Glass Plates Noise Transmission Suppression By Means of Distributed Piezoelectric Composite Actuators Shunted By an Active Circuit

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Abstract

Introduction: The noise sources density in cities is steadily increasing. Glass windows are one of them because they represent virtual sound sources for the rooms. Because of their low flexural rigidity it is very easy to make them vibrate and therefore they transmit the noise to the building interior (Figure 1). We have focused on this structure-born sound and proposed a simple way how to increase the bending stiffness which results in the fact that more acoustic pressure is reflected than transmitted through the glass plate (Figure 2). Piezoelectric Macro Fiber Composite (MFC) [1] actuators are distributed on the glass surface and are effectively stiffened by active circuits with a Negative Capacitance (NC) [2]. Use of COMSOL Multiphysics: First, the key aspects which control the vibrational response of the glass plate have to be defined using the analytic approximative model. It is the glass plate curvature and its elastic properties such as Young's modulus and stiffness bending coefficient. COMSOL Multiphysics was used for calculation of the effective Young's modulus of the MFC actuator, particularly for its frequency dependence when the actuator is shunted by the NC circuit. These data were used for calculation of acoustic pressures distribution in front of and behind the glass window and for the vibrations velocity of the glass plate. Then, it is possible to compute acoustic Transmission Loss (TL) [3], the measuring quantity of the sound shielding efficiency of the glass plate. Results: Figure 2 shows the acoustic TL computed for the case study (i) flat glass, (ii) curved glass, (iii) flat glass with shunted MFC actuators and (iv) curved glass with shunted MFC actuators. It can be seen that due to the curved geometry it is possible to increase the TL by about 25 dB at the first vibrational mode and due to the effect of shunted NC circuit the TL is increased by 25 dB at the frequency to which is the NC circuit adjusted (890 Hz is the second vibrational mode of the glass plate vibrations). Conclusion: The calculations confirm our analytical presumptions that it is possible to suppress the noise transmission through the glass window using the active stiffening of piezoelectric actuators distributed on the glass surface. The window frame boundary conditions influence is also discussed. The proposed method is quite promising because of its simplicity, generality and low energy consumption.

Reference

1. W. Wilkie et al., Low-cost piezocomposite actuator for structural control applications, Smart Structures and Materials 2000 Conference, Newport Beach, CA, 2000.
2. M. Date et al., Electrically controlled elasticity utilizing piezoelectric coupling, Journal of Applied Physics, vol. 87, no. 2, pp. 863–868, 2000.
3. Z. Maekawa and P. Lord, Enviromental and Architectural Acoustics. Taylor & Francis, 1994.

Figures used in the abstract

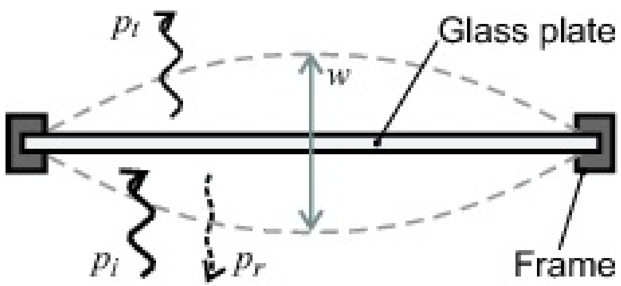

Figure 1: Acoustic pressure transmission through the glass plate because of its vibrations.

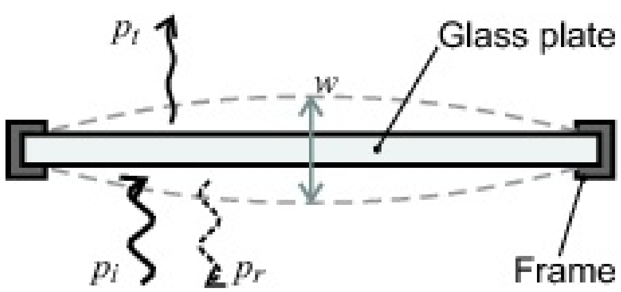

Figure 2: Decreased sound transmission through the glass plate because of its increased bending stiffness.

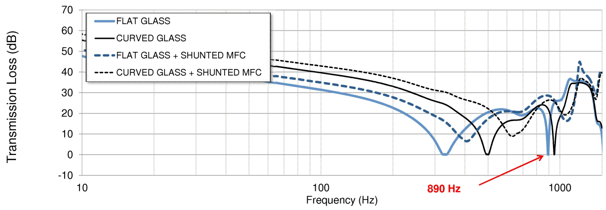

Figure 3: The computed frequency dependence of the acoustic TL of the glass plate under various conditions: Flat glass (solid thick), curved glass (solid thin), flat glass with shunted MFC's (dashed thick) and curved glass with shunted MFC's (dashed thin). The increase of the TL due to the curvature and stiffening of the MFC actuators can be seen.