Roughness and texture interaction in parallel sliding contacts

Noël Brunetière[1)*] , Kacou Dingui[2)], Jean Bouyer[1)] and Mohand Adjemout[3)]

[1)]Institut Pprime, CNRS, Université de Poitiers, Isae-Ensma, France
[2)]ENS Paris Saclay, France
[3)]Groupe Latty, Brou, France.
*Corresponding author: noel.brunetiere@univ-poitiers.fr

In parallel sliding contact, surface roughness can provide a hydrodynamic lift-off that can be improved by surface texturing. An example of such configuration is found in the sealing interface of mechanical seals. Some recent tests showed that the surface texture can reduce by about 50% the temperature rise. The gain in temperature was shown to be controlled by the texture area without any effect of the texture pattern contrary to what has been shown theoretically. A possible explanation that will be numerically analyzed in this paper is that the performance is also controlled by the roughness – texture interaction.

Keywords (from 3 to 5 max): mixed lubrication, surface roughness, surface texture, simulation

1. Introduction

It is known that surface texturing is an efficient solution to reduce friction and temperature between parallel sliding surfaces [1]. The efficiency of surface texturing appears to be due to an interaction with surface roughness [2], the texturing being unable to provide sufficient lift by itself. In a recent experimental work on mechanical seals which is a typical example of parallel sliding surfaces, it was shown that the temperature rise in the sealing interface only depends on the texture area density but not on the texture shape [3]. In the present paper, numerical simulation is used to analyze these experimental findings and discuss the possible role of surface roughness.

2. Methods

2.1. Numerical tool

The numerical tool solves the Reynolds equation coupled with a mass conserving cavitation algorithm on a very thin mesh able to capture the details of the surface topography. Thermo-mechanical fluid solid interactions are also considered. The model is fully presented in [4].

2.2. Configuration

Table 1: Configuration of the problem

Fluid	Water at 40°C and 0.5 MPa
Seal outer radius R_o [mm]	28.575
Seal outer radius R_i [mm]	25.575
Rotation speed ω [rpm]	2000
Closing force [N]	700

The parameters of the seal are given in table 1 and the seal surfaces properties given in paper [3].

2.3. Results

Figure 1 presents some examples of film thickness results obtained with different surface texture (smooth, big triangle 1, small triangle 2 and circles).
The averaged calculated temperature rise in the contact is presented in figure 2 as a function of the area texture density. As for the experiments, the simulations results show a linear decrease tendency except for circular texturing.

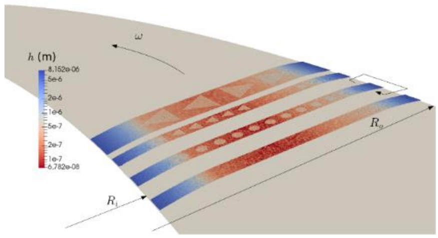

Figure 1 Configuration of the problem and example of film thickness results.

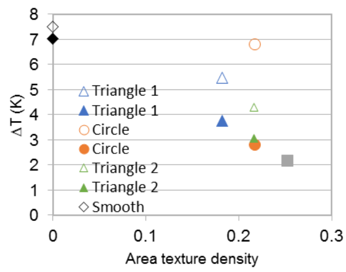

Figure 2 Average temperature rise (solid symbols = exp.).

3. Discussion

The numerical simulations exhibits very similar tendencies to the experiments, except for circular dimples. Contrary to triangles, this surface pattern provides no collective effect, thus explaining the lower performance. It could be interesting to perform simulations with several roughness distribution to have an average behavior, probably closer to experiments.

4. References

[1] Etsion, I., “State of the Art in Laser Surface Texturing,” ASME J. Tribol, 127, 2005, 248-253.
[2] Brunetière, N., Tournerie, B., “Numerical Analysis of a Surface-Textured Mechanical Seal Operating in Mixed Lub. Reg.,” Trib. Int., 49, 2012, 80-89.
[3] Dingui, K. et al., “Surface Texturing to Reduce Temperature in Mechanical Seals,” Tribology Online, 15, 2020, 222-229.
[4] Adjemout, M et al., “Friction and temperature reduction in a mechanical face seal by a surface texturing: comparison between TEHD simulations and exp.,” Trib. Trans., 61, 2018, 1084-1093.