IMPROVEMENT OF BENDING LOAD CARRYING CAPACITY OF THE SPUR GEAR BYUSING ASYMMETRIC TOOTH PROFILE

Mr.Dekhane Akshay Govardhan
PG Scholar, Department of Mechanical Engineering
Vishwabharati Academy's College of Engineering,
Ahmednagar, Maharashtra, India
agdekhane@gmail.com

Dr. L.B. Abhang
Department of Mechanical Engineering
Vishwabharati Academy's College of Engineering,
Ahmednagar, Maharashtra, India
abhanglb@yahoo.co.in

***Abstract*-Transmission is one of the important feature to transmit the motion and power . Gear is one the component of transmission system. When the motion and the power is to be transmitted from one machine element to another having relative motion between them, the component use is called as Gear. Gears are devided according to the relative position of the axes of the shaft, type of gearing, peripheral velocity of the gears and position of teeth on gear surface. Gears life is affected by the backlash, undercut & interference. Backlash is tangential space between teeth of mating gears at pitch circles. These defects can be reduced by increasing the pressure angle, by increasing the addendum of mating gear and another way of increasing the load capacity of transmissions is to modify the involute geometry. It is the standard practice in gear design for many years; the nomenclature describing these types of gear modifications can be quite confusing with reference to addendum modification or profile shift. One of the best alternative is that is very rarely used is to make the gears asymmetric with different pressure angles for each side of the tooth.**

Meshing is studiedin the design of asymmetric gear. This method is appropriate for the geometric design of spur gears with a small teeth number and is based upon the generalized model of involute meshing.

***Keywords* : Asymmetric gear, Bending stress, pressure angle, FEA**

I. INTRODUCTION

Asymmetric spur gear teeth

Gear design for asymmetric tooth profiles opens additional reserves for improvement of gear drives with unidirectional load cycles which are typical for most of the transmissions. The two profiles (sides) of a gear tooth are functionally different for many gears. The workload on one profile is generaly higher and is applied for long time than for the opposite one. The design of the asymmetric tooth shape gives this functional difference. [6]

Fig. 1 :Asymmetric spur gear

The design intent of asymmetric teeth is to improve performance of contacting profiles by degrading opposite profiles. These opposite profiles are unloaded or lightly loaded, and usually work for a short period. The improved performance could mean increasing load capacity or reducing noise, vibration, etc.

Degree of asymmetry and drive profile selection for these gears based on the application. Asymmetric profiles make it possible to manage tooth stiffness and load sharing by keeping a desirable pressure angle on the drive profiles.

The design of gears with asymmetric teeth is studied in detail in other articles [8, 10], covering topics such as FEA analysis of asymmetric gearing. Examples of gears with asymmetric tooth profiles are shown in Fig. Gears with asymmetric teeth should be considered for gear systems that require maximum performance.It is applicable for mass production transmissions where the share of the tooling cost per one gear is relatively insignificant. Molded gears arethe promising application for asymmetric profiles and powder metal gears are also. Molded gear tooling requires a custom shape, so the asymmetric profile does not significantly affect cost. [6]

Improvement of the performance of the main contacting profile is the design intent of asymmetric gear teeth which is for that purpose opposite profile is typically unloaded or lightly loaded during relatively short work periods. The circular distance (tooth thickness) between involute profiles is defined at some reference circle diameter that should be bigger than the largest base diameter. Asymmetric gears also allow an increase in the transverse contact ratio as well as operating pressure angle beyond the conventional gear limits. Asymmetric gear profiles also make it possible to manage tooth stiffness and load sharing while keeping a desirable pressure angle as well as contact ratio on the drive profiles by changing the coast side profiles. This provides higher load capacity and lower noise and vibration levels compared with symmetric gears.

