Contact stress and bending stress analysis of spur gear by finite element method (Ansys)

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Abstract—**The Contact stress and bending stress in mating gears is the key parameter in gear design. Also, Deformation of the gear is another key parameter which is to be considered in gear design. The life of gears are mainly effected due to the higher amount of stresses i.e. bending and contact stresses. This paper present the contact stress and bending stress analysis of spur gear by Finite Element Method(Ansys). The Spur gear is prepared in Catia Software. The parameters like Contact stress and bending stress are calculated from Ansys Software.**

***Keywords*—Spur gear, Contact stress, Bending stress,Catia, FEA**

I. INTRODUCTION

Gear is a rotating cylindrical wheel having teeth cut on it and which meshes with another toothed part in order to transmit the torque or power. Gear teeth normally fail when load is increased above certain limit. Gears are a critical component in the rotating machineryindustry. Gears are most common means of transmitting power in mechanical engineering. Gears are mainly type like spur gears, bevel gears, helical gears, double helical gears, crown gears, hypoid gears, rack and pinion, worm gears, epicyclic gears etc. The application of these gears field from tiny wrist watches to huge machinery equipment such as automobile, aerospace industry, rolling, hoisting and transmitting machinery, marine engines etc. Various research methods, such as theoretical, numerical and experimental methods have been done throughout the years regarding gears.

The main aim is to determine the Contact stress and bending stress Analysis of spur gear by Ansys software. For this a Spur gear is prepared in Catia Software.

II. LITERATURE REVIEW

Spur gear is a simplest type of gear having its teeth cut parallel to the axis of shaft on which gear is mounted. The spur gears are used to transmit power between parallel shafts. The operating efficiency of spur gear is about 98-99% (T. Shobha Rani et al 2013). They are usually employed to achieve constant drive ratio. There are several kind of stresses present in loaded and rotating gear teeth. But, out of all the stresses, root bending stress and surface contact stress calculation is the basic of stress analysis. We have to consider all the possibilities, so that the gears are proportional to keep all the stresses with in design limit. Generally stresses calculated in gear design formula are not necessary true stress, can make it difficult to get correct answer on gear tooth stresses, because it may not be known whether load is uniformly distributed across the face width and whether properly shared by the two or more pairs of teeth that are in mesh at the same time. Therefore, we have to make right assumption that will allow for stress concentration, residual stress, misalignment and tooth error (Sushil Kumar Tiwari et al 2012).

T. Shobha Rani et al. (T. Shobha Rani et al 2013) have used cast iron, nylon and polycarbonate as the materials of the spur gear for finite element analysis. They concluded that the deflection of cast iron is more as compared to nylon and Polycarbonate. Therefore, cast iron spur gear can be replaced with nylon gear whenever necessary to get the good efficiency, life and less noise. Also the module of a gear plays an important role in transmitting the power between two shafts. The spur gear with higher module is the best choice for transmitting large power between the parallel shafts.

Ali Raad Hassan (2009) has done a research study in whichContact stress analysis between two spur gear teeth was studied in different contact positions, representing a pair of mating gears during rotation. A platform has developed a program to plot a pair of teeth in contact. Each case was represented a sequence position of contact between these two teeth. The platform gives graphic results for the profiles of these teeth in each position and location of contact during rotation. Finite element models were made for these cases and stress analysis was done. Theresults were presented and finite element analysis resultswere compared with theoretical calculations, wherever available.

Bharat Gupta, Abhishek Choubey, Gautam V. Varde (2012) presented a paper to suggest that, thorough study of contact stress developed between the different matting gears are mostly important for the gear design. They have used Hertz equations which is analytical method of calculating gear contact stresses, originally derived for contact between two cylinders. So for contact stress they established and determined appropriate models of contact elements, and calculated contact stresses using Ansys and compared the results with Hertz theory.For determining bending stress at the root of meshing gears, Lewis formula is used. In detail study of the contact stress produced in the mating gears is the most important task in design of gears as it is the deciding parameters in finding the dimensions of the gear. Also the module of a gear plays an important role in transmitting the power between two shafts. The spur gear with higher module is the best choice for transmitting large power between the parallel shafts.

