DESIGN MODELLING AND ANALYSIS OF HELICAL GEAR USING CATIA, ANSYS AND AGMA PARAMETERS

VICKY LAD (Research scholar**)**
Department of Mechanical Engineering,
SSET, SHIATS-DU, Allahabad, India
E-Mail:vicky.lad007@gmail.com

Dr. L. P. SINGH (Associate, Professor)
Department of mechanical Engineering,
SSET, SHIATS-DU, Allahabad India
E-Mail:lpsingh1976@gmail.com

ABSTRACT

Gears are used to transmit the power between two shafts. In the gear design several stresses are present in it when they transmit the power. During transmitting the power the bending stress is considered as the main cause for failure of gear. In this paper bending stress can be calculated by using analytical method which is calculated by the AGMA (American Gear Manufacturing Association) calculation and the model is designed in CATIA V5 and saved in IGES format and then imported in the ANSYS 17 software where it can be analyzed. The main objective of this study has to investigate the stresses induced in gear tooth profile. This can be achieved by changing such design parameter in the existing design. The results are then compared with both the AGMA and ANSYS procedure.

Keywords- *Design, modeling, helical gear, AGMA, FEA and ANSYS.*

INTRODUCTION

Gears are used to transmit the power. It is widely used because it is capable of transmitting power in a very small center distance between two parallel shafts. Gear transmission systems play an important role in many industries such as automobile industry. The knowledge of gear behavior in mesh such as stress distribution, work condition and distortion is critical to monitoring and controlling the gear transmission system.

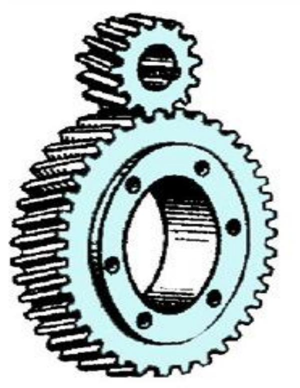

Fig: 1 Helical gear

A pair of teeth in action is generally subjected to two types of stresses- bending stresses inducing bending fatigue and contact stress causing contact fatigue. Gears are often required to work at high torque and speed. In order to avoid bending failure, the module and face width of the gear is adjusted so that the beam strength is greater than the dynamic load. When transmit the power tangential stress acting on their tooth profile.

OBJECTIVE

- Study of the helical gear
- Design and modeling through CATIA V5
- Analysis through ANSYS 17.0

MATERIALS AND METHODOLOGY

As we know that for proper designing the selection of material is a important factor. So for proper designing of helical gear we use the material i.e. structural steel.

The method of designing helical gear is as follows-
The proper 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 ratio.
(d) The centre distance (Khurmi and Gupta 2008). In this paper we designed the helical gear
According to bending strength condition and the tooth bending stress equation for helical gear teeth is given as,

The AGMA equation for bending stresses given by,

$$\sigma_b = \frac{W_t K_s K_l K_a}{bmJk_v} \text{ [MPa]}$$

$$W_t = \frac{2T}{mT_G} \text{ [N]}$$

Where,

σ_b = Root bending stress [MPa]

W_t = Transmitted tangential tooth load [N]

K_s = Size factor

K_l = Load distribution factor

K_a = Application factor

b = Face width [mm]

m = Module [mm]

J = Geometry factor

T = Torque transmitted [N-m or N-mm]

T_G = Number of teeth on gear

N = Number of revolution

α = Helix angle

Φ = Pressure angle

E = Young's Modulus [MPa]

μ = Poisson's Ratio

R_P = Pitch circle radius [mm]

R_b = Clearance circle radius [mm]

R_a = Addendum circle radius [mm]

R_d = Dedendum circle radius [mm]

For analysis of helical gear we use different module and face width to calculate helical gear tooth bending stress. For calculating bending stress we have some values and formulas.

Values are,

K_s = 1

K_l = 1.3

K_a = 1

k_v = 0.8

J = 0.56

T = 223 N-m

P = 35 KW

N = 1500r.p.m.

α = 20^0

Φ = 20^0

E = 2.e+005

μ = 0.3

And formulas are,

$R_P = m*(N/2)$

$R_b = 0.94*R_P$

$R_a = R_P + m$

$R_d = R_P - (1.25*m)$

All the above values are put in the formula,

For m=3.5, b=43.75

$W_t = \frac{2T}{mT_G} = \frac{2*223*10^3}{3.5*20} = 6371.42$ N

$\sigma_b = \frac{W_t K_s K_m K_a}{bmJk_v} = \frac{6371.42*1*1.3*1}{43.75*3.5*.56*.8} = 120$Mpa

For m=4, b=50

$W_t = \frac{2T}{mT_G} = \frac{2*223*10^3}{4*20} = 5575$ N

$\sigma_b = \frac{W_t K_s K_m K_a}{bmJk_v} = \frac{5575*1*1.3*1}{50*4*.56*.8} = 80$Mpa

For m=5, b=62.5

$W_t = \frac{2T}{mT_G} = \frac{2*223*10^3}{5*20} = 4460$ N

$\sigma_b = \frac{W_t K_s K_m K_a}{bmJk_v} = \frac{4460*1*1.3*1}{62.5*5*.56*.8} = 41$Mpa

For m=6, b=75

$W_t = \frac{2T}{mT_G} = \frac{2*223*10^3}{6*20} = 3716$ N

$\sigma_b = \frac{W_t K_s K_m K_a}{bmJk_v} = \frac{3716*1*1.3*1}{75*6*.56*.8} = 23$Mpa

RESULT AND DISCUSSION

Module and face width 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 module and face width to study their effect on the bending stress of helical gear. In order to determine the stresses variation with the module and face width four different models of helical were created by keeping other parameters (i.e. pitch circle diameter, number of teeth, helix angle, pressure angle, power, speed etc) constant. Table below shows the results of bending stress with the variation in the face width of the helical gear tooth.

