Influence of using Stress Feature on Reducing the Stress in Spur Gear

Pratik Maheshwari[1] Aum Thacker[2]
[1]P.G. Student [2]Assistant Professor
[1,2]Department of Mechanical Engineering
[1]Gujarat Technological University, India [2]Veerayatan Group of Institutions, India

Abstract— Gears generally fail when the working stress exceeds the maximum permissible stress. Number of studies has been done by various authors to analyze the gear for stresses. Gears have been analyses for different points of contact on the tooth profile and the corresponding points of contact on the pinion. In this study the technology of gears is presented along with the various types of failures that gears have. The causes of these failures are studied and one type of stress related failure due to fatigue failure of a gear tooth due to stress concentration is detailed. This work presents the stress redistribution by introducing the stress relieving features in the stressed zone to the reduction of root fillet stress in spur gear. In this work circular stress relieving features are used and better results are obtained. A finite element model with a segment of three teeth is considered for analysis and stress relieving features of various diameters are introduced on gear teeth. Analysis revealed that circular stress relieving feature at specific locations is beneficial.

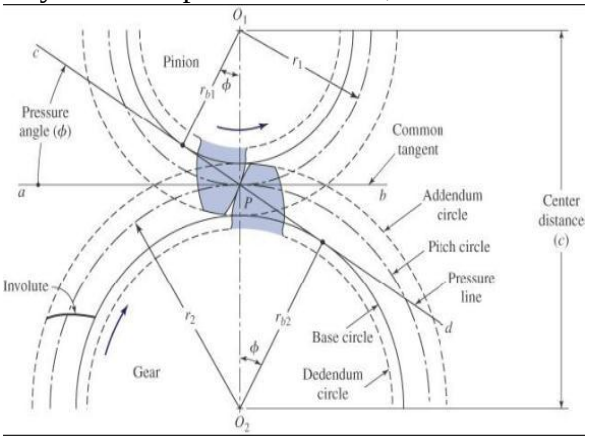
Key words: spur gear, FEA, stress redistribution

NOMENCLATURE

- Parameter Notation
- Pressure angle α
- Addendum factor hf
- Dedendum factor af
- Tooth fillet radius factor rf
- No. of teeth z
- Module m
- Profile shift factor sf
- Hole location radius h1lr
- Hole radius h1r

I. INTRODUCTION

In Engineering And Technology The Term "Gear" Is Defined As A Machine Element Used To Transmit Motion And power Between Rotating Shafts By Means Of Progressive Engagement Of Projections Called Teeth. Gears Are the Means by Which Power Is Transferred From Source to Application. Gearing And Geared Transmissions Drive the Machines Of modern Industry. Gears Rotate The Wheels And Propellers That Transport Us Over The Sea, On The Land, And In The Air. A Sizable Section Of Industry And Commerce In Today's World Depends On Gearing For Its Economy, Production, And Livelihood. The Art And Science Of Gearing Have Their Roots Before The Common Era. Yet Many Engineers And researchers Continue To Delve Into The Areas Where Improvements Are Necessary, Seeking To Quantify, Establish, And Codify Methods To Make Gears Meet The Ever-Widening Needs Of Advancing Technology. This Work Establishes The Empirical Relations To Predict The Percentage Of Reduction In Root Fillet Stress In Spur Gears Due To The Circular Stress relieving Features At The Stressed Zone



II. LITERATURE SURVEY

A. Literature review

Wilcox L. and Coleman W. [1] successfully applied the finite element method to determine the stress distribution in a spur gear at the fillet region of the tooth and the maximum surface stress at the fillet. The author is of the opinion that the accuracy with which the root fillet stress can be measured experimentally has limitations. In addition to this in experimental method a physical model of the spur gear teeth is to be constructed. He also figures out that some assumptions are inevitable in analytical approach of determining the stress.

Fredette L. and Brown M. [2] presents the possibility of reducing the gear tooth root fillet stress by adding the internal stress relief features. The theory that harshness of the stress concentration can be reduced by the Placement of the holes at the low stressed zone was based on the idea that the stress will be displaced away from the critical area. This would most likely transfer more of the stress to the compressive side of the gear. For his analysis he Has chosen a gear which is (the gears with 10 to 12 diameter pitch are more common in aerospace gears) used in the accessory gear box of commercial jet engine.

Srinivasalu B. [3] prepared a computer program to generate a finite element model of spur gear. The aim of his study was to investigate the effects of module, pressure angle, number of teeth of drivers and driven gears and fillet radius on the root fillet stress and compare the results with the results of other investigators. The author used 6 node quadratic plain strain triangular elements to mesh the model and applied the fixed and radial guided displacement boundary conditions along base and both sides of the gear tooth respectively. He carried out the analysis on single tooth spur gear segment using MSC/NASTRAN as well as the computer program developed by him. In his investigation he considered three load conditions namely (a) point load, (b) distributed load along the width of gear face, and (c) simulated the contact between mating gears using gap elements. According to his report the difference between the root fillet stresses in the gear is less than 1%.

