Analysis of Symmetric and Asymmetric Spur Gear to Improve Bending Load Carrying Capacity

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***Abstract*:-Gear is a machine element used to transmit motion and power between rotating shafts by means of progressive engagement of projections called teeth, a pair of spur gear teeth in action is generally subjected to two types of cyclic stresses as bending stresses and contact stress. These stresses cause the bending and pitting failure respectively. These types of failures can be minimized by proper analysis of the problem during the design stage and creating proper tooth profile. Normally, gear analysis is combination of various analysis method, including calculations related to the tooth stresses, wear or scoring. In this paper, bending stress analysis of the symmetric and asymmetric spur gear will be performed, while trying to design spur gears to improve the bending load of the teeth; tooth profile modification is done by modifying the pressure angle. Then bending stresses calculated using ANSYS, from that results comparison between symmetric and asymmetric spur gear is done.**

Keywords:-Spur gear, symmetric spur gear, asymmetric spur gear, bending stress, pressure angle.

I. INTRODUCTION

Gears are the most important part of transmitting power in the power transmission world. They vary from a small size used in watches to the large gears used in industrial applications and speed reducers. They plays major role of main and ancillary mechanisms in most of machines such as automobiles, tractors, cutting machine tools etc. Toothed gears are used to change the speed and power ratio as well as direction between input and output.Gear analysis is done analytical methods, which required a number of assumptions and simplifications. In this paper, bending stress analysis is done, while trying to design spur gears to improve bending load of the spur gear teeth.

A. Asymmetric spur gear teeth:-

Asymmetric gear is formed by the two involutes of different base circle diameter i.e. coast side profile and the drive side profile as shown in the fig. for the design of the asymmetric spur gear majorly pressure angle of drive side is modified so that one can get more contacting area while the tooth meshing i.e. power transmission.The main advantage of asymmetric gear is contact stress reduction on the drive flanks of the spur gear tooth, resulting in higher torque carrying capacity (load capacity per gear size). These benefits of the gears with asymmetric tooth profiles for unidirectional torque transmission are well known. Asymmetric gear tooth profile optimization leads to significant contact and bending stress reduction. This stress reduction is results in to: Higher load capacity, reduced size and weight, extended lifetime,reduced noise and vibration, higherefficiency, higher reliability, reduced cost

Now a day's CAE analysis software's are more and more powerful, so the people are tended to use numerical approaches to develop theoretical models to predict the effect of whatever is studied. This has improved gear bending stress analysis and computer simulations. Numerical methods cannot provide more accurate results since they require much less restrictive assumptions. The finite element method is very often used to analyze the stress ofstructural body with complicated geometry, such as a gear, shaft, pressure vessels etc. To analyze the spur gear there are two theoretical formulas, which deal with bending and pitting failure in the power train mechanism they are as below.

- Hertz equation: - This method is used to calculate the contact stresses in the gear tooth.
- Lewis formula: -This method is used to calculate the bending stresses in the gear tooth.

The finite element method is able to provide these results, but the time required to create such a model in the CAE tool is so large. In this paper, in order to reduce the modeling time in the CAE Software, a 3D model created in solid modeling using CREO software.CREO can generate models of three-dimensional gears easily. In CREO, the geometry is saved as anIGES file and then it can be imported in ANSYS workbench. In ANSYS workbench, one can click File > Import > IGES > and check.

The main objective of this study is:-

- To generate the profile of spur gear teeth.
- To develop and to determine bending stresses using ANSYS and compare the results between Symmetric spur gear and the asymmetric spur gear.
- To compare the accuracy of results obtained is ANSYS by varying load conditions and gear parameters.

Generation of 3D model:-

- To plot the curve in the CREO .ibl file is required; .ibl file contains X, Y and Z co-ordinates of curve.
- To generate .ibl file of the involute curve,X,Y,Z co-ordinates of the involute curve are calculated by using excel and that file is imported in the CREO

- Basic involute curves generated in the CREO are as shown in the Fig.

