$$\gamma_{2\rho}=\frac{b_M}{2h_0}\frac{\bar{\mu}_0}{\bar{\rho}_0}[u_{20}(\gamma_J+\gamma_B)]-\frac{h_0}{\bar{\rho}_0}\frac{\partial p_0}{\partial x_2} \quad (A.7)$$

$$\gamma_{1\mu}=\frac{-b_M}{2h_0}[u_{10}(\gamma_J+\gamma_B)-\Lambda_1\gamma_J] \quad (A.8)$$

$$\gamma_{2\mu}=\frac{-b_M}{2h_0}[u_{20}(\gamma_J+\gamma_B)] \quad (A.9)$$

where:

$$k_{10}=k_{20}=0.5(k_{J0}+k_{B0});\ k_{J0}=R_{J0}f_{J0},\ k_{B0}=R_{B0}f_{B0} \quad (A.10)$$

$$C_{CJ}=(1/2)[R_{J0}C_J+b_M]\gamma_J;\ C_{CB}=(1/2)[R_{B0}C_B+b_M]\gamma_B \quad (A11)$$

$$f_{J1}=\frac{(\mathrm{Re}_p\bar{\rho}_0/\bar{\mu}_0)^2h_0}{2R_{J0}}[f_{J0}+\beta_J\gamma_J] \quad (A.12)$$

$$f_{B1}=\frac{(\mathrm{Re}_p\bar{\rho}_0/\bar{\mu}_0)^2h_0}{2R_{B0}}[f_{B0}+\beta_B\gamma_B]$$

$$\gamma_J=\frac{-a_M\bullet e_M}{[f_{J0}/a_M-1]^{(1/e_M-1)}}; \quad (A.13)$$

$$\gamma_B=\frac{-a_M\bullet e_M}{[f_{B0}/a_M-1]^{(1/e_M-1)}}$$

$$\beta_J=b_M/R_{J0};\ \beta_B=b_M/R_{B0} \quad (A.14)$$

$$C_J=c_M\frac{r_J}{c_*h_0};\ C_B=c_M\frac{r_B}{c_*h_0} \quad (A.15)$$

and,

$$R_{J0}=\mathrm{Re}_p(\bar{\rho}_0/\bar{\mu}_0)h_0[(u_{10}-\Lambda_1)^2+u_{20}{}^2]^{1/2}$$
$$R_{B0}=\mathrm{Re}_p(\bar{\rho}_0/\bar{\mu}_0)h_0[(u_{10}{}^2+u_{20}{}^2]^{1/2} \quad (A.16)$$

are the zeroth-order flow field Reynolds numbers relative to the journal and bearing surfaces, respectively.

For laminar flows, (inertialess):

$$\gamma_{11}=\gamma_{22}=12\bar{\mu}_0/h_0,\ \gamma_{12}=\gamma_{21}=\gamma_{1\rho}=\gamma_{2\rho}=0$$
$$\gamma_{20}=-24\bar{\mu}_0u_{20}/h_0{}^2,\ \gamma_{10}=(-24u_{10}+12\Lambda_1)\bar{\mu}_0/h_0{}^2$$
$$\gamma_{1\mu}=12(u_{10}-\Lambda_1/2)/h_0,\ \gamma_{2\mu}=12u_{20}/h_0 \quad (A.17)$$

DISCUSSION

J. K. Scharrer[1]

The author addresses some of the issues of compressibility of cryogenic fluids with respect to hydrostatic bearing performance. However, he has neglected to consider the possibility of choked flow in the bearing. This condition can occur in liquid hydrogen bearings, especially if they are located near the turbine section of a turbopump. Has the author investigated this? If so, what were the results?

In the derivation of the first-order equations, the author shows a term for the derivative of density with respect to pressure for a barotropic fluid. However, no mention is made as to how this term is obtained in the solution. Is this obtained numerically and if so, what increments of pressure were used to determine this derivative? What were the sensitivities of the results to this increment? If it was obtained analytically, what equations were used?

In this paper, comparisons are made to liquid hydrogen test data. For these comparisons did the authors obtain leakage results by blindly applying orifice discharge coefficients and recess edge loss coefficients based on pipe flow models or did they vary these parameters to match the data? Regardless of the method, what values were used to match the data? Are these values realistic?

A. F. Artiles[2]

Professor San Andres is to be commended for accomplishing the difficult task of extending the theory of HBJ's to include barotropic fluids. It is interesting that the use of constant properties over-predicts the flow and torque relative to the full use of the variable barotropic properties, while use of linear properties has the opposite effect. One might expect that using constant properties, separately evaluated at the supply and at the discharge pressures would bracket the two variable-properties model.

It might be interesting to repeat the same comparison of the three models already done in the paper of the force coefficients on the stability indicators (threshold speed and critical mass), in order to determine whether stability predictions with constant properties are conservative or optimistic.

Now I would like to make offer some remarks concerning the pressure variation at the recess boundary. The pressure drop from the recess to the film lands is given by Eq. (7) of San Andres' paper, which is derived from Eq. (22) in the work of Constantinescu and Galetuse (1975). It consists of two terms: the pressure rise due to viscous shear and the entrance pressure drop due to the Bernoulli effect. However, Constantinescu's equation is based on an incompressible, isoviscous turbulent flow through an infinitely-long step bearing with smooth surfaces. One might question whether this equation could be generally applicable to a two-dimensional flow which is really three-dimensional at the pocket boundaries and where both the viscosity and density are strong functions of the local pressure, the variation of which is significant at the pocket boundaries. Besides the restrictions inherent in Constantinescu's formula (such as $1/\eta < 20$), it might be elucidating to know what additional restrictions apply when extending it to more general applications.

Now some clarifications concerning the implementation of Eq. (7):

1. The paper states that the viscous shear term is only present downstream of the orifice. Is this term set to zero for parts of the boundary upstream of the orifice?
2. The restriction that the component of velocity normal to the pocket boundry be positive ($\mathbf{U}-\mathbf{n}>0$) only applies to the Bernoulli pressure drop term.
3. A distinction is made between the axial and circumferential pressure drop coefficients, ξ_1 and ξ_2, respectively. Which is used at the pocket corner? Is the pressure drop allowed to be discontinuous there?

Author's Closure

The author thanks gratefully the valuable comments presented by Dr. Antonio Artiles and Dr. Joseph Scharrer.

In regard to Dr. Scharrer discussion, we have not introduced in our model the possibilities of choked flow. The hydrostatic bearing (HJBs) geometries studied, in especial for LH2, show

[1]Rockwell International, Canoga Park, CA 91304.
[2]Mechanical Technology Inc., Latham, NY.