M. Raja, P. Phani's work made an attempt tosummarize about contact stresses developed in a mating spur gear which has involute teeth. They had calculated contact stress of spur gear for materials by Analytical Method.

Vera Nikolic-Stanojevic et al. (Vera Nikolic-Stanojevic et al 2013) had determine the maximum value of active stress and stress fields on tooth flanks during the period of meshing. Finite Element Method (FEM) was used for modeling the contact of tooth flanks. From the result of equivalent stress field in contact areas, they concluded that FEM is suitable numerical method for different analysis of contact stresses on mating tooth flanks.

III. CONTACT STRESS AND BENDING STRESS ANALYSIS OF SPUR GEAR

Thebelow figure shows cad file ofa pair of spur gears with 20° pressure angle. The gears parameters are as below:
Number of teeth = 20
Module (m) = 4
Pitch circle radius $(R_p) = \frac{m \times N}{100} = \frac{4 \times 20}{100}$ =40 mm
Clearance circle radius $(R_b) = 0.94 \times R_p = 0.94 \times 40 = 37.6$ mm
Addendum circle $(R_a) = R_p + m = 40 + 4 = 44$ mm
Deddendum circle radius $(R_d) = R_p - (1.24 \times m) = 40 - (1.24 \times 4) = 35.06$ mm
Angle = $\frac{90}{N} \times 1° = \frac{90}{20} \times 1° = 4.5°$
Fillet radius = $0.39 \times m = 0.39 \times 4 = 1.56$ mm

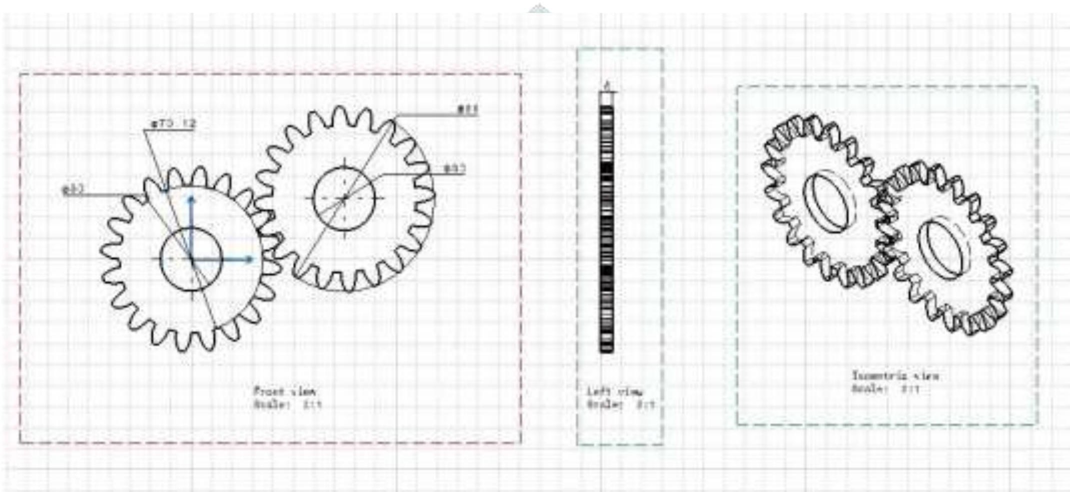

Figure 1:Gear dimensions cad file.

The two spur gears mesh with each other is shown in figure below. This is the 3-D assembly of spur gear.

