was compared with the analytical solution for some simple cases. Couette flow between two parallel infinite plates (which is equivalent to two concentric cylinders) separated by a narrow gap was considered. Two boundary conditions were considered:

1. Both the plates are at temperature T_o.
2. One plate (shaft) is at T_o and the other (bushing) is insulated. This boundary condition is the same as the one we have used for the actual bearing in most of the examples.

Agreement between our computed solution and the analytical solution was excellent for both cases. The analytical solution for the second case is (Schlichting, 1968).

$$T = T_o + \mu \frac{U_2^2}{2k}\left(1 - \frac{y^2}{h^2}\right)$$

and the maximum temperature, T_m is given by

$$T_m = \frac{\mu U_2^2}{2k}$$

Comparison with the computed solution is shown in Fig. B.1.

DISCUSSION

M. Fillon[1] and J. Frene[1]

The authors have made a valuable contribution in analyzing thermal effects in hydrodynamic bearing. The thermohydrodynamic theory uses finite volume method which can be applied successfully for different operating conditions with or without cavitation or reverse flow. The authors take into account the convention and dissipation terms in all directions. Their results show that thermal boundary conditions have a great influence on bearing performances.

For steady-state operating conditions, the discussers have shown that [1] that thermoelastic displacements of both the shaft and the bush change significantly the bearing clearance which modify consequently the bearing performances. In most cases, it appears that the THD theory alone is not sufficient to predict bearing performances [1, 21]. For the second case treated in the paper, high temperatures and high pressures are calculated; these values should produce great deformations of the solids [22, 23].

Is the effect of deformations on performances of dynamically loaded bearings, like connecting-rod bearings, be more important than the effect of viscosity variations?

The CPU time required for the resolution of the complete model seems slightly great. The adjunction of thermoelastic displacements would lead to increase drastically the calculation time. How would the authors simplify both thermal and deformation models in order to obtain reasonable computing time?

Additional References

21 Fillon, M., Friou, T., Souchet, D., and Frene, J., "Thermodynamic Analysis of Tilting-Pad Bearing Including Solid Deformations," *Tribotechnology in Theory and Practice*, Karlovy Vary, CSSR, Oct. 17–19, 1989.

22 Fantino, B., Godet, M., and Frene, J., "Dynamic Behavior of an Elastic Connecting-Rod Bearing—Theoretical Study," Paper No. 830307, SAE SP539-Studies of Engine Bearings and Lubrication, 1983, pp. 23–32.

23 Oh, K. P., and Goenka, P. K., "The Elastohydrodynamic Solution of Journal Bearings Under Dynamic Loading," ASME Journal of Tribology, Vol. 107, 1985, pp. 389–395.

M. M. Khonsari[2] and S. H. Wang[2]

We read this paper with great interest. This work is a noteworthy contribution to the thermodynamic problem in bearings in which the authors implemented the Elrod's cavitation algorithm in conjunction with the energy equation. Congratulations are in order to Drs. Han and Paranjpe for their excellent work on a difficult problem.

A number of figures in the paper clearly illustrate the profound influence of the boundary conditions on the film temperature field: imposing a constant temperature on the shaft surface without the consideration of an energy balance would, in effect, add an arbitrary heat source (or sink) into the problem. As a result, the computations may predict an unrealistic temperature (and viscosity) field which may lead to a gross error in the calculations of the load carrying capacity.

The discussers wish to invite the authors' comments regarding the following remarks:

1. In Figs. 6(*a*) and 6(*b*), the authors compare their results with those of Ott and Paradissiadis (1988). Excellent trends are observed. It seems, however, that the authors' temperature contours are somewhat displaced to the right. We wonder if the authors' computations included an iteration on the attitude angle (not shown in Fig. 1) to insure that the computed load vector for the final results is in the direction of the applied load, W? Also, the authors' computation (based on a 3-D formulation) predicts a maximum temperature of 20°C higher than that obtained by Ott and Paradissiadis which is based on a 2-D formulation. Given that all operating conditions are the same and assuming that both contours are obtained at the bearing mid-plane, unless the 2-D results reflect an average temperature in the axial direction, one would not expect a 3-D formulation to yield a much higher maximum temperature.
2. It is stated that "periodic boundary condition takes care of the recirculation flow (hot oil carry-over) outside the groove." Nevertheless, we believe that only by performing an energy balance at the supply point can the effect of the hot oil carry-over and the mixing with the supply lubricant be accurately modeled.
3. The Elrod's mass conservative algorithm, as the authors pointed out, takes the compressibility of the fluid into account through the use of the parameter, β. However, the energy equation given in (7) assumes that fluid is incompressible.
4. The Elrod's algorithm models the "physics" of the problem in a realistic manner; that is to say, it solves a time-dependent problem and allows the system to reach a steady state. It, therefore, follows that one may need to solve for the transient temperature in a similar fashion. This may be of particular importance in the case of a dynamically loaded bearing.

Once again, the authors' contribution is noteworthy and we look forward to their future papers.

Authors' Closure

The authors are grateful to the discussers for their kind words and insightful comments. We will respond to their comments one by one.

[1]Laboratoire de Mécanique des Solides, U. A. C.N.R.S. n° 040 861, 86022 Poitiers Cedex, France

[2]Department of Mechanical Engineering, University of Pittsburgh, Pittsburgh, PA 15261.