

Influence of Oil Flow Under the Flexible Sleeve of the Active Bearing on the Stability of the Rotor Bearing System

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ABSTRACT

This paper presents results of the recent research towards the development of an oil bearing for the active and passive control of vibrations of rotating machinery. There are numerous examples of active bearings in the literature. Here the concept is used of an external oil-filled chamber behind a flexible sleeve. Previous work indicated that the chamber should be made as small as possible to limit the influence of the compressibility of the oil. Here the deformation of the flexible sleeve can be controlled by oil pressure in a thin film chamber that is located underneath the sleeve. The hydrodynamic damping action of the thin film chamber helps to damp the vibrations of the rotating rotor. There is considerable energy dissipation in the thin film.

To optimize the flexible sleeve as well as the chamber parameters, both the nonlinear and linear mathematical models of a simple rotor system comprising the active bearing were developed. The dynamic properties of the flexible sleeve and the rotor were modeled by means of the FEM whereas the Reynolds equation was used to approximate the pressure distribution above and under the flexible sleeve. The mass and stiffness matrices for the rotor and sleeve are condensed down to a limited number of master degrees of freedom using the Guyan condensation method. A system of matrix equations is obtained which is converted to a system of first order equations which are solved using Runge-Kutta integration. The linear model is based on linearization about the rotor equilibrium position. These mathematical models were used for analysis of the influence of the flexible sleeve and its chamber design parameters on stability of the rotor system. The design of the chamber is critical in determining the effectiveness of the chamber in its hydrodynamic damping action. Results of numerical simulations of motion of the rotor system show that by a proper choice of the details of the chamber it is possible to increase the margin of stability in the angular velocity domain. In particular, a marked increase in stability threshold can be achieved by altering oil inlet position, so-called gap thickness and film thickness for the external chamber. Results that were obtained from the linear model were verified by the numerical integration of the non-linear model.

The agreement between solutions was found to be adequate. The system is also compared with a reference system where the chamber pressure is maintained constant without the hydrodynamic damping action being present. As expected, the energy dissipation associated with damping action leads to a marked increase in stability threshold.