ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

ANALYSIS OF SPUR GEAR SCUFFING FOR LATHE MACHINE HEADSTOCK USING PRO-E AND ANSYS SOFTWARE

Mrs.Vandana Sharma*, Prof.GVR Sheshagiri Rao
*M.E.Scholar B.M.C.T. Indore, India
Head,Mech.Deptt B.M.C.T. Indore, India

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 All Gear head stock of lathe 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 these criteria.

KEYWORDS: Spur gear, lathe machine.

INTRODUCTION

Background and Motivation:

Scuffing is one of the most common surface failure modes observed at lubricated, loaded contacts experiencing excessive relative sliding. The other two most common surface failure modes are wearing and 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 elastohydro dynamic lubrication (EHL) film causes metal-tometal 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.

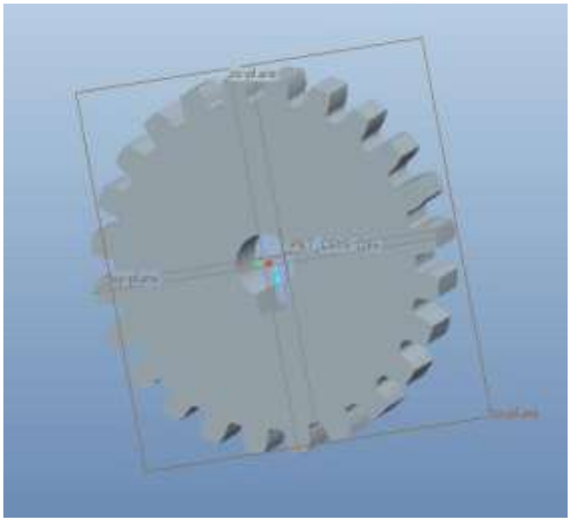

Figure 1 Driving gear

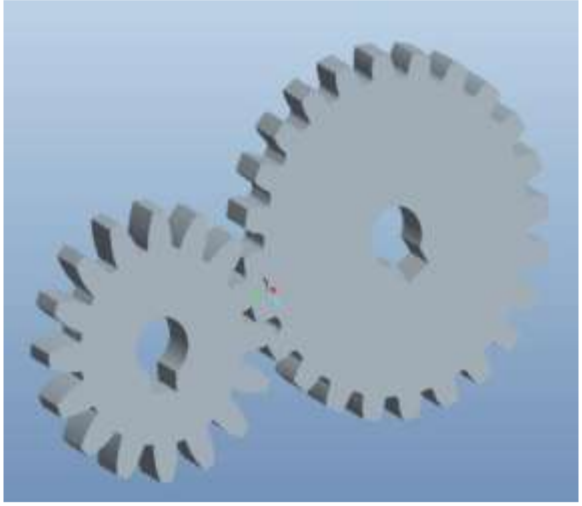

Figure 2 Assemblies of Gear Pair

Mathematical Model

The mesh for the gear pair in this study is shown in Figure 1. Each of the gears undergoes large rotation according to a prescribed, kinematics trajectory. In this two- gear case, this trajectory is that of conjugate action of the gears at specified operating speed. The elastic gear motions that superpose on this prescribed trajectory are small. If the finite element displacement vector for a particular gear is measured with respect to a reference frame that follows this known trajectory, then it is possible to represent its behavior by a linear system of equations.

RESULTS

A torque of 2.1GPa is applied at the reference point by constructing kinematic coupling with reference point as the center of the Driving gear. The Driven gear is fixed and the Driving gear is free to rotate only about z-axis to transform the torque to the driven gear. The contour for contact stress (in the normal direction) is shown in fig below.

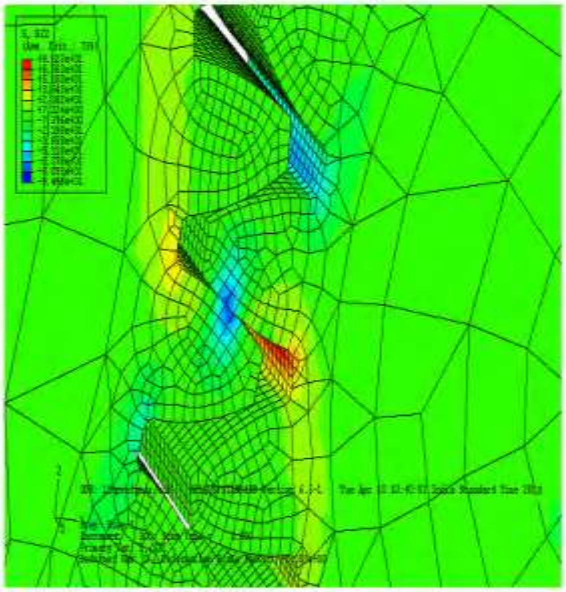

Figure 3 The contact stress distributions are plotted along the profile of gear tooth pear enlarge view.

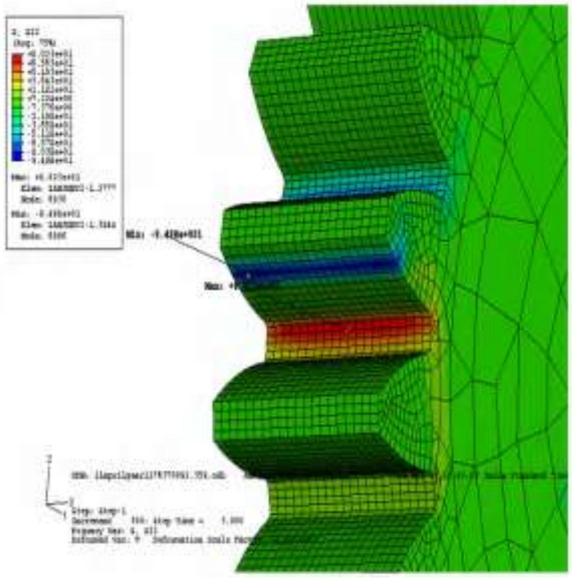

Figure 4 The contact stress distributions are plotted along the profile of gear teeth and tooth depth as shown in Figure

