# CHARACTERIZATION AND MODELING OF SHAFT CRACKS AND ROTATING ASYMMETRIES

**Xi Wu**
*California Polytechnic State University*
*San Luis Obispo, CA 93407*
*ph. 805-756-5214, fax 805-756-1137, xwu@calpoly.edu*

**Jim Meagher**
*California Polytechnic State University*
*San Luis Obispo, CA 93407*
*ph. 805-756-1115, fax 805-756-1137, jmeagher@calpoly.edu*

## ABSTRACT

A four degree of freedom mathematical model of a cracked rotor with two disks representing a turbine and generator is utilized to study vibrations of a cracked rotor and an asymmetric rotor due to imbalance and side load. A Mayes steering function is used to model a "breathing" crack. Numerical simulations demonstrates how the variation of rotor parameters affect the vibration response, particularly the effect of the crack depth on the mutual influence between torsional and lateral vibrations of a cracked rotor. Full spectrum plots and orbits are used to show the effect of increased crack depth and the difference between these rotating asymmetries. Our results show that nonlinear lateral-torsional coupling from a crack shifts the fundamental resonance peak in the torsional vibration response. The resonance peaks shift depending on the ratio of the lateral to torsional natural frequencies with the peak torsional responses occurring at non-integer values of the lateral natural frequency. When the general nonlinear model used in this study is constrained to be purely torsional vibration, the peak responses occur at commonly reported integer ratios. Comprehensive orbit comparisons between cracked and asymmetric rotors are also investigated. Full spectrum analyses of the X and Y vibrations reveal distinct vibration characteristics of both cracked and asymmetric rotors such as forward or backward whirl at various speeds. An RK4 rotor kit equipped with lateral proximity probes and torsional vibration transducers will be used to experimentally verify the predicted computer results.

**Keywords:** Cracked Shaft, Asymmetric Shaft, Full Spectrum, Orbit, Nonlinear