



Contact Stress Analysis of Helical Gear by Using AGMA and ANSYS

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ABSTRACT:

Gears are one of the most critical components in mechanical power transmission systems. The gears are generally used to transmit power and torque. The efficiency of power transmission is very high when compared to other kind of transmission. In the gear design the bending stress and surface strength of the gear tooth are considered to be one of the main contributors for failure of the gears in gear set. The analysis of stresses has become popular as an area of research on gears to minimize and reduce the failures. The present investigation is carried out to make use of helical gear, by analyzing the contact stresses for different Pressure angles (14.5°, 16°, 18°, 20°) Helix angles (15°, 20°, 25°, 30°) and (80mm, 90mm, 100mm, 110mm, 120mm) Facewidth. A Three-dimensional solid model is generated by Pro-E that which is powerful and modern solid modeling software. The numerical solution is done by Ansys, which is a finite element analysis package. The analytical approach is based on contact stress equation, to determine the contact stresses between two mating gears. The results obtained from Ansys values are compared with theoretical values are in close agreement. The present analysis is useful in quantifying the above said parameters that helps in safe and efficient design of the helical gear.

Key words: Helical gear, AGMA, Ansys, Pressure angle, Helix angle, Face width.

INTRODUCTION

One of the best methods of transmitting power between the shafts is gears. Power transmission has always been of high importance. The efficiency of any machine depends on the

amount of power loss in the process. Gears are mostly used to transmit torque and angular velocity. The design and manufacture of precision cut gears are made from high strength of materials. Gears are used in many fields and under a wide range of conditions such as aircrafts, automobiles, ship buildings, small watches and lifting cranes. Helical gears are the modified forms of spur gears, in which all the teeth are cut at a constant angle, known as helix angle, to the axis of the gear, where as in spur gear, teeth are cut parallel to the axis. Helical gears are also employed to transmit power between two shafts parallel to the axis. The gear teeth should have sufficient strength, so that they will not fail under static and dynamic loading during normal running conditions. The gear teeth should have clear characteristics so that their life is satisfactory, the use of space and material should be economical. The alignment of the gears and deflections of the Shafts must be considered, because they affect the Performance of the gears. Helical gears are currently being used increasingly as a power transmitting gear owing to their relatively smooth. Designing highly loaded helical gears for power transmission systems that are good in strength and low level in noise. B.Venkatesh et al [1] presented in their paper that the stresses were calculated for helical gear by using different materials. Pushpendra Kumar et al [2] explained about the bending stress for different face width of helical gear calculated by using MATLAB Simulink. Prashanth Patil, et al [3] investigated the 3D photo elastic and finite element analysis of helical gear. Khalish.C et al [4] in their paper focused on Lewis beam strength equation was used to finding out bending strength of a helical gear. Yi-Cheng Chen et al [5] 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.

S.Vijayaragan etal [6] carried out a static analysis of composite helical gears using three dimensional finite element methods to study the displacements and stresses at various points on a helical gear tooth. For determining the stresses at any stage during the design of gears helix angle and face widths are important. Muthuveerappan etal [7] have explained the geometry of helical gears by simple mathematical equations. Based on the above reviews shows that plenty of work has been done on helical gears. Hence this paper mainly aims to study the effect of contact stress on helical gears due to changes in helix angle, face width and pressure angle.

Table: 1 Parameters of Helical gear:

S.No	Description	Value
1	Pressure angle	20°
2	Helix angle	20°
3	Face width(mm)	120
4	Module(m) (mm)	10
5	No. of Teeth	30
6	Pitch diameter(mm)	300 mm
7	Addendum(mm)	1m
8	Dedendum(mm)	1.25m
9	Modulus of elasticity	210 X 10 ³ N/mm ²
10	Poisson's ratio	0.3

II. DESIGN OF HELICAL GEAR

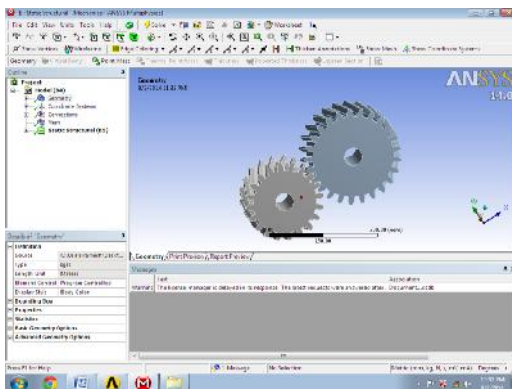


Fig -1: Mechanical Windows

The procedure to model the gear of 20 number of teeth with the combination of the all above mentioned parameters in the Pro/Engineer

Wildfire, other set of gears are modeled in the similar way. Part parameters are the basic parameters defining the gear. These part parameters determine all the other parameters that define the gear tooth profile using the tools/relation menu.

