reported in the literature, was probably not the result of the liberation of the dissolved air within the fluid.

7. The visual study performed could not provide the answer to the question on the contents of the cavitation bubble. To shed some light on this subject, measurement of the pressure inside the cavitation bubble is planned.

Acknowledgments

The authors would like to thank Mr. Eugene Farkus for his painstaking assistance in every detailed aspect of this work, and Mr. David Clinton for carrying out the laborious task of photographing the cavitation.

References

Brewe, D. E., 1986, "Theoretical Modeling of the Vapor Cavitation in Dynamically Loaded Journal Bearings," ASME JOURNAL OF TRIBOLOGY, Vol. 108, pp. 628–638.

Dowson, D., and Taylor, C. M., 1974, "Fundamental Aspects of Cavitation in Bearings," Paper I(iii), *Proceedings of the 1st Leeds-Lyon Symposium on Tribology*, The University of Leeds, England.

Elrod, H. G., 1981, "A Cavitation Algorithm," ASME JOURNAL OF LUBRICATION TECHNOLOGY, Vol. 103, pp. 350–354.

Feng, N. S., and Hahn, E. J., 1987, "Effects of Gas Entrainment on Squeeze Film Damper Performance," ASME JOURNAL OF TRIBOLOGY, Vol. 109, pp. 149–154.

Hibner, D. H., and Bansal, P. N., 1979, "Effects of Fluid Compressibility on Viscous Damper Characteristics," *Proceedings, Conference on the Stability and Dynamic Response of Rotors with Squeeze Film Bearings*, U.S. Army Research Office, pp. 116–132.

Jacobson, B. O., and Hamrock, B. J., 1983a, "High-Speed Motion Picture Camera Experiments of Cavitation in Dynamically Loaded Journal Bearings," ASME JOURNAL OF LUBRICATION TECHNOLOGY, Vol. 105, pp. 446–452.

Jacobson, B. O., and Hamrock, B. J., 1983b, "Vapor Cavitation in Dynamically Loaded Journal Bearings," *Proc. Inst. Mech. Eng.*, C206/83, pp. 133–140.

Walton, II, J. F. et al, 1987, "Experimental Observation of Cavitating Squeeze-Film Dampers," ASME JOURNAL OF TRIBOLOGY, Vol. 109, pp. 290–295.

White, D. C., 1970, *Squeeze Film Journal Bearings*, Ph.D dissertation, Cambridge University.

Zeidan, F. Y., and Vance, J. M., 1989, "Cavitation Leading to a Two Phase Fluid in a Squeeze Film Damper Bearing," *STLE Tribology Transactions*, Vol. 32, pp. 100–104.

DISCUSSION

J. F. Walton II[2]

The authors are to be congratulated on the thoroughness of their experimental cavitation study and the well conceived test facility that they developed. The results of this work are seen to support and confirm earlier work in the field, a reassuring occurrence. None-the-less, several questions do arise which the authors may be able to clarify. In assessing the onset speed of cavitation, was consideration given to pressurizing the oil supply to permit variations of this parameter for comparison with the clearance changes? In a prior experimental study it was demonstrated that increasing oil supply pressure raised the cavitation onset speed significantly. Could the authors comment further on the bubble growth process observed within the oil squeeze film? For example, was the growth and collapse of the cavitation bubbles, for the noncentered case, synchronous with rotational speed? Was the apparent movement of the cavitation zone, again for the noncentered case, strictly the result of growth and collapse of the bubble or was the cavitation zone precessing in the direction of whirl? Finally, were the cavitation zones one bubble which moved or was the apparent circumferential movement the result of a series of adjacent bubbles growing and collapsing in a stationary position? In prior experiments by this discusser it was observed that the cavitation zone is comprised of many small cavitation bubbles, which as they grew merged with neighboring bubbles to form larger voids, but with little circumferential or axial movement to produce the observed apparent cavitation zone precession.

With regard to the lack of residual bubbles in the aftermath of the cavitation event, could the authors comment on the apparent contradiction with earlier reports by Walton et. al. (1987) and Zeidan and Vance (1989), where bubbles were observed in the high pressure regions? It is possible that the low speeds tested and the relatively small resulting cavitation zones provided sufficient time for the gas/vapor bubbles to re-dissolve in the fluid? Finally, in your rotating journal tests, you indicate that the journal surface carried the cavitation bubble with it and prolonged its duration. Could you clarify how you distinguished between movement of the cavitation bubble in this case and the apparent movement of the cavitation zone when the journal was not rotating as in the centered squeeze film tests?

The authors results and observations have added admirably to the body of work in this important area and have raised questions as well. Again the authors are to be congratulated for their fine experimental efforts and the test facility that they have developed.

Additional References

Walton, II, J. F. et al., 1987, "Experimental Observation of Cavitating Squeeze Film Dampers," ASME JOURNAL OF TRIBOLOGY, Vol. 109, pp. 290–295.

Zeidan, Y. F., and Vance, J. M., 1989, "Cavitation Leading to a Two Phase Fluid in a Squeeze Film Damper Bearing," *STLE Tribology Transactions*, Vol. 32, pp. 100–104.

[2]Program Manager/Senior Scientist, Mechanical Technology Inc., Latham, N.Y. 12110.

J. M. Vance[3]

One of the main conclusions of this paper is "that the formation of a two-phase fluid, as reported in the literature, was probably not the result of the liberation of the dissolved air within the fluid."

This conclusion is certainly valid for the experiments on a squeeze film damper reported jointly by Zeidan and the discusser (1989). In fact, air was visually observed (through a transparent housing) to enter the squeeze film through a small clearance at a piston ring type of end seal (see Fig. 8). After some efforts to prevent the ingress of air were unsuccessful, it was concluded that most, if not all, aircraft engine dampers in operation today probably have large amounts of air entrained in the lubricant film.

Our dynamic force measurements showed that air entrainment at high speed (>2500 rpm) typically reduced the effective damping coefficient by a factor of six when compared to the predictions of Reynolds' lubrication theory for a single-phase fluid.

Figure 9 shows how the peak to peak dynamic film pressure varies with speed in our test rig. Notice that the peak pressure becomes almost constant, at a relatively low value, as the speed increases above 2500 rpm. Our visual observations through the transparent housing suggested that the fraction of air becomes fairly constant and well mixed with the oil at high speeds.

So what causes the ingress of environmental air? Our measurements showed that the prelude to the ingress of air (as the

[3]Professor, Department of Mechanical Engineering, Texas A&M University, College Station, Texas 77843.

