Journal of Tribology Discussion

Angular-Compliant Hydrodynamic Bearing Performance Under Dynamic Loads[1]

M. M. Khonsari.[2] The authors have presented an interesting angular-compliant bearing design which, in comparison to conventional journal bearings, appears to yield some improvement in the dynamic characteristics. The discusser wonders if the author could comment on the followings:

1. What do the authors perceive to be the primary application of the angular-compliant bearings? Would such a design be suitable for use in aircraft engines where conventional hydrodynamic bearings may pose a potential risk of failure?

2. It appears to the discusser that with the outer surface rotating—akin to a floating ring bearing—it may be possible to achieve a uniform temperature profile in the sleeve, thus reducing the bearing peak temperature. The implication of a superior thermal characteristic of such a bearing may be greater than its improvements in terms of the dynamic performance.

F. Dimofte.[3] The authors are to be commended on their interesting composite bearing concept consisting of a hydrodynamic sleeve inside a ball bearing. The shaft speed is split between the hydrodynamic bearing and the ball bearing. The composite bearing concept also uses a "centrifugal brake" to control the sleeve and ball bearing speeds. This centrifugal brake should reduce and, maybe, eventually stop the ball bearing from turning at high shaft speeds. At low speeds, the ball bearing rotates while the sleeve remains stationary with respect to the shaft due to the big difference in friction between the sleeve and the ball bearing. To lubricate the sleeve the oil is fed in the axial direction.

Orcutt and Ng (1965 and 1968), Tanaka and Hory (1972), Nikolajsen (1973), and Rhode and Ezzat (1980) also contributed to the idea of splitting the total shaft speed between two bearings was also developed by using two hydrodynamic bearings in series (floating ring or bush bearing). The desired ratio between bearing speeds can be established, for instance, by choosing the corresponding ratio between bearing clearances. The authors' sleeve cannot float but is free to rotate, which makes it similar to the floating ring or bush.

The use of a ball bearing in series with a hydrostatic (hybrid) bearing was also done by Anderson et al. (1970, 1971), and Spica (1986). This concept uses the ball bearing to reduce the wear of fluid film bearing at the start and stop time and to improve the life of the ball bearing by reducing the ball bearing speed. Since the concept keeps the fluid film bearing over the outer ring of the ball bearing, the fluid film bearing has enough room to accommodate a proper diameter and length. Whereas, the authors' concept limits the length and diameter of the fluid film bearing by location the sleeve inside the inner race of the ball bearing. The authors' concept, however, allows the sleeve to axially self-align to the shaft by using an axially self-aligned ball bearing; It may be more appropriate to call this bearing a self-aligned hydrodynamic bearing since there is actually no compliant (flexible) part.

The authors' analysis gives valuable information of the steady-state and dynamic behavior of such a composite bearing. Of course, the designer of such a composite bearing, as well as any bearing design, should use a computer simulation to determine the bearing dynamic performance.

The authors are using a different approach in their composite bearing concept than what was considered in the previous works. This new concept presents some difficult challenges in developing a viable bearing for actual applications. The hydrodynamic bearing inside the ball bearing reduces the diameter of the hydrodynamic bearing, limiting its performance capabilities. In addition, a reasonable balance between the performance of two bearings may be difficult to achieve. The centrifugal brake/clutch system also appears difficult to realize since it must fit in the space beside the ball bearing, must work reliably for a reasonable life (longer than the ball bearing life), and must not contaminate the ball bearing with wear particles. The axial lubrication scheme will be difficult to design to provide adequate control over the split in torque between the ball bearing and the sleeve bearing. The lubrication requirements of the sleeve bearing, may cause the ball bearing cavity to be flooded, resulting in an excessive and unknown torque on the ball bearing. To address these concerns the authors should develop a design example and conduct a thorough experimental effort.

Additional Reference

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