Control of Energy Flow and Wave Propagation by Periodically Distributing Piezoelectric Materials with Identical Shunting Circuits

***Y. Fan[1], †L. Li[1], O. Bareille[2] and M. Ichchou[2]**

[1]School of Energy and Power Engineering, Beihang University, China.
[2] LTDS, Ecole Centrale de Lyon, France

*Presenting author: fanyu04@buaa.edu.cn
†Corresponding author: feililin@buaa.edu.cn

Abstract

An electromechanical waveguide can be constructed by periodically distributing piezoelectric materials on to the host structure and shunting identical electric circuits to each parts. The design of electric impedances endows the waveguide with the desired dynamic features for vibration control or wave filtering, leading to the reduction of structural response and energy flow. In this paper we investigate the energy flow characteristics of the electromechanical waveguide when it is assembled into an existing structural system and working as a substructure. The engineering background can be the control of energy flow injected to a car chassis or a fuselage from the engines. A rapid multi-scale numerical strategy is employed to analyze the forced response and energy flow of such built-up structures. The influence of number of piezoelectric patches and the excitation are discussed, showing the necessity of evaluating the waveguide performance in the proposed context. Results indicate the essential difference between waveguides with finite and infinite unit cells. We show that a band gap in the periodic substructure does not directly link to a low vibration and low energy frequency range of the built-up structure, especially when there is a small number of patches. Bragg band gap and damping mechanisms are compared, clarifying the their intrinsic differences in terms of energy flow. Finally the electric impedance formed by negative capacitance and resistor is optimized when the unit cell's geometric configuration is fixed. Different criteria are used as objective functions, leading to different mechanisms of preventing the energy injection.

Keywords: Energy flow, piezoelectric shunting circuit, periodic structures, band gap, wave and finite element method

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