On the Performance of Hybrid Foil-Magnetic Bearings

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Recent technological advancements make hybridization of the magnetic and foil bearings both possible and extremely attractive. Operation of the foil/magnetic bearing takes advantage of the strengths of each individual bearing while minimizing each others weaknesses. In this paper one possible hybrid foil and magnetic bearing arrangement is investigated and sample design and operating parameters are presented. One of the weaknesses of the foil bearings, like any hydrodynamic bearing, is that contact between the foil bearing and the shaft occurs at rest or at very low speeds and it has low load carrying capacity at low speeds. For high speed applications, AMBs are, however, vulnerable to rotor-bending or structural resonances that can easily saturate power amplifiers and make the control system unstable. Since the foil bearing is advantageous for high speed operation with a higher load carrying capacity, and the magnetic bearing is so in low speed range, it is a natural evolution to combine them into a hybrid bearing system thus utilizing the advantages of both. To take full advantage of the foil and magnetic elements comprising a hybrid bearing, it is imperative that the static and dynamic characteristics of each bearing be understood. This paper describes the development of a new analysis technique that was used to evaluate the performance of a class of gas-lubricated journal bearings. Unlike conventional approaches, the solution of the governing hydrodynamic equations dealing with compressible fluid is coupled with the structural resiliency of the bearing surfaces. The distribution of the fluid film thickness and pressures, as well as the shear stresses in a finite-width journal bearing, are computed. Using the Finite Element (FE) method, the membrane effect of an elastic top foil was evaluated and included in the overall analytical procedure. Influence coefficients were generated to address the elasticity effects of combined top foil and elastic foundation on the hydrodynamics of journal bearings, and were used to expedite the numerical solution. The overall program logic proved to be an efficient technique to deal with the complex structural compliance of various foil bearings. Parametric analysis was conducted to establish tabulated data for use in a hybrid foil/magnetic bearing design analysis. A load sharing control algorithm between the foil and magnetic elements is also discussed.

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