In propulsion gear transmissions, the tooth load on one flank is significantly higher and is applied for longer periods of time than that of the opposite one. An asymmetric tooth shape gives this functional difference. Improvement performance of the primary drive profiles at the expense of the performance for the opposite coast profiles is the design intent of asymmetric gear teeth. The coast profiles are unloaded or lightly loaded during a relatively minimum work period. Asymmetric tooth profiles also make it possible to simultaneously increase the contact ratio also the operating pressure angle be yond the conventional gears' limits. [7, 10]

II. Literature Review

The paper given by the scientist OgnyanAlipiev gives an idea about the design of symmetric and asymmetric gears also focused on the load carrying capacity of gear. This is the practical realization of the gearing theory of generalize parameters.This method is very verysuitable but not so simple for the geometric design of spur gears with a small number teeth numberthe FEA analysis is one of the important part.. Asymmetric gear design is not constrained by standardized tooling and the tool based design approach is used for conventional gears [1].

The theory of asymmetric involute teeth applied by the scientist V. Senthil Kumar, D.V. Muni [2].The design intent of asymmetric gear teeth is to improve the performance of the primary contacting profile by degrading the performance of the opposite profile.This paper focused on the increasing the load carrying capacity of assymetric gears.

Alexander Kapelevichfocused on the asymmetric teeth by reducing the weight. Gears with asymmetric teeth should be less in weight as compare to the symmetric one[3]. Asymmetric profiles make it possible to manage tooth stiffness and load sharing while keeping a desirable pressure angle. It also provides many variety of solutions for a particular couple of gears that are included in the area of existence .

The scientistNiels L. Pedersen suggested that the bending stress and the weight can be reduced significantly with the help of asymmetric gear teeth by proper analysis and by experimental analysis[4].Using the direct design approach for asymmetric gear teeth is easier than for conventional gears. This suggests the use of two new standard cutting tools.

III. PROBLEM STATEMENT

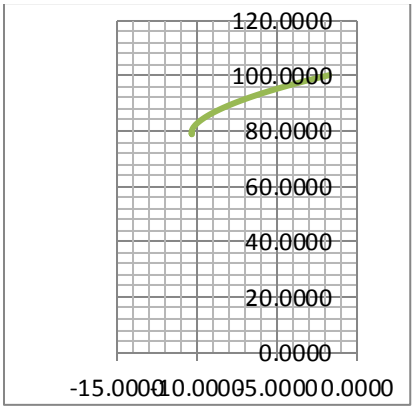
- Improvement of bending Load carrying capacity of the Involute Spur Gear by using asymmetric tooth profile.
- FEA Analysis of the bending stress in gear tooth.

IV. OBJECTIVE OF THE PRESENT WORK

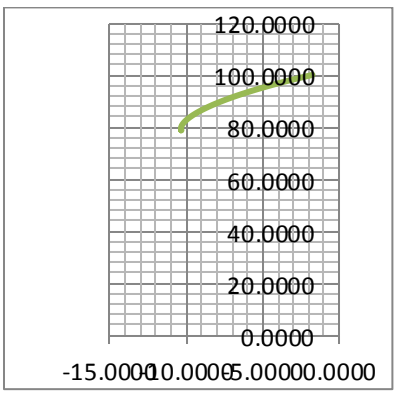
- The principal objective of the work is to improve the bending Load carrying capacity of the Involute Spur Gear by using asymmetric tooth profile.
- To calculate the Design parameters of asymmetric gears.
- To develop an efficient and reliable program in ANSYS parameter design language to automate the process of finite element analysis.
- Experimental stress analysis.

V. Research Methodology

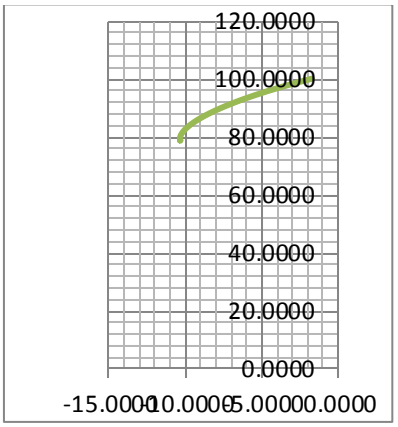
1) Design of Spur gear Profile
   - Calculation of design parameters
   - To calculate co-ordinates of involute profile :
   - Torchoidal Profile Calculations
2) Graph of Involute profile by using different pressure angle