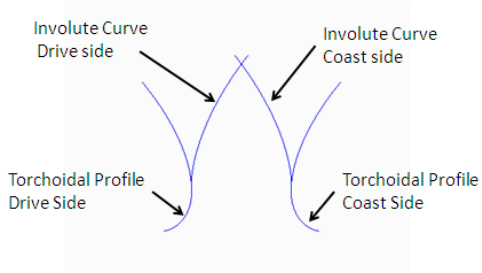


Fig 1 Curves generated in the CREO

- Now With the help of some gear parameters like Outer Diameter, Pitch Circle Diameter, Base Circle Diameter 3D model is created and saved in the IGES file as shown below.
- Now the spur gear is ready for a finite element analysis.
- In this study, For the analysis only one teeth is considered,

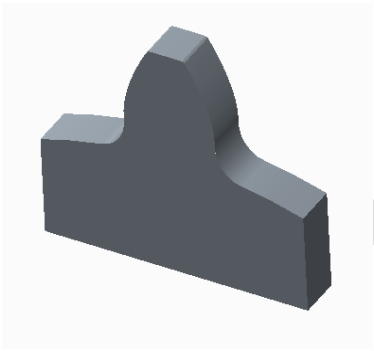


Fig 2 Spur gear teeth

Finite Element Analysis of the bending stress in the spur gear tooth:-

In this study, for the analysis of the bending stress in the gear tooth Ansys 13 (Workbench) software is used .In that FEA Analysis is done using static structural tool. For the FEA analysis using ansys workbench follow the below procedure;

- Preprocessing: -In the preprocessing gear geometry is imported and meshing is done as shown in the fig**.,** for the analysis acrylic material is considered having density 1400kg/m3 , Poisson ratio 0.35and Young's modulus 3.5 GPA

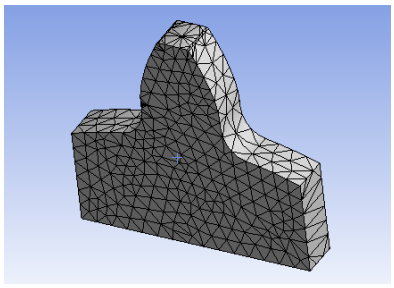


Fig 3 Tooth Meshing

- Post processing **:-**In the post processing stage boundary conditions are applied as shown

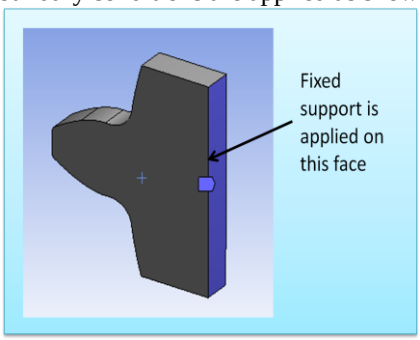


Fig 4 Fixed Support applied

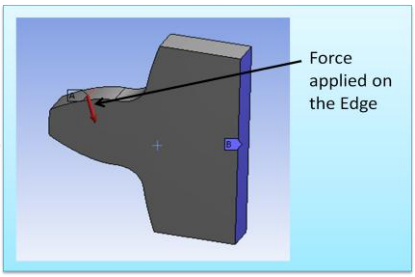
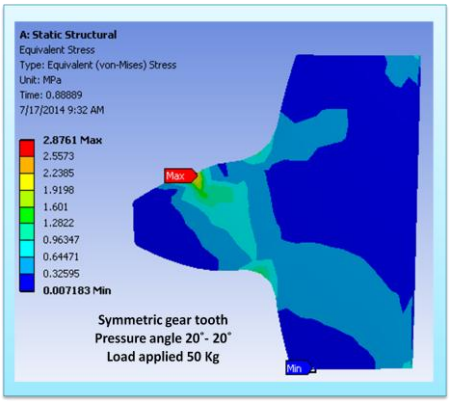


Fig 5 Force Applied

- Solution**:-**In this study, Equivalent Von-Mises stress result are studied. For the result refer below snaps.

