Active Control of Sound Transmission

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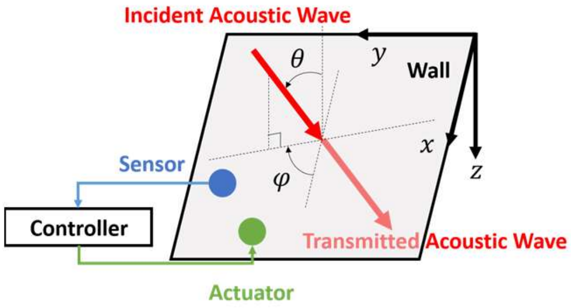
Introduction

The research objective is to reduce the sound transmission. Though the sound can be reduced by making the wall heavier, weight saving is usually required in commercial products. To reduce the sound without increasing the wall's mass, we control the structural vibration by using light-weight sensors and actuators. Such approach is known as active control, and there are many earlier works. However, it is not straightforward to design control systems because of the complexity of the structural-acoustic coupled systems.



Methodology

Structural modes couple with each other and mutually contribute to the sound transmission. If the most contributive mode is identified, the sound could be reduced effectively by controlling that mode selectively. However, it is difficult to evaluate the contribution of each mode, because the modes couple with each other. In our study, the modal contributions are approximately calculated as the structural modal sound transmission coefficients or the structural modal acoustic potential energies. By referring to these quantities, we can identify the most contributive mode. The identified mode can be independently controlled by using structural modal filters, i.e., modal sensors and actuators.

Computer simulation

Fig. 1 shows frequency characteristics of the modal sound transmission coefficient under the condition where an acoustic plane wave is obliquely incident on a simply supported rectangular plate in an infinite baffle. It is found that the (1,1) mode is dominant throughout the frequency range of interest. It should be noted that 16 modes are resonant in this frequency range, yet the (1,1) mode is exceptionally contributive to the sound transmission.

Figs. 2, 3, and 4 show frequency characteristics of the sound transmission coefficient, structural kinetic energy of the plate, and spatially averaged mean-square sound pressure in the near-field, respectively. The black and red lines indicate before and after control for the (1,1) mode, respectively. Reducing the amplitude of this mode decreases the sound transmission coefficient without increasing the structural kinetic energy and near-field sound.

Fig. 1

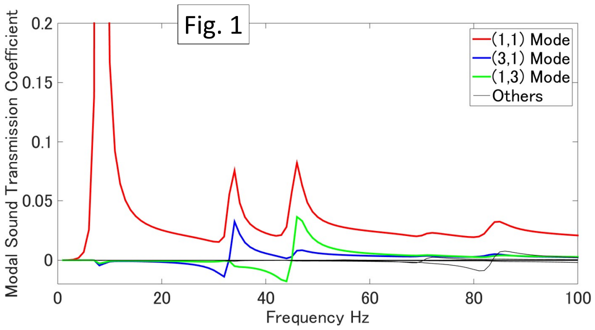


Fig. 2

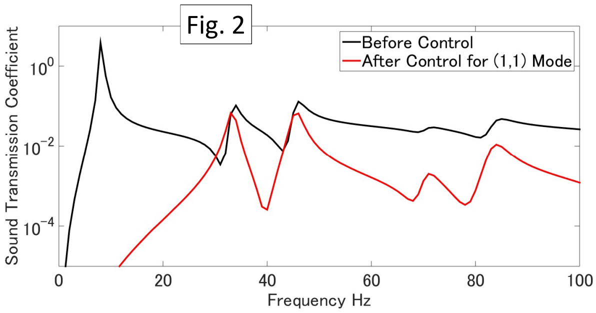


Fig. 3

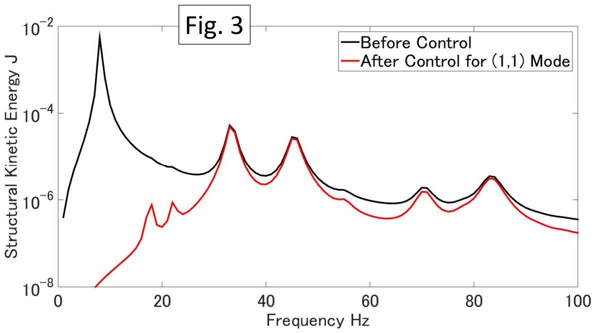
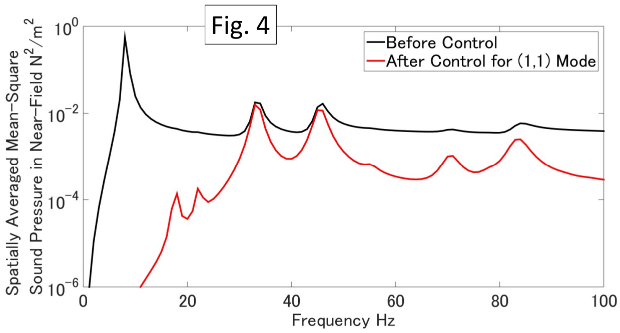


Fig. 4



Publications

Kaizuka, T., Tanaka, N., and Nakano, K., Active control of sound transmission using structural modal filters, Journal of Sound and Vibration, 381, 14-29, 2016.

Kaizuka, T. and Nakano, K., Active control of sound transmission into an enclosure using structural modal filters, Journal of Sound and Vibration, 431, 328-345, 2018.