Impedance control of wave transmission in the cylindrical rod using shape memory alloy : numerical simulation

王家文、羅正忠

E-mail: 321433@mail.dyu.edu.tw

ABSTRACT

Shape memory alloy(SMA) with high stiffness and fine damping, the impedance characteristics and the Young's Modulus of correlation. In short, SMA can sense external temperature and self-change Young's Modulus, this unique tunable is short of the other metals. Therefore, SMA components can be as a filter of pass-band, through careful design, it only allows a specific vibration energy wave of bandwidth through and block off the other, achieve impedance control, amplitude suppression, vibration absorption and vibration localized purposes. Using ANSYS WORKBENCH simulated Ni-Ti SMA insert to control wave propagation and impedance, let to produce the effect of impedance mismatch with structure, and then consider the transverse and longitudinal vibration energy of the cylindrical rod, and in three simulated conditions of SMA insert to consider the structure suppress the vibration energy wave conditions: (a) changes of insert Young's Modulus; (b) change of insert length and (c) changes of insert location and distribution. By the preliminary results show that low frequency vibration difficult to suppression(transverse first mode);high frequency vibration can efficiently suppression (transverse second、third modes and longitudinal first mode).

Keywords : wave propagation、impedance mismatch、vibration reduction、shape memory alloys

Table of Contents

REFERENCES

[1]楊大智，智能材料與智能系統，新文京開發出版股份有限公司，2004。

[2]林振寧，“形狀記憶合金之彈性係數的溫度效應之研究”，國立成功大學碩士論文，2005。

[3]Rao S.S., Mechanical Vibration, Addison-Wesley, New York (1995).

[4]Nashif D., Jones D.I.G., and Henderson J.P., Vibration Damping, JohnWiley & Sons, New York (1985).

[5]Pelinescu I. and Balachabdran B.,“Active Control of Vibration Transmission through Struts,”Proceeding of SPIE, Vol.3329, 1998.

[6]Douglas J. Ortel and B. Balachandran,“Control of Flexural Wave Transmission through Struts,”Proceeding of SPIE, Vol.3668, pp.80-91, 1999.

[7]Pelinescu I. and Balachabdran B.,“Analytical Study of Active Control of Wave Transmission through Cylindrical Struts,”Smart Materials and Structures, Vol.10, pp.121-136, 2001.

[8]Ruzzene M. and Baz A.,“Control of wave propagation in periodic composite rods using shape memory inserts,”Journal of Vibration and Acoustics 122: 151-159,2000.

[9]Ruzzene M. and Baz A.,“Attenuation and localization of wave propagation in periodic rods using shape memory inserts,”Smart Materials and Structures 9:805-816 ,2000.

[10]Chen T., Ruzzene M. and Baz A.,“Control of wave propagation in periodic composite rods using shape memory inserts: Theory and Experiments,”Journal of Vibration and control, 6: 1065-1081,2000 [11]Baz, A.“Spectral Finite-Element Modeling of the Longitudinal Wave Propagation in Rods Treated with Active Constrained Layer Damping,”Smart Materials and Structures, Vol.9, pp. 372-377, 2000.

[12]Brillouin L., Wave propagation in periodic structures 2nd ed. Dover, New York(1953).

[13]Heckl M.A.,“ Investigation on the vibration of grillages and other simple beam structures, ” Journal of the Acoustical Society of America 36: 1335-1343, 1964.
[14]Mead D.J. and Wilby E.G.,“ The random vibrations of a multi-supported heavily damped beam ” , The Shock and Vibration Bulletin 35: 45-55, 1966.
[15]Mead D.J.,“ Wave propagation and natural modes in periodic systems, ” Journal of Sound and Vibration 40: 1-18 , 1975.
[16]Mead D.J. and Markus S.,“ Coupled flexural-longitudinal wave motion in a periodic beam, ” Journal of Sound and Vibration 90: 1-24,1983.
[17]Mead D.J.,“ A new method of analyzing wave propagation in periodic structures, ” Journal of Sound and Vibration 104: 9-27 ,1986.
[18]Mead D.J. and Bardell N.S.,“ Free vibration of a thin cylindrical shell with periodic circumferential stiffeners, ” Journal of Sound and Vibration 115: 499-521 ,1987.
[19]Mead D.J. and Yaman Y.,“ The harmonic response of rectangular sandwich plates with multiple stiffening: a flexural wave analysis, ” Journal of Sound and Vibration 145:409-428, 1991.
[20]Mead D.J.,“ Wave propagation in continuous periodic structures: search contributions from Southampton 1964-1995, ” Journal of Sound and Vibration 190: 495-524, 1996.
[21]Mester S. and Benaroya H.,“ Periodic and near-periodic structures, ” Shock and Vibration 2: 69-95.104, 1995.
[22]Ruzzene M. and Baz A.,“ Active control of wave propagation in periodic fluid-loaded shells, ” Smart Materials and Structures 10: 893-906, 2001.
[23]Mangaraju V. and Sonti V.R.,“ Wave attenuation in periodic three-layered beams:analytical and FEM study, ” Journal of Sound and Vibration 276: 541-570, 2004.
[24]Barbarosie C. and Neves M.M.,“ Periodic structures for frequency filtering: analysis and optimization, ” Computers and Structures 82: 1399-1403, 2004.
[25]Thompson P., Balas G.J. and Leo P.H. “ The Use of Shape Memory Alloys for Passive Structural Damping, ” Journal of Smart Materials and Structure,4:36-42, 1995.
[26]Feng Z.C. and Li, D.Z. “ Dynamics of a Mechanical System with a Shape Memory Alloy Bar, ” Journal of Intelligent Material System and Structure,7:339-410, 1996.
[27]Peter, W.C. “ Experimental and Analytical Studies of Shape Memory Alloy Damper for Structural Control, ” In: Proceedings of SPIE 2445, pp. 241-251, 1995.
[28]Brennan M.J., Elliott S.J. and Pinnington R.J.,“ Strategies the Active Control Of Flexural Vibration on a Beam, ” Journal of Sound and Vibration,186(4),pp.657-688, 1995.
[29]Elliott S.J. and Billet L.,“ Adaptive Control of Flexural Waves Propagation in a beam, ” Journal of Sound and Vibration,163(2),pp.295-310, 1993.
[30]Baz, A.,“ Active control of periodic structures, ” ASME Journal of Vibration and Acoustics, Vol. 123,pp.472-479, 2001.
[31]Robert, K., Jack, H. and Steve, S. “ Structural Damping with Shape Memory Alloys: One Class Device, ” In: Proceedings of SPIE 2445, pp. 225-240, 1995.
[32]Han, Y. L., Li, A.Q., Lin, P.H., Li, Q.S. and Leung, A.Y.T. “ Structural Vibration Control by Shape Memory Alloy Damper, ” Earthquake Engineering and Structural Dynamics, 32(3):483-494, 2003.
[33]Higashino, M., Aizawa, S., Clark, P.W., Whittaker, A.S., Aiken, I.D. and Kelly, J.M. “ Experimental and Analytical Studies of Structural Control System using Shape Memory Alloy, ” In: Proceedings of 2nd International Workshop on structural Control, Hong Kong, pp. 221-229, 1996.
[34]簡勤哲，“ 自行車壓電纖維複材把手管件的制動控制，使用離散參數模型 ”，大葉大學碩士論文，2005。
[35]陳精一，ANSYS振動學實務分析，高立圖書有限公司，2005。
[36]蔡國忠，ANSYS Workbench有限元素分析及工程應用，加樺國際有限公司，2008。