Discussion on Paper XI (iii) by H. Okamura: "Contribution to the numerical analysis of isothermal elastohydrodynamic lubrication"

this method over the inverse method of solution which does not have any problems of pressure oscillations in the heavily loaded region and can give the detailed film thickness analysis which you seem to require?

Reply by Dr. H. Okamura (Toyota Motor Corporation, Japan). I appreciate your advice and comments about compressibility of the lubricant. I haven't yet tried the calculation under the consideration of compressibility. Regarding your question concerning the advantages of my method over the inverse method, please refer to the chart B. I think this chart will clear up any hesitations you may have with the use of my method.

Mr. H.J. Van Leeuwen (Eindhoven University of Technology, Holland). In his paper the author presents some keen numerical methods to handle the explosive pressure increase around the Petrusevich spike for an exponential relationship for the viscosity vs. pressure (the so-called Barus relationship). By doing this, he is able to overcome Hertzian pressures of the order of 0.8 GPa (8,000 bar), which is a very good result. Under stationary conditions, the fluid behaviour is much milder than the Barus relationship predicts especially over 0.3 GPa (3,000 bar). I have the idea that convergence of the iterative procedure will be even better if a more realistic relationship is used, thus giving the opportunity to introduce thermal effects for example, without exceedingly large calculation times. Can the author give some more detail on the current computer running time? It should be noted that a Newtonian fluid model, as used by the author, will only be valid for very low sliding ratios and that a very comprehensive study on the inverse EHL analysis has been published by Blok in 1963 (referenced in the preceeding paper). From the designer's point of view, relationship (θ_2) and the analogue formula for the minimum film thickness is very important. Do the author's data yield the same formula as suggested by Dowson and Higginson? And, if the numerical procedure still converged at high loads and low entrainment velocities, it is possible to enlarge the field of application of the film thickness formulas to even much more headily loaded cases?

Reply by Dr. H. Okamura (Toyota Motor Corporation, Japan). I agree with your opinion that the thermal effect is important.

I haven't yet tried the EHL calculation under the consideration of thermal effects. If the isothermal EHL calculation can be done, then it may be possible to estimate the lubricant temperature contrariwise from the measurement of the traction coefficient by using the chart of viscosity-pressure coefficient vs temperature.

I used quadruple precision and it takes about 20-30 minutes and 10-30 iterations to take the convergence for one case.

EDITORIAL NOTE

Subsequent to the presentation of his paper Dr. Okamura had extensive discussions with Dr. H.J. Van Leeuwen and Professor H. Blok in Holland. During these discussions it became apparent that some of Dr. Okamura's elastohydrodynamic solutions for line contacts were not fully flooded, but exhibited a degree of starvation. Whilst such a consideration does not imply any incorrectness in either the analysis technique described or the results presented in the paper, for which the assumed conditions are clearly stated, Dr. Okamura would like attention to be drawn to the importance of establishing the degree of starvation.

Such a consideration is vital in determining the variation of film thickness with the operating parameters, particularly if a formula of the Dowson and Higginson type, as mentioned in Mr. Van Leeuwen's discussion, is to be evolved. Dr. Okamura has indicated that he hopes in due course to extend his studies to such considerations, including the presentation of a normalized film thickness/load parameter map of the type developed by other authors for line contacts situations.

Contribution by Associate Professor J. Jakobsen and Mr. L. Petersen (Technical University of Denmark).
Pressure Profiles of Sliding and Rolling Elastohydrodynamic Point Contacts Determined with Light Interferometry. Properties of lubricants under extreme stresses as found in elastohydrodynamic contacts, piston ring - liner films, dynamically loaded bearings of combustion engines, etc., are of interest for an improved evaluation of bearing surface reliability as well as of other characteristics. General experimental methods that will allow an estimate of lubricant behaviour in extreme stress situations, for instance relations between pressure (p), temperature (T), shear stress (τ) and time (t), i.e. relations incorporating as well Non-Newtonian properties as non-liquid states are, however, not yet well enough developed for use in the design process. This discussion presents an approach to measuring pressure profiles in realistically operating surface contacts (1) combined with some results for a polymer blended base oil in comparison to its base oil. It is intended that the method should be a pressure determining part of a general viscometric procedure for describing lubricant behaviour in terms of p, T, τ, and - if possible - time derivatives especially under extreme conditions.

The main approach is the measuring of the contact-deformations (1, 2) and calculations (2) of the pressures. The experimental data are obtained through an elastohydrodynamic simulator and an interferometer (1) which will give the elastic deformation distribution of the contacting surfaces as deviations of interference fringes from the fringe pattern of an unloaded simulator contact. Figure 1 depicts the generation of the fringe pattern and exemplifies this for a point contact at 1) zero velocity and 2) a low velocity (u = .13 m/s). The sketch, Figure 1 shows, for demonstrational purposes, an exaggeration of the angle v between the load direction of the contact and the optical axis of the interferometer, the normal to the reference mirror of the interferometer.

The pressure difference Δp between the lubricant generated profiles and the Hertzian pressure profiles are sought. The deviation δ of lubricant generated deformations from