III. FINITE ELEMENT SYSTEM

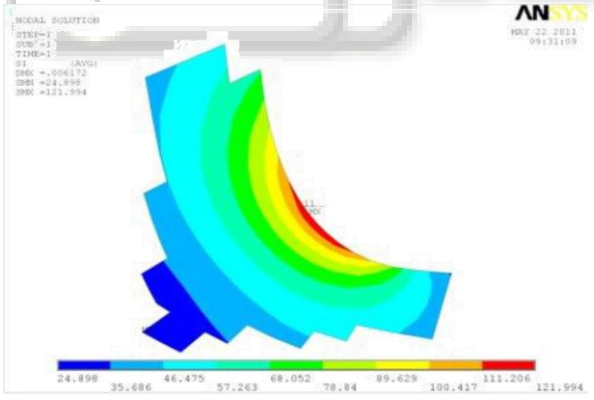
A. Introduction to FEM

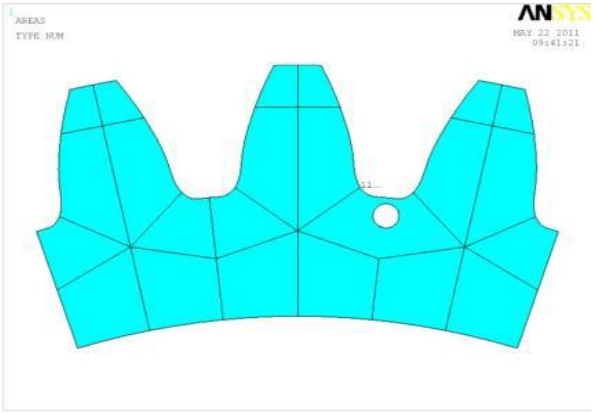
FEA consists of a computer model of a material or design that is loaded and analyzed for specific results. It is used in new product design, and existing product refinement. A Company is able to verify that a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

The finite element method is a numerical method, which can be implemented to solve many problems. The FEM was first developed in 1956 for the analysis of aircraft structural problems there after within a decade, the potential of the method for the solution of different types of applied sciences and engineering problems were recognized. Over the years, the finite technique has been so well established that today it is considered to be one of the best methods for solving a wide variety of practical problems efficiently.

B. FEM procedure

- Discretization of given domain into a collection of prescribed finite elements.
- Derivation of element equations for all typical elements in the mesh
- Assemble element equations to obtain the equations of the whole problem.
- Solution of the assembled equations
- Post Processing of the results.
- Complete the gradient of the solution or other desired quantities from the primarydegrees of freedom





IV. CONCLUSION

As per analysis stress reduction by means of introducing stress reliving feature is possible. The redistribution is highly sensitive to the change in size of the stress relieving feature. A careful selection of more than one location for introducing stress relieving feature is more beneficial than choosing only one. Stress reductions by means of introducing circular stress reliving features are found to be better. The circular stress relief feature have better control over changing the stress redistribution pattern. The introduction of a circular hole below the root circle diameter between two teeth reduces the stress levels by a very high percentage about 42%.So by optimizing the diameter and position of the stress relief hole we can reduce the stress value in a gear tooth by a considerable amount without affecting the functioning of the gear.

REFERENCES

[1] Srinivasalu B, "Spur Gears- A new Approach in to Tooth Design" American Gear Manufacturers Association, Technical Paper 1992FTMSI.
[2] Fredette, M. Brown, "Gear Stress Reduction Using Internal Stress Relief Feature", Transaction of ASME Journal of Mechanical Design, Vol. 119, December 1997, PP. 518– 521.
[3] Tsai, M. and Y. Tsai, Design of High Contact Ratio Spur Gears Using Quadratic Parametric Tooth profiles. Mechanism and Machine Theory, 33:551-542. 1998
[4] Herring, D.H., Why Vacuum Carburizing Is Effective for Today and Tomorrow: II, Industrial Heating, pp 22-26, 1987.
[5] Spitas, Th. Castopoulos and C. Spitas, Increasing the Strength of Standard Involute Gear Teeth with Novel Circular Root Fillet Design, American Journal of Applied Sciences 2 (6): 1058-1064, 2005
[6] S. Sankar, M. Sundar Raj, M. Nataraj, "Profile Modification for Increasing the Tooth Strength in Spur Gear Using CAD" Scientific Research,doi:10.4236/eng.2010.29096 Published Online September 2010
[7] Daniela Ristić, "Numerical Stress Concentration Analysis of a Driven Gear Tooth Root With Two Fillet Radius" Scientific Technical Review,Vol.LIX,No.3-4,2009
[8] Dippery R E, "A study in stress concentration optimization Using Boundary Element Methods", Ph D. Dissertation, University of Cincinnati, 1990
[9] Ashwini Joshi, Vijay Kumar Karma, "Effect on Strength of Involute Spur Gear by Changing the Fillet Radius Using FEA" International Journal Of Scientific & Engineering Research Volume 2, Issue 9, September-2011 ISSN 2229-5518
[10] M.S. Hebbal, V.B. Math, C.M. Veerendrakumar, S. B. Kerur, "An Approach to the redistribution of Root Fillet Stress in Spur gear", National Conference on Recent Advances in Design engineering (RADE 2007)
[11] Litwin, F.L., L. Qiming and A.L. Kapelvich, Asymmetric Modified Spur Gear Drives:

Reduction of Noise, Localization of Contact, Simulation of Meshing and Stress Analysis. Computer Methods in App. Mechanics and Eng., 188:363-390, 2000.

[12] J. D. Andrews, "A Finite element analysis of bending stresses induced in external an internal spur gears", Journal of strain analysis, Vol. 26,No.3, 1991, pp 153-163.

[13] H. Von Eiff, K. H. Hirschmann, G. Lechner, "Influence of Gear Tooth Geometry on Tooth Stress of External and Internal Gears", Journal of Mechanical Design, Vol. 112, December 1990, PP. 575 – 583.

[14] Townsed, D.P. and E.N. Bambeger, Surface Fatigue Life of Carburized And Hardened M50nil And Aisi 9310 Spur Gears And Rolling Contact Test Bars. J. Propulsion And Power, Vol: 7, 1991.

