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Designing Highly Loaded Spur Gears using ANSYS

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***Abstract*— Designing highly loaded spur gears for power transmission systems that are both strong and quiet requires analysis methods that can easily be implemented and also provide information on contact and bending stresses, along with transmission errors. The finite element method is capable of providing this information, but the time needed to create such a model is large. In order to reduce the modeling time, a preprocessor method that creates the geometry needed for a finite element analysis may be used, such as that provided by Solid Works. Solid Works can generate models of three-dimensional gears easily. In Solid Works, the geometry is saved as a file and then it can be transferred from Solid Works to ANSYS.**

***Index Terms*—Modeling Time, Solid Works, Highly loaded Spur Gears, Bending stresses.**

I. Introduction

Pitting and scoring is a phenomena in which small particles are removed from the surface of the tooth due to the high contact stresses that are present between mating teeth. Pitting is actually the fatigue failure of the tooth surface. Hardness is the primary property of the gear tooth that provides resistance to pitting. In other words, pitting is a surface fatigue failure due to many repetitions of high contact stress, which occurs on gear tooth surfaces when a pair of teeth is transmitting power.

According to the position of axes of the shafts - The axes of the two shafts between which the motion is to be transmitted, may be (a) Parallel, (b) Intersecting, and (c) Non-intersecting and non-parallel.

According to the peripheral velocity of the gears. The gears, according to the peripheral velocity of the gears, may be classified as (a) Low velocity, (b) Medium velocity, and (c) High velocity.

According to the type of gearing. The gears, according to the type of gearing, may be classified as (a) External gearing, (b) Internal gearing, and (c) Rack and pinion.

According to the position of teeth on the gear surface. The teeth on the gear surface may be (a) Straight, (b) Inclined, and (c) Curved.

The 14 /2° composite system is used for general purpose gears. It is stronger but has no interchangeability. The tooth profile of this system has cycloidal curves at the top and bottom and involute curve at the middle portion. The teeth are produced by formed milling cutters or hobs. The tooth profile of the 14 /2° full depth involute system was developed for use with gear hobs for spur and helical gears. The tooth profile of the 20° full depth involute system may be cut by hobs. The increase of the pressure angle from 14 /2° to 20° results in a stronger tooth. The 20° stub involute system has a strong tooth to take heavy loads.

[1] presented a research study in which Contact stress analysis between two spur gear teeth was considered in different contact positions, representing a pair of mating gears during rotation. A programme has been developed to plot a pair of teeth in contact. Each case was represented a sequence position of contact between these two teeth. The programme 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.

[2] provides a novel method to model lead crowned spur gears. The teeth of circular and involute crowned external spur gears are modeled for the same crowning magnitude. Based on the theory of gearing, mathematical model of tooth generation and meshing are presented. Effect of major performance characteristics of uncrowned spur gear teeth are studied at the pitch point and compared with longitudinally modified spur gear teeth. The results of three dimensional FEM analyses from ANSYS are presented.

II. DESIGN CONSIDERATIONS OF A GEAR DRIVE

In the design of a gear drive, the following data is usually given:

- The power to be transmitted.
- The speed of the driving gear,
- The speed of the driven gear or the velocity ratio, and
- The centre distance.

The following requirements must be met in the design of a gear drive :

(*a*) The gear teeth should have sufficient strength so that they will not fail under static loading or dynamic loading during normal running conditions.

(*b*) The gear teeth should have wear characteristics so that their life is satisfactory.

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(*c*) The use of space and material should be economical.

(*d*) The alignment of the gears and deflections of the shafts must be considered because they effect on the performance of the gears.

(*e*) The lubrication of the gears must be satisfactory.

TABLE – I
SPECIFICATION OF PINION AND GEAR

S. No	PINION	GEAR
Material	C 45	C 45
No. of Teeth	18	54
Module (mm)	5	5
Pitch Circle Diameter (mm)	90	270
Input Power (KW)	30	
Face Width (mm)	54	54
Input Speed (r.p.m)	1200	
Young's Modulus (N/mm^2)	2.1×10^5	2.1×10^5

The software of CAD (Computer Aided Design) to complete the three-dimensional parametric modeling of gears. Using the functionality of three dimensional solid modeling software it is easy to implement parametric gear drive and it also has a good interface with the Finite Element Software. During the gear design, the main parameters that would describe the designed gear such as module, pressure angle and tooth thickness, number of teeth could be used as the parameters to define the gear.

