ABSTRACT

Vibration in rotating machinery is mostly caused by unbalance, misalignment, mechanical looseness, shaft crack and other malfunctions. An important rotor fault, which can lead to catastrophic failure if undetected, is a fatigue crack in the shaft. Misalignment, inspite of its practical importance, has received less attention. Since the presence of crack or misalignment in a rotor system alters its vibrational characteristics, these can be used to detect it. In the context of the fault detection, in spite of the importance of the both problems, sensitivity studies and condition monitoring aspects of rotors with both cracks and coupling misalignment are seldom found in literature. Both, crack and misalignment produce similar vibrational symptoms and thus need to be distinguished one from the other. In the present work, finite element analysis for flexural vibrations of a rotor system with faults such as shaft cracks and coupling misalignment are considered.

New detection approaches namely mechanical impedance and wavelet techniques have been developed for transverse crack. The influence of transverse crack on the mechanical impedance of a rotor-bearing system has been analyzed for both open and breathing cracks. The mechanical impedance changes substantially with the presence of crack exhibiting definite trends depending upon the location and depth of crack. The transient analysis of rotor-bearing system with transverse breathing crack has been studied. Continuous wavelet transform (CWT) is found to be a useful tool for extracting the salient features such as sub-harmonic resonant peaks from the time response of the cracked rotor passing through its critical speed.

Lateral vibration response of a slant-cracked rotor passing through the critical speed has been analyzed and suggestions were made to detect a slant crack through the transient response. Detection of slant crack in a rotor-bearing system has also been developed by using mechanical impedance of the system. The substantial changes of mechanical impedance due to presence of a slant crack in a rotor system are found at its natural frequency, running frequency and also at some significant frequencies.
Coupling misalignment has been simulated by modelling the coupling in two different ways. One having a frictionless joint and other as a joint with stiffness and damping. The transient response of a misaligned rotor system has been studied for parallel and angular misalignments using CWT. The analysis has been carried out by considering two aforementioned coupling models. The CWT is found to be a useful tool for feature extraction from the time response of the misaligned rotor-coupling bearing system.

The transient response of the rotor system with crack and coupling misalignment has been considered separately to distinguish crack from coupling misalignment. Some suggestions have been made to distinguish a crack from that of misalignment through the salient features which are extracted through CWT.

Finally, experiments were conducted on a rotor-bearing test-rig for crack detection. Mobility measurements and transient time response measurements were made on the test-rig to analyze them for crack detection. Good agreement between the experimental results and numerical simulations was observed.