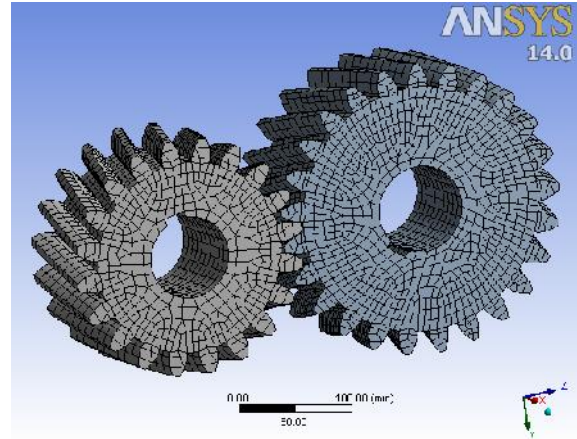


Fig: 2 Finite element meshing on helical gear

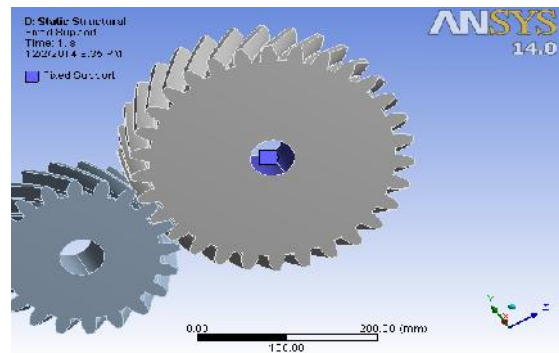


Fig-3: Fixed Support

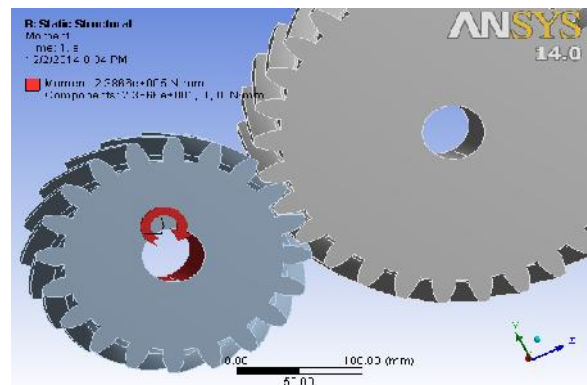


Fig-4: Moment Applied

Required Input Parameters:

Power = P=10000 KW

At Speed of Pinion, N1= 4000 r.p.m

Gear Ratio= N1/N2= 20/30=0.666

Material Selection:

The material for pinion & Gear is AISI 4340 alloy steel. Its max. Tensile strength & Yield strengths are $\sigma_t = 745 \text{ N/mm}^2$, $\sigma_y = 470 \text{ N/mm}^2$
Density = 7850 kg/m^3
Young's Modulus = $210 \times 10^3 \text{ N/mm}^2$
Poisson's ratio (ν) = 0.30

HILAGMA equations used to calculate contact stresses :

$$\sigma_c = c_p \sqrt{\left(\frac{F_t}{b d I} \left(\frac{\cos \psi}{0.95CR} \right) \right) k_v k_o (0.93 k_m)}$$

$k_v = 1.47, k_o = 1, k_m = 1.3$

$c_p = 191.58 \text{ N/mm}^2, F_t = 2386.634 \text{ N}$

For 20° Pressure Angle:

CR = 2.75, I = 0.0049, b=80mm, d=1.75mm

$$\sigma_c = 191.58 \sqrt{\left(\frac{2386.63}{80 \times 175 \times 0.049} \right) \left(\frac{\cos 20^\circ}{0.95 \times 2.75} \right) \times 1.47 \times 1 (0.93 \times 1.3)}$$

$\sigma_c = 285.7 \text{ N/mm}^2$

For 20° Helix Angle:

R = 2.132, I = 0.064.

$$\sigma_c = 191.58 \sqrt{\left(\frac{2386.63}{80 \times 175 \times 0.064} \right) \left(\frac{\cos 20^\circ}{0.95 \times 2.132} \right) \times 1.47 \times 1 (0.93 \times 1.3)}$$

$\sigma_c = 283.92 \text{ N/mm}^2$

For 120mm Face Width:

R = 2.132, I = 0.064

$\sigma_c = 191.58$

$$\sqrt{\left(\frac{2386.63}{120 \times 175 \times 0.064} \right) \left(\frac{\cos 20^\circ}{0.95 \times 2.132} \right) \times 1.47 \times 1 (0.93 \times 1.3)}$$