The process information such as quality of grades, metallurgical properties and even load classifications for the gear being designed. Therefore to reduce the modeling time a pre-processor method that builds up the geometry required for finite element analysis may be used, such as Solid Works. Solid Works can generate three dimensional models of gears. The Solid Works CAD software is a mechanical design automation application that lets designers quickly sketch out ideas, experiment with features and dimensions, and produce models and detailed drawings. This document discusses concepts and terminology used throughout the Solid Works application.

The method of gear tooth geometry and parametric modeling is as follow,

- Determining the basic parameter
- Determining the geometric parameter
- The characteristic parameter

The assembly which was created in Solid works is imported in ANSYS for Contact Stress analysis. It is done by saving drawing in IGES file format in Solid Works. After the assembly is imported in ANSYS the both teeth are already in contact, the main purpose is to find contact stress.

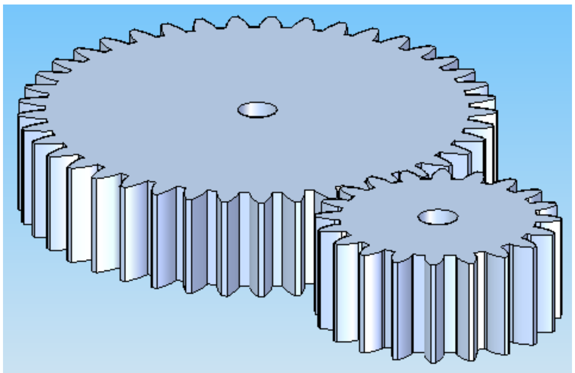

Fig.1. 3-D Model of Spur Gear

Spur Gear is made up of alloy steel, which is modeled in solid works and after rendering it will appear as shown in Fig.2.

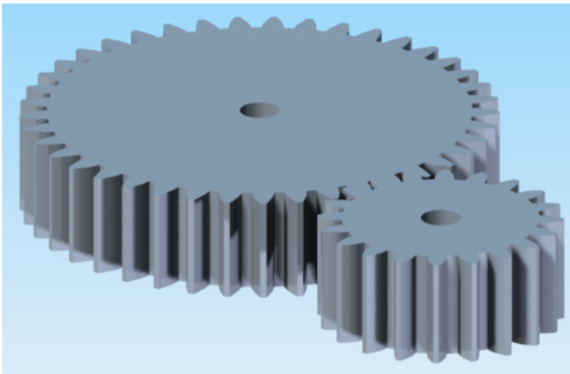

Fig.2. 3-D Model of Spur Gear after Rendering

III. RESULTS AND DISCUSSION

One of the most important things is to change the "Interface Treatment" to "Adjust to Touch" This is helping us to define the kind of contact between the selected bodies. Despite the importance of contact in the mechanics of solids and its engineering applications, contact effects are rarely seriously taken into account in conventional engineering analysis, because of the extreme complexity involved. Mechanical problems involving contacts are inherently nonlinear. Fig.3. shows the zoom model of contact region of the spur gear.

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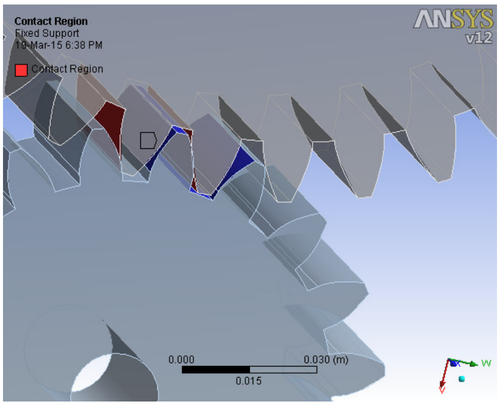

Fig.3. Zoom model of contact region of the spur gear.

Point-to-point contact: the exact location of contact should be known beforehand. These types of contact problems usually only allow small amounts of relative sliding deformation between contact surfaces.

