

$$\frac{\partial T_{11}}{\partial t} = A_{11} \frac{\partial u}{\partial X_1} + B_{11}. \quad (\text{A18b})$$

Equations (A18) comprise a quasilinear strongly hyperbolic system of partial differential equations to be solved subject to the boundary conditions on the two faces of the specimen. Initially all stresses, velocities and deformations are zero.

This system is solved numerically using a second order accurate difference scheme based on integration along characteristics. The computed normal velocity histories are matched with the experimental normal velocity time histories over the entire range of pressure to obtain the values of the constants K and a . The results of the comparison are shown in Fig. 9 for a particular test. A plot of the variation of the computed total stretch with time is presented in Fig. 12. The computed stretch decreases until it levels off at a value corresponding to the final stretch used in the compressibility diagrams, Figs. 10 and 11.

APPENDIX II

Properties of 5P4E

Lubricant Specification	: OS124
Name	: Polyphenyl Ether 5P4E
Appearance	: Clear Liquid
Refractive Index at 25°C	: 1.631
Specific Gravity at 25°C	: 1.199
Viscosity m ² /s at 37.8°C	: 362 × 10 ⁻⁶
Pour Point (°C)	: 1.7
Specific Heat (Joule/kg °C) at 260°C	: 1.467 × 10 ³
Coefficient of Thermal Expansion (per °C) at 38°C	: 0.00059
Vapor Pressure at 260°C (Pa)	: 1.36

DISCUSSION

Scott Bair¹ and W. O. Winer¹

The author has presented two experimental techniques for determining the pressure-volume behavior of EHD lubricants for short pressurization times. These methods are apparently new to tribology and may further clarify the role of structural relaxation in EHD. It is interesting to compare Fig. 5 of the authors with a pressure volume curve which was generated using a high-pressure dilatometer during the program of research described in Alsaad, Bair et al. (1978)². See Fig. A1. The dilatometer data was obtained for a total pressurization time of about 1000s and a temperature of 34.5°C. The sample liquid was the same as used by the author and no correction was applied for pressure vessel deformation. (The real liquid response should be somewhat stiffer than shown.) Although the times vary by about 7 orders of magnitude, the dilatometer results fit within the error limits of most of the short time results. Also, the discontinuity of compressibility, which was used in the 1978 paper to establish the glass transition pressure at 260 MPa, is evident in both the dilatometer and Kolsky bar data. Apparently, structural relaxation is absent to 600 MPa for the time scales investigated. The increase of compressibility with pressure at 600 MPa in the data of the author may seem troublesome. However, Bridgman (1964) reported compressibility increases with pressure for glasses.

¹George W. Woodruff School of Mechanical Engineering, Georgia Institute of Technology, Atlanta, GA 30332.

²Refer to references in paper.

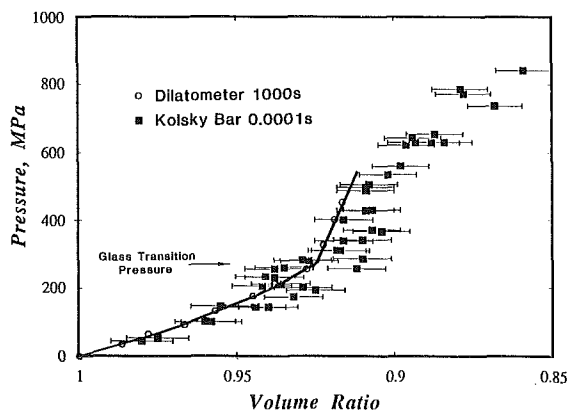


Fig. A1 Pressure-volume response of 5P4E

Additional Reference

P. W. Bridgman, 1964, *Collected Experimental Papers*, Vol. III, Harvard Univ. Press, pp. 1984-49.

B. Jacobson³

The author is to be congratulated on a very nice piece of work, showing that the time delay for the compression of the tested lubricant is so short that it does not effect the lubrication of normal elastohydrodynamic contacts. That is a very important observation.

Regarding the rest of the paper I have some comments and a question. In the work in reference [21] the discussor found that the parameter $\bar{\eta}$ equation (20) in this paper was equal to zero for all the tested lubricants when they were compressed into the glassy state. As long as the pressure was below the glass transition pressure at the tested temperature the parameter value $\bar{\eta}$ was rather large (13.47–25.27).

If the value $\bar{\eta} = 0$ is used for the glassy state lubricant, equation (20) becomes virtually identical with equation (18) in the discussed paper. It is then rather natural that equation (18) fits the measured values very well.

This is not true for pressures below the glass transition pressure (0.14 GPa at 20°C 0.16 GPa at 25°C) because there equation (18) does not describe the compression of the lubricant accurately. This can also be clearly seen in Fig. 11, where there is a jump in the measured pressure values at the volume ratio 0.9. At that compression the lubricant reaches the glass transition.

The glass transition of the lubricant at the very low pressure ~0.15 GPa can also explain the strange result in the Kolsky bar experiment. In 1974 the discussor published (Jacobson, 1974) an experimental investigation of the time needed to convert the lubricant from liquid to solid behavior using a very similar geometry with a split Hopkinson bar.

The difference was that the collar surrounding the tested lubricant had thicker walls and was clamped to a heavy table. The momentum transferred from the projectile to the input bar and from the input bar to the output bar was analyzed.

If the lubricant specimen thickness in the bar direction was of the order 1 mm, the lubricant pressure caused by the impact was large enough to compress the oil into the glassy state, and the lubricant worked like a tin or silver soldering in the high

³SKF Engineering & Research Centre B. V., Nieuwegein, The Netherlands.