The High Shear Stress Rheology of Liquid Lubricants at Pressures of 2 to 200 MPa

Chengwei Wu. The authors are to be congratulated with their great success in attaining the realistic traction data at high shear strain rate. Their work is very interesting and important. It is well known that the traction of a lubrication film has a closely linear relationship with the relative sliding of the lubricated surfaces at low sliding speed but holds a constant at a high sliding speed [A1]. This very important phenomenon might mainly result from the following three possible mechanisms:

(1) The non-Newtonian rheological behavior of the lubricant under high shear strain rate.

(2) The boundary tangential velocity slip [A2-5]. At small shear stress, many experimental observations show that there is no slip between the liquid and solid at the solid surface. But there seems no experimental observation of non-slip at high shear stress. Recently, however, Kaneta et al. [A5] reported their important observation of wall slip in EHL.

(3) The temperature rise in the lubricant at high strain rate. However, first, the authors used only the first mechanism to explain their experimental data but precluded the last two mechanisms. Although they have made a simple analysis for the thermal effect, the authors did not consider any thermal effect in the reported data. The paper said “Rather than apply thermal and response time corrections, all reported data were obtained under conditions for which corrections would be negligible.”

Second, the paper obtained the shear strain rate by the relationship \( \dot{\gamma} = \frac{U_x}{h} \), where \( U_x \) is the sliding velocity and \( h \) the mean separation of the two walls. This relationship would be valid only when at least the following two assumptions are made: (a) there is no tangential velocity slip and (b) the cylinder pairs are absolutely concentric. Any tangential velocity slip and mis coaxality would cause the relationship \( \dot{\gamma} = \frac{U_x}{h} \) invalid.

Have the authors obtained any experimental observations for these problems at such high shear rate and pressure as is shown in the paper?

Finally, I would like to know the constant temperature situations of 5°C, 10°C, and 20°C in Figs. 7, 8, and 9 of the paper.

Additional References

Authors’ Closure

The authors appreciate the comments of the discusser and will attempt to address each one. Firstly, all data reported were obtained in a concentric cylinder rheometer and not from contact traction.

Contrary to the discussers statement that we “did not consider any thermal effect in the reported data,” two sections of the paper were devoted to consideration of steady and transient thermal effects. Inaccuracies due to thermal effects and thermal corrections were avoided by discarding data for which the thermal corrections determined from the analysis would be significant.

Concentricity of the cylinder pair is maintained by hydrodynamic forces which tend to center a rotating shaft in a bushing. This is the basis of operation of several commercial...