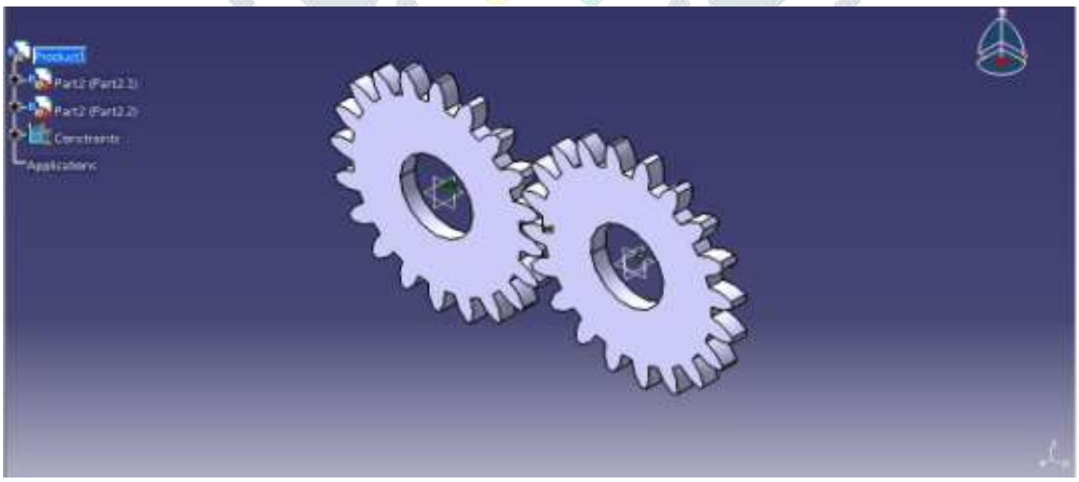

Figure 2:Catia spur gear assembly.

The below figure shows the meshing of spur gear assembly.

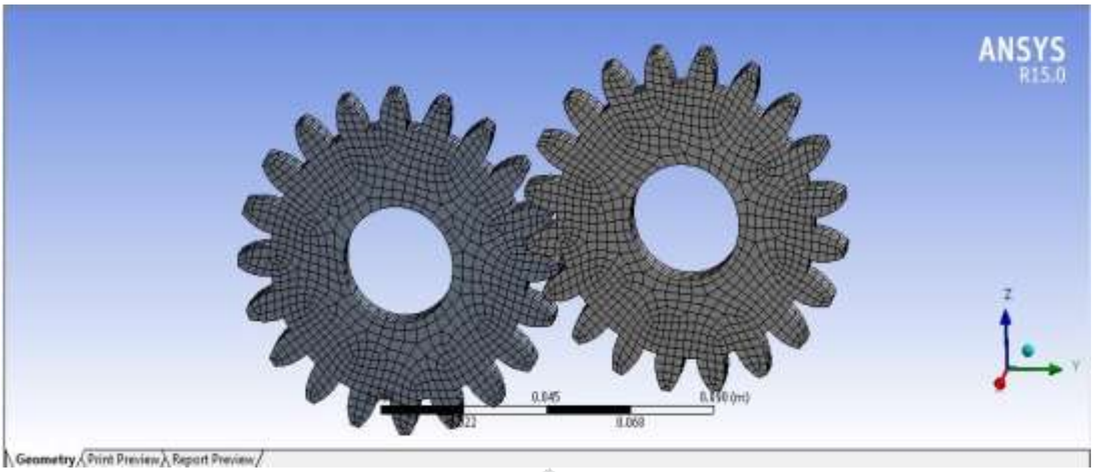

Figure 3:Meshing of spur gear assembly

The below figure shows the 20 N-m moment constraining of diagram in ansys.

