Active Multi-Modes Vibration Control of PZT Honeycomb Sandwich Plates

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ABSTRACT

The purpose of this project is to develop an active multiple mode vibration control of PZT honeycomb sandwich plate system. Active control in multiple modes of vibration of structures remains an engineering challenge issue. The research topics of this issue include the minimum numbers of sensors/actuators, the optimum locations of sensors/actuators, the development of simplified mathematic model for control design, the minimum control effort and the stability, robustness of the controller. The PZT adaptive remains that were developed at the Chung-Shan Institute of Science and Technology, which has been utilized in the area of structural vibration control and flutter suppression. The d31 type piezoelectric actuators evaluated in this study include PZT with inter digital electrodes (IDE) and Macro Fiber Composites (MFC). Interdigitated electrodes (IDEs) are used for poling and to direct the electric field along the axis with major actuation of PZT. The PZT with inter digital electrodes actuators achieve greater actuation energy density by exploiting the d31 effect versus the d31 actuation used in most monolithic piezoceramic materials. The analysis for the composite plate model with d31 type piezoelectric actuators conducted by the laminate plate theory accounts for the anisotropic characteristics of d31 type piezoelectric actuators/composite plate. This model will be used to develop the active controller in suppression structural vibration and flutter. The candidates of active controller include the velocity feedback control, the LQR method and the filter-x LMS method. The active control system designed for flutter suppression and vibration attenuation requires the equation of motion to be expressed in a linear time-invariant state-space form. The doublet-lattice method is utilized to compute unsteady aerodynamic forces, which are approximated as the transfer functions of the Laplace variable by the minimum-state method. The feedback control gains are obtained by solving coupled nonlinear matrix equations via numerical routines. This project will demonstrate the effectiveness of vibration reduction of the d31 type piezoelectric actuators/composite plate in the aspects of the theoretical predictions and experimental validations.Moreover, numerical simulation of flutter suppression of the d31 type piezoelectric actuators/composite plate will be presented in this study.

Keywords : macro fiber composites, vibration reduction, flutter control

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REFERENCES

[1.] 劉孝偉, 〝複合三明治平板黏彈性分析〞, 國立中正大學碩士 論文, 2003 [2.] www.smart-materials.com [3.] Millar, D.“ The Behavior of Light Weight Honeycomb Sandwich Panels Under Acoustic Load, ” Proceedings of the Sixth International Conference on Recent Advances in Structural Dynamics, Vol. 2, Southampton, pp. 995-1006, 1997.

[4.] Cunningham, P. R. and White, R. G., “ Free Vibration of Doubly Curved Composite Honeycomb Rectangular Sandwich Panels, ” Proceedings of the 17th International Modal Analysis Conference, Vol. 1, pp. 65-71, 1999.

[5.] Cunningham, P. R., White, R. G. and Aglietti, G. S., “ The Effects of Various Design Parameters on the Free Vibration of Doubly Curved

Composite Sandwich Panels, ” Journal of Sound and Vibration, Vol. 230, pp. 617-648, 2000.
[6.] Oskooei, S. and Hansen, J. S., “ Higher-order Finite Element for Sandwich Plates, ” AIAA Journal, Vol.34, pp. 525-533, 1999.
[7.] Lok, T. S. and Cheng, Q. S., “ Free Vibration of Damped Orthotropic Sandwich Panel, ” Journal of Sound and Vibration, Vol. 229, pp.311-327, 2000.
[8.] Lai, L., “ Study of Free Vibration of Aluminium Honeycomb Panels, ” MASc Thesis, University of Toronto, Canada, 2002.
[9.] Tang, Y. Y., Robinson, J. H. and Silcox, J., “ Sound Transmission Through a Cylindrical Sandwich Shell with Honeycomb Core, ” AIAA paper 1996-877.
[10.] Yu, S. D. and Cleghorn W. L., “ Free Flexural Vibration Analysis of Symmetric Honeycomb Panels ” , Journal of Sound and Vibration, Vol. 284, pp.189-204, 2005.
[11.] Sorokin S. V., Grishina, S. V. and Ershova, O. A., “ Analysis and Control of Vibrations of Honeycomb Plates by Parametric Stiffness Modulation ” , Smart Materials and Structures, Vol.10, pp. 1031-1045, 2001.
[12.] Yoshiaki Yasui[10] “ Dynamic axial crushing of multi-layer honeycomb panels and impact tensile behavior of the component members ” ,vol.24,pp.659 - 671,2000.
[13.] Tongan Wang, Vladimir S. Sokolinsky 1, Shankar Rajaram,Steven R. Nutt * [11] “ Assessment of sandwich models for theprediction of sound transmission lossin unidirectional sandwich panels ” , Applied Acoustics 66245-262,2005.
[14.] Huang Wen-chao and Ng Chung-fai “ Sound insulation improvement using honeycomb sandwich panel ” ,Applied Acoustics,vol. 1-3, pp. 163-177, 1998.
[15.] Deyu Li, Jeffrey S. Vipperman “ On the noise transmissionand control for a cylindrical ” Journal of Sound and Vibration 288 235 – 254, 2005.
[16.] W. C. Tang,*H. Zheng and C. F. Ng “ Low Frequency Sound Transmission Through Closed-fitting Finite Sandwich Panels ” ,Applied Acoustics, vol. 55, No. 1, pp. 13-30, 1998.
[17.] Ruzzene* M. “ Vibration and sound radiation of andwich beamswith honeycomb truss core ” , Journal of Sound and Vibration 277 741 – 763, 2004.
[18.] P. THAMBURAJ AND J. Q. SUN “ Optimization of anisotropic sandwich beams for higher sound transmission loss ” , Journal of Sound and Vibration 254(1), 23}36, 2002.
[19.] Sergey V. Sorokin “ Vibrations of and sound radiation from sandwich plates in heavy fluid loading condition ” , Composite Structures 48 219-230, 2000.
[20.] Williams, R. B., Inman, D. J. and Wilkie, W. K., “ Temperature-Dependent Coefficients of Thermal Expansion for Macro Fiber Composite Actuators ” , [21.] Williams, R. B., Inman, D. J. and Wilkie, W. K., “ Nonlinear Mechanical Behavior of Macro Fiber Composite Actuators ” , [22.] Williams, R. B., Schultz, M. R., Hyer, M. W., Inman, D. J. and Wilkie, W. K., “ Nonlinear Tensile and shear behavior of Macro Fiber Composite Actuators, ” [23.] Azzouz, M. S., Mei, C., Bevan, J. S. and Ro, J. “ Finite Element Modeling of MFC/AFC Actuators and Performance of MFC ” , Journal of Intelligent Materials Systems and Structures, 12(9), pp. 601-612, 2001.
[24.] Kim, Seung Jo, Hwanh, Joon Seok and Paik, Seung Hoon “ Direct Numerical Simulation of Active Fiber Composite, ” Proceedings of SPIE 5053, pp. 568-575, 2003.