Graph 1 : Involute profile

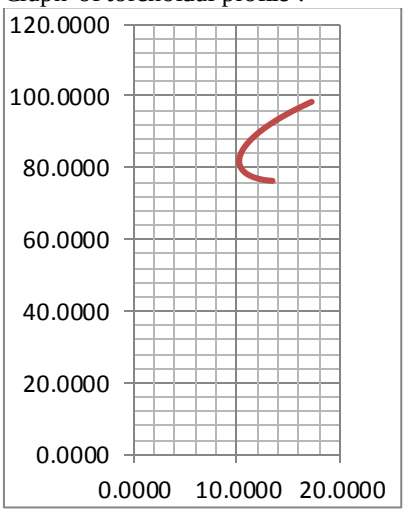


Graph 2 : Involute profile

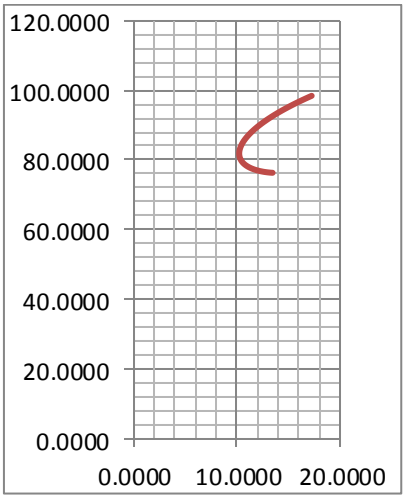


Graph 3 : Involute profile

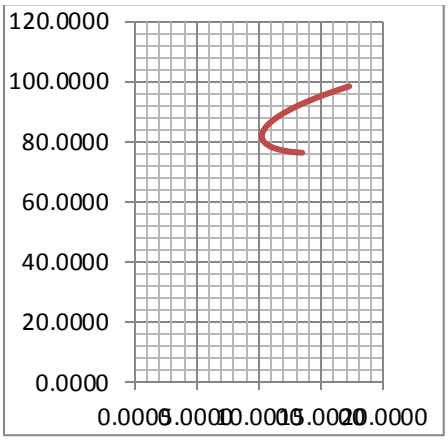
3) Graph of torchoidal profile :



Graph 4 :Torchoidal profile



Graph 5 :Torchoidal profile



Graph 6 :Torchoidal profile

VI. Modeling of the Gear in Pro-E

To plot the involute curve:

1. To plot the curve in the pro-e .ibl file is required.
2. .ibl file contains X, Y and Z co-ordinates of curve.
3. to generate .ibl file need to do below procedure:
   - Copy the co-ordinates from the excel file and paste in the notepad file.
   - At the start of the notepad file write below programming codes to convert text file to .ibl file
     OPEN
     ARCLENGTH
     BEGIN SECTION! 1
     BEGIN CURVE
     Below this line paste the co-ordinates of the required curve.
     For details Refer the .ibl file in the annexure no .------
4. After generation of .ibl file next step is to call .ibl file in the pro-e.
   a. Open part file in the Pro-e.
   b. Select the Curve option from the tool bar in that select curve from file
   c. -Select the generated .ib; file and ok.
   d. Involute curve is generated.
   e. Follow the same procedure to plot curve for the coast side, drive side and Torchoidal profile.
   f. Now the basic curves are generated in the Pro-E. as shown in the Fig.

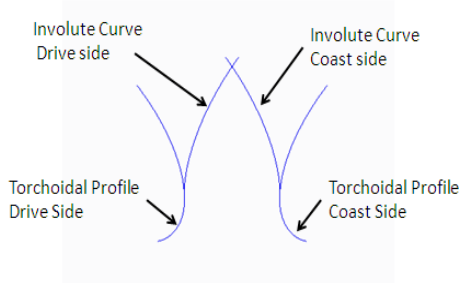


Fig. 2 :Curves generated in the Pro-E

- Now With the help of Outer Diameter, Pitch Circle Diameter, Base Circle Diameter calculated in the excel file. Generate the tooth profile as shown in fig.

