IJISET - International Journal of Innovative Science, Engineering & Technology, Vol. 3 Issue 7, July 2016
ISSN (Online) 2348 – 7968 | Impact Factor (2015) - 4.332
www.ijiset.com

An Analytical Approach for the Stress Distribution in Helical Gear Pair

Harshal Mahale[1], Poonam Talmale[2]

[1]PG Student, KCT'S, Late G. N. Sapkal of College of Engineering,
Nasik, Maharashtra, India

[2] Assistant Professor, Late G. N. Sapkal of College of Engineering,
Nasik, Maharashtra, India

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. This paper investigates the characteristics of an involute helical gear system mainly focused on bending and contact stresses using analytical analysis. The analytical investigation is based on Lewis stress formula which determines the stresses to determine the safety of gear pair.

Keywords: *Bending stresses, surface strength, Contact Stresses, lewis Stress formula*

1. Introduction

Gearing is one of the most effective methods transmitting power and rotary motion from the source to its application with or without change of speed or direction. Gears will prevail as a critical machine element for transmitting power in future machines due to their high degree of reliability and compactness. The rapid development of heavy industries such as vehicle, shipbuilding and aircraft industries require advanced application of gear technology. 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, analysis of the characteristics of helical gears in a gearbox is studied using finite element analysis.

The crucial requirement of effective power transmission in various machines, automobiles, elevators, generators, etc. has created an increasing demand for more accurate analysis of the characteristics of gear systems. For instance in automobile industry highly reliable and light weight gears are essential. Furthermore the best way to diminution of noise in engine requires the fabrication of silence gear system. Noise reduction in gear pairs is especially critical in the rapidly growing today's technology since the working environment is badly influenced by noise. The most successful way of gear noise reduction is attained by decreasing of vibration related with them. The reduction of noise by vibration control can be achieved through a research endeavor by an expert in the field.

2. Literature Review

S. Jyothirmai et al. in their paper a Finite element Approach to Bending, Contact and fatigue Stress Distribution in Helical Gear Systems stated as the objective of this 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. The benefit of such a comparison is quickly estimating the stress distribution for a new design variant without carrying out complex theoretical analysis as well as the FEA analysis gives less scope for manual errors while calculating complex formulas related to theoretical analysis of gears. It will significantly reduce processing time as well as enhanced flexibility in the design performance

A. Sathyanarayana Achari et al. in their paper A comparison of bending Stress and contact stress of a helical gear as calculated by AGMA standards and FEA states that bending stress at the root of the helical gear tooth and surface contact stresses are computed by using theoretical method as well as FEA. Ultimately, these two methods, tooth root bending stress and contact stress results are compared with respect to each other.

A.Y Gidado et al. in their paper Design, Modeling and Analysis of Helical Gear According Bending Strength Using AGMA and ANSYS stated as there are two kinds of stresses in gear teeth, root bending stresses and tooth contact stresses. These two stresses results in the failure of gear teeth, root bending stress results in fatigue fracture and contact stresses results in pitting failure at the contact surface. To estimate the bending stress, three dimensional solid models for different face width are generated by Pro/Engineer that is a powerful and modern solid modeling software and the numerical solution is done by ANSYS, which is a finite element analysis package. The analytical investigation is based on Lewis stress formula. The results are then compared with both AGMA and FEM procedure.

3. Design and optimization of Helical gear System

3.1 Basis of Work

This work shows the stress distribution of helical gear pair using the listed below to study the different helical pair specifications in terms of tooth bending stress and contact stress and as well as other stresses such as allowable fatigue stresses, contact stress, bending fatigue strength, tooth surface strength of gear & pinion.

Table 1. Specifications considered for Study

Gear Ratio (G) = 1.5
Face Width in Meters (b) = 0.075
Type of Gear Teeth System = 20^0 (Stub Involute Profile)
Torque in Newton-Meter (T) = 132.63
Center Distance between Gear and Pinion shaft in meters = 2.5
Angular Velocity of Pinion in Rad/Sec (ω_p) = 150.79
Material for Gear and Pinion = Structural
Source of Power = Uniform
Type of Driven Machinery = Uniform
Type of Load = Continuous
Factor of Safety (FoS) = 1.1
Poisson's Ratio (M) = 0.3
Young's Modulus in Gpa (E) = 207
Module in Mm (m_n) = 10

