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Modelling of acoustic transmission through perforated layer

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Abstract

The paper deals with modeling the acoustic transmission through a perforated interface plane separating two halfspaces occupied by the acoustic medium. We considered the two-scale homogenization limit of the standard acoustic problem imposed in the layer with the perforated periodic structure embedded inside. The homogenized transmission conditions govern the interface discontinuity of the acoustic pressure associated with the two halfspaces and the magnitude of the fictitious transversal acoustic velocity. By numerical examples we illustrate this novel approach of modeling the acoustic impedance of perforated interfaces.

Keywords: acoustic transmission, perforated layer, homogenization technique

1. Introduction

The purpose of the paper is to demonstrate the homogenization approach applied to modelling of the acoustic transmission through perforated planar structure. We consider the acoustic medium occupying domain Ω which is subdivided by perforated plane Γ_0 in two disjoint subdomains Ω^+ and Ω^-, so that $\Omega = \Omega^+ \cup \Omega^- \cup \Gamma_0$, see Fig. 3. In the differential form the problem for unknown acoustic pressures p^+, p^- reads as follows:

$$
\begin{aligned}
c^2\nabla^2 p^+ + \omega^2 p^+ = 0 &\quad \text{in } \Omega^+, \\
c^2\nabla^2 p^- + \omega^2 p^- = 0 &\quad \text{in } \Omega^-, \\
+ \text{ boundary conditions} &\quad \text{on } \partial\Omega,
\end{aligned} \tag{1}
$$

In a case of no convection flow the usual transmission conditions are given by

$$
\frac{\partial p^+}{\partial n^+} = -\mathrm{i}\frac{\omega\rho}{Z}(p^+ - p^-), \quad \frac{\partial p^-}{\partial n^-} = -\mathrm{i}\frac{\omega\rho}{Z}(p^- - p^+), \tag{2}
$$

where n^+ and n^- are the outward unit normals to Ω^+ and Ω^-, respectively, ω is the frequency, ρ is the density and Z is the *transmission impedance*; this complex number is characterized by features of the actual perforation considered and is determined using experiments in the acoustic laboratories, see e.g. [6].

We suggest a more refined mathematical treatment of such transmission problem, which results in constraints involving several *homogenized coefficients* computed directly for a specified shape of perforation. As an advantage, with such modelling approach one can think of *inverse problems* aimed at optimal design of the perforated structure to obtain a desired acoustic response, see e.g. [1, 8].

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