Design of Contact Stress Analysis in Straight Bevel Gear

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Abstract

Our present work concentrates on the three dimensional fillet stress analysis of bevel gear tooth using finite element method using APDL (Ansys Parametric Design Language). The stress distribution of bevel gear at the root of the tooth is evaluated under various load conditions such as uniformly varying load and a concentrated load at pitch point load. This paper also discusses load distribution on the pitch line and the stress distributions at the root fillet.

Keywords:*bevel gear; root fillet; finite element method.*

I. INTRODUCTION

Gears are used to transmit the power from one shaft to another shaft. For bevel gear is used to transmit the motion and power between to intersecting shaft and non-intersecting shaft. In recent years many approaches have done for stress analysis in straight bevel gear. Nalluveettil and Muthuveerappan [1] evaluate the bending stress of bevel gear by using FE method by changing pressure angle, torque, shaft angle, rim thickness and face width in gear model. Ramamurti, Nayak, Vijayendra and Sujatha [2] using finite element method, studied the three dimensional stress analysis of bevel gear teeth using cyclic symmetry concept.In this concept the displacement of a tooth is computed for each Fourier harmonic component of the contact line load and its reduced the computational effort. Nour, Djedid, Chevalier, Si-Chaib, Bouamrene [3] using FE method the contact analysis of spiral bevel gear has is done to evaluate the stress at root fillet of gear tooth. Vijayarangan and Ganesan [4] using three dimensional FE methods to analysis the behavior of composite bevel gear and it's compared to the carbon steel and they concluded that boron/epoxy composite material is very much thought of as material for transmit the power. Faydor, Litvin and Alfonso Fuentes [5] is evaluate the stress analysis for low-noise spiral bevel gear drives with adjusted bearing contact using FE method.

As, the stress value of gear is depends upon the parameters of the gear and loading conditions on it. In our, work, the influence of stress at root of bevel gear under different loading conditions are discussed.

II. MODELING OF GEAR TOOTH

The bevel gear geometrical model is developed in finite element software package ANSYS through APDL (ANSYS Parametric Design Language) program using analytical equations given by Buckingham [1]. The gear specifications considered for analysis in this work are given in Table 1. The sequence of operations done to generate the geometrical model of the bevel gear is given in Fig. 1. 20 noded iso-parametric 3 dimensional element having 3 Degrees of freedom per node (solid 95) is used to descritize the geometric model. In this model 54000 element are used for the present study. Single tooth is considered for finite element analysis. The single tooth sector finite element model is shown in fig.2

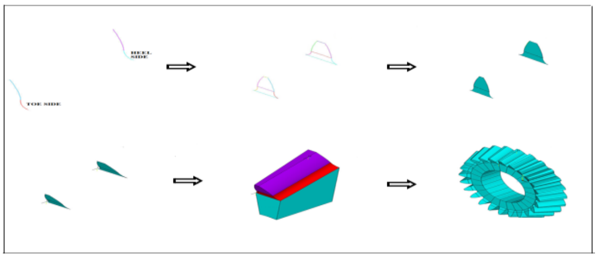


Fig 1 Bevel gear tooth model

III. Bevel gear specification [4]

Table 1

S.NO	PARAMETERS	VALUE
1	Pressure angle, α	20°
2	Shaft angle, β	90
3	Module(mm)	4
4	Addendum(mm)	5.38
5	Dedendum(mm)	3.37
6	Rim thickness(mm)	18.8
7	Number of teeth	24
8	Face width(mm)	20
9	Cone distance(mm)	107.33
10	Pitch radius (mm)	48
11	Semi cone angle, δ	26 °.34'
12	Root fillet	Trochoid
13	Material	C45Steel
14	Poisson ratio	0.3
15	Young's Modulus	2.01e5N/mm^2

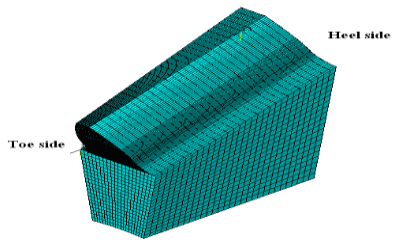


Fig 2 Meshed tooth model (Number of elements: 54000)

III. BOUNDARY CONDITIONS FOR APPLYING LOAD

The nodes at the inner radius of the rim are constrained in all directions and nodes in the side face of rim are constrained in the direction perpendicular to the surface area. A study has been made for two different loading conditions. They are uniform linear distributed load, and pitch point load at pitch point. The face width of the bevel gear tooth has divided into 31 nodes for applying load and to evaluate.In our work, the total resultant force for applying load in gear is 1651N from [4]. In bevel gear, resultant tooth force Fn is applied in tangentially (torque producing), radially (separating), and axially (thrust) components to the pitch point of gear, is designated Ft, Fr and Fa, respectively shown in figure-3.

