A parametric analytic study of Transmission Loss and Noise Reduction factors of an infinite multi-layered cylinder

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Abstract

Multi-layered shells are increasingly used in aeronautics and aerospace industries. They are found in a wide range of applications such as helicopters, space launch vehicles or aircrafts. Generally designed to reduce the mass of the structures, these shells must also take into account the problem of inner noise transmission. Indeed, whether it is for the passengers' comfort or the payload protection, a noise protection is still necessary in such structures. Consequently, the prediction of the sound transmission through multi-layered shell structures must be carefully examined.

In order to understand the main phenomena of sound transmission through multi-layered cylinders, many analytical studies have been led. Two kinds of analytical models can be distinguished. (i) First, a 3-dimensional elastic model can be used for isotropic cylinders. This model is not simplified and is accurate over all the frequencies. (ii) Then, for orthotropic cylinders, only a shell model is available. It is based on a simplified displacement field which does not take into account the deformation through the thickness of the layer. Consequently, this model is only available for thin layers and can show some limitations in high frequencies.

The aim of this paper is to present an analytical model which allows coupling orthotropic layers with a 3-dimensional theory of elasticity available for isotropic layers. An exact analytical method has been developed to calculate the Transmission Loss (TL) and Noise Reduction (NR) factors of an infinite multi-layered cylinder excited by an incident acoustic plane wave. This analytical formulation has been developed and numerical results have been validated by comparison to numerical results published on recent papers. A parametric study has also been conducted to study the influence of various parameters such as the angle of incidence, the thickness and the mechanical properties of each material layer. The results are presented for a cylinder composed by three layers of materials: two orthotropic sheets separated by an isotropic polymer core inducing vibration damping. The parametric study shows that the TL and NR factors can be strongly enhanced at the low and medium frequency bands by introducing a polymer core layer having optimized mechanical properties to achieve maximum damping around the ring frequency of the cylinder.