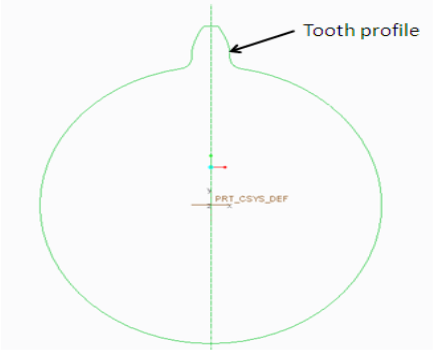


Fig. 3: Sketch of gear teeth

- With help of this sketch generate the 3D Model.
- Now the gear is ready.
- In this study, For the analysis only one teeth is considered, so model as shown in the fig5.3 is generated.

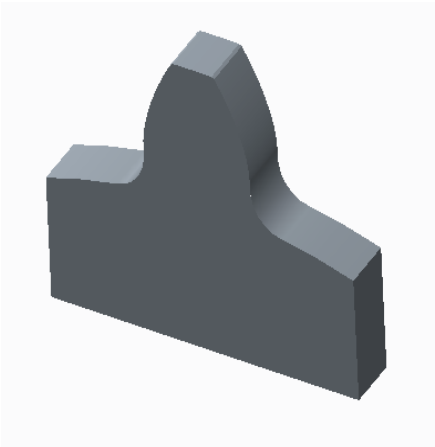


Fig. 4 :3D model of Gear Teeth

- Save the CAD model in the .step file so that it can be imported for the analysis for the further calculations.

VII. FEA Analysis

FEA analysis of the bending stress in the 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:-

- Open Ansys workbench
- Start the structural tool in the home window.
- In that specify the desired properties of the gear material (in this study for the practical validation Perspex acrylic is used so the same material is selected in the CAE also)
- All the material properties enter in the Engineering data.
- Now next step is to import the CAD data in the CAE tool.
- Now from the geometry tab import the step file generated in the PRO-E.
- Open the model from the model tab.
- In that from the mesh tab generate the mesh.
- Preprocessing stage is completed as shown In the fig.

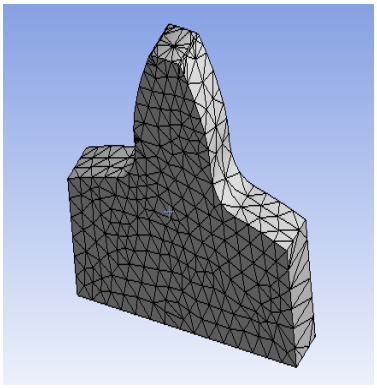


Fig. 5: Tooth Meshing

Post processing :-

- In this stage , need to apply the boundary conditions and forces on the model, for that follow the below procedure.

- Bour in the mode

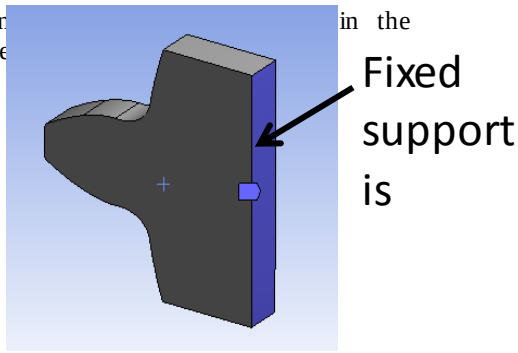


Fig. 6: Fixed Support

- Force is applied on the flank as shown in the fig.
- Force is applied on the edge as shown because while application of the gear line contact between pinion and gear.

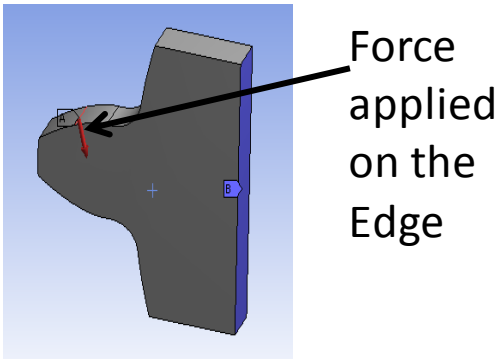


Fig. 7: Force Applied

Result:-

From the below result it is prove that, it is possible to increase the bending load carrying capacity of spur gear by modifying symmetric geometry to Asymmetric geometry as explained in this study.