$\sigma_c = 231.82 \text{ N/mm}^2$

IV. Contact Stress calculation by using Ansys

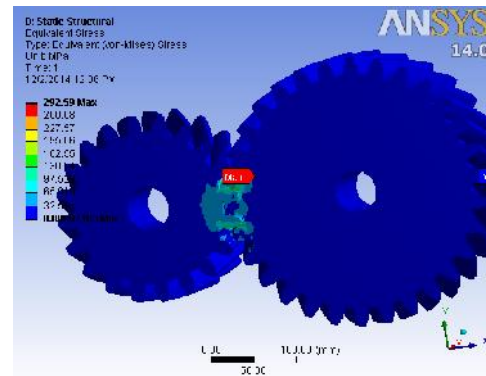


Fig: 5 The effect of Von-Misses stress on 14.5° Pressure angle

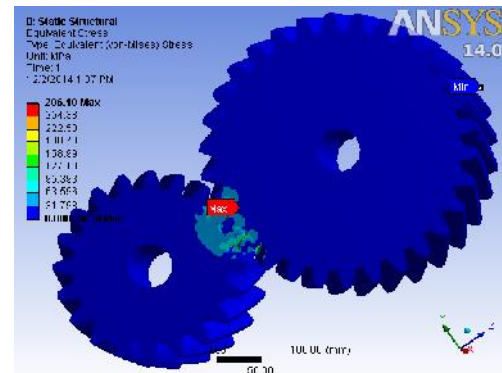


Fig: 6 The effect of Von-Misses stress on 20° pressure angles

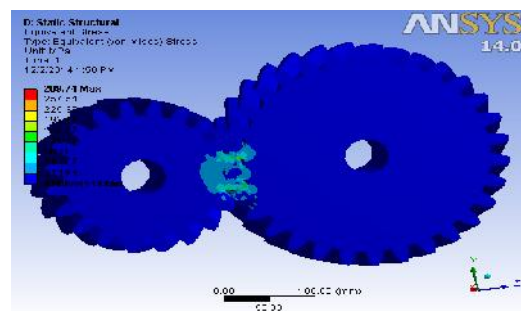


Fig-7: The effect of Von-Misses stress on 15° Helix angle

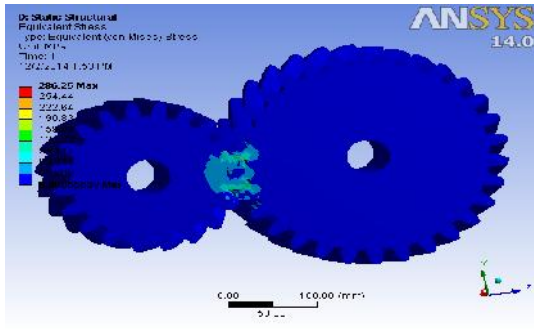


Fig-8: The effect of Von-Misses stress on 20° Helix angle

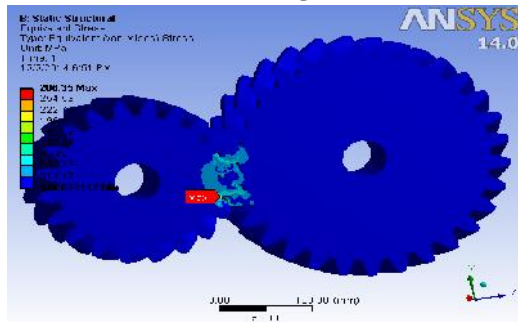


Fig: 9 The effect of Von-Misses stress for 80mm Face Width

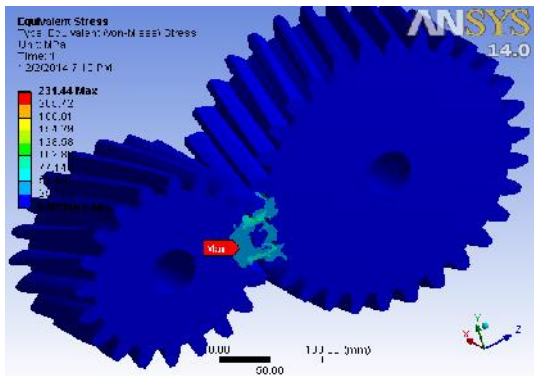


Fig-10: The effect of Von-Misses stress For 120mm Face Width

V. RESULTS AND DISCUSSIONS

Table: 2 Pressure Angle Vs Theoretical and Ansys Stress Values.

