A Review of Bending Stress on Spur Gear Using DOE Technique

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ABSTRACT

Gears are one of the most important component in mechanical power transmission systems. The bending stress of the gear tooth is regarded as one of the key contributors for the failure of the gear in the gear set. Thus, analysis of stresses has become popular as an area of study on gears to minimize the chances of failures and also for the optimal design of gears. The study is based on Modified Lewis formula and design of experiment. The work is basically concerned with analysis of spur gears which are actually used in all types of two wheelers. For doing analysis the paper has been present the various literature and find out the better optimization techniques i.e. response surface optimization in ANSYS in this work.

Keywords: *Spur Gear, Bending Stress, Optimization, Response surface optimization.*

I. INTRODUCTION

A Gear defined as the mechanical element used for transmitting power and rotary motion from one shaft to another by means of progressive engagement of projections called teeth. Spur Gears use no intermediate link or connector and transmit the motion by direct contact. The two bodies have either a rolling or a sliding motion along the tangent at the point of contact. No motion is possible along the common normal as that will either break the contact or one body will tend to penetrate into the other. Thus, the load application is gradual which results in low impact stresses and reduction in noise. Therefore, the spur gears are used in transmitting power with very less friction losses.

A gearbox consists of a set of gears, shafts and bearings that are mounted in an enclosed lubricated housing. They are available in a broad range of sizes, capacities and speed ratios. Their function is to convert the input provided by the prime mover into an output with lower speed and corresponding higher torque. In this thesis, contact stress analysis of Spur gear is studied using finite element analysis.

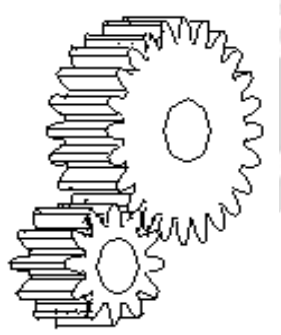

Fig 1. A pair of Spur Gear

II. LITERATURE REVIEW

Singh & Parvez, [1], concluded that the strength of the gear tooth is a crucial parameter to prevent failure. In this study, it is shown that the effective method to estimate the root bending stresses using three-dimensional model of the gear and to verify the accuracy of this method the results with different number of teeth are compared with the standard formula. Based on the result from the contact stress analysis the hardness of the gear tooth profile can be improved to resist pitting failure: a phenomenon in which a small particle is removed from the surface of the tooth that is because of the

high contact stresses that are present between mating teeth. As it is expected, in this work the maximum bending stress decreases with increasing face width and it will be higher on gear of lower face width with higher helix angle. As a result, based on this finding if the material strength value is criterion then a gear with any desired helix angle with relatively larger face width is preferred.

Rathore and Tiwari [2], work on gear teeth failure due to fatigue is a general incident observed. Yet a minor drop in the root bending stress results in enormous enhancement in the bending fatigue life of a spur gear. If gear fails in tensile fatigue condition the results are cataclysmic and arise with modest or no notification. So in spite of the reasons stated above, this paper is of more practical significance. Up till now the gear design has been enhanced by using better material, surface hardening and carburization, and shot penning for surface finish etc. Some extra efforts have been completed to enhance the durability and strength by changing the various parameters i.e. pressure angle, by asymmetric teeth, by root fillet curve alteration and so on. The majority of these techniques do not provide assurance for the interchangeability of the existing gear design. This work shows the potential by means of the stress concentration methods by inserting the stress relieving features at the most stressed area for the reduction of root fillet or bending stress in spur gear. In this work, circular and elliptical stress relieving holes are employed, and better results are obtained than using circular stress relieving holes, which were employed in previous researches. A finite element model of spur gear is considered for analysis and compared with the analytical method and stress relieving features of various sizes are inserted on gear teeth at root area. In this work the optimum size and location of the stress relief features for Spur gear are proposed, which help in reducing the fatigue failure in gears.

Sahu et. al., [3], In this paper, the analysis of involute and cycloidal tooth spur gear design has been done to investigate the bending stresses induced in the gear tooth for different modules by finite element analysis. The mathematical models have been generated based on the theory of gearing. Models are made in Creo Parametric software tool. The bending stresses induced in the gear tooth obtained from FEA corresponding to different modules for both involute and cycloidal profile spur gear are compared with the values obtained by Lewis equation. It is observed that the FEA results are having a slight variation with Lewis equation. It is found that the bending stress reduces with the increase in module and the bending stress values for involute profile spur gear is less than the cycloidal profile for the same module and involute spur gear teeth is stronger than cycloidal spur gear teeth.

Venkatesh & Murthy, [4] mentioned analytical and Finite Element Analysis methods that are used to predicting the Bending and Contact stresses of involute helical gear. Pro-e solid modeling software is used to generate the 3-D solid model of helical gear. Bending stresses are calculated by using modified Lewis beam strength equation and ANSYS software package. Contact stresses are calculated by using AGMA contact stress equation and ANSYS software package. Finally, these two methods bending and contact stress results are compared with each other.

