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Design and Analysis of Roller Machine Spur Gear to Overcome Gear Stucking and Scuffing

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ABSTRACT

Scuffing is a prominent surface failure mode of loaded, lubricated contacts of gears and rolling element bearings experiencing excessive relative sliding and high speeds. This temperature-induced failure occurs suddenly when the contact temperatures reach a critical level due to the frictional heat generated at the contact interface. Material properties and geometry of contacting surfaces, operating conditions (normal load, relative sliding and speed), surface texture (roughness amplitude and direction) as well as physical and chemical properties of the lubricant all influence the scuffing behavior of such components. In this study, a physics-based methodology is proposed for predicting thermal conditions of lubricated contacts under combined sliding and rolling, and for relating these thermal conditions to the likelihood of scuffing. The methodology combines (i) a mixed thermal elastohydrodynamic lubrication (EHL) model to predict temperatures of the contacting surfaces and in the lubricant film in between, (ii)a convective heat transfer model to predict the time-varying temperature distributions of the contacting bodies, and (iii)a scuffing criterion to predict the onset of scuffing. The proposed general methodology is applied to a spur gear problem by considering variations of contact parameters along the tooth surfaces and incorporating a gear load distribution to predict contact loads. This spur gear scuffing model are gear of rolling machine uses a one-dimensional (line contact) thermal EHL model and a convective heat transfer model of a gear pair in an iterative manner to predict the maximum instantaneous contact temperatures, which are used with the scuffing temperature limits established by the experiments to determine the likelihood of scuffing to occur. At the end, the proposed methodology is compared to the conventional gear scuffing criteria to highlight its capabilities to overcome the major shortcoming the secretarial.

Keywords- **Bending and contact stress analysis, Gear design, Mesh generation, Spur gears**

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I. INTRODUCTION

Gears examination in the past was performed utilizing scientific strategies, which obliged various suspicions and rearrangements. When all is said in done, rigging examinations are multidisciplinary, including estimations identified with the tooth stresses and to tribological disappointments, for example, similar to wear. [3] Designing exceptionally stacked goad gears for force transmission frameworks that are both solid and calm obliges examination techniques that can without much of a stretch be executed furthermore give data on contact and twisting anxieties, alongside transmission lapses. The limited component strategy is equipped for giving this data. The limited component system is frequently used to dissect the anxiety condition of a versatile body with confused geometry, for example, a rigging. [3]The life and execution of rigging teeth are specifically identified with the capacity of the teeth to withstand contact stresses. Contact anxieties may deliver setting inside of the contact zone and in the end lead to tooth disappointment. Notwithstanding the significance of contact hassles in riggings, thorough investigations of these anxieties have not been broadly reported in the writing. [3]

Wear is only dynamic expulsion of metal from the surface. Subsequently tooth weakens and gets debilitated. Setting is a surface weakness disappointment of the rigging tooth. It happens because of misalignment; wrong thickness choice of the ointment utilized, and contact anxiety surpassing the surface exhaustion quality of the geometry of the reaching surfaces. In spite of the fact that these presumptions are required for the traditional techniques, their utilization brings up issues about the exactness and materialness of the results.[3] Material in the weakness district gets uprooted and a pit is framed. The pit itself will bring about anxiety focus and soon the setting spreads to contiguous area till the entire surface is secured. Accordingly, higher effect burden coming about because of setting may bring about break of officially debilitated tooth. [3]

Gear Stucking or Scuffing:

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.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.

Fig.1. Gear scuffing Effect

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.