Point-to-surface contact: the exact location of the contacting area may not be known beforehand. These types of contact problems allow large amounts of deformation and relative sliding. Surface-to-surface contact is typically used to model surface-to-surface contact applications of the rigid-to-flexible classification.

Fig.4. shows Boundary condition refers to the external load on the border of the structure. The gear is with fixed support and pinion is subjected to a tangential load.

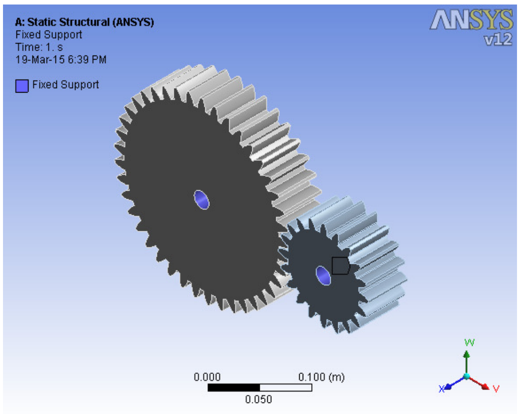

Fig.4. Boundary condition

Fig.5. shows the Von Mises stresses on the root of tooth were carried out in order to know if they match the results from ANSYS.

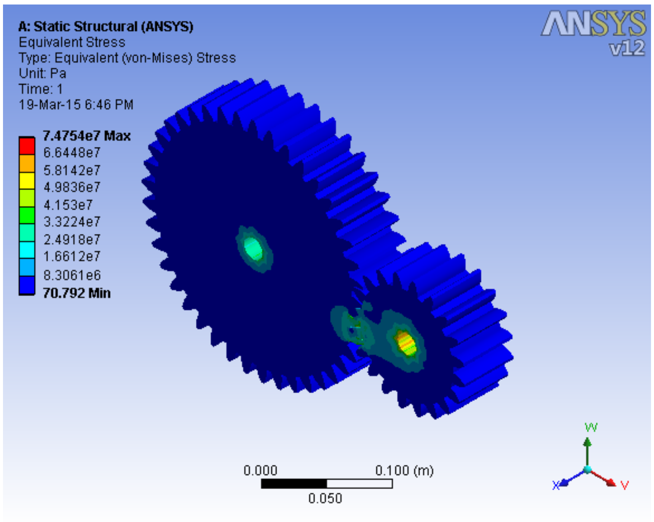

Fig.5. Von Mises stresses

The stress analysis has been done by ANSYS software, where the results have been presented by contours and numerical values. The maximum Von Mises stress value for this model was 74 MPa. Figure 5.3 shows the zoom model of the Von Mises stresses in spur gear model.

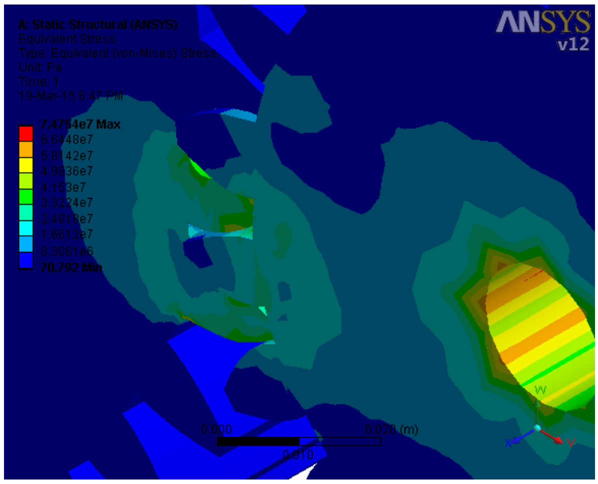

Fig.6. Zoom model of spur gear

IV. CONCLUSION

Designing highly loaded spur gears for power transmission systems that are both strong and quiet requires analysis methods that can easily be implemented and also provide information on contact and bending stresses, along with transmission errors. The finite element method is capable of providing this information, but the time needed to create such a model is large. In order to reduce the modeling time, a preprocessor method that creates the geometry needed for a finite element analysis may be used, such as that provided by Solid Works. Solid Works can generate models of three-dimensional gears easily. In Solid Works, the geometry is saved as a file and then it can be transferred from Solid Works to ANSYS.

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