Multi-scale surface patterning ? an approach to control friction and lubricant migration in lubricated systems

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Purpose: The paper aims to investigate the possibilities to control friction in lubricated systems by surface patterning, making use of a multi-scale approach. Surface patterns inside the tribological contact zone tend to directly reduce friction, whereas surface patterns located in the close proximity of the contact area can improve the tribological performance by avoiding lubricant starvation and migration. Finally, optimized surface patterns were identified by preliminary laboratory tests and transferred to a journal bearing, thus testing them under more realistic conditions.

Design/methodology/approach: Surface patterns on a large scale (depth > 10 µm) were fabricated by micro- and roller-coining, whereas surface patterns on a small scale (depth < 2 µm) were produced by direct laser interference patterning. The combination of both techniques resulted in multi-scale surface patterns. Tribologically beneficial surface patterns (verified in ball-on-disk laboratory tests) were transferred onto a journal bearing?s shaft and tested on a special test-rig. To characterize the lubricant spreading behavior, a new test-rig was designed, which allowed for the study of the lubricant?s motion on patterned surfaces under the influence of a precisely controlled temperature gradient. Findings: All tested patterns accounted for a pronounced friction reduction and/or an increase in oil film lifetime. The results from the preliminary laboratory tests matched well, with results from the journal bearing test-rig, both tests showing a maximum friction reduction by a factor of 3-4. Numerical investigations, as well as experiments, have shown the possibility to actively guide lubricant over patterned surfaces. Smaller periodicities, as well as greater structural depths and widths, led to a more pronounced anisotropic spreading and/or greater spreading velocities. Multi-scale surfaces demonstrated the strongest effects regarding the lubricant?s spreading behavior. Originality/value: Friction, as well as lubricant migration, can be successfully controlled by using micro-coined, laser-patterned and/or multi-scale surfaces. To the best of the authors? knowledge, the study demonstrates for the first time the unique possibility to transfer results obtained in laboratory tests to a real machine component.