ISCORMA–3, Cleveland, Ohio, 19–23 September 2005

HEALTH MONITORING OF ROTATING MACHINERY THROUGH EXTERNAL FORCING

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ABSTRACT

Well-established procedures exist to monitor and diagnosis fairly severe problems during the operation of rotating machinery. However, the need for longer operation between maintenance outages, coupled with the increased dangers of failure in older equipment, require a more sophisticated diagnostic approaches to detect machinery faults at earlier stages. This work describes the foundations of one such technique for the detection of shaft cracks in rotordynamic systems, considering the dynamical behavior of a rotating cracked shaft is under the application of external loads. The response is modeled as a modified Jeffcott rotor, while the crack is assumed to induce a time-varying stiffness in the model.

The goal of this work is to develop external loading strategies that will enable the detection of the crack depth, as represented by the magnitude of the damage-induced time-varying stiffness, from vibrational measurements. This entails developing external forcing functions for which features of the vibrational response are sensitive to the presence of the damage.

The development of such inputs is based on a multiple-scales analysis of the full equations of motion, including the time-varying stiffness. From this, a resonance is identified between the operating speed of the shaft, the fundamental frequency of the shaft, and the frequency of the external forcing. When the system is operated at this resonant condition, the translational vibrations of the shaft contain a spectral component near at the fundamental shaft frequency that is proportional to the amplitude of the time-varying stiffness. This provides a framework for the development of a damage detection techniques for rotating machinery.

Keywords: Damage Detection, Shaft Cracks, Resonance