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Journal Bearing with Controllable Radial Clearance, Design and Analysis

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Abstract : The hydrodynamic instability phenomenon in a journal bearing may occur by either a reduction in the load carried by journal bearing, by an increase in the journal speed, by change in the lubricant viscosity, or a combination of these factors. The previous research and development work done to overcome the instability issue of journal bearings, operating in hydrodynamic lubricate regime, can be categorized as follows: A) Actively controlling the bearing sleeve by using piezo actuator, b) Inclusion of strategically located and shaped internal grooves within inner surface of the bearing sleeve, c) Actively controlling the bearing sleeve using an electromagnetic actuator, d)Actively and externally pressurizing the lubricant within a journal bearing set, and e)Incorporating tilting pads within the inner surface of the bearing sleeve that assume different equilibrium angular position in response to changes in the bearing design parameter such as speed and load. This work presents an innovative design concept for a 'smart journal bearing' set to operate in a stable hydrodynamic lubrication regime, despite variations in bearing speed, load, and its lubricant viscosity. The proposed bearing design allows adjusting its radial clearance for an attempt to maintain a stable bearing operation under those conditions that may cause instability for a bearing with a fixed radial clearance. The design concept allows adjusting the radial clearance at small increments in the order of 0.00254 mm. This is achieved by axially moving two symmetric conical rigid cavities that are in close contact with the conically shaped outer shell of a sleeve bearing. The proposed work includes a 3D model of the bearing that depicts the structural interactions of the bearing components. The 3D model is employed to conduct finite element Analyses to simulate the mechanical behavior of the bearing from a structural point of view. The concept of controlling of the radial clearance, as presented in this work, is original and has not been proposed and discuss in previous research. A typical journal bearing was analyzed under a set of design parameters, namely r =1.27 cm (journal radius), c = 0.0254 mm (radial clearance), L=1.27 cm (bearing length), w = 445N (bearing load), μ = 0.028 Pascale (lubricant viscosity). A shaft speed as 3600 r.p.m was considered, and the mass supported by the bearing, m, is set to be 4.38kg. The Summerfield Number associated with the above bearing design parameters turn to be, S=0.3. These combinations resulted in stable bearing operation. Subsequently, the speed was postulated to increase from 3600 r.p.mto 7200 r.p.m; the bearing was found to be unstable under the new increased speed. In order to regain stability, the radial clearance was increased from c = 0.0254 mm to0.0358mm. The change in the radial clearance was shown to bring the bearing back to stable an operating condition.

Keywords : adjustable clearance, bearing, hydrodynamic, instability, journal
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