REVIEW ON- DESIGN AND ANALYSIS OF SPUR GEAR TO OVERCOME GEAR STUCKING AND SCUFFING

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ABSTRACT

Scuffing is a failure that occurs suddenly, resulting incomplete destruction of contacting surfaces such as gear teeth. Scuffing is often characterized as a lubrication failure frequently accompanied by a sudden increase in friction and the instantaneoustemperature at the contact zone. Gear is one of the most critical components in a mechanical power transmission system, and most industrial rotating machinery. A pair of spur gear teeth in action is generally subjected to two types of cyclic stresses: bending stresses inducing bending fatigue and contact stress causing contact fatigue. Both these types of stresses may not attain their maximum values at the same point of contact fatigue. These types of failures can be minimized by careful analysis of the problem during the design stage and creating proper tooth surface profile with proper manufacturing methods. In general, gear analysis is multidisciplinary, including calculations related to the tooth stresses and to tribological failures such as wear or scoring.

Keyword: *-Bending and contact stress analysis, Gear design, Mesh generation, Spur gears*.

1. INTRODUCTION

1.1 Gear Stucking or Scuffing:

Scuffing is one of the most common surface failure modes observed at lubricated, loaded contacts experiencing excessive relative sliding. The other most common surface failure modes are wearand contact fatigue (micro-pitting and stalling). Scuffing is a failure that occurs suddenly, resulting in complete destruction of contacting surfaces such as gear teeth. Scuffing is often characterized as a lubrication failure frequently accompanied by a sudden increase in friction and the instantaneous temperature at the contact zone. In case of contacts operating at high speeds, any breakdown of full elasto hydrodynamic lubrication (EHL) film causes metal-to-metal contacts. The metal-to-metal contacts together with significant sliding motion generate considerable heat at the contact interface. The temperature at the interface may increase to levels that cause surface asperities weld together and then tear apart as the motion continues. The breakdown of full EHL is a necessary but not a sufficient condition for scuffing to occur. Available evidence suggests that the film breakdown depends not only on the operating conditions but also on the physical and chemical nature of the lubricant as well as the material properties of the contacting surfaces.

It is safe to consider that scuffing failure is induced by temperature, and the frictional heating due to interacting asperities impacts it drastically from the point of view of engagement, scuffing typically occurs either at the tips or at the root son gear teeth especially if the gear teeth have little or no profile modification. The sliding velocities have their maximum value either at the start of active profile (SAP) or at the tip of the gear tooth such that the built –up heat becomes more critical in these areas of the tooth surface. From the point of view of operation, scuffing is more likely to occur at high-load and high-speed conditions as in typical rotor craft and air craft gearing increased contact loads tend to enhance the asperity contacts such that lubrication conditions are in a mixed EHL type. Under such conditions, both fluid film and asperity contacts share the normal load applied. As the frequency of loading at each tooth surface increases with increasing operating speed, the rate of heat generation increases. Under such severe conditions, the lubricant temperature might reach its flash point and the lubricant film starts to vaporize. The breakdown of lubricant film in the contact causes welding and tearing on the metal surfaces, which is often referred to as hot scuffing. However, a similar damage also occurs on the surfaces of gears operating at low speeds without the instantaneous welding phenomenon. This damage typically occurs at high-load and low-speed conditions and is termed cold scuffing.

While other modes of lubrication related tooth failures such as contact fatigue (pitting and micro-pitting) and wear generally take a long period of operation to reach the state of catastrophic failure, scuffing occurs early in the life span of a gear pair.

Fig.1. Gear scuffing Effect

In fact, gears are more vulnerable to scuffing when they are new and their tooth surfaces have not yet been smooth end by run-in. Therefore, scuffing is the most immediate failure mode that must be dealt with. The other failure modes become simply irrelevant on gear scuffs. In other words, any well designed and manufactured gear set has the hurdle of avoiding scuffing before other considerations come to play.