ReasonfortheGearToothFailure**:**The diverse methods of disappointment of apparatus teeth are bowing disappointment, setting and scoring, destructive wear. In bowing disappointment each apparatus tooth goes about as cantilever. In the event that aggregate dreary element burden following up on the apparatus tooth is more noteworthy than the pillar quality of the rigging tooth, then the apparatus tooth will come up short in twisting. In setting disappointment it is surface weakness disappointment which happens because of numerous redundancy of Hertz contact stress. The disappointment happens when the surface contact hassles are higher than the continuance furthest reaches of the material. Scoring-it will be a tick slip wonder in which exchange sharing and welding takes place quickly at most astounding spots. It will be stayed away from by appropriately planning the parameters such as velocity, weight and fitting stream ointment. Destructive wear-the consumption of the tooth surfaces is pin particular brought about because of the vicinity of destructive components , for example, added substances exhibit in the greasing up oils. To maintain a strategic distance from this anticorrosion operators are used. [1]

CONTACT STRESS : Contact anxiety is for the most part the central element for the determination of the essential measurements of apparatuses. Research on apparatus activity has affirmed reality that alongside contact weight, sliding speed, thickness of grease and in addition different components, for example, frictional powers, contact focuses on likewise impact the arrangement of pits on the tooth surface. So exhaustive investigation of contact anxiety grew between the diverse tangling apparatuses are basically essential for the rigging outline. Adapting is a standout amongst the most discriminating parts in mechanical force transmission frameworks. Current Analytical techniques for computing rigging contact hassles use Hertz's comparisons, which were initially determined for contact between two chambers. So for CONTACT STRESSES it's important to create and to focus proper models of contact components, and to ascertain contact anxieties utilizing ANSYS and contrast the outcomes and Hertzian hypothesis. Contact stress examination between two goad gear teeth was considered in diverse contact positions, speaking to a pair of mating riggings amid pivot. A project has been created to plot a couple of teeth in contact. This project was keep running for each 3° of pinion revolution from the first area of contact to the last area of contact to deliver 10 cases. Every case was spoken to an arrangement position of contact between these two teeth.

HERTZ CONTACT STRESS

One of the principle gear tooth disappointment is setting which is a surface exhaustion disappointment because of numerous reiteration of high contact hassles happening in the rigging tooth surface while a couple of teeth is transmitting force. Contact disappointment in apparatuses is at present anticipated by contrasting the figured Hertz contact stress with tentatively decided admissible qualities for the given material. The technique for ascertaining apparatus contact push by Hertz's mathematical statement initially inferred for contact between two barrels. Contact hassles between barrels are demonstrated in fig.1.

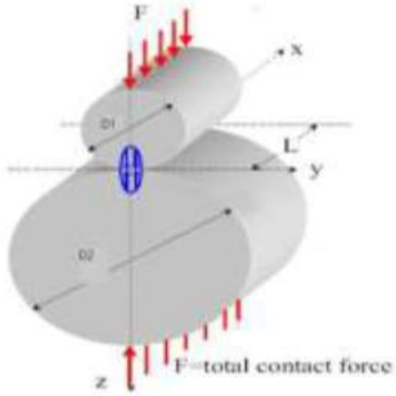

Fig.2. Contact Hertz Stress

In machine plan, issues habitually happens when two individuals with bended surfaces are twisted when squeezed against each other offering ascent to a territory of contact under compressive burdens specifically compelling to the apparatus originator is the situation where the bended surfaces are of tube shaped shape on the grounds that they nearly take after rigging tooth surfaces. In Fig.1 two apparatus teeth are demonstrated in mating condition at the pitch point.[4]

A. Modeling and Analysis of Spur Gear:

We can utilize the product of CAD (Computer Aided Design) to finish the three-dimensional parametric displaying of gears. Using the usefulness of three dimensional strong demonstrating programming it is anything but difficult to execute parametric rigging commute and it additionally has a decent interface with the Finite Element Software. Amid the rigging plan, the fundamental parameters that would depict the outlined apparatus, for example, module, weight edge and tooth thickness, number of teeth could be utilized as the parameters to characterize the rigging. Taking into account the parameters we can assemble show in strong works displaying bundle. Anyhow, the parameters don't need to be just geometric. They can likewise be key procedure data, for example, nature of evaluations, metallurgical properties and even load characterizations for the apparatus being designed.[4]

Along these lines to decrease the displaying time a preprocessor strategy that develops the geometry needed for limited component examination may be utilized, for example, Solid Works. Strong Works can create three dimensional models of apparatuses. The Solid Works CAD programming is a mechanical outline mechanization application that lets planners rapidly draws out thoughts, explores different avenues regarding components and measurements, and produce models and itemized drawings. [4] This archive talks about ideas and phrasing utilized all through the Solid Works application. It acclimates you with the generally utilized elements of Solid Works. The method of gear tooth geometry and parametric modeling is as follow,