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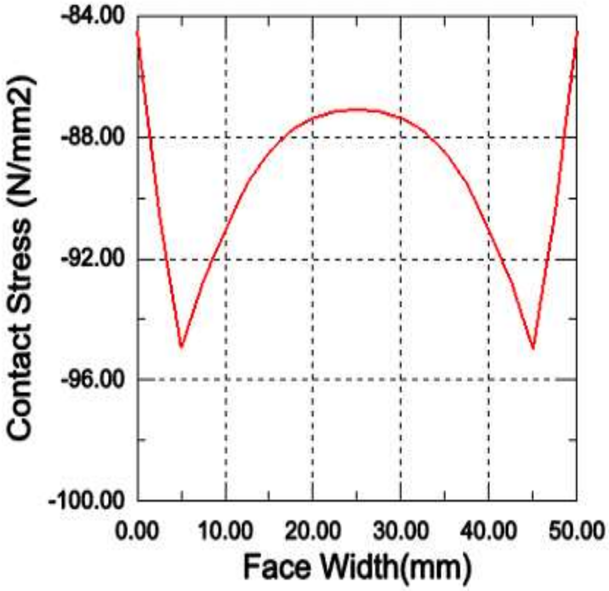
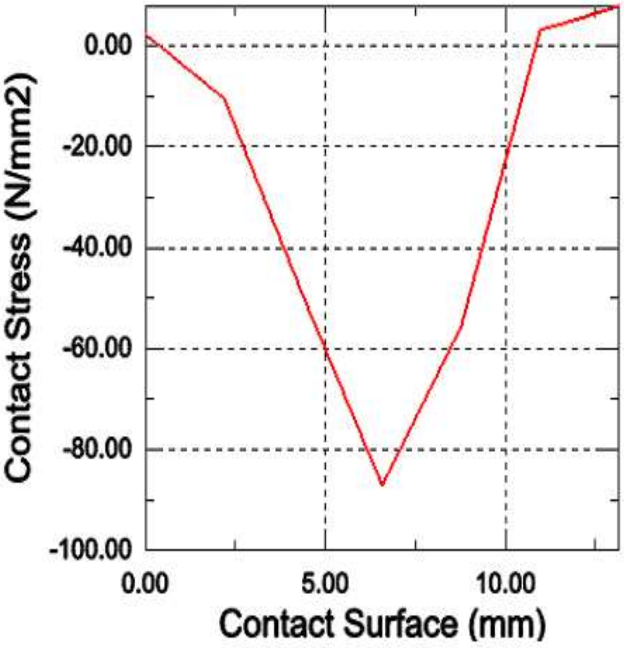


Graph 1 Contact stress Vs Face Width



Graph 2 Contact Stress Vs Contact Surface

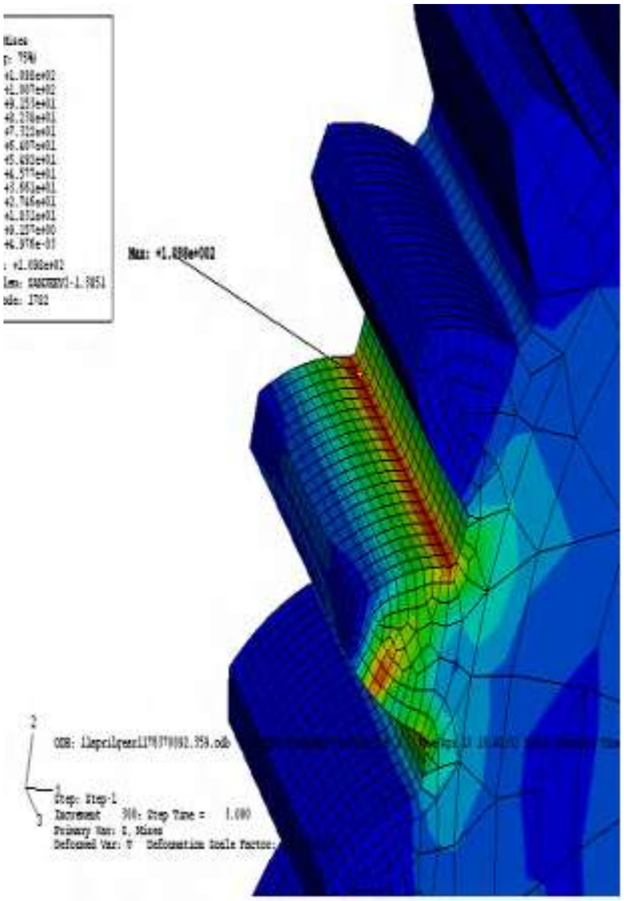


Figure 5 showing node of maximum von mises st stress

Table1:The maximum of various stresses are as follows

1) Max. contact stress:	+80.36 MPa		(Node no.:6936)
2) Min. contact stress:		-94.98 MPa	(Node no.:6996)
3) Max. Radial stress:	+81.7 MPa		(Node no.:1717)
4) Min. Radial stress:		-115.1MPa	(Node no.:1774)
5) Max. von mises stress:	+109.8 Mpa		(Node no.:1782)

CONCLUSION

Predicted bulk temperatures of the proposed scuffing model for a point contact problem show a good agreement with the corresponding measurements from both the traction and scuffing measurements. This can be interpreted such that both the mixed thermal EHL model and transient heat transfer model for the contacting disks and their supporting structures are accurate in their ability to capture the physics of the contacts.

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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