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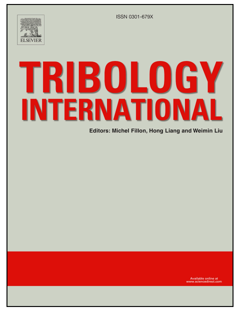

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Impact of morphological furrows as lubricant reservoir on creation of oleophilic and oleophobic behaviour of metallic surfaces in scuffing

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Abstract

This paper analyses the key role of the surface morphology in the creation of oleophilic or oleophobic behaviour (via oil capacity) of metallic surfaces and its hypothetical influence on the initiation of the catastrophic mechanism of scuffing. Taking into consideration the fact that the commonly used roughness parameters do not correlate with the scuffing performance, the application of the morphological furrows to analysis of the susceptibility of metallic surfaces to this type of surface failure was proposed and elucidated. Furrows characteristic was based on the analysis of their three typical parameters (max. and mean depth and max. density, in the initial and scuffed surface state) in the mechanical and physicochemical aspects of the surface and lubricant relationship. Improved strategy offering the discriminating methodology of scuffing transition was presented and discussed. Obtained results enabled the identification furrows' parameters predisposed to scuffing prediction and therefore worthy to consideration for use in manufacturing of frictional operating metallic parts exposed to catastrophic failures.

Nomenclature:	
HD	Hydrodynamic lubrication
EHL	Elastohydrodynamic lubrication
MDF	Mean depth of furrows [μm]
Sa	Arithmetic mean height [μm]
Sz	Maximum roughness height [μm]
t_{SC}	Time to scuffing [s]
XDF	Maximum depth of furrows [μm]
XNF	Maximum density of furrows [cm/cm^2]

1. Introduction

The surfaces of all solids in nature have some texture. However, the textures can differ in properties, from the smoothest polished plate glass to the rough surface of mountain ranges as can be seen on aerial pictures. These specific, textural properties of a surface determine its interaction with the surrounding environment. In the technical sense, texture can be defined as irregularities (peaks and valleys) formed on the surface by the machining or treatment process. Generally, it is accepted that texture is composed of two elements: waviness (widely spaced unevenness generated by vibrations during a machining or treatment process) and roughness (smaller irregularities produced by the direction of the machining). Commonly, the terms "surface texture" and "surface roughness" are synonymous. This is due to the fact that roughness parameters are measured and analysed in engineering practice more often than waviness characteristics [1].

Superficial properties (including roughness and waviness) can be used to accurately analyse specific surfaces, which can make it possible for these surfaces to be consciously formed in a way that makes them suitable for their purpose. That is why surface texturing is gaining a more and more important role in modern science and engineering. Its application covers such completely different areas as classifying skin lesions [2], identifying wood surface defects [3], analysing the lunar surface [4], evaluating concrete features [5] and even industrial robots learning to distinguish between different materials based on their texture [6].

In tribology, surface texturing is mostly used to prepare surfaces for cooperation with lubricants and/or in order to reduce friction (very popular in a design and manufacturing of cylinder liners [7,8] or bearing components [9,10]). One way of doing this is by increasing the surface's oil capacity with the formation of some special "pockets" or "grooves" obtained by different treatment methods, e.g. by laser techniques [8,11], the combination of laser and heat treatment [12], milling [13], burnishing [14] or plateau honing [15]. The increased oil capacity ensures a better distribution of oil in the real contact zone and hence a faster and easier formation of the lubricant's film between rubbing surfaces. In addition, oil "pockets" can be used as a type of "waste-basket" for debris generated during friction. As long as the volume of the pockets ensures the storage or leading out of wear debris, the flow of oil in the contact zone remains unthreatened. However, if the volume of the pockets is not able to accommodate a larger quantity of debris, this debris will accumulate in the contact zone [16]. Consequently, the oil flow will be disturbed and the scuffing process will be activated. Additional attention also needs to be paid to the relationship between the oil capacity of the surface and the volume of oil distributed into the contact zone. It is theoretically possible that oil pockets with too much

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