3.2 Equations

1) Tooth Bending Stress

$$\sigma_P = \frac{F_t}{bmJ} K_v K_O \{0.93\ Km\}$$

$$\sigma_P = \frac{1356}{75\ \times 10\ \times 0.56} \times 1.30 \times 1 \times \{0.93\ \times 1.6\}$$

$$\sigma_P = 6.24\ \text{MPa}$$

2) Bending Fatigue Strength

$$\sigma_e = \sigma_e' \times K_L \times K_V \times K_s \times K_r \times K_T \times K_f \times K_m$$

$$\sigma_e = (0.5\times500)\times1.0\times0.85\times0.60\times1.0\times1\times1\times1.6$$

$$\sigma_e = 183.6\ \text{N/mm}^2$$

3) Permissible Bending Stress

$$\sigma_b = \frac{\sigma_e}{FOS}$$

$$\sigma_b = \frac{183.6}{1.1}$$

$$\sigma_b = 166.90\ \text{N/mm}^2$$

4) Contact Stresses

$$\sigma_H = C_P \sqrt{\frac{F_t}{bdl}\left(\frac{\cos\psi}{0.95 \times CR}\right) \times K_V \times K_O \times (0.93\ K_m)}$$

$$\sigma_H = 191 \sqrt{\frac{1356}{75 \times 195.48 \times 0.096}\left(\frac{\cos 23}{0.95 \times 21.66}\right) \times 1.30 \times 1 \times (0.93 \times 1.6)}$$

$$\sigma_H = 54.68\ \text{N/mm}^2$$

Table 2. Result table

Sr. No	Parameters	Result (N/mm^2)
1	Tooth Bending Stress(σ_p)	6.24
2	Bending Fatigue Strength(σ_e)	183.6
3	Permissible Bending Stress(σ_b)	166.90
4	Contact Stress(σ_H)	54.68

4. Conclusions

It is observed that the values various stresses and strength are determined by analytical approach. The design for safety is predicted by comparing the tooth bending stress with that of permissible bending stress. From the above analytical approach we determine that tooth bending stress is less than that of permissible bending stress. Hence we determine that factor of safety for the helical gear pair lies between 1.1 and 1.5

.

References

[1] S. Jyothirmai, R. Ramesh, T. Swarnalatha, D. Renuka, “Finite element Approach to Bending, Contact and fatigue Stress Distribution in Helical Gear Systems”, Procedia Materials Science, Elsevier, February 2014, pp 907 – 918.

[2] A. Sathyanarayana Achari, R. P. Chaitanya, Srinivas Prabhu, “A comparison of bending Stress and contact stress of a helical gear as calculated by AGMA standards and FEA”, International Journal of Emerging Technology and advanced Engineering, Vol 4, May 2014, pp 38 – 43.

[3] A.Y Gidado, I. Muhammad, A. A. Umar, “Design, Modeling and Analysis of Helical Gear According Bending Strength Using AGMA and ANSYS”, International Journal of trends and technology, Vol 8, February 2014, pp 495 – 499.

[4] Tanvirkhan A. Malek, Prof Amit B. Solanki, “A review Design & Modeling and stress analysis of high speed helical gear according to bending strength and contact strength using AGMA and Ansys” , International Journal of trends and technology, Vol 22, April 2015, pp 526 – 530.

[5] Sachin M. Kamble, Abhishek Chaubey, “Stress analysis of herringbone gear by using FEA” , International Journal of research and technology, Vol 2, October 2013, pp 3488 – 3491.

[6] Prakash Kumar Sen, Shailendra Kumar Bohidar , Satish Kumar Patel, Rajendra Kumar Patre, Shankar Dayal Patel, International Journal of research, Vol 1, November 2014, pp 1782 - 1786

Harshal R mahale was born on 8 Jan 1993 in India. He is a student of M.E. Mechanical (Design) of Late G. N Sapkal College of Engineering, Nashik. He has completed his B.E. in Mechanical Engineering Pune university, Matoshri College of Engineering and Research centre, Nasik in the year 2014.

Poonam Talmale is working as a Assistant Professor in Late G. N. Sapkal COE. She has completed her Masters degree in CAD/CAM. She has over 8 years of teaching experience. She is a excellent mentor and guide who has published both national and international papers.

.