

Numerical Model of the Insertion Loss Promoted By the Enclosure of a Sound Source

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Abstract

Usually, the enclosure of a sound source is employed in order to control the noise radiated by industrial machines [1,2]. This structure changes the path of sound transmission between the sound source and the receiver, imposing a high impedance to the wave propagation. However, the enclosure design requires attention since the enclosure and its panel's vibrational modes will influence its performance. Although there are models to assess the acoustic performance of enclosures [3,4], the multiphysics nature of the problem makes its analytical modeling unfeasible in practice. Thus, this study aims to develop and validate a finite element numerical model to represent the Insertion Loss (IL) promoted by the enclosure of a sound source. For the validation, an enclosure prototype was built in wood and its IL was measured in laboratory. The idea is to develop an efficient analysis model that would be suitable for enclosure's design and optimization.

The 3D model was set in the software COMSOL Multiphysics® based on the physics included in the Acoustics module. A hemisphere of radius 50 cm was designed to represent the fluid domain (air). Inside it, the enclosure, a rectangular box (32 cm x 22 cm x 26.5 cm), was centered on the plane surface of the hemisphere (Figure 1). The structural domain was modeled using a shell element and coupled with the acoustic domain using the Acoustic-Shell Interaction physics interface. The plane surface of the hemisphere was defined as a Sound Hard Boundary Wall and a slightly larger hemisphere was designed in order to define a Perfectly Matched Layer on the outer boundaries, emulating a non-reflective boundary condition. All enclosure's boundaries were fixed, except for the 4 free boundaries of the enclosure in contact with the hard boundary that models the floor. The sound source was modelled as a point source at the geometric center of the enclosure's interior. The source average sound power was characterized according to the ISO 3741 [5] and used as an input to the model. A secondary and simplified model is designed with the absence of the enclosure, representing a situation with free wave-path. The numerical model validation is carried out deriving the Insertion Loss from the measured power attenuation.

The preliminary results shows a comparison between the IL obtained experimentally and numerically (Figure 2). Although both model and measured ILs are similar in shape, there was an evident frequency shift. Future work shall analyse if this uncertainty can be related to the

approximated properties of the enclosure's wood, obtained by a database [6].

This study aims to present a multiphysical model to estimate the Insertion Loss promoted by the enclosure of a sound source. The model takes into account the source nominal sound power, which was obtained experimentally. Although the preliminary results showed good agreement between numerical and experimental results of IL, the model validation procedure needs to be improved with further investigations about the model uncertainties.

Reference

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- [6] Institutos de Pesquisas Tecnológicas - IPT, http://www.ipt.br/informacoes_madeiras/38.html

Figures used in the abstract

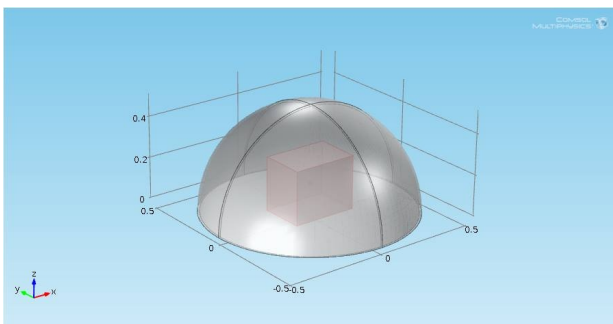


Figure 1: Numerical model illustration

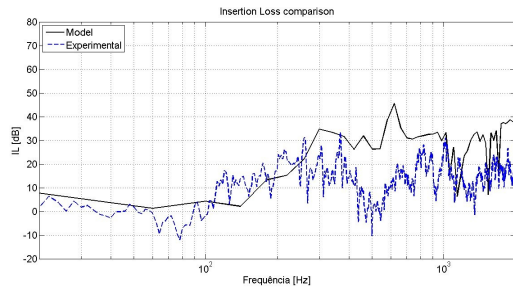


Figure 2: Comparison between numerical (solid line) and experimental (dashed line) results