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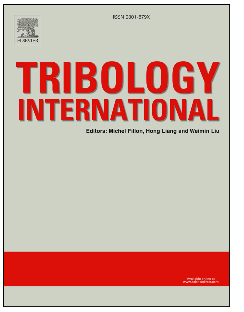

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An Investigation of Misalignment Effects on the Performance of Acetal Gears

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Abstract

This paper concentrates on the effects of misalignment on meshing behaviour of acetal gears as hardly any misalignment investigations on polymer gears in the existing literatures. The experimental results show that the wear of acetal gears is insensitive to radial and axial misalignments but sensitive to yaw and pitch misalignments which degrade the conjugate contact action. Yaw misalignment leads to 'scoop' wear marks near tooth pitch points. Pitch misalignment causes 'superimposed palisade' wear marks and micro cracks near tooth roots. Compared with metal gears, the effects of small pitch angle on acetal gears are insignificant which may be linked closely to polymer's low elastic modulus. Strikingly different wear striations and various debris morphologies are observed by using scanning electronic and optical microscope (SEM, OM) and misalignment effects can be noted.

Keywords: Acetal spur gear; Misalignment; Wear debris morphology; Micro cracks

1. Introduction

The increasing use of polymer and polymer composite gears in transmission system such as acetal, polycarbonate, PEEK, and carbon/glass fibre reinforced PEEK gears is driving manufacturing industry into a new energy-saving era. Great efforts have been made to investigate and understand the wear mechanisms of polymer and polymer composite gears in the past 40 years such as design standard [1-5], sources of heat generation [6], varying temperature effect [7-12] and effect of sliding-rolling contact [13-19] and so on.

However, almost no literature has been found on the subject of polymer gear tooth contact under misaligned condition although in depth research has been conducted on metal gears. Houser et al [20] listed major sources of misalignment, defined three categories of misalignment for metal helical gears and presented some possible methods such as lead crowning and end relief to reduce the detrimental effects of misalignment; Li [21-23] developed a finite element method (FEM) to investigate the effects of shaft misalignment. It is found that misalignment on the plane of action exerts significant effect on contact stress (CS) and tooth root bending stress (TRBS) while misalignment on the vertical plane of action exerts minimal effect. Prabhakaran et al [24] calculated and modelled the variations of the bending stress (BS) and CS of a spur gear pair which are exerted by misalignment on the plane of action. Lias et al [25] attempted to use FEM to analyse theoretical forces that create stresses due to misalignment in a spur gear pair. It is found that the CS is proportional with the misalignment deviation and its concentration is higher in tooth contact region and root as an increase in misalignment angle. Ameen [26] used distributed point loads to describe the non-uniformity in load distribution under misalignment and found an increase in angular misalignment results in an increase in maximum BS and stress concentration (SC) on the edge of tooth. Driot and Liaudet [27] modelled the dynamic behaviour of a spur gear pair due to shaft misalignments. Velex and Maatar [28] introduced a comprehensive mathematical model. Saxena et al [29] calculated the mesh stiffness of a spur gear pair subject to yaw misalignment using potential energy method considering the effect of friction force. Jones [30] investigate the static effects of misalignments through using FEM on the LSR and reaction force under contact to approximate contact in dynamic model. A similar method with computer aid was applied by Simon [31-33]. It is found that the misalignments degenerate conjugate action and result in an increase of CS, BS and transmission error (TE).

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