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Open Forum

Each of the papers contained in this STP were presented on 6 Dec. 1988 at the Symposium on High-Temperature, High-Shear (HTHS) Oil Viscosity: Measurement and Relationship to Engine Operation. After the presentation of the last invited paper, the symposium was converted to an Open Forum during which individuals could express their feelings and opinions regarding any of the topics covered. What followed was more than an hour of spirited discussion regarding the implications and problems of incorporating HTHS viscosity limits in the Engine Oil Viscosity Classification, SAE J300. As with most Open Forum discussions, questioners and commenters were assured that their remarks would be "off the record." However, it was also indicated that, if individuals felt strongly enough on a particular topic, they could fill out a specific comment form and have their remarks included in this STP. Two comment forms were received by the Editor after the symposium and before the publication of this document. These comments are published here in total and as received without rebuttal.

"Development of ASTM Standard Test Methods for Measuring Engine Oil Viscosity Using Rotational Viscometers at High-Temperature and High-Shear Rates"—R. B. RHODES

Comment in response to questions about use of the Cross equation: The polymer-derived contribution to high-shear viscosity decreases at very high shear rates but the base oil contribution does not. This is an important formulation consideration. For example, given a specified additive package and base oil (or base oils) that are to be used for a specified multigrade oil, say an SAE 5W-30, and given the choice of a specified family of VI improvers (either PMAs or OCPs, and so forth) having different molecular weights, a lubricant manufacturer may choose to increase the high-temperature, high-shear rate viscosity of the multigrade by switching to a polymer having a lower molecular weight. This generally will result in an increase in the cold cranking simulator viscosity, and it is likely that he will have to reduce the viscosity of the base oil (or base oil combination) to maintain 5-W performance.

This results in a reduction in the Newtonian oil's contribution to high-shear rate viscosity; the lubricant manufacturer has increased the viscosity at one million reciprocal seconds. But, as the extended Cross equation analyses sometimes indicate, he may have *decreased* the lubricant's viscosity at higher magnitudes of shear, at the shear rates where bearing wear or distress are most likely to occur.

Discussion of "The Future of a High-Temperature, High-Shear Engine Oil Viscosity Classification in SAE J300"—Robert L. Stambaugh, by T. W. BATES

From an evaluation of the extensive experimental bearing oil film thickness (BOFT) studies carried out both in our laboratory (Bates and Benwell, SAE Paper 880679) and by ASTM and CEC BOFT Task Forces, we have drawn the following conclusions.

1. High-temperature, high-shear viscosity, $V_d(10^6)$, at a fixed shear rate of 10^6 s^{-1} correlates MOFT results on monograde oils significantly better (95% confidence level) than those on multigrades formulated from different VI improver types. Thus, in our V-6 big-end bearing studies, correlation coefficients R^2, are 0.98 for the monogrades and 0.88 for multigrade and monograde oils combined (46 data points, involving 4 different VI improver chemistries).

2. Although low-shear-rate kinematic viscosity, V_k, correlates MOFT data for multigrade oils less well than $V_d(10^5)$, the difference can be quite small. Thus for the multigrade oils discussed in Paragraph 1 above, R^2 decreases from 0.88 to 0.82 when replacing $V_d(10^6)$ by V_k, the difference being significant only at the 85% confidence level.

3. One of the main reasons that $V_d(10^5)$ is deficient in correlating multigrade BOFT data is that shear rates in journal bearings are not constant at 10^6 s^{-1}. Thus, for big-end bearings at 400 r/min, they are close to 10^7 s^{-1} and vary from oil to oil (Bates and Vicars, 4th CEC Symposium, Paris, April 1989). Viscosity/shear rate measurements on multigrade oils carried out in our laboratory show that viscosity rankings found at 10^6 s^{-1} are not necessarily the same as those obtained at the higher shear rates more relevant to journal bearing operation.

4. A viscosity at 10^6 s^{-1} is, therefore, a compromise in terms of shear rates relevant to high temperature operation. It is not a fundamental rheological parameter capable of predicting accurately the journal bearing performance, or for that matter, fuel economy of multigrade oils. Incorporation of $V_d(10^5)$ into the SAE J300 Viscosity Classification System would not, in our view represent a major advance over V_k(100°C) in terms of providing a guide to a lubricant's journal bearing performance.

5. The experimental BOFT data generated over the last few years demonstrates the complexity of the relationship between BOFT and oil rheology for multigrade oils for which factors other than viscosity can be important (for example, elasticity—see SAE Paper 860376). The problems of identifying a simple viscometric test to predict the journal bearing performance of multigrade oils remain almost as severe as ever.

6. In view of the deficiencies of assessing journal bearing performance from a relatively simple viscometric test such as $V_d(10^6)$, it is preferable to measure load bearing capacity directly. There are three possibilities: (a) a bearing durability test, (b) a simple bench test designed to simulate a journal bearing (such a test is currently under development in our laboratory), and (c) a bearing oil film thickness test involving, for instance, a back-to-back test with a reference oil; different reference oils could be chosen to provide different levels of performance.