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

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Introduction: Usually, the enclosure of a sound source is employed in order to control the noise radiated by industrial machines. 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. Hence, the enclosure's structure response and the acoustic field must be correctly coupled. This study aims to develop and validate experimentally a Finite Element numerical model to represent the Insertion Loss (IL) promoted by the enclosure of a sound source. The idea is to develop an efficient analysis model that would be suitable for enclosure's design and optimization.

Use of COMSOL Multiphysics®: The efficiency of an enclosure can be better represented by the insertion loss (IL), which quantifies the decrease in the sound power radiated due to insertion of the enclosure over the acoustic source. Thus, first the Pressure Acoustics, Frequency Domain interface was used to model the sound source radiating in a free field condition. The second model (Figure 1) includes the enclosure, thus it uses the Acoustic-Shell Interface, Frequency Domain to couple the structural and acoustic domains.

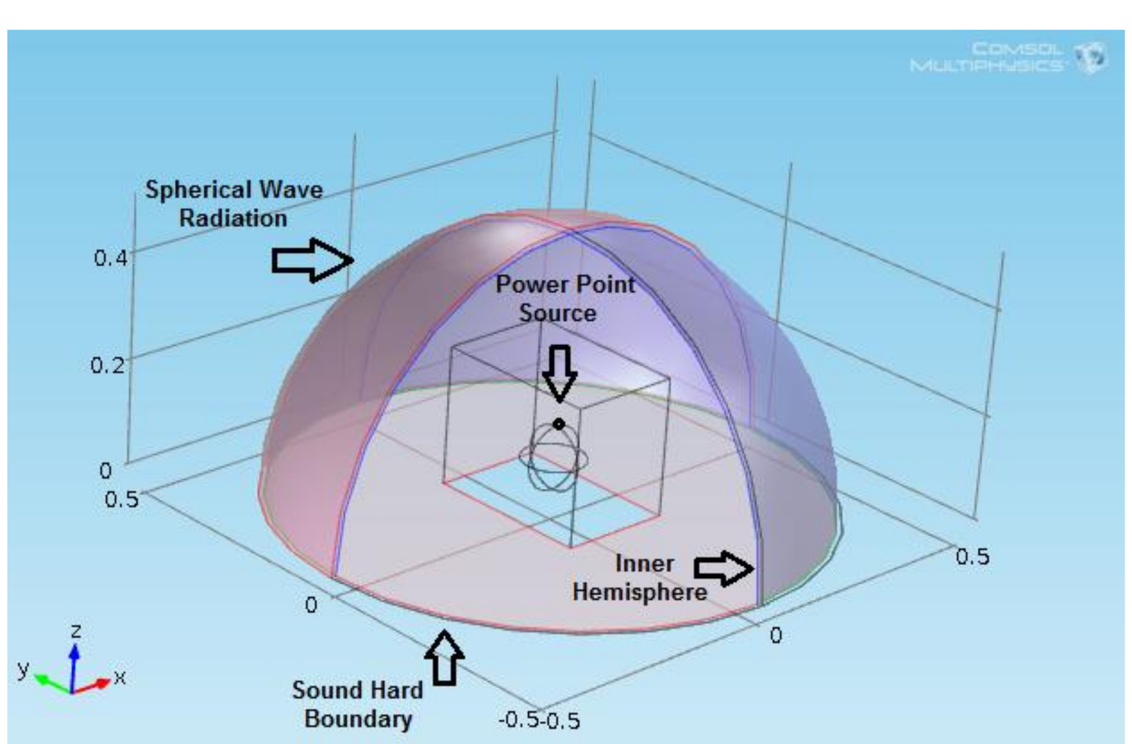


Figure 1. Coupled Acoustic-Structure Model Illustration.

As the numerical model validation was intended to be done by means of IL, the Average Sound Power Level (Lw) was estimated on the inner hemisphere surface. The sound power is calculated in terms of Sound Pressure Level (Lp dB re 20 μPa) [1] by:

$$Lw = Lp + 10\log_{10}(2\pi r^2) \text{ dB re } 10^{-12} \text{ W}.$$

The Insertion loss is the reduction of the sound power level radiated by the enclosed source, and thus, can be derived by:

$$IL = Lw_0 - Lw_E,$$

where Lw_0 is the source power level and Lw_E is the sound power level of the enclosed source.

Results: The FE model validation is carried through experimental measurement. For that, one enclosure prototype was built in wood (Brazilian ipe) and the sound power was measured in according to ISO 3741 [2]. The IL results are showed in Figure 2.

