STUDY ON THE INFLUENCE OF THERMO-CAPILLARY MIGRATION ON LUBRICATION

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ABSTRACT
The purpose of this study was to determine the influence of thermo-capillary migration of droplet on surface lubrication properties. An experimental set-up was designed to investigate the migration behavior of paraffin oil driven by temperature gradient. Friction tests were carried out to evaluate the influences of lubricant migration on tribological performance. Aspects of the temperature gradient, oil volume and initial migrating time were taken into account.

The experimental results showed that temperature gradient exhibits the dominated effect on surface lubrication properties and starvation first takes place at the highest temperature gradient. In addition, a transition of wear mechanism from an abrasive to adhesion wear is observed in particular situations.

Keywords: surface migration, temperature gradient, lubrication, space tribology.

INTRODUCTION
Nowadays, with the development of space cause, space lubrication, which is one of the basic technologies of spacecraft, has been becoming far more pivotal. NASA reported that many mechanical failures occurred in spacecraft were caused by lubrication problems (Fusaro, 2007). Though solid lubricant has been used for decades, many MMAs still rely on liquid lubricant to provide reliable, long-term performance under high load, high speed and low torque conditions (Sathyan, 2012).

Typically, MMAs are initially lubricated with a small charge (mg) that is supposed to last the entire mission lifetime, often well in excess of five years. Avoiding lubricant loss is one of the top priorities and evaporation is a main way of oil loss in space environment. Surface migration or creep is another escaping manner for lubricant over long lifetimes of operation. The migration refers to the phenomenon that the lubricant freely expands on a contact surface without any action. Generally, the migration is caused by surface tension.

In this paper, oil migration induced by the temperature gradient was adopted. The experiment was performed using a substrate of 316 stainless steel. Two temperature-controlled blocks were fixed on the ends of the substrate (See Fig.1). One block was heated by an embedded ceramic plate heater. The other was thermoelectric cooler, by which the end surface of substrate could be maintained at a constant. Using the blocks, a temperature gradient could be generated along the length of the substrate and a digital video was employed to record the oil migration process.
Tribological experiments were performed using a reciprocating sliding tribometer (Sinto Scientific, JAP) (see Fig.1). It consisted of a stationary holder where a commercial bearing ball with a diameter of 8 mm was placed and a reciprocating table where the substrate with heating and cooling blocks was mounted. The reciprocating motion was perpendicular to the direction of temperature gradient and a stroke of 40 mm with a sliding velocity of 8.3 mm/s was used. The normal load of 2 N, was applied for all the experiments.

After the testing, the micro morphologies of the worn surface were observed by a scanning electron microscopy and surface mapping microscope.

RESULTS AND CONCLUSIONS
In this paper, the influences of thermo-capillary migration of oil droplet on surface lubrication properties were investigated. The main results can be summarized as follow:

1) The temperature gradient and oil drop volume show strong influences on the average velocity of drop migration. And it increases with the increasing of temperature gradient and oil drop volume. In addition, the average velocity of drop migration decreases dramatically during the migration process.

2) Among the three of temperature gradient, oil drop volume and initial migrating time, temperature gradient shows the dominated effect on the lubrication properties and starvation first takes place at higher temperature gradient.

3) At a higher temperature gradient, the wear mechanisms changed from a mild abrasive to severe adhesion wear with the increase of initial migrating time.

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REFERENCES