Short Abstract

The conventional influence coefficient method is being widely utilized for on-site balancing of the rotor system. For the balancing of the flexible rotor, the system is required to be operated above critical speeds, which is difficult in the presence of residual unbalances. Also, repetitive stopping and the opening and closing of the casing of the rotor system for the manual addition of trial unbalances (conventional method), the system may get contaminated with foreign particles. To solve the above difficulties, a new balancing method has been proposed using the Virtual Trial Excitation Influence Coefficient Method (VTEICM) for a flexible rotor system integrated with Active Magnetic Bearing (AMB). The AMB is utilized for both controlling vibrations while accelerating through various critical speeds during measurements and generating virtual trial unbalance (VTU) as magnetic excitation. The VTU allows the identification of unbalances with a lesser number of rotor runs and manual effort than the conventional method. Initially, for numerical illustration of the VTEICM, the mathematical model of the rotor-AMB system is developed using the finite element method. The effectiveness of the VTEICM is shown through the balancing of the rotor-AMB system with the estimated unbalances. However, the occurrence of failure in the system while surpassing critical speed even in the presence of a control structure is required to be reduced. The periodic balancing of the flexible rotor system with the change in the level of unbalances is required to be carried out while operating the system at low speeds. A new technique is developed with Virtual Excitation at Low-Speed for High-Speed Balancing (VELSHSB) that utilizes the influence coefficients obtained at high speed and unbalances identified at the low speed to effectively estimate the balance masses required for the high-speed flexible rotor balancing. The influence coefficients at high speeds are required to be obtained just once, whereas the balance masses can be estimated periodically by identifying the unbalances at low speeds. The methodology is extended to balance the dual rotor system that is widely utilized in aero-engines because of its compact structure and efficient operation. Due to the compact structure of the system, it is difficult to balance the rotor system with the manual addition of the trial unbalances. Hence, a novel balancing strategy, i.e., Multiple Virtual Excitation for Dual rotor Balancing (MVEDRB), has been utilized to balance the dual rotor system with AMB control and excitation. Also, the rotor system with multiple faults such as cracked rotor system are required to be analyzed with the utilization of AMBs. Therefore, an identification algorithm is designed to obtain the fault parameters in the cracked rotor system integrated with AMB based on the Multiple Harmonic Influence Coefficient Method (MHICM). The present approach allows us to monitor the behavior of a fatigue crack in the system and to successfully estimate the additive crack stiffness, residual unbalances, and the internal damping factor in the system. There is a lot of practical difficulty in high-speed balancing with accelerating the rotor system above its critical speed in the presence of AMB. The control structure of the AMB requires a large magnitude of bias current to accommodate the excessive control current near the critical speed that increases the heating of coils and power consumption. So, the implementation of VTEICM for high-speed balancing of experimental rotor test rig supported on the conventional bearings and integrated with the AMB is also carried out. The control structure with PID controller is developed on dSPACE-SIMULINK platform based on the differential driving mode control. To limit the utilization of bias current, the switching of bias current is performed that allows the rotor-AMB system to switch between high and low values of the bias current on the requirement. The practical difficulties in synchronizing the excitation frequency of VTU and operating speed are addressed with voltage/speed factor and phase-lag correction in the motor speed control unit.