DYNAMIC ANALYSIS OF A TURBOCHARGER IN FLOATING BUSHING BEARINGS

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ABSTRACT

This paper presents the linear and nonlinear dynamical behavior of a typical turbocharger in floating bush bearings. In this paper, the linearized stability of the system was computed for various bushing inner and outer clearance ratios. The turbocharger has two principal modes in which it can exhibit whirl instability. The first is a conical mode that is essentially a rigid body mode. The second mode is an in-phase whirling mode in which over 50% of the system strain energy is associated with shaft bending. These whirling modes may be only 1/6 and 1/4 of running speed. Experimental data indicates that either one or both of these modes may exist simultaneously. Although the, turbocharger exhibits self excited bearing instability at very low onset speeds, the turbocharger is able to operate with controlled limit cycle motion at speeds of 100,000 RPM and higher due to the nonlinear action of the fluid film floating bush bearings. In order to examine limit cycle motion, the system finite element dynamical equations of motion were numerically integrated forward in time. Included also in the analysis are the effects of rotor unbalance and destabilizing Alford type forces, acting at the compressor and turbine wheels. These effects can strongly influence the limit cycle orbits and the bearing forces transmitted. The rotor could be made to whirl in either the first conical mode or the second in-phase mode by changes in the compressor or turbine bushing bearing clearances. A third bending critical speed was evaluated for unbalance response. This third mode may occur at peak speeds and may limit the maximum operating speed due to the high compressor bearing forces encountered and subsequent shaft bending.

Keywords: Turbocharger stability, limit cycle motion, rotor whirling, time transient rotor dynamics