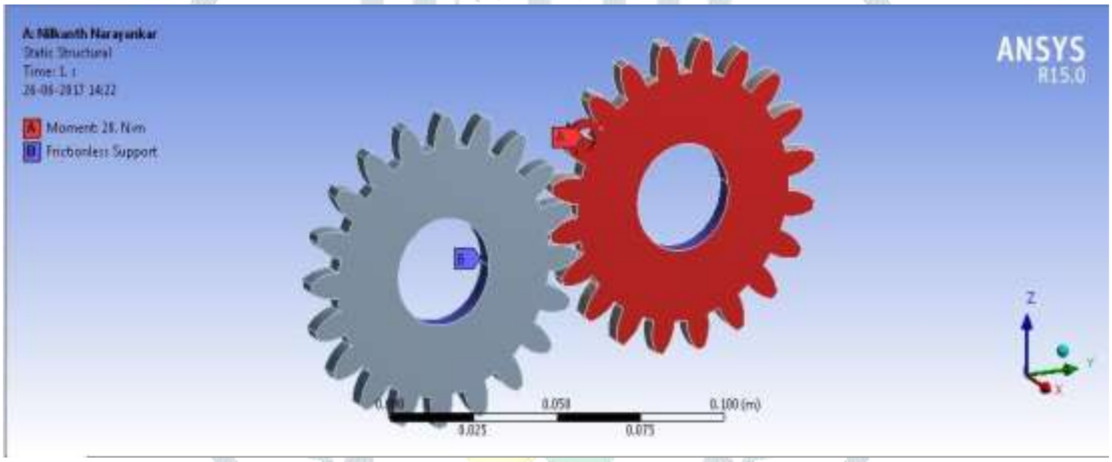

Figure 4:Moment constraining of diagram in ansys

The below figure shows the 20 N-m moment equivalent (von-mises) stress produced in X-Axis.

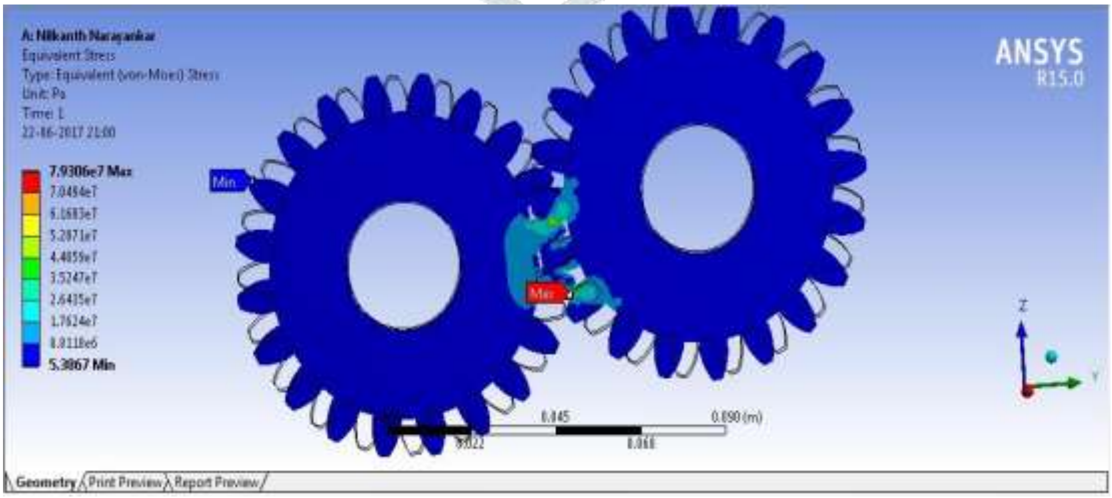

Figure 5:Equivalent (Von-mises) stress

The below figure shows the 20 N-m moment normal stress produced in X-Axis.

