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Limitations of the short bearing approximation in dynamically loaded narrow hydrodynamic bearings

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Abstract

Transient solutions are still widely used for evaluating the vibrational behavior of rotor bearing systems containing dynamically loaded journal bearings with large unbalance, or noncircular orbit type squeeze film dampers, such as dampers without centralizing springs. For parametric design studies, such transient analyses need rapid means for evaluating the motion dependent fluid film forces and for narrow bearings or dampers (aspect ratios less than 0.5) the short bearing approximation (SBA) to the Reynolds equation has generally been assumed. Comparisons with exact numerical solutions under conditions of static loading and pure squeezing show that the SBA pressure profile predictions are significantly in error for aspect ratios as low as 0.25 at eccentricities around 0.9, whereas the optimal parabolic axial profile approximation (MSBA), while retaining all the rapid calculation features of the SBA, is accurate to within 1 percent under the same conditions and to within 3 percent for aspect ratios around 1.0. Using the MSBA as a yardstick under transient solution conditions, the SBA, while satisfactory for aspect ratios of 0.05, was found to be inadequate in predicting transient and steady state orbits and transmitted forces at aspect ratios of 0.5. At these aspect ratios, jump speeds and instability threshold speeds were also found to be erroneously predicted, with speed overestimates of 30 percent possible for practical unbalance situations. In view of the vastly improved accuracy obtainable by the MSBA, its use is to be preferred to the SBA under dynamic loading conditions for aspect ratios around 0.5, and probably around 0.25 or lower.

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