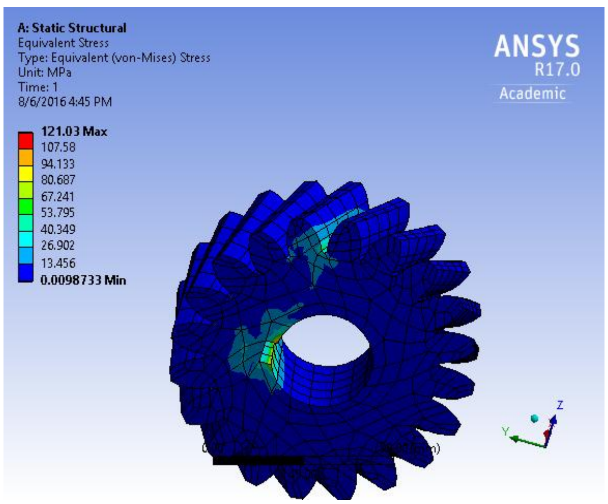

Fig: 2 Equivalent stress of module 3.5

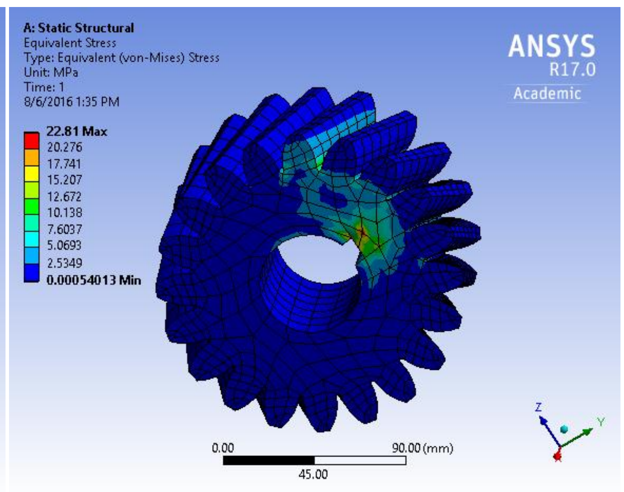

Fig: 3 Equivalent stress of module 6

TABLE- I Bending Stress [MPa]

S. No.	Module [mm]	Face Width [mm]	$\sigma_{b(AGMA)}$ [MPa]	$\sigma_{b(ANSYS)}$ [MPa]	Differences [%]
1	3.5	43.75	120	121	0.8
2	4	50	80	78	2.5
3	5	62.5	41	40	2.4
4	6	75	23	22	4.3

The above table-I clearly shows that as the module and face width is increasing there is a corresponding decrease in the value of 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 module and face width is suitable.

CONCLUTION

The results obtained from ANSYS when compare with the AGMA procedure, it shows that there is a little variation with a higher difference in percentage of 4.3%. From the results we can conclude that ANSYS can also be used for predicting the values of bending stress at any required module and face width which is much easier to use and to solve the complex design problems like gears.

FUTURE SCOPE OF WORK

Recommendation and Future work

The following areas are worthy for further research in the light of this work.

- The three dimensional numerical methods of investigation and study can be conducted on the analysis of bending for all types of gears such as spur, bevel and other tooth forms.
- Numerical method of investigation and study can be conducted on the whole gearbox with all elements in the system including gear casing and bearing.
- Numerical method of investigation and study can be conducted on gears in mesh under dynamic condition with and without cracked teeth, surface pitting or wear.
- Using different parameters such as module, face width, No. of teeth and helix angle can give more result.

REFRENCES

[1]. Norton, R.L., Machine Design: An Integrated Approach, New Jersey: prentice-Hall Inc. 1996.
[2]. Yonatan, F., Variable Mesh Stiffness of Spur Gear Teeth Using FEM, M.sc. thesis, Department of mechanical Engineering, Addis University
[3]. Vijayarangan, S., and Ganesan, N., A Static Analysis of Composite Helical Gears Using Three-dimensional Finite Element Method, Computers & Structures, 49,pp.253-268,1993.
[4]. Saxena, Rajul., 2004,"Finite Element Stress Analysis of Spur Gear Teeth" M.Sc. Thesis, the University of Texas at Arlington.
[5]. Rao, C.M., and Muthuveerappan G., Finite Element Modeling and Stress Analysis of Helical Gear, Teeth, Computers & structures, 49, pp.1095-1106, 1993.
[6]. CATIA V5 R20.
[7]. Marappan, S. and Verkataramana, ANSYS Reference Guide, CAD CENTRE, India, 2004.

[8]. Shreyash D Patel, Finite Element Analysis of Stresses in involute Spur Helical gear, M.Sc. Thesis, the University of Texas at Arlington,2010