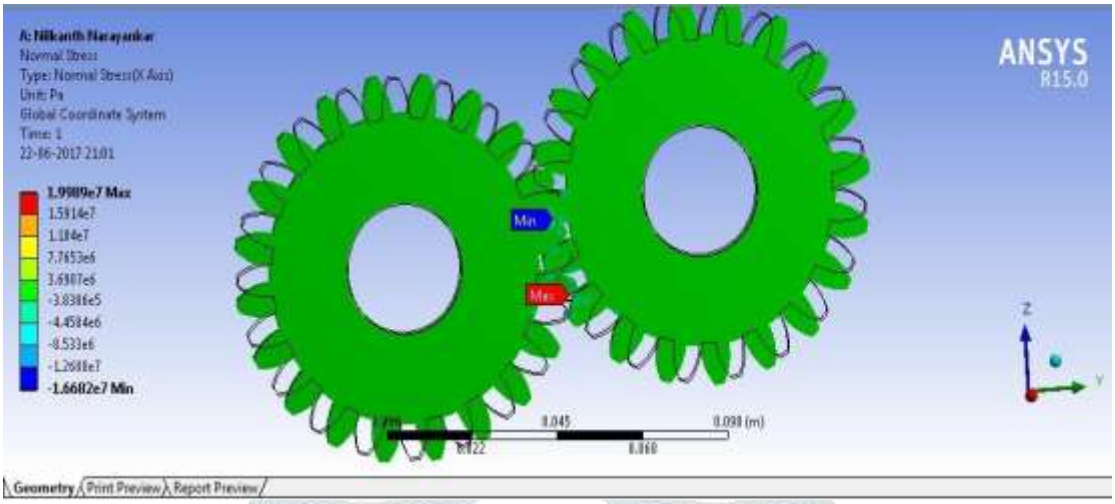

Figure 6:Moment normal Stress

The below figure shows the Equivalent elastic strain of mating teeth of the gear in ansys.

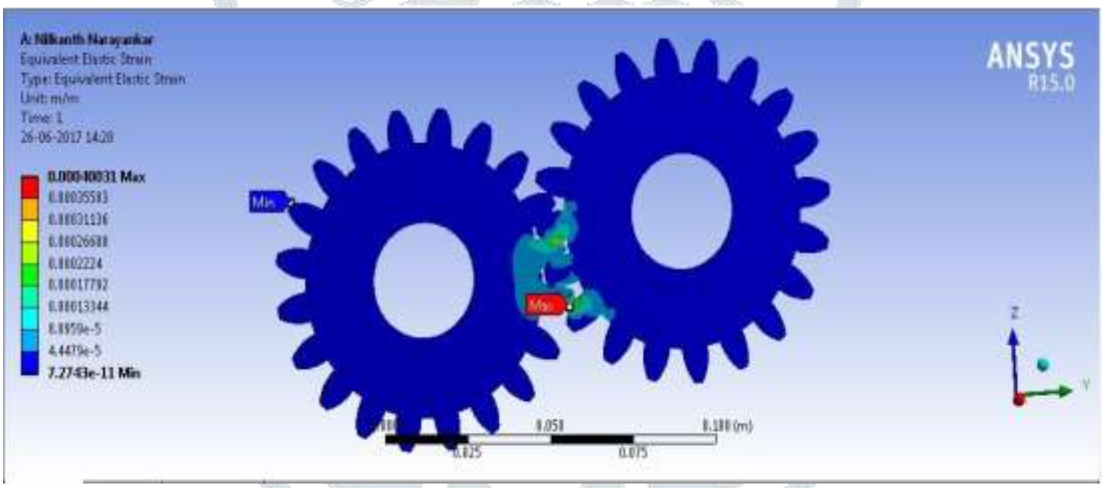

Figure 7:Equivalent elastic strain

The below figure shows the 20 N-m moment directional deformation produced in X-Axis.