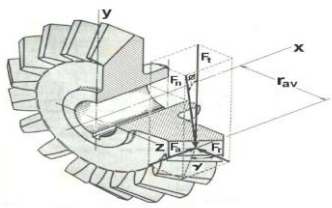


Fig 3 Gear tooth forces

IV. PITCH POINT LOAD

In this loading conditions Fn is resolved in to Ft, Fr and Fa and they are applied to the pitch point. The pitch point load in bevel gear tooth shown in figure-4. The loads are calculated using the expressions,

$$Fn = Ft/\cos\alpha,\ Fr = F_t \tan\alpha \cos\delta,\ Fa = F_t \tan\alpha \sin\delta$$

Where,
Ft = Tangential force
α = Pressure angle
δ = Semi cone angle

V. UNIFORMLY DISTRIBUTED LINEAR LOAD

The load uniformly distributed along the face width on pitch line and it is shown in figure.5

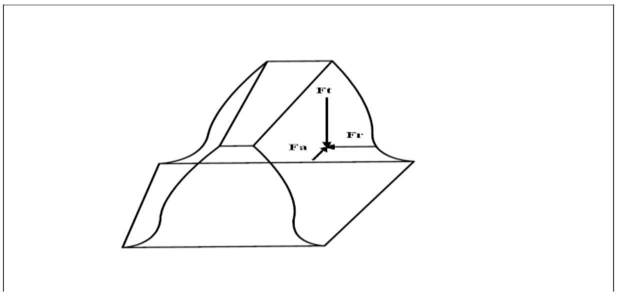
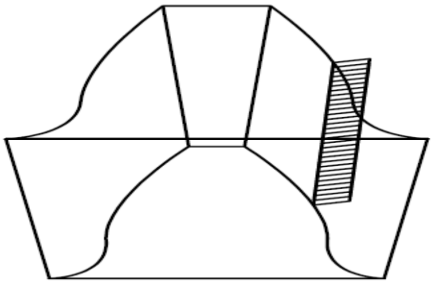


Fig 4 Pitch point load

Fig 5 Uniform distributed Linear load



VI. EVALUTION OF STRESS AT THE ROOT FILLET

The tooth behavior is studied for the given load and the maximum principle stress is illustrated in Fig 6,7, for various loading conditions. The maximum fillet stress calculated as per AGMA standard for the given load is only 52.43N/mm².

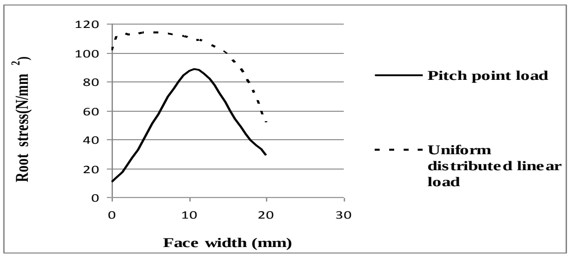


Figure 6 Root stress's at drive side along face width

It is observed from the graph that for the pitch point load the fillet stress at the drive side is gradually increasing from toe side to mid section and similar manner from the mid section to heel side it is gradually reducing. When the load is uniformly distributed along the entire pitch line, the stress value is more nearer to toe side when compare to that of heel side.

Figure 7 Root stress's at non drive side along face width

It is observed from the graph that for the pitch point load the fillet stress at the non-drive side is gradually decreasing from toe side to mid section and similar manner from the mid section to heel side it is gradually increasing. When the load is uniformly distributed along the entire pitch line, the stress value is more nearer to toe side when compare to that of heel side

VII. CONCLUSION

3D bevel gear model at finite element model using ANSYS has been generated and analyzed in this work. The influence load on the root stress in straight bevel gear is evaluated for two different conditions. The stress in gear tooth is high at toe side and comparatively low at heel side.

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