The Rheological Assumptions of Classical EHL: What Went Wrong?

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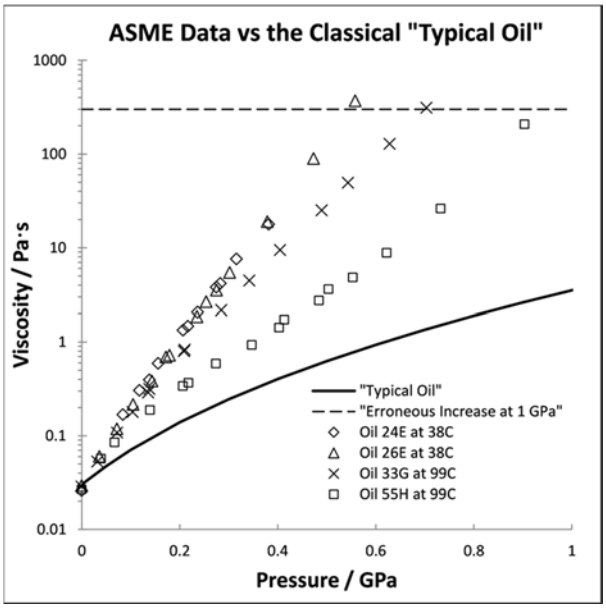
In 1973 Hutton and Phillips [1] at Shell Research measured the viscosity of a polyphenyl ether that had been used [2] at Imperial College in the previous year to study the time evolution of the film thickness in a stationary contact. At a pressure of only 200 MPa the viscosity measured in their Couette viscometer was four orders of magnitude greater than the viscosity which was needed to explain the film thickness with the Newtonian assumption. In spite of the obvious discrepancy, this technique of adjusting the viscosity at high pressure to lower values has persisted and, until about twelve years ago, had completely replaced viscosity measured in viscometers in the classical study of elastohydrodynamic lubrication (EHL) [3] as shown in the figure below.



Viscosities reported in the 1953 ASME Pressure-Viscosity Report compared with the “erroneous increase at 1 GPa” and the “typical oil” as presented to tribology students in a tribology textbook [4].

Two assumptions regarding the pressure, temperature and shear dependence of viscosity have been essential to the way that classical EHL developed over the last forty years.

1. The liquid in the inlet zone responds in Newtonian fashion.
2. The shear stress versus shear rate relationship of the liquid has the same functional form as the average shear stress versus average shear rate obtained from a traction curve.

The new, quantitative, approach employs transport properties measured in instruments (such as viscometers) which do not rely upon these assumptions, primary measurements. There has been a rapid succession of advances in understanding of film forming and of friction under the new approach. This paper compares the assumed viscosities with accurate measurements and explores the history of and possible motivations for the efforts to reject primary measurements.

References

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