- determining the basic parameter
- determining the geometric parameter
- the characteristic parameter [4]

B. Basic Steps in Finite Element Method:

1. Discretization of the space continuum is separated into a no. of limited components by fanciful lines or surfaces. The interconnected components may have distinctive sizes and shapes. The achievement of this admiration lies in how nearly this discretized continuum speaks to the real continuum. The decision of the basic components or higher request components, straight or bended, its shape, refinement are to be chosen before the scientific plan begins.
2. ID of variables the components are thought to be joined at their crossing focuses alluded to as nodal focuses. At every hub, obscure relocations are to be endorsed. They are subject to the current issue. The issue may be distinguished in such a path, to the point that notwithstanding the relocation which happens at the hubs relying upon the physical way of the issue.
3. Decision of approximating capacities After the variables and neighborhood directions have been picked, the following step is the decision of removal capacity, which is the beginning stage of scientific examination. The capacity speaks to the variety of the dislodging inside of the component. The state of the component or the geometry might likewise inexact.
4. Arrangement of component solidness framework After the continuum is discretized with coveted component shapes, the component firmness grid is formed. Fundamentally it is a minimization method. The component solidness framework for greater part of components is not accessible in express shape. They require numerical mix for this assessment.
5. Arrangement of the general firmness grid after the component solidness network in worldwide directions is framed, they are amassed to frame the general solidness lattice. This is done through the hubs which are regular to adjoining components. At the hubs the progression of the removal capacities and their subsidiaries are set up.
6. Joining of limit conditions The limit restriction conditions are to be forced in the solidness network. There are different strategies accessible to fulfill the limit conditions. 3.7. Development of the component stacking framework. The stacking inside a component is exchanged at the nodal focuses and reliable component stacking network is shaped.
7. Development of the general stacking grid The component stacking lattice is joined to frame the general stacking network. This network has one section for each stacking case and it is either a segment vector or a rectangular framework relying upon the no. of stacking conditions.

8. Arrangement of synchronous comparisons: All the mathematical statements needed for the arrangement of the issue is currently created. In the relocation system, the questions are the nodal uprooting. The Gauss disposal and Choleky„s factorization are most regularly utilized strategies.
9. Count of anxieties or anxiety resultants. The nodal removal qualities are used for computation of burdens. This may be ruined all components of the continuum or may be restricted just to some foreordained elements.[6]

The limited component technique is numerical examination specialized of optioning surmised answer for a wide verity of designing issues. as a result of its differences and adaptability as an examination apparatus , it is accepting much consideration in building school and commercial ventures in more designing circumstance today , we observe that it is important to get surmised answer for issues instead of accurate close from arrangement it is unrealistic to get expository scientific arrangements are numerous building's prob-lems. An investigative arrangement is a numerical expression that gives estimation of the yearning obscure amount an any area in the body, as outcome it is substantial for boundless number of area in the body. For issue including complex material properties and bounder condition, the designer asset to numerical system that give inexact that palatable arrangement.

I. 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.
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 solid10 node quadratic tetrahedral.
Define boundary condition for analysis: Boundary condition play the important role in finite element calculation.[7]

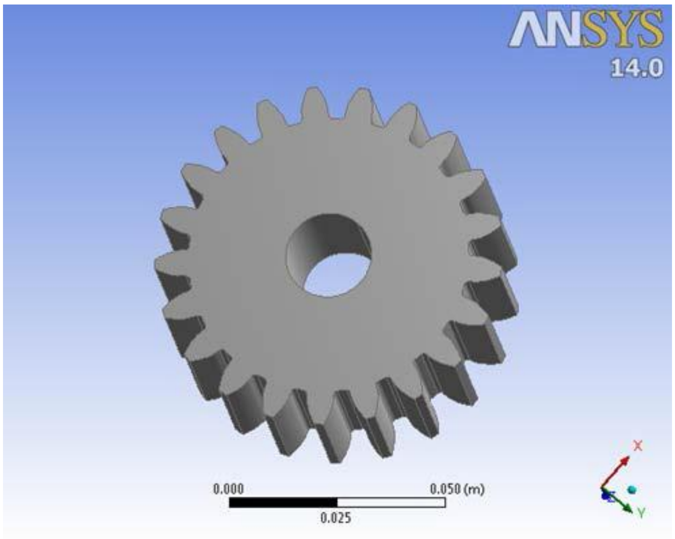

Fig.3. Example of modeling of GEAR[7]

