OPTIMASI DENSITAS FILTER BERBAHAN SERBUK ARANG KAYU-PE MEASUREMENT OF THE SURFACE TOPOGRAPHY CHANGE ON A BOUNDARY LUBRICATED RECIPROCATING SLIDING CONTACT

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Abstract

This paper presents experiments to study the change of the surface topography on a boundary lubricated reciprocating sliding contact system. A Micromap 512 optical profilometer is employed for measuring surface characteristics. The change of the surface topography before and after the experiment is determined in detail and accurate (microscopically) by the Matching and Stitching method. Plot of the profile of the surface roughness for a certain number of running-in cycles were presented in a figure for before, after and difference, so that analysis of the surface topography change can be accurately performed

Key words: measurement, roughness, sliding contact

INTRODUCTION

Even a highly polished surface has surface roughness on many different length scales. When two bodies with nominally flat surfaces are brought into contact, the area of real contact will usually only be a small fraction of the nominal contact area. It can be visualized that the contact regions as small areas where asperitics from one solid are squeezed against asperities of the other solid; depending on the conditions the asperities may deform elastically or plastically. How large is the area of *real* contact between a solid block and the substrate? This fundamental question has extremely important practical implications. For example, it determines the contact resistivity and the heat transfer between the solids. It is also of direct importance for sliding friction [1], e.g., the rubber friction between a tire and a road surface, and it has a major influence on the adhesive force between two solid blocks in direct contact.

Determining the regions where solids contact plays a central role in studies of adhesion, friction, lubrication and wear. For example, the adhesive and frictional forces between two solids arise from regions where their atoms are close enough to interact. The area and geometry of these contacts affects the stiffness and electrical and thermal conductivity of the interface, and is determined by elastic and plastic deformation that extends well below the surface. This deformation may lead to local heating and wear that limits the useful lifetime of sliding contacts.

The practical importance of contact has motivated many theoretical studies. The original work of Hertz [2] provided a solution for frictionless, non-adhesive contact of a single spherical bump or asperity with a flat surface. However, real material surfaces have roughness on a wide range of length scales. Archard [3], Greenwood and Williamson [4] pioneered the development of models for contact between such complex surfaces.

The surface texture, such as artificial micro-grooves or micro-dimples fabricated on the contact surfaces has proven to be effective to improve the tribological performances of sliding [5–10]. These discoveries have induced many successful applications of surface texture on golf ball, engine cylinder [11,12], sliding bearing and mechanical seal [13,14], slider and disk of hard disk driver [15,16], etc.

Many studies show that the benefits of surface texture could be obtained from boundary to hydrodynamic conditions. The friction reduction mechanisms of surface texture depend on contact conditions, materials and lubricants. Figur 1 shows an example of the surface texture.

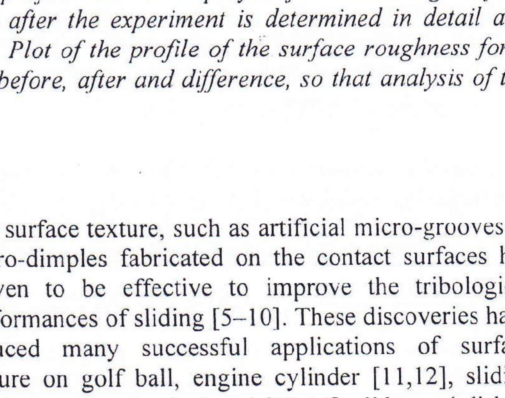

Figure 1. An example of surface texture.

Generally, to generate additional hydrodynamic pressure is considered as the most significant effect of surface texture under full fluid lubrication condition, so that it has attracted much more focusing historically and presently [17,18]. The main principle is that each feature acts as a hydrodynamic micro-bearing while fluid is driven and flowing over the textured surface. The pressure increased in the converging region could be greater than that of pressure decreased in diverging region of the texture since cavitations happen there. Therefore, this asymmetric hydrodynamic pressure distribution generates additional load carrying capacity for sliding surfaces. Usually, micro-grooves or micro-dimples are designed evenly distributed on the surface. The dimensions and area ratio of the texture are considered as important parameters related to the generation of hydrodynamic pressure. Recently, Etsion and coworkers have used partially textured surface to emphasize the hydrodynamic effect, showing a new attempt to optimize the surface texture design through its layout or distribution [19].

