2 JUNE 1976

SUPPLEMENT TO RESEARCH PROPOSAL SUBMITTED TO THE NATIONAL SCIENCE FOUNDATION (Eng.-7604343) ON "THE EXPERIMENTAL DETERMINATION OF THERMODYNAMIC EQUILIBRIUM DIAGRAMS FOR LUBRICANTS"

HIGH PRESSURE LUBRICANT MODELS

Elastohydrodynamic (EHD) research has provided a good understanding of the behavior of lubricants for applications involving nonconformal machine elements over moderate pressure ranges. However, at very high pressures, in excess of 150,000 psi, the application of EHD principles is severely limited by inadequate modeling of the lubricant properties. As a result, the theory has not been able to accurately predict the traction forces on bearings or gears and this, in turn, has grossly limited the ability to predict the operating life of these heavily loaded elements.

Sanborn and Winer[10,11] have developed a technique to map the temperature in an EHD region using infrared techniques. They completed measurements using a naphthenic mineral oil for peak Hertzian pressures of 148 and 219 kpsi at sliding speeds ranging from 13.4 to 500 ips. The technique uses a 52100 steel ball rotating and loaded against a sapphire flat and an infrared microdetector. The technique is very promising.

In another study,[12] Sanborn and Winer obtained pressure-viscosity data for five lubricants by means of a capillary tube at pressures cited as the glass transition. In the transition region and beyond the properties of the lubricants have only been inferred by extrapolation. Their work has considerably advanced the understanding of EHD lubrication phenomena. They have clearly made great progress toward establishing criteria to distinguish dissipative heating effects from effects of non-Newtonian properties in capillary tube measurements and toward attaining fluid shear stresses in capillary tube viscometry approaching the average shear level experienced in an elastohydrodynamic film.

Gentile and Paul[13] completed a comprehensive survey of high pressure lubricant models. In their survey, they observed that available traction studies show that EHD traction cannot be predicted from low pressure viscosity measurements. They note that somewhere between the low and high pressure regions there is a transition from classical pressure-viscosity properties to a much more complex type of lubricant behavior. The transition has been attributed to several different possible phenomena. The approaches were divided into four types of lubricant models:

1. The critical shear stress hypothesis,
2. Thermodynamic change of state,
3. Viscoelasticity, and
4. Time dependent viscosity or pressure.

Although all the models have met with limited success none of the models fits all the observed facts. More data at conditions approaching those found in EHD contact are needed.

Clearly one of the main questions about the lubricant is its precise thermodynamic state. This proposal seeks to furnish more data to better determine a suitable EHD model through a better understanding of the thermodynamic phase and chemical structure of the lubricants at operating pressures. Once an adequate EHD model is established it will be possible to design to increase fatigue life and to reduce friction and wear.

REFERENCES AND BIBLIOGRAPHY

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CURRENT RESEARCH SUPPORT

DR. J. N. CRISP

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2. 10 percent effort (1.2 months annually)
Investigator in lubrication areas -- sponsored under various internally and externally sponsored research projects.