Check for updates

returns to the mode of prolonged contact with the sleeve. Whether the subsequent motion being rolling or sliding depends on the condition of the last collision.

(8) Several frequencies (oscillational, rotational, and collisional) can be identified in the problem, which are associated respectively with the various modes of the journal's motion. With experimental data for comparison it would be possible to pinpoint which frequency is responsible for the high pitch noise noted in connection with dry whirl.

As revealed by the analysis, the starting characteristics of an unlubricated journal bearing are crucially dependent on the various operating parameters, in particular the friction coefficient and the normal and tangential restitution coefficients. This suggests that perhaps these coefficients can be determined by measuring the journal's motion in an unlubricated bearing.

Acknowledgments

The first author wishes to acknowledge his former colleagues at the General Motors Research Labs, Messrs. Arnold (Butch) O. DeHart and Richard C. Rosenberg for introducing him to the intriguing phenomenon of dry whirl; Professor Richard F. Schwartz of SUNY-Binghamton for educating him on the operating characteristics of electric motors; and Professors John F. Booker and Michel Y. Louge of Cornell University for stimulating discussions on collision dynamics.

References

Ehrich, F. F., 1969, "The Dynamic Stability of Rotor/Stator Radial Rubs in Rotating Machinery," ASME *Journal of Engineering for Industry*, Vol. 91, pp. 1025–1028.

Foerster, S. F., Louge, M. Y., Chang, Hongder, and Allia, Khedidja, 1994, "Measurements of the Collision Properties of Small Spheres," *Physics of Fluids*, Vol. 6, pp. 1108–1115.

Press, W. H., et al., 1986, *Numerical Recipes*, Cambridge University Press, pp. 550–554.

Sapetta, L. P., and Harker, R. J., 1967, "Whirl of Power Screws Excited by Boundary Lubrication at the Interface," ASME Paper 67-Vibr-37.

Shaw, M. C., and Macks, E. F., 1949, *Analysis and Lubrication of Bearings*, McGraw-Hill, pp. 367–369.

Xu, Jing, 1995, "A Study of the Starting Characteristics of an Unlubricated Journal Bearing," Master's thesis, State University of New York at Binghamton.

DISCUSSION

M. M. Khonsari[1]

This is an interesting paper with important practical application. The paper is well-written and the analysis is thorough. Particularly interesting is how the authors have extended ideas from collisional theory of granular material to model the impact of the journal with the bushing. To this end, is there any experimental evidence or justification for the β_n and β_t values used in the simulations? Also, one would wonder if the wear patterns on the sleeve of a blower motor could give evidence of the predicted impact trajectories.

With regard to the unlubricated journal bearing analysis, there is a crucial problem of excessive heat generation at the shaft/sleeve interface which would affect the predicted results. In fact, the time scale associated with the shaft expansion, depending on the operating conditions, could be short enough to give rise to a catastrophic seizure within a few seconds. This problem has been investigated both experimentally and theoretically by Dufrane and Kannel (1989) and later extended by Khonsari and Kim (1989) and Hazlett and Khonsari (1992a,b). The last article, in particular, presents detailed FEM prediction of the contact forces as the bushing tends to ovalized and as the shaft encroachment progresses to eventual seizure.

[1]Department of Mechanical Engineering, University of Pittsburgh, Pittsburgh, PA 15216.

Additional References

Dufrane, K., and Kannel, J., 1989, "Thermally Induced Seizure of Journal Bearings," ASME JOURNAL OF TRIBOLOGY, Vol. 111, pp. 288–292.

Khonsari, M., and Kim, H., 1989, "On Thermally Induced Seizure in Journal Bearings," ASME JOURNAL OF TRIBOLOGY, Vol. 111, pp. 661–667.

Hazlett, T., and Khonsari, M., 1992a, "Finite Element Analysis of Journal Bearings Undergoing Rapid Thermally Induced Seizure," *Tribology International*, Vol. 25, pp. 183–190.

Hazlett, T., and Khonsari, M., 1992b, "Thermoelastic Behavior of Journal Bearings Undergoing Seizure," *Tribology International*, Vol. 25, pp. 183–198.

Authors' Reply

The authors appreciate Dr. Khonsari's interest and valuable comments.

Dry whirl is a nuisance in the operation of bearings. The phenomenon was often reported in the field, and that prompted an early experimental study (quoted in the paper) by Mr. Butch DeHart at the General Motors Research Laboratories. Most of the dry whirl features shown in this paper were observed in the laboratories. Unfortunately, because Mr. DeHart did not publish his findings, a comparison of the parameters used in the two studies is not possible.

Dr. Khonsari's interesting work on thermally induced seizure in journal bearings may inspire a possible application of the present theory, which provides some insight on the manner frictional heat is produced. The theory shows that, during the start-up period, steady-state dry rubbing between the journal and sleeve surfaces does not occur. Instead, the journal can slide back and forth along the sleeve, or slide along and fall off the sleeve repeatedly.

Downloaded from http://solarenergyengineering.asmedigitalcollection.asme.org/tribology/article-pdf/117/2/223/5938001/223_2.pdf by guest on 09 August 2024

Copyright © 1995 by ASME