11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

PASSIVE, ACTIVE AND ACTIVE-PASSIVE VIBRATION CONTROL OF PLATE STRUCTURES USING DISTRIBUTED PIEZOELECTRIC PATCHES

M.A. Trindade*, T.C. Godoy, C.C. Pagani Jr. and H.F.L. Santos

Department of Mechanical Engineering, São Carlos School of Engineering, University of São Paulo, São Carlos, SP 13566-590, Brazil, trindade@sc.usp.br, http://www.eesc.usp.br/labdin

Key words: *Vibration control, piezoelectric materials, active-passive piezoelectric networks, spatial modal filters, finite element method.*

Since the early 80s, several studies focused on the use of distributed piezoelectric patches for the vibration control of thin plate-like structures [1, 2]. The main goal was to obtain a so-called adaptive structure with very integrated sensors and actuators so that adaptive/reconfigurable vibration mitigation solutions could be part of the structural design phase. However, the performance and interest of such solutions were always limited to the relatively weak actuation power of piezoelectric patches and the required cumbersome power electronics. Therefore, most research groups migrated to passive and/or semi-active solutions to escape from the power required by active control while still maintaining the adaptivity provided by the piezoelectric patches. Much fewer studies attempted to tackle the issue of increasing the ratio performance/power and/or miniaturizing the power electronics required for active control solutions [3, 4].

One alternative would be to combine the active vibration control solutions to passive and/or semi-active ones so that the required performance of the active part, and consequently the power required, could be diminished. For instance, this could be achieved using an optimized combination of viscoelastic treatments for passive damping and piezoelectric actuators for active control [5, 6, 7]. However, this approach does not increases the performance/power ratio of the active solution, although it can indeed decrease the power required for a given overall performance and also increase the frequency range and robustness of the combined solution.

Therefore, recent studies were performed with the objective of maximizing the control authority of piezoelectric patches in order to improve the performance/power of active control solutions. These studies include the use of resonant shunt circuits in series with the active control voltage source to improve the control authority [8, 9] and also the use of spatial modal filters to minimize the power spilled to control non-interesting dynamics [10, 11]. Presented results show that the active vibration control performance can be substantially increased with the use of such strategies. In addition, the adaptivity of solution is preserved in the sense that it can modified in real time according to the operation and/or performance criteria.

REFERENCES

[1] M. Sunar and S.S. Rao. Recent advances in sensing and control of flexible structures via piezoelectric materials technology. *Applied Mechanics Review*, Vol. **52**, Vol. 1, 1–16, 1999.

[2] M. Ahmadian and A.P. DeGuilio. Recent advances in the use of piezoceramics for vibration suppression. *The Shock and Vibration Digest*, Vol. **33**, No. 1, 15–22, 2001.

[3] J. Tang, Y. Liu and K. Wang. Semiactive and active-passive hybrid structural damping treatments via piezoelectric materials. *The Shock and Vibration Digest*, Vol. **32**, No. 3, 189–200, 2000.

[4] J. Sirohi and I. Chopra. Actuator power reduction using L-C oscillator circuits. *Journal of Intelligent Material Systems and Structures*, Vol. **12**, No. 12, 867–877, 2001.

[5] M.A. Trindade, A. Benjeddou and R. Ohayon. Finite element modelling of hybrid active-passive vibration damping of multilayer piezoelectric sandwich beams – Part I: Formulation and Part II: System analysis. *International Journal for Numerical Methods in Engineering*, Vol. **51**, No. 7, 835–854, 855–864, 2001.

[6] M.A. Trindade and A. Benjeddou. Hybrid active-passive damping treatments using viscoelastic and piezoelectric materials: review and assessment. *Journal of Vibration and Control*, Vol. **8**, No. 6, 699–746, 2002.

[7] M.A. Trindade. Optimization of activepassive damping treatments using piezoelectric and viscoelastic materials. *Smart Materials and Structures*, Vol. **16**, 2159–2168, 2007.

[8] T.C. Godoy and M.A. Trindade. Modeling and analysis of laminate composite plates with embedded active-passive piezoelectric networks. *Journal of Sound and Vibration*, Vol. **330**, 194–216, 2011.

[9] H.F.L. Santos and M.A. Trindade. Structural vibration control using extension and shear active-passive piezoelectric networks including sensitivity to electrical uncertainties. *Journal of the Brazilian Society of Mechanical Sciences and Engineering*, Vol. **33**, 287–301, 2011.

[10] M.A. Trindade, C.C. Pagani Jr. and L.P.R. Oliveira. Semi-modal active vibration control of plates using discrete piezoelectric modal filters, 22nd International Conference on Adaptive Structures and Technologies, October 10-12, Corfu, Greece, 2011.

[11] C.C. Pagani Jr. and M.A. Trindade. Optimization of modal filters based on arrays of piezoelectric sensors. *Smart Materials and Structures*, Vol. **18**, No. 9, art. 095046, 2009.