BOUNDARY LUBRICATED FRICTION EXPERIMENTS WITH COARSE SURFACE TEXTURE

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ABSTRACT
Low-speed friction experiments were conducted under boundary lubrication in a pin-on-disk tester. The 304 stainless steel disk had smooth areas alternating with areas of coarse surface texture consisting of indents or macroscopic grooves, 0.3-0.4 mm in size and in area fractions varying between 25 and 70%. The 3.2 mm flat pin was also SS304. The coarse texture has detrimental effects. For each pattern the friction coefficient is greater than for the smooth areas. It becomes independent of load as boundary conditions set in. In comparing various patterns it is noted that this friction coefficient increases with pressure or with the amount of area removed to form the texture. It is suggested that partial removal of surface area to form the texture reduces the number of trapped liquid patches, which otherwise can provide low-friction load support. The coarse texture may also conduct lubricant away from the contact area.

Keywords: friction, boundary lubrication, surface texture

INTRODUCTION
Tribological success with engineered surface texture has been reported for a number of quite disparate fields: face seals [1], metal forming [2], and laboratory wear tests [3,4], for example. Reported benefits of texture can be very substantial: decrease in operating temperature by tens of degrees [5], decrease in friction by 30% [1], moving the Stribeck curve to the left [4], increase in seizure or breakdown load by 2-10 times [5,6], etc. However, in other cases only negative effects have been reported [7,8]. No predictive tool exists for the phenomenon at this stage. These initial studies reported here were intended to help delineate some of the parameter boundaries.

EXPERIMENTAL
Pin-on-disk tests were run with a flat 3.2 mm pin against a partially textured disk, both of 304 austenitic stainless steel.

Loads of 2-20 N (0.28-2.8 MPa) and a speed of 0.01 m/s were used with a pure paraffin mineral oil lubricant. The texture is shown in Fig. 1. It was generated by the spherical tip of a Rockwell C diamond hardness indenter followed by polishing. Four different patterns were produced in different quadrants of the disk surface, separated by non-textured areas:
1) 290 µm diameter indentations (i = indents) spaced at 500 µm in a square pattern with depth of 66 µm and area coverage 27%.
2) 225 µm wide grooves, approximately transverse to the sliding direction (wt) and spaced at 500 µm, with depth 36 µm and area coverage 45%.
3) grooves identical to 2) but parallel (p) to the sliding direction, and
4) 185 µm wide, close transverse grooves (ct) spaced at 255 µm, with a depth of 20 µm and area coverage 72%.

Figure 1. Patterned SS304 disk. Circle shows trajectory of pin. (i = indents; p and wt = parallel and transverse wide grooves; ct = close transverse grooves)
RESULTS

An example of a friction trace is shown in Fig. 2. The various types of texture used here invariably result in an increase in friction. For example, at 15 N load (2.1 MPa), the friction is about 0.085 on the non-textured areas, 0.115 on the indents, and 0.135 on the grooves regardless of their orientation or spacing. The operating region is clearly in the boundary lubrication regime. For the low load of Fig. 2, 2 N (0.28 MPa), the non-textured smooth regions show a coefficient of friction of about 0.01, the indented region 0.08, the wide grooves in both directions about 0.13, and the close transverse grooves 0.135. Here, the smooth region operates near the hydrodynamic to mixed lubrication transition regime, the indented region in the mixed lubrication regime, and the grooved areas under boundary lubrication.

CONCLUSIONS

The coarse texture is detrimental under the conditions used. It may serve to remove oil from the contact and to remove surface area, which can provide load support through trapped liquid film patches.

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REFERENCES