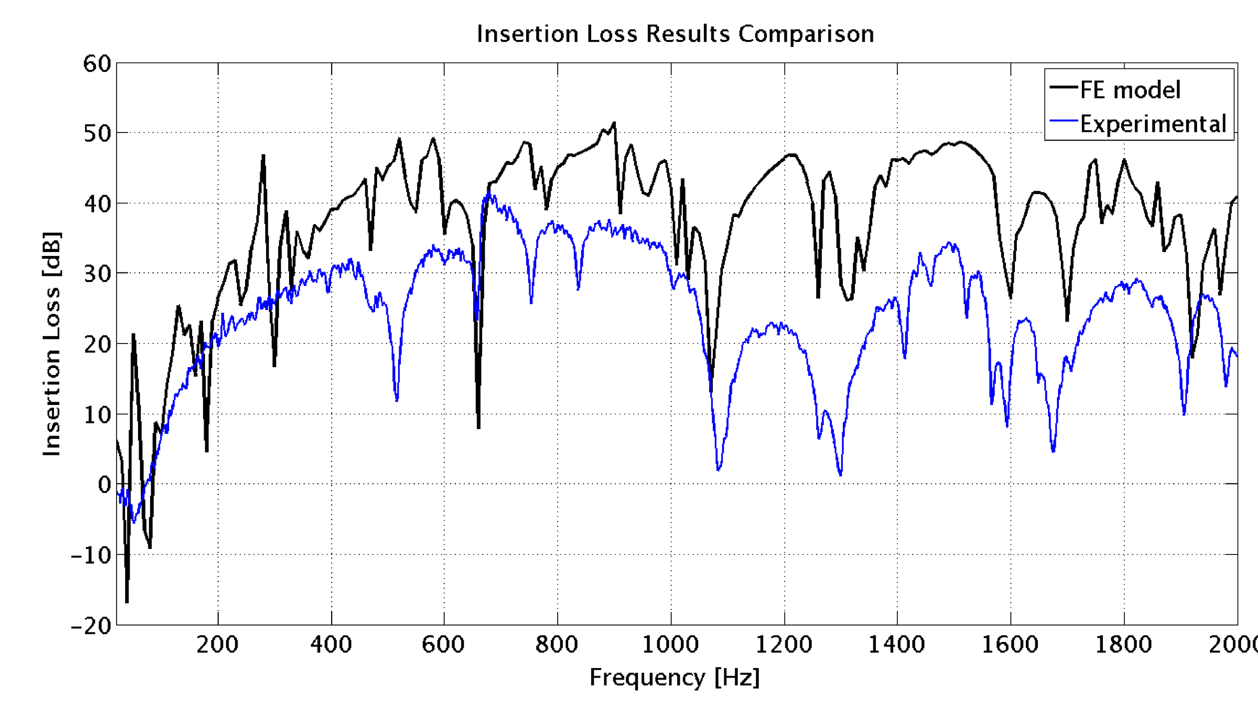


Figure 2. Insertion Loss Results Comparison.

Figure 3 shows the enclosure structural displacement, which will give us an insight about the enclosure's structural modes.