Pressure Angle	Theoretical Stress(N/mm ²)	Ansys Results(N/mm ²)
14.5°	289.9	292.59
16°	288.9	291.87
18°	287.4	289.03
20°	285.7	286.18

Table: 3 Helix Angle Vs Theoretical and Ansys Stress Values.

Helix Angle	Theoretical Stress(N/mm ²)	Ansys Results(N/mm ²)
15°	285.7	289.74
20°	283.88	286.25
25°	310.57	284.98
30°	385.64	282.63

Table: 4 Face Width Vs Theoretical and Ansys Stress Values.

Face Width(mm)	Theoretical stress(N/mm ²)	Ansys Results(N/mm ²)
80	283.91	286.35
90	267.68	273.45
100	253.94	264.85
110	242.12	253.27
120	231.81	231.44

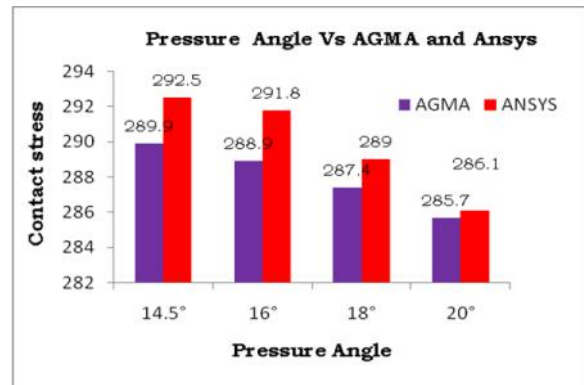


Fig: 11 Pressure angle v, AGMA and Ansys

The effect of pressure angles on contact stress is studied by varying the pressure angles shown in fig: 11. It can be observed that the variation in the magnitude of stress to pressure angles. When compared, AGMA values are little lower than the Ansys values. Finally at 20° pressure angle the results are very close agreement.

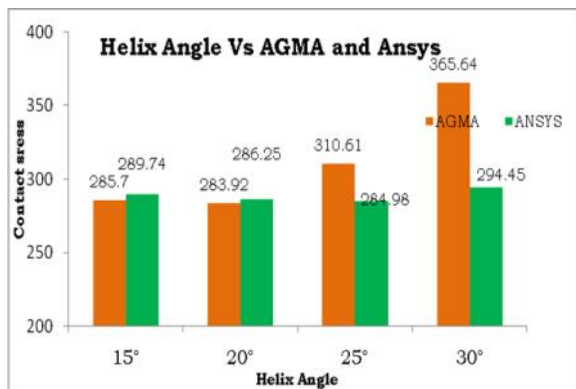


Fig: 12 Helix angle Vs AGMA and Ansys

The effect of helix angle on contact stress is studied by varying the helix angle for four different angles are 15°, 20°, 25°, 30°. A typical trend has been observed when the 15° helix angle stress value is 285.7 high when compared to 20° helix angle. The highest stress was developed at 25° helix angle among the other helix angles the comparison of analytical and Ansys stress values are little lower than the 15° and 20° helix angles.

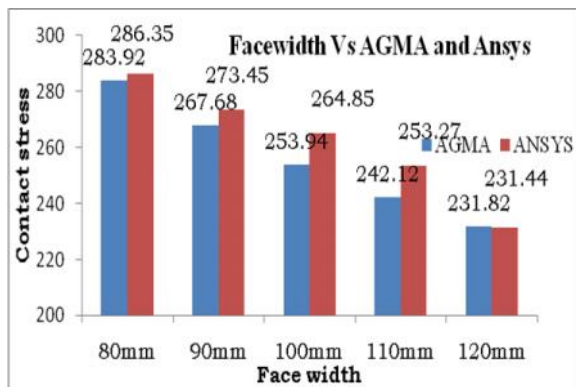


Fig: 13 Face width vs AGMA and Ansys

The effect of face width on Von-Mises stress is studied by varying the face width for different values are (80mm, 90mm, 100mm, 110mm & 120mm) respectively. A steady rate of stress values can be observed in above graph except for 120mm face width. The results are indicated that as the face width increases contact stress decreases. When compare with the ANSYS and AGMA stress values are little higher than theoretical values.

VI CONCLUSIONS

1. Pressure angles, helix angles and face widths are important geometrical parameters in determining the state of stresses during the design of gears.

2. By observing the analysis results, the stress values obtained are less than their yield stress. So we can decide that our design is safe under working conditions.

3. This above parameters can be correlated that good contact ratio of gears low stress was developed.

4. The helix angle, pressure angle and face width values of helical gear obtained using AGMA equation is little higher than Ansys values.

5. During the contact of gear and pinion, the contact stress is decreased with the increase of face width.

VII. REFERENCES

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