RESULT AND CONCLUSION



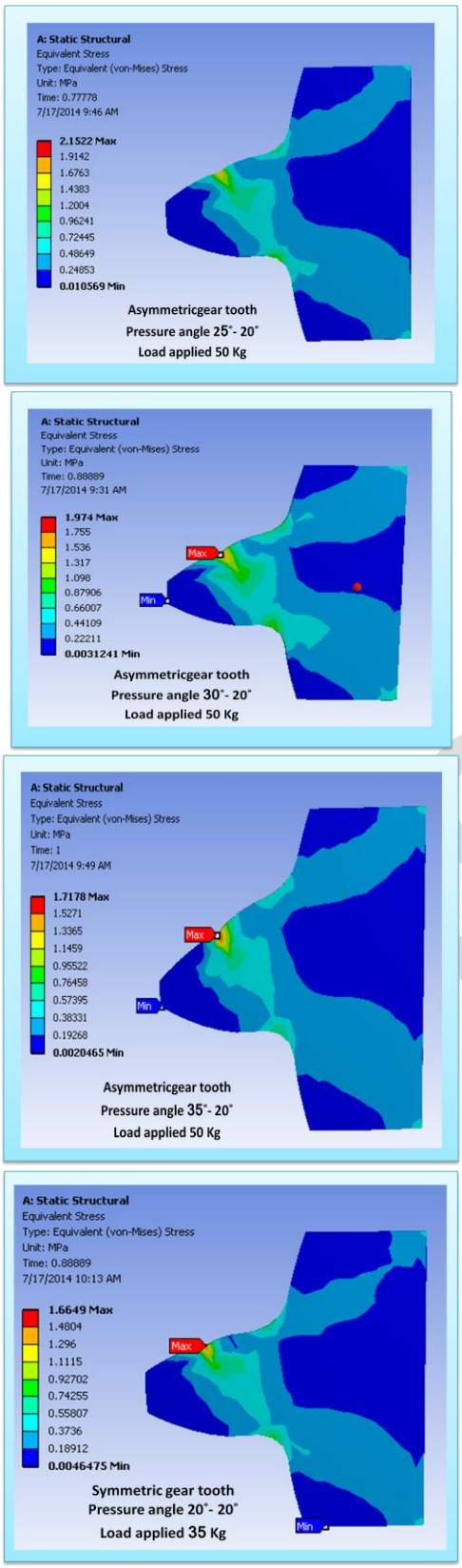


Fig 6.1 Ansys results

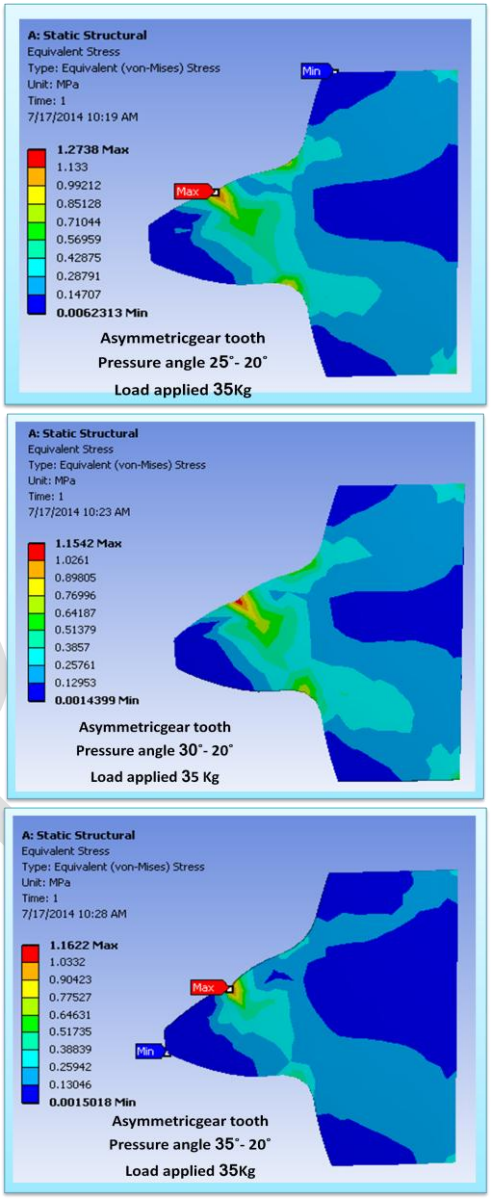


Fig 6.2Ansys results

Test specimen	Tooth profile pattern	Load applied (Kg)	Pressure angle (Drive side-coast side)	Maximum bending stress (σ) MPa
1	Symmetric	50	20°-20°	**2.876**
2	Asymmetric	50	25°-20°	2.152
3	Asymmetric	50	30°-20°	1.974
4	Asymmetric	50	35°-20°	1.718
5	Symmetric	35	20°-20°	**1.6649**
6	Asymmetric	35	25°-20°	1.273
7	Asymmetric	35	30°-20°	1.152
8	Asymmetric	35	35°-20°	1.162

Table 1 FEA estimations of maximum stresses of the specimens

From the above finite element analysis result it can be concluded that, it is possible to increase the bending load carrying capacity of spur gear by modifying symmetric geometry to Asymmetric geometry. In case of spur gear with asymmetric tooth profile bending load carrying capacity can be increase up to 30% as compared to symmetric spur gear.

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