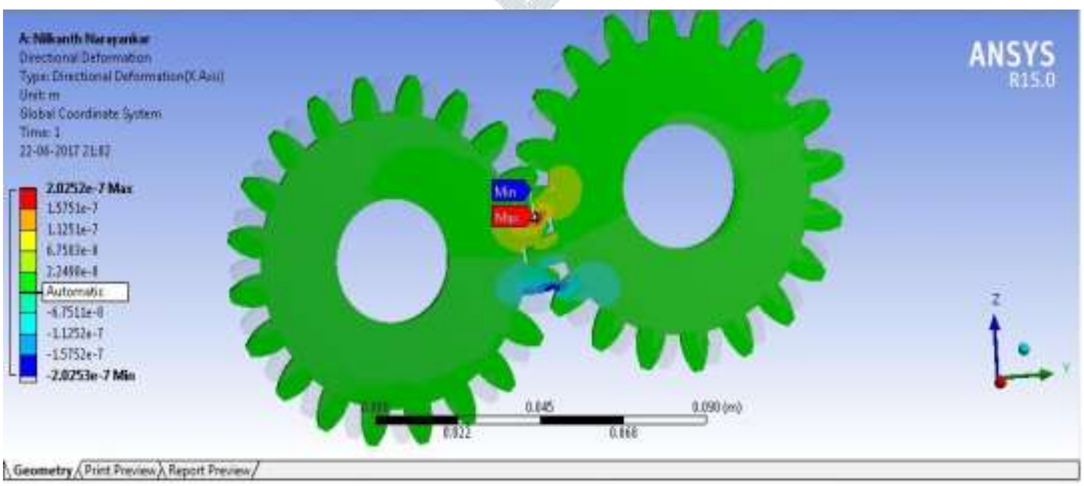

Figure 8:Directional deformation

The below figure shows the total deformation for desired rotation or moment of gear.

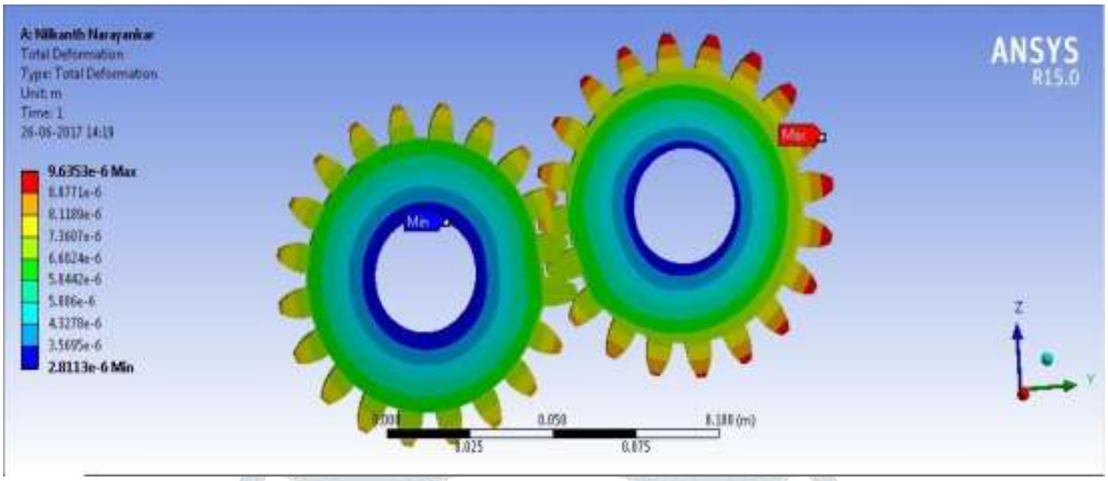

Figure 9:Total deformation for desired moment of gear

The results obtained from finite element method (Ansys) are as given in table 1.

Table 1 Ansys (Finite element method) Result

Applied moment (N-m)	*Contact stress (Mpa)*	*Bending stress (Mpa)*	*Directional deformation (m)*
20	79306	19989	2.0252×10^{-7}

IV. CONCLUSION

As the driving torque or moment 20 N-m is applied to the gear then, maximum contact stress produced in mating teeth of gear is 79306 Mpa and bending stress developed is 19989 Mpa. Also directional deformation of the mating teeth of spur gear is 2.0252×10^{-7}m. These results are calculated from Ansys software (Finite element method). Finite element method is easy method to calculate contact stress and bending stress developed in mating teeth of spur gear.

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