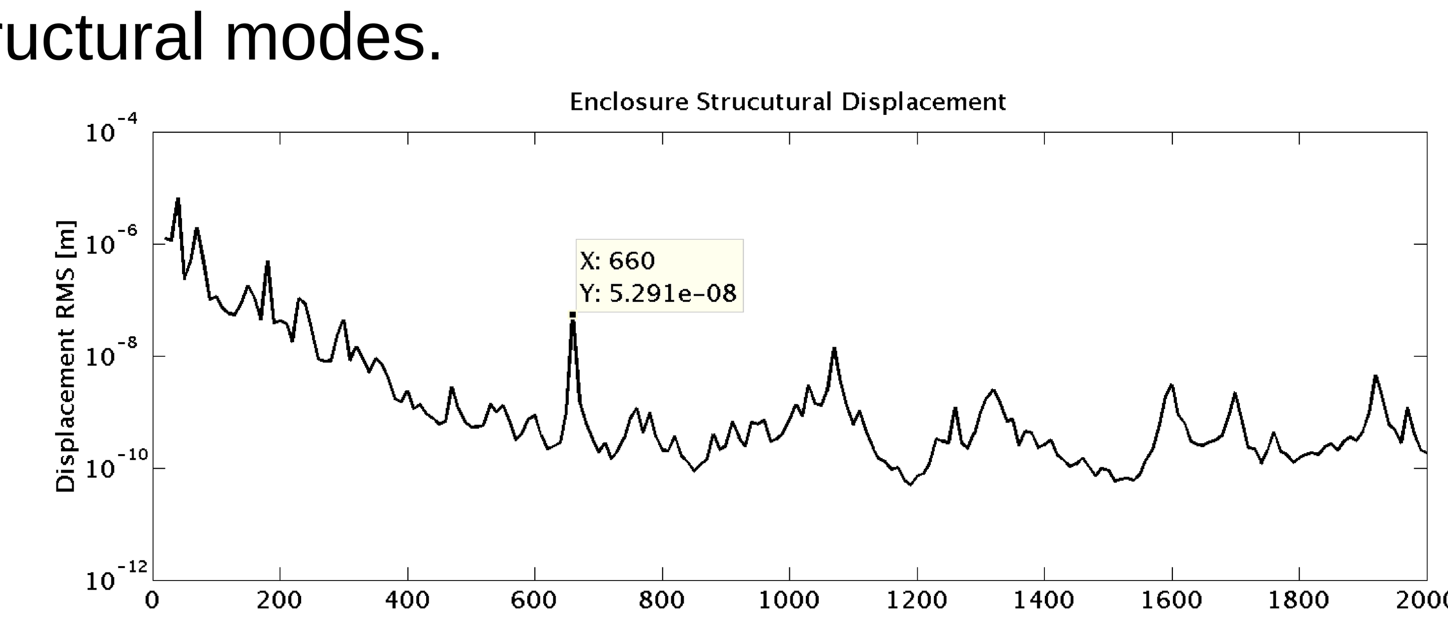
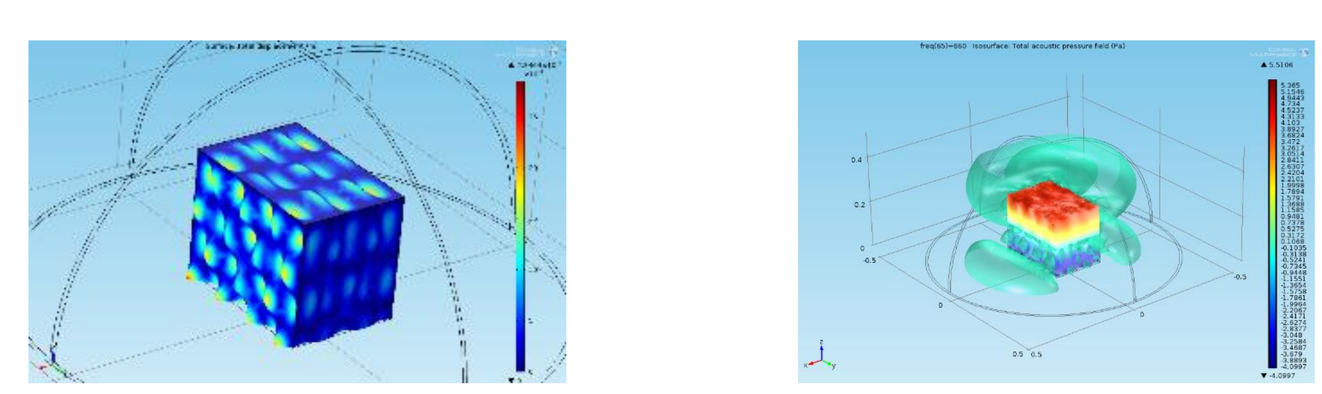


Figure 3. Enclosure's Structural Displacement (Surface Average).

It is noticeable in Figure 3, that a structural mode occurs in 660 Hz, which leads to a IL decrease (Figure 2). Figure 4 allows a better visualization of the modal shape and radiation pattern at 660 Hz.



(a) **(b)**

Figure 4. Surface Total Displacement **(a)** and total acoustic pressure **(b)** at 660 Hz.

Conclusion: This poster presented a coupled acoustic-structural 3D FE model to predict the IL promoted by the enclosure of a sound source. Despite uncertainties as BC and the materials properties, the model was experimentally validated, showing good agreement in terms of resonance frequencies.

References:

1. Bies, David and Hansen, Colin. Engineering Noise Control: Theory and Practice, CRC Press, 2009.
2. ISO 3741:2010, Acoustics - Determination of sound power levels and sound energy levels of sources using sound pressure - reverberation test rooms, 1999.