Theoretical Analysis of Mindlin Plate and Experimental Measurement on Three Dimensional Dynamic Characteristics for Piezoelectric Thick Plate

Yi-Chuang Wu[1], Chien-Ching Ma[2]

[1]Department of Mechanical Engineering, National Chung Cheng University, Chinese Taipei, [1]Department of Mechanical Engineering , National Taiwan University, Chinese Taipei

In this study, the Mindlin plate theory is applied to deriving the analytical solution for the flexural and extensional vibrations of a piezoelectric thick plate. First of all, the equation of motions and boundary conditions of a piezoelectric continuum can be given by Hamilton's principle and variation method. The resonant frequencies and mode shapes of piezoelectric rectangular thick plate with completely free boundary conditions are analyzed, and the three dimensional displacement functions of the flexural mode and extensional mode are presented base on the superposition method. This solution provides the result for the coupling of out-of-plane and in-plane vibrations with the dominated motion of flexural or extensional motion and has excellent convergence for numerical calculation. To verify the validity of theoretical solution, the resonant frequencies and the corresponding mode shapes are compared with that obtained by FEM calculation and experimental measurement using amplitude-fluctuation electronic speckle pattern interferometer (AF-ESPI) technique. This measurement method can obtain the resonant frequencies and associated mode shapes at same time. Since the piezoelectric materials have the characteristic of electro-mechanical interaction, the electric impedance analyzer is used to obtain the extensional resonant frequencies. It is shown in this study that this method can be used to determine the mode shapes and resonant frequencies of the piezoelectric thick plate with great accuracy.