

A REVIEW ON STUDY OF BENDING STRESS AND CONTACT STRESS OF HELICAL GEAR AS CALCULATED BY AGMA STANDARD AND FEA

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Abstract—Gears are one of the most critical components in mechanical power transmission systems. The bending and surface strength of the gear tooth are considered to be one of the main contributors for the failure of the gear in a gear set. Thus, analysis of stresses has become popular as an area of research on gears to minimize or to reduce the failures and for optimal design of gears. The helical gears can fail due to excessive bending stress at the root of gear tooth or surface contact stresses. This can be avoided only by minimizing bending stresses and contact stress or by modifying the geometry or parameters of the gear tooth. This paper presents the comparative study of bending stress and contact stress of helical gear using AGMA standard and FEA. Ultimately results of two methods compared with respect to each other.

Keyword- helical gear, bending stress, contact stress

I. INTRODUCTION

Power transmission has always been of high importance. The efficiency of any machine depends on the amount of power loss in the process. Gears are mostly used to transmit torque and angular velocity. A helical gear has teeth in form of helix around the gear. Two such gears may be used to connect two parallel shafts in place of spur gears. The helixes may be right handed on one gear and left handed on the other. The pitch surfaces are cylindrical as in spur gearing, but the teeth instead of being parallel to the axis, wind around the cylinders helically like screw threads. The teeth of helical gears with parallel axis have line contact, as in spur gearing. This provides gradual engagement and continuous contact of the engaging teeth. Hence helical gears give smooth drive with a high efficiency of transmission. The helical gears may be of single helical type or double helical type. In case of single helical gears there is some axial thrust between the teeth, which is a disadvantage. In order to eliminate this axial thrust, double helical gears (herringbone gears) are used. It is equivalent to two single helical gears, in which equal and opposite thrusts are provided on each gear and the resulting axial thrust is zero. One of the main reasons of the failure in the helical gear is bending stresses and vibrations. But the stresses are occurred due to the contact between two gears while power transmission process is started. Due to meshing between two gears contact stresses are evolved, which are determined by using analyzing software called ANSYS. Finding stresses has become most popular in research on gears to minimize the vibrations, bending stresses.

II. LITERATURE SURVEY

Tejas K. Patil and V. G. Bhamre ^[1] had reviewed the work on Design and analysis of helical gear using ANSYS, FEM & AGMA standards, which provides information of surface strength and tooth root strength of helical gear in static condition. By analytical methods, the calculated bending stresses and contact stresses have errors. The error percentage is 1 % in contact stresses & 6 % in bending stresses respect to ansys. Parametric study is done by varying the geometry of the teeth. By varying the parameters like module, pressure angle, face width the new modified gear tooth is obtained and modified helical gear have more capacity contact stresses compared with normal helical gears. By using AGMA equation the values of pressure angle, helix angle & face width are little higher than ansys values.

A.Sathyanarayana Achari, R.P.Chaitanya and Srinivas Prabhu ^[2] had done the investigation on comparison of bending stress and contact stress of helical gear as calculated by AGMA standards and FEA. To estimate the bending stress at the tooth root Lewis beam strength method was applied. NX CAD 8.5 modeling software package is used to create the 3D solid model of helical gear pairs. NX Nastran 8.5 software package is used to analyze the gear tooth root bending stress and contact stress. Ultimately, these two methods, tooth root bending stress and contact stress results are compared with respect to each other. By observing the theoretical and FEA results, error percentage is very less i.e, from 0.4 to 2.1 % in bending stress and about 3% error in surface contact stress. So, Finite Element Analysis is an easy method of finding the bending stresses at the root of the gear tooth and surface contact stresses of an involute helical gear with less time consuming.

Govind T Sarkar, Yogesh L Yenarkar and Dipak V Bhope ^[3] had done the work on stress analysis of helical gear. The involute profile of helical gear has been modelled and the simulation is carried out for the bending and contact stresses by finite element method and result obtained in analysis were compared with AGMA standard. It can be concluded that the helix angle is critical for contact stress as increasing helix angle increases contact stresses because it increases length of contact in the area. Face width increased causes decreases the bending stresses as bearing area at the root increases. Hence the face width and helix angle are an important geometrical parameters during the design of gear. As a result, if the material strength value is criterion then a gear with any desired helix angle with relatively larger face width is preferred.

S. Jyothirmai, R. Ramesh, T. Swarnalatha and D. Renuka ^[4] had done the investigation on a finite element approach to bending, contact and fatigue stress distribution in helical gear system. The objective of their work is to conduct a comparative study on helical gear design and its performance based on various performance metrics through finite element as well as analytical approaches. The theoretical analysis for a single helical gear system based on American Gear Manufacturing Association (AGMA) standards has been assessed in Matlab. The effect of major performance metrics of different helical gear tooth systems such as single, herringbone and crossed helical gear are studied through finite element approach (FEA) in ANSYS and compared with theoretical analysis of helical gear pair. Structural, contact and fatigue analysis are also performed in order to investigate the performance metrics of different helical gear systems. It was found that the overall performance of crossed helical gear was found to be the best in terms of stress as well as tooth strength at low speeds and low loads whereas herringbone and single helical gear systems are employed for optimum values of speeds and loads. The low stresses observed in case of single helical gear makes its use in case of high speeds and heavy loads.

