ABSTRACT

Recently developed deterministic-stochastic techniques that account for measurement and modeling errors have proved to be efficient for real-world structural dynamics problems. Such techniques use a state-space model of the system and response measurements for state and/or input estimation.

In this research, a deterministic-stochastic technique is used to identify the external forces acting on a vibrating plate from limited response measurements. A Kalman filter and recursive least-square estimator (KF-RLSE) is used along with a reduced-order model of a clamped plate. Numerical simulations are presented for different types of loads acting at single and multiple locations on the plate. The method is tested with different levels of white Gaussian noise in response data. In practical applications, the inaccuracies in the mode shapes, boundary conditions, material properties, etc., causes additional errors in the estimation process. Modeling errors are incorporated by changing the true natural frequencies, and its effects are shown. In order to increase the bandwidth of the estimated forces, more responses need to be included in the measurement vector. A system equivalent reduction expansion process (SEREP) is used to predict the responses at unmeasured locations prior to force estimation. Experimental verification is presented using a laboratory scale clamped plate set-up. A vibration shaker is used for the excitation at a single location, and the force is measured using an impedance head for comparison with the estimated forces.

Next, the KF-RLSE is used for unbalance force estimation in a rotor-bearing system. Least-square technique is used for unbalance identification by comparing the estimated unbalance force and force due to fault model. The modeling of the rotor-bearing-coupling system has been done using finite element method. A modified SEREP technique is employed for reduced-order modeling. A joint input state estimation (JIS) technique is also used along with a rigid rotor model for unbalance identification. Effects of different measurement sets, measurement noise levels, and operating conditions are shown and discussed. Different unbalance conditions are configured in a machinery fault simulator and the proposed technique is applied for unbalance identification using a rigid rotor model and limited vibration measurement.