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Vibration Control of a Horizontally Supported Rotor System by Using a Radial Active Magnetic Bearing

Authors : Vishnu A., Ashesh Saha

Abstract : The operation of high-speed rotating machinery in industries is accompanied by rotor vibrations due to many factors. One of the primary instability mechanisms in a rotor system is the centrifugal force induced due to the eccentricity of the center of mass away from the center of rotation. These unwanted vibrations may lead to catastrophic fatigue failure. So, there is a need to control these rotor vibrations. In this work, control of rotor vibrations by using a 4-pole Radial Active Magnetic Bearing (RAMB) as an actuator is analysed. A continuous rotor system model is considered for the analysis. Several important factors, like the gyroscopic effect and rotary inertia of the shaft and disc, are incorporated into this model. The large deflection of the shaft and the restriction to axial motion of the shaft at the bearings result in nonlinearities in the system governing equation. The rotor system is modeled in such a way that the system dynamics can be related to the geometric and material properties of the shaft and disc. The mathematical model of the rotor system is developed by incorporating the control forces generated by the RAMB. A simple PD controller is used for the attenuation of system vibrations. An analytical expression for the amplitude and phase equations is derived using the Method of Multiple Scales (MMS). Analytical results are verified with the numerical results obtained using an 'ode' solver in-built into MATLAB Software. The control force is found to be effective in attenuating the system vibrations. The multi-valued solutions leading to the jump phenomenon are also eliminated with a proper choice of control gains. Most interestingly, the shape of the backbone curves can also be altered for certain values of control parameters.

Keywords : rotor dynamics, continuous rotor system model, active magnetic bearing, PD controller, method of multiple scales, backbone curve
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