Simulating and Testing the Transient Response of Rotors Equipped With Externally Pressurized Bearings Using State Space Modeling

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Analytical rotor modeling is an essential aspect of machinery diagnostics and stability analysis. This work utilizes multivariable rotor modeling techniques that enable steady state and transient rotor response modeling for both linear and non-linear system simulation. The Bently-Muszynska rotor model provides the core of the analysis. The rotor model produces a unique vector of state variables for each input vector at each time step in the simulation. As time progresses and the dynamic system changes, the system moves to a new point in state space. The locus of state points predicts the dynamic system response to transient inputs and system stability is determined via root locus techniques.

Transient response predictions are verified using an experimental test rig with a rotor mass supported between an outboard oil bearing and a mid-span air bearing. Both fluid bearings are externally pressurized thus allowing variable stiffness, damping, and fluid circumferential velocity. Step and ramp changes in fluid pressure produce a corresponding change in bearing characteristics and rotor response. Analytical and experimental results conclude that delaying pressure increase until after the low-stiffness critical speed is traversed results in larger stability margin and reduced amplification factor.

Key words: pressurized bearing, rotor modeling, state space, root locus, stability analysis