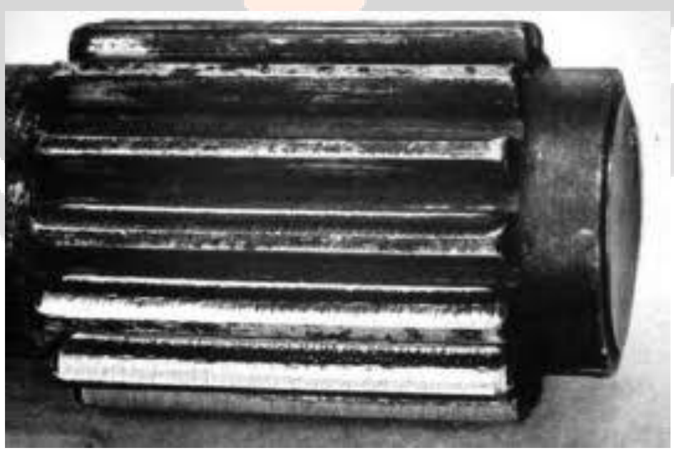

Fig.2. Effect of Gear stucking

Scuffing is not limited to gears, and may occur in many other mechanical components such as the piston-pin/bore bearings, piston skirt/liners, and cam/follower contacts. Since the lubrication conditions characterizing the rolling and sliding motion in the tooth contact differ from those in bearings or other components, and gear applications are the primary focus of this study, only gear scuffing phenomenon will be considered in this study. The main goal here is to validate physics-based models for prediction of the onset of scuffing for general two dimensional contacts in combined sliding and rolling, and to apply them to study scuffing of gears.

2. LITERATURE REVIEW

Many researchers are focused on gear analysis, the major concerns of gear analysis deals with the analysis of gear stresses, transmission errors, dynamic loads, noise, and failure of gear tooth, which are very useful for optimal design of gear set.

2.1 Literature Survey

By Xiang yang Jin (2012) [1] studied on utilize the coordinate transformation method to establish the surface equation for gear tooth. Techniques such as feature modeling, parametric driving, two-dimensional and three-dimensional full dynamical correlation are also used to process the tooth surface and add features according to the relationship between individual features and creating order. A number of rotation and duplication is also utilized to obtain all the cogging, finally completing the detail design for each feature. This method has avoided the shortcomings of traditional three-dimensional dynamic assembly and excessive motion simulation computing, greatly improved the operational efficiency, reduced the size of storage file and decreased requirements for computer hardware Use Pro / E software to create three-dimensional model for each component of reducer. This model is based on some advanced techniques such as feature modeling, parameter-driving, single database, 2D and 3D full dynamical correlation, so it is a kind of complete model which can express and process three dimensional objects.To improve the efficiency of the system's modeling, the component should be analyzed before the design and examine it from the overall look to form the general idea about it, determine the composition, creating order and improvement of its features

1. Complete the three-dimensional solid modeling of components of reducer, summarize the modeling techniques, and introduce the modeling process of components taking the shell of inner gear as an example.
2. Component modeling is a process from course to fine. First create the rough model for components, and then add features according to the relationship between the various features and the creating order, finally complete the details. For each individual feature, its relationship with others should be cleared and the internal link also needs attention.

S. Jyothirmaia, et al (2014) [2] : Describes that in the face of extensive research into the theoretical basis and performance characteristics of helical gear design, a complete mathematical description of the relationship between the design parameters and the performance matrices is still to be clearly understood because of the great complexity in their interrelationship. 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 Mat lab. 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.

Venkatesh, et al (2014) [3] : Says Current trends in engineering globalization require results to revisit various normalized standards to determine their common fundamentals and those approaches needed to identify best practices, cost containment related to adjustments between manufacturers for missing part interchangeability and performance due to incompatibility of different standards. The work is to focus on investigating the combined effect of gear ratio, helix angle, face width and normal module on bending and compressive stress of high speed helical gear.

Mrs. C.M. Meenakshi et al (2012) [4]: The objective of paper is to study the various stress state of spur gear. They calculated the tangential and radial forces which acts on various point upon that basis we can analyze by applying the forces. By using Ansys software bending stress and contact stress on the tooth of spur gear drive is found Gears are machine elements used to transmit power between rotating shafts by means of engagement of projection called teeth. Gears are most common means of transmitting power in the wooden mechanical world. They vary from a tiny size used in watches to larger gears used in massive speed reducers, bridge lifting mechanism and rail road turn table drive. The gears are vital elements of main and auxiliary mechanism in many machines such as automobiles, tractors, metal cutting machine tools rolling mills hosting and transmitting and transporting machinery, massive engines etc.

