

NONLINEAR WHIRL RESPONSE OF A HIGH-SPEED SEAL TEST ROTOR WITH MARGINAL AND EXTENDED SQUEEZE-FILM DAMPERS

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ABSTRACT

Synchronous and nonsynchronous whirl response analysis of a double overhung, high-speed seal test rotor with ball bearings supported in 0.23- and 0.50-inch-long, uncentered squeeze-film oil dampers is presented. The design is similar to certain high-speed aircraft HP gas turbine rotors with squeeze-film oil dampers. Test performance with the original 0.23-inch damper was marginal, with nonsynchronous whirling at the overhung seal test disk and high amplitude synchronous response above 32,000 rpm near the drive spline section occurring. A system critical speed analysis of the drive system and the high-speed seal test rotor indicated that the first two critical speeds are associated with the seal test rotor. Nonlinear synchronous unbalance and time transient whirl studies were conducted on the seal test rotor with the original and extended damper lengths. With the original damper design, the nonlinear synchronous response showed that unbalance could cause damper lockup at 33,000 rpm. Alford cross-coupling forces were also included at the overhung seal test disk for the whirl analysis. Subsynchronous whirling at the seal test disk was observed in the nonlinear time transient analysis. With the extended damper length of 0.50 inch, the subsynchronous motion was eliminated and the rotor unbalance response was acceptable to 45,000 rpm with moderate rotor unbalance. However, the nonlinear analysis shows that with high rotor unbalances, damper lockup could also be obtained at 33,000 rpm, even with the extended squeeze-film dampers. Therefore, the test rotor must be reasonably balanced in order for the uncentered dampers to be effective.

Keywords: Nonlinear whirl response, squeeze-film dampers, damper lockup