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Effects of the micro surface texturing in lubricated non-conformal point contacts

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Abstract

This paper presents an experimental study on the effects of micro-textured surfaces on lubricated non-conformal point contacts. Thus, we focus on a regime poorly investigated in literature, where the contact area and the micro-holes have a comparable size. Tribological characterization are performed on three geometrical patterns, which are textured on stainless steel polished surfaces. Experiments are carried out on a rheometer, where a steel ball slides against the surface of the samples. These samples are tested with two different viscosities of the PAO (Poly-Alpha-Olefin)as a lubricant. Results show the change in the friction with respect to the sliding velocity under different lubrication regimes due to the stress, void ratio and two different kinematic viscosities of PAO. In particular, we show that, depending on the void ratio, a significant friction reduction or, on the contrary, a deterioration of the frictional performances can affect the boundary and mixed lubrication regimes. This is due to the simultaneous occurrence of two competing effects. One is related to the stress intensification, due to the presence of the micro-hole edges on the contact topography, which leads to a consequent increase in wear and friction. On the other hand, micro-texture may play a positive role in the friction optimization given the possibility, offered by the micro-holes, to entrap wear debris and, then, to preverse a smoother interface between the contacting pairs.

Keywords: Surface Texturing, femtosecond laser ablation, lubrication, non-conformal, friction.

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1. Introduction

Topography of the surfaces plays important role in influencing the tribological properties of the materials and, in particular, the friction behavior of the two-rubbing surfaces during conformal and non-conformal contacts. Different research groups around the globe are trying to understand the complex behavior of the tribological properties,in terms of friction and wear, in order to improve the efficiency and to increase the life time of the mechanical systems or components [1].Over the past decades, surface texturing has shown to be an emerging technique to control the friction and wear. It consists of fabricating a pattern of small dimples or grooves on the surface of the materials in a very controllable way, which causes the change in the surface topography. In an engineering setting, the concept of "micro-irregularities" was first introduced by Hamilton and Allen in 1966 [2,3]. They pointed out that by adding "asperities and depressions" to one face of a parallel rotary-shaft face seal, the load support capabilities of the seal could be improved.Various techniques can be employed for surface texturing, which includes vibro-rolling (Schneider- 1984) [4], reactive ion etching (Wang-2003) [5] and Laser Surface Texturing (LST) (Etison-1996) [6],but the latter is probably the most advanced so far. LST is a process that can generate periodic micro or nano or hierarchical micro/nano structures involving very thin layer of material surface by laser ablation. The generated micro-dimples can serve either as a micro-hydrodynamic bearing in cases of full film lubrication or mixed lubrication, a micro-reservoir for lubricant in cases of starved lubrication conditions, or a micro-trap for wear debris in either lubricated or dry sliding [7,8]. So, if properly designed, the macroscopic effect of such micro structuring is an enhancement of the load capacity, wear resistance, and friction properties of the laser-treated surfaces. Recently, Gachot et al. summarized the effects of surface textures under the operative lubrication regimes in the Stribeck curve, with a clear distinction between conformal-