Based on these phenomena, optimizing the surface texture is very important. Obtaining the texture affects not only on hydrodynamic pressure generation but also on running-in process promotion. As a tool for determining an optimum surface, experiments which are able to measure the surface topoghraphy and its change are inevitable. Therefore, a study is performed to determine the microscopically change in the surface topography in a boundary lubricated ball-on-plate reciprocating sliding experiment.

EXPERIMENTAL APPARATUS

S-Tribometer

Figure 2 shows schematically the setup of S-tribometer to carry out a reciprocating sliding contact. The apparatus executes a sinusiodal reciprocating motion of a hemispherical specimen on the stationary counterface with amplitude of 46 mm. The hemispherical specimen is fixed in a holder, held in a loading arm, connected to the slider/support. The pivot of this loading arm lies in the plane of the sliding contact. The slider/support is driven by a gear mechanism connected by a chain transmission to a motor with a continuously variable speed.

Micromap

Optical profilometry Micromap 512 was used to measure the surface topography parameters in the present experiments. The Micromap 512 has the characteristics: high resolution of approximately 1 nm, size of the measured area 110x85 μm up to 4.42x3.45 mm and 304x228 pixels (at very smooth surfaces 640x478 pixels /phase mode).

EXPERIMENTAL PROCEDURES

Three hardened steel AISI 52100 plates and three SKF standard balls with the diameter of 20 mm were used as samples. Each pair of ball and plate was run under conditions as indicated in Table 1.

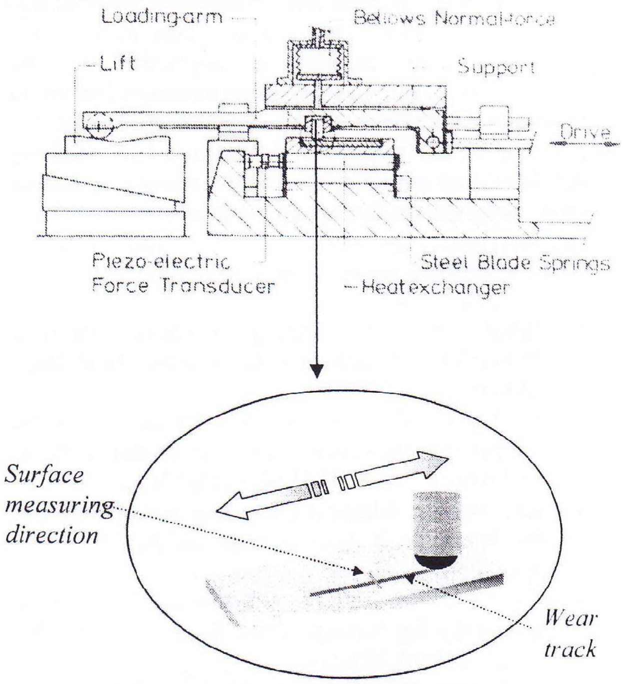

Figure 2. General layout of S-Tribometer.

Table 1

Experimental conditions

Parameters	Value(s)
Sliding velocity (m/s)	0.01
Applied load (N)	100
Ambient temperature (°C)	25
Initial roughness value R_a of the ball (nm)	8.5
Initial roughness value R_a of the plate (nm)	40
Number of cycles	1, 3 and 5

Lubricant used in this experiment is Shell Tellus R5 which has the property of viscosity η = 5.43 mPas at $T \approx 25$°C.

RESULTS AND DISCUSSIONS

Figure 3 depicts the measurement results of the surface topography before and after 3 cycles running for ball. The difference image between before and after experiment is also shown in this figure. It can be seen from the figure that a change in surface topography of the surfaces before and after an experiment for a small number of running cycles is hard to see by the naked eye. However, when we look at the difference images by the Matching and Stitching method it is clear that there are some scratches or micro-wear during the experiment.

Figure 4 shows the detail information of the change of the asperities in 2D (profile). Here, the more detail information about the surface change can be observed.

CONCLUSIONS

A new method for measuring the surface topography before and after experiment was introduced. The method is applicable to the experiments on ball-on-plate under boundary lubricated reciprocating sliding contact. Results show that the powerful of the method is demonstrated by showing the detail and accurate information about the surface topography change due to experiments.

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