Patil et, al., [5] presented the contact stresses among the helical gear pairs, under static conditions, by using a 3D finite element method. The helical gear pairs on which the analysis is carried are 0, 5, 15, 25-degree helical gear sets. The Lagrange multiplier algorithm has been used between the contacting pairs to determine the stresses. The helical gear contact stress is evaluated using FE model and results have also been found at different coefficient of friction, varying from 0.0 to 0.3.

Malek, [6] In this paper author have been presented a brief review of design and modeling and analysis of high speed helical gear using AGMA and ANSYS with various face width and helix angle and found their effect due to bending and contact stress and its value compared with ANSYS and AGMA.

Anusha et. al., [7] In this paper the bending stress and surface strength of the gear tooth are one of the main contributors for failure of the gears in gear set. The analysis of stresses has become popular as an area of research on gears to minimize and reduce the failures. The present investigation is carried out to make use of helical gear, by analyzing the contact stresses for different Pressure angles (14.5˚, 16˚, 18˚, 20˚), Helix angles (15˚, 20˚, 25˚, 30˚) and Face width (80mm, 90mm, 100mm, 110mm, 120mm). A Three- dimensional solid model is generated by Pro-E which is powerful and modern solid modeling software. The numerical solution is done by ANSYS, which is a finite element analysis package. The analytical approach is based on contact stress equation, to determine the contact stresses between two mating gears. The results obtained from ANSYS values are compared with theoretical values are in close agreement.

Venkatesh et. al., [8] In this work, structural analysis on a high speed helical gear used in marine engines, have been carried out. The dimensions of the model have been arrived at by theoretical methods. The stresses generated, and the deflections of the tooth have been analyzed for different materials. Finally, the results obtained by theoretical analysis and Finite Element Analysis are compared to check the correctness. A conclusion has been arrived on the material which is best suited for the marine engines based on the results. Basically, the project involves the design, modeling and manufacturing of helical gears in marine applications. It is proposed to focus on reduction of weight and producing high accuracy gears.

Vishwakarma et. al., [9] This paper investigates finite element model for monitoring the stresses induced of tooth flank, tooth fillet during meshing of gears. The involute profile of helical gear has been modeled and the simulation is carried out for the bending and contact stresses and the same have been estimated. To estimate bending and contact stresses, 3D models are generated by modeling software CATIA V5 and simulation is done by finite element software package ANSYS 14.0. Analytical method of calculating gear bending stresses uses Lewis and AGMA bending equation. For contact
stresses Hertz and AGMA contact equation are used. Study is conducted by varying the face width to find its effect on the bending stress of helical gear. It is therefore observed that the maximum bending stress decreases with increasing face width. The stresses found from ANSYS results are compared with those from theoretical and AGMA values.

Chen & Chung, [10] Evaluated the contact stress and bending stress of a helical gear set with localized bearing contact, by means of finite element analysis (FEA). The proposed helical gear set comprises an involute pinion and a double crowned gear. Mathematical models of the complete tooth geometry of the pinion and the gear have been derived based on the theory of gearing. Accordingly, a mesh- generation program was also developed for finite element stress analysis. The gear stress distribution is investigated using the commercial FEA package, ABAQUS/Standard.

Patil et. al., [11] This paper represents the study of contact stresses among the helical gear pairs, under static conditions, by using a 3D finite element method. The helical gear pairs on which the analysis is carried are 0, 5, 15, 25-degree helical gear sets. The FE results have been further compared with the analytical calculations. The analytical calculations are based upon Hertz and AGMA equations, which are modified to include helix angle. The contact stress results have shown a decreasing trend, with increase in helix angle. Summary of Literature Review To minimize or to reduce the failures and for optimal design of gears, analysis of stresses become popular as an area of research. From the above literature review, the bending stress and contact stress of the gear tooth are examined. Most of the researchers used AGMA equations for finding the bending and contact stresses theoretically and ANSYS software package for their analysis purpose. Analysis results are compared with analytical one. Findings on Literature Review The extensive research in the field of stress analysis of helical gear is going on. Many researchers reported study on contact stress of helical gear for specific helix angle (i.e.0, 5, 15, 25, 30 only). PRO-E & ANSYS software's are used for analysis purpose.

III. CONCLUSION

In this study, a literature review was conducted to identify recent finite element models of spur gear and better optimization techniques. On ground of geometrical model, numerical model of spur gear is performed using finite element. Spur gear tooth profile done using parametric equations the results confirm that the proposed design method is more flexible to control the shape of the gear by action of gear modification. The strength of the gear drive designed by using the proposed method is analyzed and optimized by an FEA simulation ANSYS software. The latest research results a reduce bending stress of the gear.

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