For the Details refer the below results.

Test specimen	Maximum stress (σ) MPa
1	2.876
2	2.152
3	1.974
4	1.718
5	1.6649

6	1.273
7	1.152
8	1.162

FEA estimations of maximum stresses of the specimens

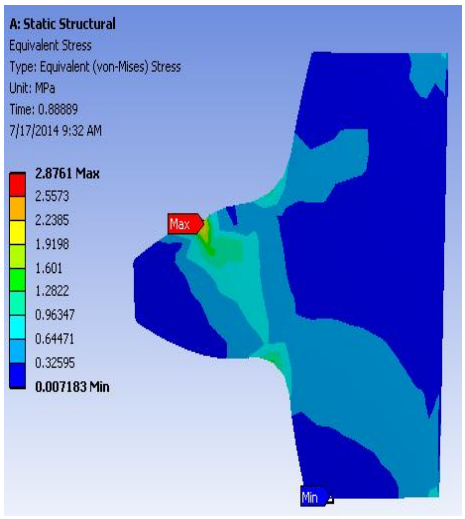


Fig. 8:Symmetric gear tooth
Pressure angle 20˚- 20˚

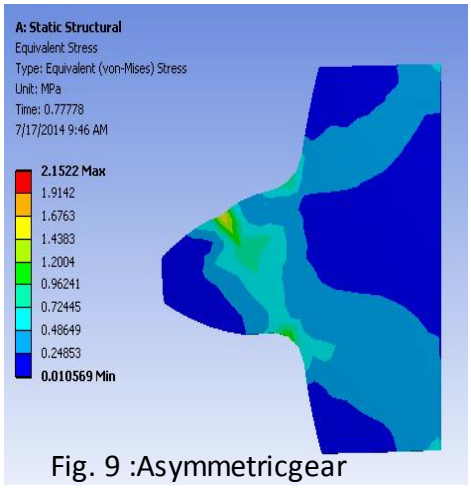


Fig. 9 :Asymmetricgear tooth
Pressure angle 2**5**˚- 20˚

Experimental Stress Analysis

Experimental stress test:-

In this study, for the testing of bending stress in the gear tooth "Diffused light polariscope" is used.

Diffused Light Polariscope:-

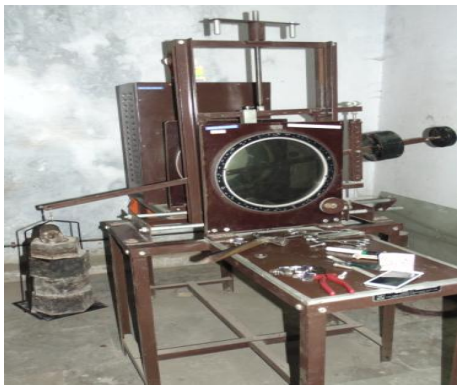


Fig.10 : Diffused Light Polariscope

Photoelasticity is a nondestructive method, birefringence. It is the whole-field, graphic stress-analysis technique based on an optomechanical property, possessed by many transparent polymers. Combined with other optical elements as well as illuminated with an ordinary light source, a loaded photoelastic specimenposseses fringe patterns that are related to the difference between the principal stresses in a plane normal to the light propagation direction.

The method is widely used primarily for analyzing twodimensional plane problems, which are also comes in themathematicalmodelling. A

method called stress freezing allows the method to be extended to two dimensional and threedimensional problems. Photoelastic coatings are used for many applications and to analyze surface stresses in bodies of complex geometry is one of the application of the same.

Conclusion

The basic geometric theory of the gears with asymmetric teeth has been developed. This theory allows to research and design gears independently from generating rack parameters. It also provides wide variety of solutions for a particular couple of gears that are included in the area of existence. The following conclusions can be drawn from this research:

1. The asymmetric tooth geometry allows for an increase in the pressure angle and contact ratio for drive sides.

2. General characteristics of the asymmetric gearing are optimized and we can improve the other parameters of gear profile.

3. The formulas and equations for gear and generating rack parameters are determined.

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