Babita Vishwakarma and Upendra Kumar Joshi ^[5] had done the work on finite element analysis of helical gear using three dimensional CAD model. In this paper, for estimation of bending and contact stresses, 3D models are generated by modelling software CATIA V5 and simulation is done by finite element software package ANSYS 14. Study is conducted by varying the face width to find its effect on the bending stress of helical gear. It is observed that the maximum bending stress decreases with increasing face width and hence face width is an important geometrical parameter in design of helical gear.

Babita Vishwakarma and Upendra Kumar Joshi ^[6] had reviewed the papers on finite element analysis of helical gear which provides the information of calculating the stresses of an involute helical gear in meshing. This review presents that the Finite Element Method is widely used for stress analysis in a pair of gear. The gear stress distribution is investigated using the commercial FEA package. The FEM-based contact model gives a reasonable approximation of contact parameters when the mesh size is fine enough. Such as in helical gears, require small element size, i.e. a large number of elements to avoid element dimensional distortion.

J. Venkatesh and Mr. P.B.G.S.N. Murthy ^[7] had done the investigation on design and structural analysis of high speed helical gear using ansys. In this paper bending and contact stresses are calculated by using AGMA stress equation. Pro-e solid modelling software is used to generate the 3 D solid model and ansys 12.1 software package is used to analysed the bending and contact stresses. At the end result obtained are compared, it is found that Error percentage is around 6 % in bending stresses and around 1 % in contact stress analysis. Induced bending stress is a major function of number of teeth and helix angle influence is less on contact stresses. As a result, based on this finding if the material strength value is criterion then a gear with minimum number of

teeth with any maximum helix angle of more face width is preferred.

Tribhuvan Singh and Mohd. Parvez ^[8] did the comparative study of stress analysis of helical gear using AGMA standard and FEM. In this study, to estimate the bending stress 3 D solid models for different number of teeth are generated by Pro/Engineer software and numerical solution is done by Ansys, which is a finite element analysis package. Parametric study is conducted by varying the face width and helix angle to study their effect on the bending stress of helical gear. 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.

Dr. M. S. Murthy and Pushpendra Kumar Mishra ^[9] had done the investigation on stress analysis of helical gear by FEM techniques with variation in face width and helix angle. In this investigation, study is conducted on various works in which the effect of varying face width and helix angle on the bending stress of helical gear are studied. In most of the approaches FEM was used as a tool for the analysis. From the various results obtained it can be easily realized that the results obtained by using FEM are very close to the results of other methods. The main advantage of the FEM is that it can give the solution of very complex design problems. However, Modeling and simulation of the design problem takes much longer time through FEM. A parametric study was also made to study the effect on the root stresses of helical gears by varying the face width and the helix angle. Many authors agree that if material strength is the criterion then a gear with any desired helix angle with a relatively larger face width is preferred.

Pushpendra Kumar Mishra and Dr. M.S. Murthy ^[10] had done the investigation on bending stresses for different face width of helical gear obtained using MATLAB Simulink with AGMA and ANSYS. In this paper we modelled a helical gear on Pro engineer wildfire 5.0 and stress analysis part is done on ANSYS 12.0. A Simulink model is generated by using curve fitting. The results are compared with both AGMA and FEM procedures. The results obtained from both ANSYS and Simulink are closed to the results obtained from AGMA procedure. From the results it is justified that Simulink can also be used for predicting the values of bending stress at any required face width which is much easier to use to solve complex design problems. During the investigation it is found that the complex design problem of helical gear requires superior software skills for modelling and analysis, which can be done by MATLAB Simulink environment.

III. SUMMARY

Above literature gives information of work did by the various researchers in the field of design of helical gear. Previously, Lewis equation and Buckingham's equation are used for design of gears to avoid bending and pitting failure. Modifications are made in conventional design process and various factors are used to consider the effect of dynamic loading in the AGMA method which gives the accurate design of gears. It involves less no. of iterations. Finally AGMA results are compared with the

Finite element analysis to check the accuracy of design. The values of bending and contact stress by FEA are less than the value obtained by AGMA standard. In FEA boundary conditions are applied as per the Lewis bending stress equation for analysis of bending stress and static loading is considered, whereas in AGMA standard various factors are considered to introduce the effect of dynamic loading on the gear tooth profile. Hence bending and contact stress calculated by AGMA bending stress equation and AGMA contact stress equation gives higher value than the FEA.

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