RESULTS OF FEA:
Analytical method of gear analysis uses number of assumptions and simplifications and it is intended to determine the maximum stresses and deformations values. In this paper, numerical approach has been used for predicting the static and dynamic contact stresses of spur gear. The contribution of this work can be summarized as follows:

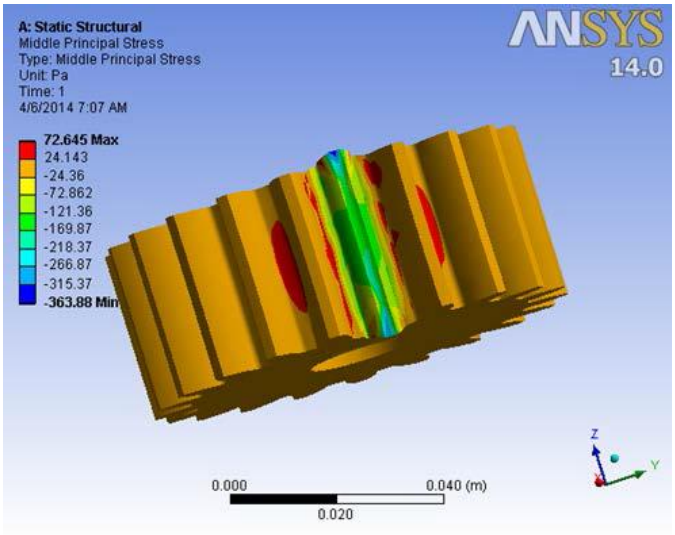

Fig.4.Example of FEA of Gear[7]

a) It is demonstrated that the viable strategy to gauge the contact anxieties and distortions was by utilizing three dimensional model of the apparatus tooth;
b) The sort and heading of stacking has a major part in determining the bearing and augmentations of the came about misshapenness;
c) The 3D FEM stress figures empowered the knowledge into the tooth root stress dispersion along the face width, which is not accessible by expository 2D methodology;
d) The anxiety increment fundamentally because of triangle burden conveyance. That implies under non - uniform contact conditions in the cross section process; and
e) The depicted numerical investigation strategy and the broke down results are another perspective in rigging

computation. Coordinating new routines into standard figuring's of goad riggings could be exceptionally helpful for designers and researchers whom exploring goad gear.

Ideal parameters for most extreme element tooth stack: The impact of rigging proportion, face width and ordinary module on ideal element tooth burden is done. In the event that face width, rate and typical module with the exception of apparatus proportion are kept steady and rigging proportion is expanded, the comparing element tooth burden stayed consistent. At the point when gear proportion, speed, typical module aside from face width are kept consistent and face width is expanded, the relating element tooth burden stayed steady. The face width, gear proportion and rate with the exception of typical module are kept consistent and ordinary module is expanded, the relating element tooth burden diminishes. The ordinary module 2.5mm, relating to most extreme element tooth burden is taken as consistent. [2]

Ideal parameters for most extreme shaft quality: The impact of rigging proportion, face width, typical module on ideal pillar quality is done. In the event that face width, pace and ordinary module with the exception of rigging proportion are kept steady and apparatus proportion is expanded, the comparing shaft quality stayed consistent. The apparatus proportions, speed, typical module aside from face width are kept consistent and face width is expanded, the comparing shaft quality found to increment. The face width 49cm, relating to greatest shaft quality is taken as consistent. The face width, gear proportion and rate with the exception of typical module are kept steady and ordinary module is expanded, the comparing shaft quality found to increase.[2]

II. 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 state 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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