自行車壓電纖維複材把手管件的振動控制使用有限元素模型法

魏騰佑、羅正忠

E-mail: 9419551@mail.dyu.edu.tw

摘 要

本論文的目的是為了發展自行車把手管件的振動抑制技術， 其研究方式是使用壓電纖維複合材料(Macro fiber composite)作為致動器，在控制的方法分別選擇使用主動式控制與被動式壓電 分流器，而在主動式控制方面使用速度回饋控制和線性二次最佳 化(Linear Quadratic Regulator)控制來決定回饋的增益。被動式壓 電分流器則選用電阻分流器(Resistor shunt)與共振分流器(Resonant shunt)，兩種分流電路。 使用有限元素法建構系統數學模型，推導狀態空間方程式， 進而利用數值模擬和實驗驗證分別探討其控制效率，來達到研發 出一種簡單、穩定而又有效的複材自行車把手管件的振動抑制技 術。在本篇論文中被使用減振技術的結構為自行車把手管件，因 此抑制振動所需壓電元件不同於一般傳統平板型壓電陶瓷，相對 的其振動控制機制亦較為複雜，其特點需求必須配合複合結構之 外型、受力負荷形式，尋求最佳的裹埋位置、控制電路，以進行 含MFC 管件結構振動控制。並由MFC/自行車把手的振動分析、 實驗量測、控制法則及控制電路設計與製作驗証，建立自行車管 件最佳化振動控制功能設計製作。

關鍵詞 : 壓電纖維複合材料，自行車把手管件，線性二次最佳化，被動式壓電分流器，有限元素法

目錄

參考文獻

[1] Gaudenzi, P. and Carbonaro, R.,“ Control of beam vibrations by means of piezoelectric devices: theory and experiments ”, Composite Structures, 50, pp. 373-379 , 2000.

[2] Lin, C. C. and Huang, H. N.,“ Vibration control of beam-plates with bonded piezoelectric sensors and actuators ”, Computers & Structures, 73, pp.239-248 , 1999.

[3] Xu, S. X. and Koko T. S.,“ Finite element analysis and design of actively controlled piezoelectric smart structures ”, Finite Elements in Analysis and Design, 40, pp.241-262 , 2004.

[4] Park, C. H.,“ Dynamics modeling of beams with shunted piezoelectric elements, ” Journal of Sound and Vibration, 268, pp. 115-129, 2003.

[5] Ahmadian, M. and Deguilio, A. P.,“ Recent Advances in the Use of Piezoceramics for Vibration Suppression, ” The Shock and Vibration Digest, 33(1), pp. 15-22, 2001.

[6] Forward, R. L.,“ Electronic Damping of Vibration in Optical Structures ”, Journal of Applied Optics, 18(5), pp. 690-697, 1979.

[7] Hagood and von Flotow, A., “ Damping of Structural Vibrations with Piezoelectric Materials and Passive Electrical Network ” , Journal of Sound and Vibration, 249(2), pp. 227-250, 2002.
[8] Agneni, A., Mastroddi, F., and Polli, G. M., “ Shunted Piezoelectric Patches in Elastic and Aeroelastic Vibrations, ” Computers & Structures, 81(2), pp.91-105, 2003.
[9] Tylikowski, A., “ Control of Circular Plate Vibrations via Piezoelectric Actuators Shunted with a Capacitive Circuit, ” Thin-Walled Structures, 39(1), pp. 83-94, 2001.
[10] Saravanos, D. A., “ Damped Vibration of Composite Plates With Passive Piezoelectric-Resistor Elements, ” Journal of Sound and Vibration, 221(5), pp. 867-885, 1999.
[11] Davis, L. C. and George, A. L., “ an Actively Tuned Solid-state Vibration Absorber Using Capacitive Shunting of Piezoelectric Stiffness, ” Journal of Sound and Vibration, 232(3), pp. 601-617,2000.
[12] Seong, H. M. and Seung, J. K., “ Suppression of Nonlinear Composite Panel Flutter with Active/passive Hybrid Piezoelectric Networks Using Finite Element Method, ” Composite Structures, 59(4), pp. 525-533, 2003.
[13] Thorp, O., Ruzzene, M., and Baz, A., “ Attenuation and Localization of Wave Propagation in Rods with Periodic Shunted Piezoelectric Patches, ” Smart Materials and Structures, 10(5),pp.979-989, 2001.
[14] Cross, C. J. and Fleeter, S., “ Shunted Piezoelectrics for Passive Control of Turbomachine Blading Flow-Induced Vibrations, ” Smart Materials and Structures, 11(2), pp. 239-248, 2002.
[15] Zhang, J. M., Chang, W., Varadan, V. K. and Varadan, V. V., “ Passive Underwater Acoustic Damping Using Shunted Piezoelectric Coatings, ” Smart Materials and Structures, 10(2),pp. 414-420, 2001.
[16] Behrens, S., Fleming, A. J., and Moheimani, S. O. R, “ Abroadband Controller for Shunt Piezoelectric Damping of Structural Vibration, ” Smart Materials and Structures, 12(1), pp.18-28, 2003.
[17] Fleming, A. J. and Moheimani, S. O. R., “ Adaptive Piezoelectric Shunt Damping, ” Smart Materials and Structures, 12(1), pp.36-44, 2003.
[18] Kim, J., Ryu, Y-H. and Choi, S-B., “ New Shunting Parameter Tuning Method for Piezoelectric Damping Based on Measured Electrical Impedance, ” Smart Materials and Structures, 9(6), pp.868-877, 2000.
[19] Caruso, G., “ A Critical Analysis of Electric Shunt Circuits Employed in Piezoelectric Passive Vibration Damping, ” Smart Materials and Structures, 10(5), pp. 1059-1068, 2001.
[20] Corr, L. R. and Clark, W. W., “ Comparison of Low-Frequency Piezoelectric Switching Shunt Techniques for Structural Damping, ” Smart Materials and Structures, 11(3), pp. 370-376,2002.
[21] Moheimani, S. O. R., Fleming, A. J. and Behrens, S., “ On the Feedback Structure of Wideband Piezoelectric Shunt Damping Systems, ” Smart Materials and Structures, 12(1), pp. 49-56,2003.
[22] Fleming, A. J., Behrens, S. and Moheimani, S .O. R., “ Reducing the Inductance Requirements of Piezoelectric Shunt Damping Systems, ” Smart Materials and Structures, 12(1), pp. 57-64, 2003.
[23] Lee, J-K., Kim, J., Rhee, C-J., Jo, C-H. and Choi, S-B., “ Noise Reduction of Passive and Active Hybrid Panels, ” Smart Materials and Structures, 11(6), pp. 940-946, 2002 [24] Saravanos, D. A., “ Passively Damped Laminated Piezoelectric Shell Structures With Integrated Electric Networks, ” AIAA Journal, 38(7), pp. 1260-1268, 2000.
[25] Thornburgh, R. P. and Chattopadhyay, A., “ Simultaneous Modeling of Mechanical and Electrical Response of Smart Composite Structures, ” AIAA Journal, 40(8), pp. 1603-1610, 2002.
[26] Erwin, D. J., Modal Testing: Theory, Practice and Application, Research Studies Press, England, 2nd edn., 2000.
[27] Park, C. H., “ Dynamics modeling of beams with shunted piezoelectric elements, ” Journal of Sound and Vibration, 268, pp.115-129, 2003.