

ABSTRACT

Plates are extensively used in all engineering sectors and they are subjected to various loadings. Many a times, abnormal vibration response of a plate (e.g., an aircraft wing) determines the fate of a whole structure. So, development of an accurate vibration monitoring method is of utmost necessity. Vibration and acoustics based techniques are most suitable for condition monitoring of structures. Experimental techniques are limited to detection and localization of damage. Several numerical and analytical methods have been developed in the past for accurate prognosis of the structure.

In this research, the linear and nonlinear vibro-acoustic characteristics of cracked plates are analyzed. Cracks are assumed to be always open. The Ritz method and the Galerkin's method are used for the study of small (linear) and large (nonlinear) amplitude vibration respectively. For linear vibration study, a rectangular plate with a side crack is analyzed. Displacement function is constructed using orthogonal polynomials and corner functions. Orthogonal polynomials are used for uncracked plate and the corner functions are added to generate the effect of a crack. The natural frequency variations with different crack parameters are studied. The mobility variations are also studied for change in crack parameters and the same is proposed for crack detection. Later, the model is extended to study the radiation efficiency and radiated sound power of a cracked plate. Natural frequency veerings are found to decrease the radiation efficiency abruptly. Sound power variation is observed to be useful for crack monitoring in plates. Experimental modal testing is also carried out to determine the natural frequencies and mode shapes of side cracked rectangular plates.

Next, the large amplitude vibrations of cracked rectangular and circular plates are studied. A rectangular plate having an arbitrary surface crack is modeled and for the circular plate, a circumferential crack is considered. Mid-plane stretching (which result in inplane force) due to large deflection is considered in both cases. In the first case, the governing equation is modified to consider the effect of a crack as the exact modal functions are unavailable. The modified line spring model is introduced to formulate the crack terms. In the second case, the governing equation is kept unaltered as the exact modal functions are available. The Line spring model is used here to formulate the crack terms. In both cases, the Berger's approximation is used to get the inplane forces and then the Galerkin's method is applied to yield the Duffing equation. Both quadratic and cubic nonlinearities are found in the first case, but only cubic nonlinearity is found in the second case. Then the method of multiple scales is used to get the amplitude and phase curves. In both cases, the amplitude and phase plane plots are found to be affected by a change in crack parameters. Phase plane plots are found to be important for crack detection for simply supported plates. In case of the circular plate, at certain position of the circumferential crack the natural frequency is observed to be close to that of the uncracked plate.