Observation of lubrication behaviours by a liquid droplet

F. Guo*, X. M. Li

School of Mechanical Engineering, Qingdao Technological University, 16 Fushun Road, Qingdao, 266033, China

*Corresponding author for tribo-lyon2013@sciencesconf.org

1. Introduction

Lubrication by liquid droplets can find its application in cases such as high speed bearings and micromachining, and is superior to traditional lubrication strategies in terms of low-friction, minimizing oil consumption and environmental friendliness. Published researches are mainly concerned with technological applications, and the testing methods available are very limited [1]. Fundamental data of lubrication within the contacts are insufficient, and the mechanisms therein cannot be well understood. The concept of droplet lubrication has also been proposed for the lubrication of microelcetronicmechanical system by purposely designed interface properties, and it was showed that the droplet lubrication can achieve very low friction [2]. In the present work, with a small slider bearing, the spreading and the film formation of a water droplet were observed experimentally, and it was found that one liquid droplet can lubricate the contact well.

2. Apparatus

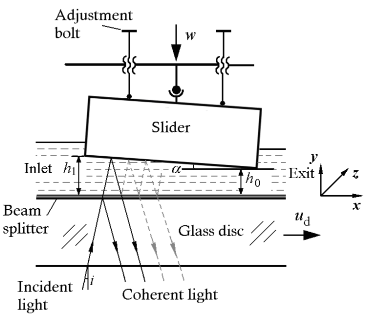
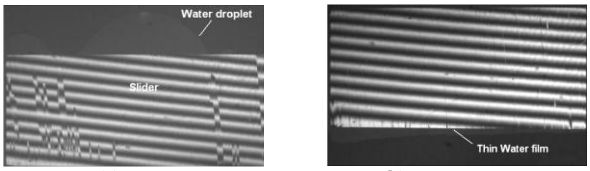


Fig. 1 Schematic illustration of the slider bearing test rig

A newly developed slider bearing test rig (Model FST-II) was used in the present study as shown in Fig. 1[3]. The lubricated contact consists of a stationary steel slider (or steel ball) and a rotating transparent disc. The slider is made of ANSI52100 steel, and its surface is high-precision polished. The disc is of BK7 glass and its contact surface is coated with bi-layer films (Cr film at the bottom and SiO_2 layer on the top) to facilitate interferometry measurement of the lubricating film. Water droplets were used as the lubricant supply.

3. Results

Experiments were carried out with a fixed slider inclination. It was found that even with one droplet, the contact could be fairly lubricated. When the droplet enters into the wedged gap and could sustain the slider with an exit film thickness of around 30nm. Figure 2 presents one picture captured.



(a) (b)

Fig.2 Lubrication film formation by a water droplet, load = 1N, speed = 3 mm/s, inclination = 1: 1835: (a) water droplet supply at the inlet; (b) water film at the exit.

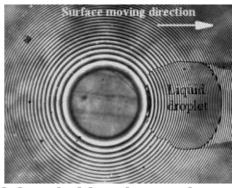


Fig.3 A liquid drop held at the exit by capillary effect

In Fig.2, the water droplet was put on the moving disc surface and then entrained into the converging gap between the slider and the disc. Due to the capillary force, part of the droplet spreads quickly into the contact area, and loading force was generated by hydrodynamic effect. Furthermore, it was found that the moving disc surface cannot drain the water droplet out of the contact through the nano-scale gap at the exit, and the slider seems to hold the droplet with the contact region. This is quite different from the lubrication under fully flooded lubricant supply, where the lubricant is drained out of the contact region continuously. At the moment, the authors attributed the phenomenon to surface tension effect at the exit. To confirm this speculation, by replacing the slider with a steel ball, a water droplet was located at the exit region, and it could be found that the liquid can be held firmly by capillary effect and the moving bounding surfaces cannot remove it.

References:

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