Friction behaviour of meso-scaled textured metallic surfaces using numerical and experimental methods

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Abstract

Meso-scale surface texturing, incorporating features such as grooves, pillars, or bumps, has traditionally been studied to enhance the performance of tribosystems, primarily by improving lubrication characteristics (1). Recently, surface texturing has demonstrated the potential to control the friction coefficient between flat and textured surfaces, laying the groundwork for the development of frictional meta-interfaces (2). To further investigate the capability of controlling frictional behavior within tribopairs, this study explores a range of meso-scale textures, including bio-inspired designs that mimic surface structures of geckos and desert scorpions (3), alongside conventional geometries such as bumps, sinusoidal patterns, and rectangular textures. The frictional properties of these textures are evaluated through a dry sliding contact model between two metallic surfaces, a rigid cylindrical indenter and an elastic textured surface, using a 2D finite element analysis (FEA) model developed in COMSOL Multiphysics. This metal-to-metal contact analysis focuses on frictional forces, stress distributions, and contact areas. The simulation results are compared to assess the influence of each texture on frictional behavior, contact stresses, and the overall contact surface. Furthermore, prototypes of the textured surfaces are fabricated using the Selective Laser Melting (SLM) method, aiming also to explore the capability of this manufacturing process to accurately fabricate meso-scaled textures. These prototypes are then tested experimentally with a pin-on-disk tribometer in dry and lubricated conditions in order to verify the simulation results and to provide a comprehensive understanding of the frictional performance of the textures.

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