driving torque.

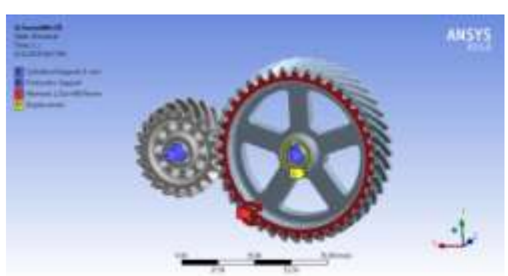

Figure 4 Boundary Condition

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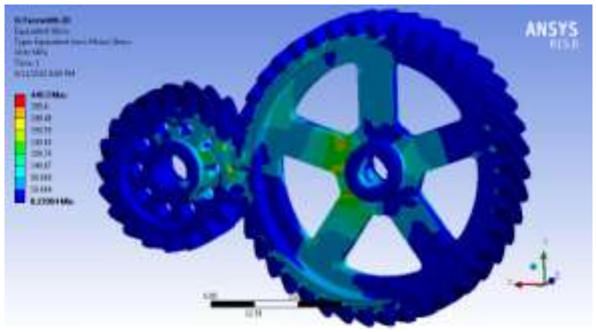

Figure 5 Static analysis of Gear

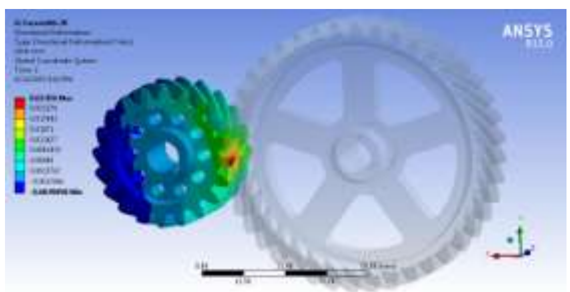

Figure 6 Deformation Pattern of Gear

V. RESULT AND DISCUSSION

Face width and helix angle are important geometrical parameters in determining the state of stresses during the design of gears. Thus, the objective of this work is to conduct a parametric study by varying the face width to study their effect on the bending stress of helical gear. In order to determine the stresses variation with the face width five different models of helical were created by keeping other parameters (i.e. module, pitch circle diameter, number of teeth, helix angle etc) constant. Table 2 below shows the results of bending stress with the variation in the face width of the helical gear tooth.

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Table -2 Bending Stress

S.No.	Face width (mm)	Ansys (MPa)	AGMA (MPa)
1	20	405.65	441.84
2	30	255.63	294.56
3	40	184	220.92
4	50	140	176.73
5	60	112	147.28

The table above clearly shows that as the face width is increasing there is a corresponding decrease in the value of the tooth bending stresses of a helical gear calculated from the AGMA as well as that obtained from ANSYS analysis. Therefore, from the results obtained we can say that for any constant load and speed, the gear with higher face width is suitable

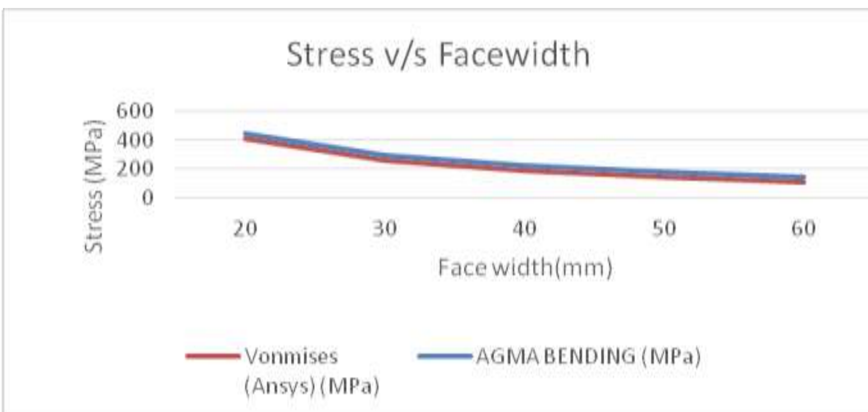

Figure 7 Graph of Bending Stress [MPa] against Face width

VI. CONCLUSION

Here the theoretical maximum Bending stress is calculated by AGMA Bending Equation. Also the finite element analysis of helical gear is done to determine the maximum Bending stress by

ANSYS 15.0. It was found that the results from both AGMA Bending equation and Finite Element Analysis are comparable. From the results we can conclude that ANSYS can also be used for predicting the values of bending stress at any required face width which is much easier to use to solve complex design problems.

REFERENCES

- B.venkatesh, V.Kamala, A.M.K.Prasad “Design, Modeling and Manufacturing of Helical
- Gear” International Journal of Applied Engineering Research, Dindigul”volume 1, no1, 2010
- [issn 09764259] .
- Pushpendra kumar, Mishra and Dr.M.S.Murthy, Comparison of Bending stress for Different
- Face width of helical Gear Obtained Using MATLAB Simulink with AGMA and Ansys ,
- ISSN 2231-5381, 2013.
- Khailash C.Bhosale,Analysis of Bending Strength of helical Gear by FEM, ISSN 2222-
- 1727, 2011.
- Cheng Y, and Tsay C.B, Stress analysis of Helical Gear set with Localized Bearing Contact,
- Finite Element in Analysis and Design, PP.707-723, 2002.
- Tribhuwan Singh, Mohd. Parvez “Comparative Study of Stress Analysis of Helical Gear using
- AGMA standards and FEM” “International Journal of Engineering Sciences & Research
- Technology” “IJESRT” ,2[7]: July, 2013
- Vijayarangan, and Ganesan N,A Static Analysis of Composite Helical Gears Using Three-
- dimensional Finite Element Method, Computers & Structures, PP.253- 268, 1993.
- Rao C.M, and Muthuveerappan G, Finite Element Modeling and Stress Analysis of Helical
- Gear, Teeth, Computers & structures, PP.1095-1106, 1993.