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Friction and film thickness of EHL contact with various surface structures during running-in

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Thinning of film thickness is an evident ongoing trend that dictates to decrease surface roughness considerably. It forms a question what surface structure is optimal for the best tribological performance after running-in. The optimum is affected by wear processes that take place during running-in phase. In this phase several not trivial processes take please, i.e. surface roughness influences elastohyrodynamic lubrication, surface features are deformed elastically or plastically, and surface structure is modified by wear. This study combines in-site and ex-site measurements of film thickness, friction and surface topography for several various structures to uncover what is the optimal surface roughness.

Keywords: surface roughness, mixed lubrication, running-in, optimal surface roughness

1. Introduction

During the running-in phase the surface roughness is changing significantly. Surface peaks forms preferential wear area, while surface valleys are often untouched by wear thus, they influence lubrication for long time. Rough surface has general trend to get more smooth but too smooth surface can be recreated to rougher during running-in phase.

2. Methods

Several surface structures were produced on a bearing steel balls. Each of surface were operated in mixed lubrication regime in a contact with sapphire for conditions of the same nominal film parameter. Friction and film thickness were measured in-situ in optical tribometer and results compared to measurements of surface topography.
The RMS surface roughness of surfaces at the beginning and after running-in are in Table 1. Grinded surfaces by different grinding papers (G1-3), lapped surface (L1) and lapped+polished surface (LP1) have been investigated. Contact was run with PAO4 lubricant at 1.2 GPa Hertzian pressure, 50% slide/roll ratio and nominal film parameter of 0.6 for total 88 000 cycles.

Table 1: Parameters of surfaces

	Initial Rq (μm)	Final Rq (μm)
G1	0.39	0.21
G2	0.19	0.14
G3	0.1	0.06
L1	0.19	0.15
LP1	0.18	0.14

2.1. Results
The grinded surfaces exhibit longer and continues friction decrease, while L1 and LP1 surfaces lead to friction stability much earlier. G3 surface which was produced by the finest grinding paper provides relatively the lowest friction.
Figure 1 shows optical interferograms of surfaces after running-in test in EHL contact. Film thickness was evaluated by Thin film colorimetric interferometry.

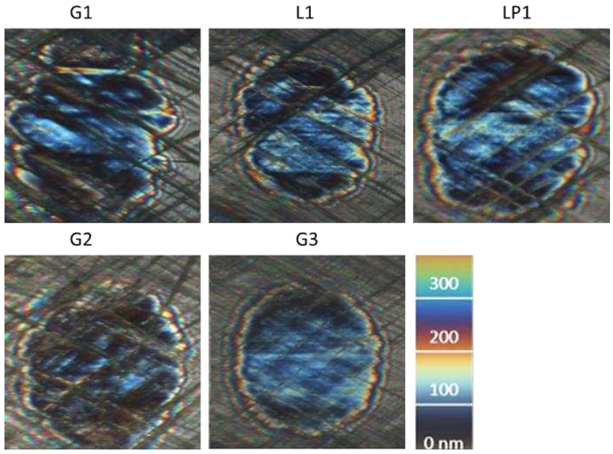

Figure 1: Interferograms of surfaces in EHL contact

3. Discussion

From roughness parameters in Table 1 it is evident that lapping and polishing can decrease surface roughness significantly. Despite it can speed up running-in phase it does not provide the best frictional performance.
In Figure 1, significant surface features with large longitudinal wavelengths can be seen in surface structures G1, L1, LP1. These features negatively influence film thickness formation that limits the final frictional performance. Lapping and polishing processes cannot remove deep grooves which disrupt film formation. It is consistent with results of previous studies with single model groove [1, 2].
In full paper there are included other spatial and hybrid surface roughness parameters and bearing curves, friction trends are shown in detail and film thickness analyzed statistically and deterministically. It shows that there is limited correlation between amplitude roughness parameters and frictional performance.

4. References

[1] Zapletal, T., et al. "The effect of surface grooves on transition to mixed lubrication." Trib Int 114 , 2017, 409-417.
[2] Sperka, P., et al. "The effect of surface grooves on film breakdowns in point contacts." Trib Int 102, 2016, 249-256.