Multiple Steady State Solution Solver For Nonlinear Rotordynamic Systems (Mr. Sitae Kim)

Unlike linear system, multiple steady-state orbits (e.g., multiple synchronous, multiple harmonic orbits, multiple whirl or whip) can exist in nonlinear rotordynamic system at the same location, rpm and imbalance. In general, nonlinear rotordynamic analysis to steady state response employs Transient, Numerical Integration Scheme (TNIS), but TNIS has some limitation such that users need to specify initial condition for all degrees of freedom (e.g. positions and velocities) and important response states may miss on the initial conditions. On the other hand, Multiple Response States Prediction (MRSP) employs an algorithm directed search to determine all steady state response. MRSP nonlinear vibration analysis insures that a high vibration state was not missed by the TNIS. Numerical algorithms such as Shooting, Deflation, Genetic, and Pseudo arclength Continuation with system reduction technique has been studying in this research to develop nonlinear solvers which is able to analyze autonomous/non-autonomous large order rotor bearing system. The solver is aimed to be compatible to various nonlinear force models for rub, fixed and tilting pad bearings, squeeze film dampers, floating ring bearing and seals. Fig.1 shows an example of multiple response in a rotor system supported by floating ring bearing. MRSP identified that three different limit cycles can coexist near Hopf bifurcation point. In addition, this project includes topics of nonlinear behaviors in rotor bearing system such as chaos and synchronization. (See Fig. 2)

Keywords: Nonlinear vibrations, multiple response, Shooting, Continuation, system reduction, chaos

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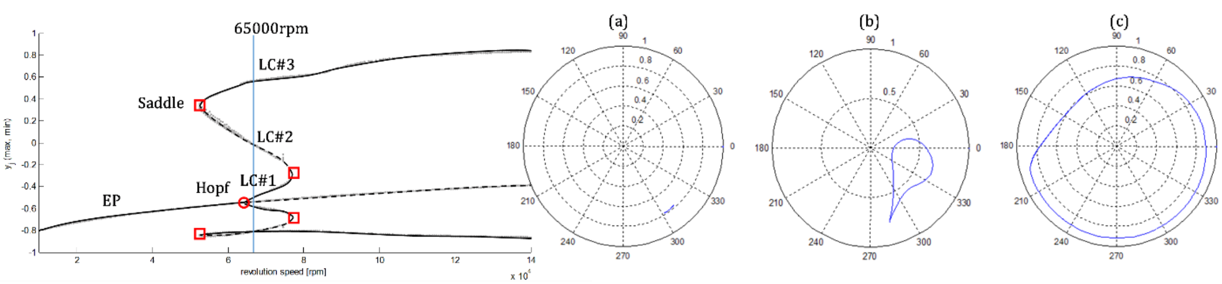

Fig.1. Bifurcation diagram of an autonomous rotor supported by floating ring bearing (Left) and identified journal limit cycles at 65,000 rpm(Right): (a) limit cycle #1 (Stable*), (b) limit cycle #2 (Unstable*), (c) limit cycle #3 (Stable*). *the stability of the responses are evaluated by Floquet theory.

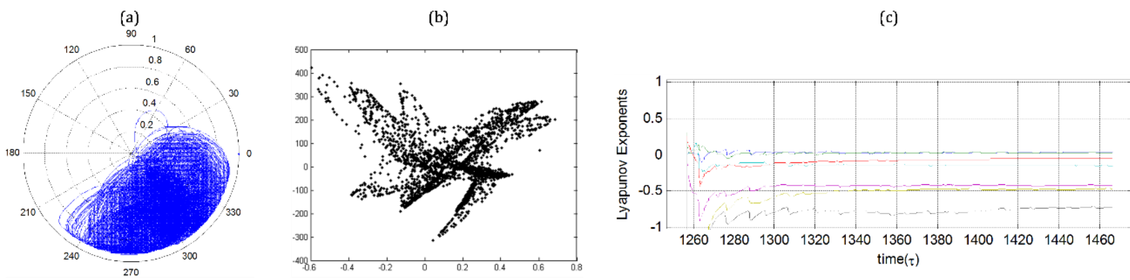

Fig.2. Chaotic motion of a non-autonomous rotor system supported by floating ring bearing: (a) journal orbit relative to ring, (b) associated strange attractor (*x* vs. *x*') (c) associated Lyapunov exponent spectrum