By Atul Kumar et al (2013) [5] : Says that Spur gear wears either due to rubbing action between the meshed gears or by the occurrence of unwanted elements like dust particles, metal fragments, etc. which reduces its efficiency and service life. It is always a challenging task to determine the remaining life of a component or the strength of a component once wear has occurred on teeth surface. This paper presents an application of reverse engineering approach for reconstruct the spur gear 3D CAD model using scanned data. A gear has been scanned using PICZA 3D laser scanner (RolandLPX60).

M. Raja Roy et al (2014) [6]: Made an attempt to summarize about contact stresses developed in a mating spur gear which has involute teeth. A pair of spur gears are taken from a lathe gear box and proceeded forward to calculate contact stresses on their teeth. Contact failure in gears is currently predicted by comparing the calculated Hertz contact stress to experimentally determined allowable values for the given material. The method of calculating gear contact stress by Hertz‟s equation originally derived for contact between two cylinders. Analytically these contact stresses are calculated for different module, and these results are compared with the results obtained in modeling analysis in ANSYS.

3. PROBLEM DEFINATION

Current design is giving the problem of Gear stucking and scuffing for Strip Roller Machine of Wheel Rim Manufacturing unit. In spite of the number of investigations devoted to gear research and analysis there still remains to be developed, a general numerical approach capable of predicting the effects of variations in gear geometry, Hertz contact stresses, bending stresses and Von Mises stresses. The objectives of this thesis are to use a numerical approach to develop theoretical models of the behavior of spur gears in mesh, to help to predict the effect of gear tooth stresses and transmission error. The main focus of the current research as developed here is:

Fig.3. Gear Arrangement for Analysis and Design

To develop and to determine appropriate models of contact elements, to calculate contact stresses using ANSYS and compare the results with Hertzian theory. To generate the profile of spur gear teeth and to predict the effect of gear bending using a three dimensional model and two dimensional model and compare the results with those of the Lewis equation.

To determine the static transmission errors of whole gear bodies in mesh.

Fig.4. Gear Problem Area

The objectives in the modeling of gears in the past by other researchers have varied from vibration analysis and noise control, to transmission error during the last five decades. The goals in gear modeling may be summarized as follows:

Stress analysis such as prediction of contact stress and bending stress.

-Prediction of transmission efficiency.

-Finding the natural frequencies of the system before making the gears.

-Performing vibration analyses of gear systems.

Evaluating condition monitoring, fault detection, diagnosis, prognosis, reliability and fatigue life.

4. METHODOLOGY

1) To generate finite element models (FEM) of the gears based on the accurate solid models and gear assembly. In order to obtain the reliable results of the stress analysis, a 2D FEM model will be generated in ANSYS and a 3D FEM model will be created by applying Solid Works.

2) To investigate gear stress distribution along the meshing path of tooth of spur gears and surface contact behaviors. In order to achieve the accurate stress analysis, global sensitivity analysis of the FEM models will be carried out by refining the elements to determine two critical stresses of the gear — maximum von mises stress and maximum first principal stress.

3) To study gear surface contact behavior and effect on the contact stress from misaligned assembly and geometry modification. Meshing simulation of gears in a mesh cycle will be conducted. Three different FEM scenarios will be created — normal involute gears with accurate assembly, normal involute gears with 0.1 deg shaft misalignment and tooth profile modified gears with accurate assembly. The analysis of contact stress in a mesh cycle in these scenarios will be conducted.

4.1 FEM Procedure

Procedure of static analysis:

First of all, we have prepared assembly in Pro/E for spur gear and save as this part as IGES for Exporting into ANSYS work-bench Environment. Import IGES mode in ANSYS workbench simulation module.

Apply material for spur gear (structural steel).

Meshing criteria:

Element type solid 10 node quadratic tetrahedral.

Define boundary condition for analysis:

Boundary condition play the important role in finite element calculation here, I have taken both remote displacement for bearing supports are fixed.

5. CONCLUSIONS

The results of point and line contact scuffing analyses indicate that asperity interactions are significant at typical speed, load and temperature conditions with typical surface roughness profiles. The heat generated at the contact under these conditions is much larger to enhance the likelihood of scuffing significantly. With this, it can be stated that any scuffing model must have the capability to capture mixed EHL conditions accurately. This is especially true for most automotive, wind turbine and industrial applications.

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