A Hybrid Radial Bearing with Improved Rotordynamic Stability

Luis San Andrés
Mechanical Engineering Department
Texas A&M University
College Station, TX 77843-3123

ABSTRACT

Process fluid hybrid (hydrostatic/hydrodynamic) bearings find numerous applications in high performance turbomachinery operating under severe environmental constraints. Hybrid cryogenic liquid bearings currently replace ball bearings in space propulsion turbopumps due to their high stiffness and damping characteristics derived from the turbulent fluid flow through the bearing film lands induced by the high rotational speeds and large pressure differentials. Extensive analytical and experimental research has shown that hybrid bearings are prone to show two types of dynamic instabilities. Operation with compressible fluids could lead to pneumatic hammer if the bearing recesses and feed restrictor and supply line are not properly designed. Operation at high rotor speeds, on the other hand, generates large cross-coupled forces and induces a hydrodynamic instability characterized by rotor whirl at subsynchronous frequencies, typically 50% of the rotor speed. This instability cannot be easily removed within the constraints of a rigid bearing geometry, except for angled injection against rotation, adequate only for low to moderately high rotor speeds. A hybrid bearing geometry allowing stable operation at larger rotor speeds than with conventional multi-pocket hybrid bearings is presented. The rudiments of the analysis are highlighted followed by a discussion on computed results (force coefficients and leakage) for the novel bearing and a conventional one in a cryogenic turbo pump application. The novel design exploits the features of geometric asymmetry and recess (pocket) positioning to produce a bearing with a low whirl frequency ratio while still maintaining adequate levels of direct stiffness and damping coefficients. Experimental results conducted on a water lubricated hydrostatic bearing facility at TAMU have fully confirmed the advantages of the novel bearing.

Keywords: Fluid film bearings, rotordynamic instability