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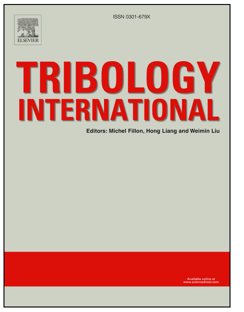

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An experimental investigation of scuffing initiation due to axial displacement in a rolling/sliding contact

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Abstract

This paper presents an investigation into the effect of axial displacement on the initiation of scuffing in a rolling/sliding contact by means of a twin-disc test device. Firstly, an existing twin-disc test device is modified to be suitable for applying axial displacement cycles and a rolling/sliding motion to the disc contact. Secondly, the results of two test series are analysed. Both series are subjected to a combined step-wise increasing normal force and constant rolling/sliding loading. The first series is without axial displacement, while in the second series, continuously reciprocating axial displacement cycles are applied starting at a specific normal force level. The results show that a stabilized axial displacement loading can increase the scuffing load carrying capacity.

Keywords: Scuffing, twin-disc, axial displacement, friction.

1. Introduction

Ship shafting lines usually transfer power through bevel gears. These mechanical systems experience occasional overload cycles caused, for example, by the ship's propeller hitting hard obstacles such as ice floes when operating in polar regions. The resulting deformation of the supporting structures can cause axial displacement of one or the other of the gear wheels located between the shafts. Consequently, additional sliding between interacting gear teeth may occur, which may disturb stabilized behaviour of the contact during operation.

There appears to be a close relationship between the initiation of scuffing and the lubricant film breakdown [1]. The thickness of the elastohydrodynamic lubrication (EHL) film may decrease as its viscosity decreases due to extensive frictional heating, which in turn is caused by the high surface sliding velocity and the contact pressure. This may lead to damaging asperity contacts. According to Jacobson [2], if the shear stresses in the lubricant reach the shear strength of the lubricant in the prevailing condition, the oil is no longer dragged along the surfaces straight into the contact. The oil loses its grip on the surface and slides down into the valleys between the surface asperities. This can cause the surface asperities to break through the oil film and come into direct contact with the opposite surface. On the other hand, if most of the limited shear stress of the lubricant is utilised in the main direction of the sliding movement, even relatively minor sliding in another direction may allow the lubricant to slip out sideways. This results in a thinner oil film or film breakdown [2]. Moreover, Larsson et al. have reported that a high sliding speed also seems to increase the risk for oil film breakdown [3] and Castro et al have proposed an approach for predicting the likelihood of scuffing by dividing the problem in global and local parts and by considering the state of the running-in of the surfaces [4]. Additionally in a study by Li et al the interactions between the gear dynamics and the gear tribological behaviour was researched [5]. It was found that not only the line-of-action dynamic response but also the off-line-of-action vibratory motion affects the surface flash temperature. For the reason that in extreme conditions scuffing can initiate after only a short period of severe load cycles, axial displacement may well have an effect on the lifetime of a gear mechanism.

The traditional experimental approach to assessing the scuffing load-carrying capacity of a lubricant-material pair has been standardized and is conducted with FZG tests [6]. Additionally, bevel-gear-based test devices have been utilised successfully over the years. In such studies, the focus has been on varying the lubricant, the oil temperature, the applied loading, the amount of oil supplied and the effect of a coating [7, 8]. However, these studies have used a fixed gear geometry, which limits the extent of the variations in the types of loads that can be applied.