Noise reduction with laminated double-panel structure

W. Larbi, R. Assaf, F. Guillemard

Conservatoire National des Arts et Métiers
292 rue Saint Martin, 75003 Paris, France
walid.larbi@cnam.fr

ABSTRACT

Double-wall panels are widely used in engineering applications in order to reduce structural vibrations and interior noise due to their superiority over single-leaf structures. Typical examples include double glazed windows, fuselage of airplanes, etc.. By introducing a thin viscoelastic interlayer within the panels, a better acoustic insulation is obtained. In fact, sandwich structures with viscoelastic layer are commonly used in many systems for vibration damping and noise control especially at the medium and high frequency ranges. In such structures, the main energy loss mechanism is due to the transverse shear of the viscoelastic core.

This paper describes a reduced order finite element models for the sound transmission analysis through a double sandwich panels with viscoelastic core inserted in an infinite baffle. The structure is excited by a plane wave at the source side and fluid loading is neglected. The proposed FE model is derived from a variational principle involving structural displacement and acoustic pressure in the fluid cavity. To solve the vibro-acoustic problem, the direct solution can be considered only for small model sizes. This has severe limitations in attaining adequate accuracy and wider frequency ranges of interest. Thus, a reduced order-model is then proposed to solve the problem at a lower cost. The presented methodology, based on a normal mode expansion, requires the computation of the uncoupled structural and acoustic modes. The uncoupled structural modes are the real and undamped modes of the sandwich panels without fluid pressure loading at fluid-structure interface, whereas the uncoupled acoustic modes are the cavity modes with rigid wall boundary conditions at the fluid-structure interface. Moreover, the effects of the higher modes of each subsystem are taken into account through an appropriate so-called "static correction". Two types of static corrections are presented and compared: (i) a posteriori static correction based on the computing of the quasi-static flexibility matrix, which requires physical understanding of the dynamic behavior of the coupled problem and has the advantage of not increasing the number of the retained eigenvectors in the truncated bases, (ii) a priori static correction based on adding the static modes, defined as the deformation shape at every load, to the truncated bases which leads the loss of the diagonal character of generalized matrices but can correctly represents the frequency behavior of the original system.

As a next step, the sound transmission through double walls with air cavity is investigated. When the normal velocity distribution of the panel is known, the acoustic pressure field generated in the outward direction of the two plates can be calculated with the so-called Rayleigh integral for two dimensional sound radiation. For this purpose, it is assumed that the double wall panels are placed in an infinite baffle. The normal incidence sound transmission is chosen in order to evaluate the acoustic performances and the sound insulation of the double wall.

Example of the normal sound transmission loss of double panels with viscoelastic core is shown in order to illustrate the accuracy of the proposed reduced order models in terms of noise attenuation prediction compared to direct methods.