Droplets impacting and migrating on structured surfaces with imposed thermal gradients

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In aeroengine bearing chambers, liquid lubricants are dispersed into numerous droplets of different sizes due to high rotating speed. Droplets would impact on the chamber wall, forming a lubricant film. Since the chamber works in a wide temperature range, it is not clear what will happen on the generated lubricant film. In this study, we confirmed the impacting and migrating phenomena of liquid droplets on solid surfaces subjected to thermal gradients. To manipulate the dynamic processes, surface with different microgrooves were fabricated, and the dynamic features were discussed by quantifying the temporal variations in impacting velocity, spreading diameter, thermal gradient and migration distance. In the meanwhile, the physical mechanism were revealed.

Keywords: liquid lubricant, droplet impacting, migration, microgrooves

1. Introduction

Droplets impacting and bouncing on solid surfaces is a topic of intense research interest because of its scientific and practical importance in many applications including lab-on-chip, heat removal, anti-icing, and self-cleaning [1]. This phenomenon of liquid lubricants is also widely encountered in aeroengine bearing chambers, and since the chamber works in a wide temperature range, lubricants can migrate away easily from warm to cold regions [2]. To manipulate the dynamic processes of lubricants, in this study, we investigated the impacting and migrating of lubricant droplets on solid surfaces with different structures subjected to a thermal gradient.

2. Methods

2.1. Experimental setup

Fig. 1 shows the designed experimental system to investigate the droplets impacting and migrating phenomenon. The test conditions are shown in Table 1.

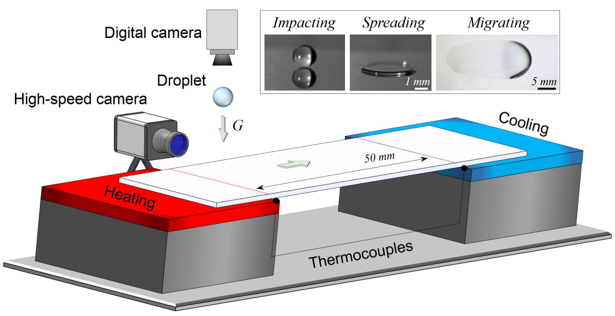

Fig. 1 Schematic of the experimental apparatus.

2.2. Result

Fig. 2 shows the dynamic phenomena on surfaces with microstructures of smooth, parallel, perpendicular, divergence and convergence grooves under experimental conditions of d= 2 mm, V= 3.5 m/s, and ΔT= 4.28 °C/mm. As shown in Fig. 2a, on surfaces with different microstructures, oil droplets would impact, spread, retract, be stable, and migrate to the cold side, sequentially. The migration process on these surfaces within the following 30 s are shown in Fig. 2b.

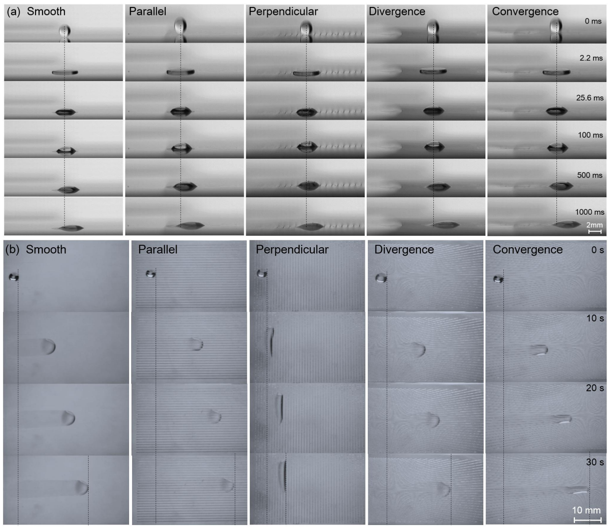

Fig. 2 Impacting and migrating processes on surfaces with different microstructures.

3. Discussion

The current results indicate that decorating surfaces with microstructures could yield significant differences in impacting and migrating processes. As the last panels of Fig. 2a indicates (at 1000 ms), asymmetrical shapes of droplets are formed on these surfaces, and this transformation is least remarkable on the surface with perpendicular microgrooves. The magnitudes of migration distance on surfaces with divergence or convergence grooves are higher than these with parallel or perpendicular ones.

4. References

[1] Y. Liu, et al., Symmetry breaking in drop bouncing on curved surfaces, Nature Communications 6 (2015) 10034.

[2] M. Flouros et al., Thermal and flow phenomena associated with the behavior of brush seals in aero engine bearing chambers, Journal of Engineering for Gas Turbines and Power 137(9) (2015).