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Two-scale numerical simulation of acoustic transmission in interaction with flow

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Our previously developed two-scale models of the acoustic transmission on perforated plates, e.g., [1–3] or [4], consider acoustic wave propagation in a stationary acoustic medium. In this contribution, we present the computational algorithm for solving the extended problem of acoustic transmission on a rigid perforated plate interacting with an incompressible flow. The numerical solution consists of two separate problems involving two-scale computations. In the first problem, the potential flow through the rigid perforated interface is computed and the results are employed in the second problem, where the homogenized acoustic coefficients are calculated and the distribution of the global acoustic pressure is found. Both problems require solving the local (microscopic) subproblems defined in a reference cell Y, which represents the periodic structure of the perforated interface, and solving the macroscopic subproblems in order to get the global responses in a macroscopic domain, see Fig. 1.

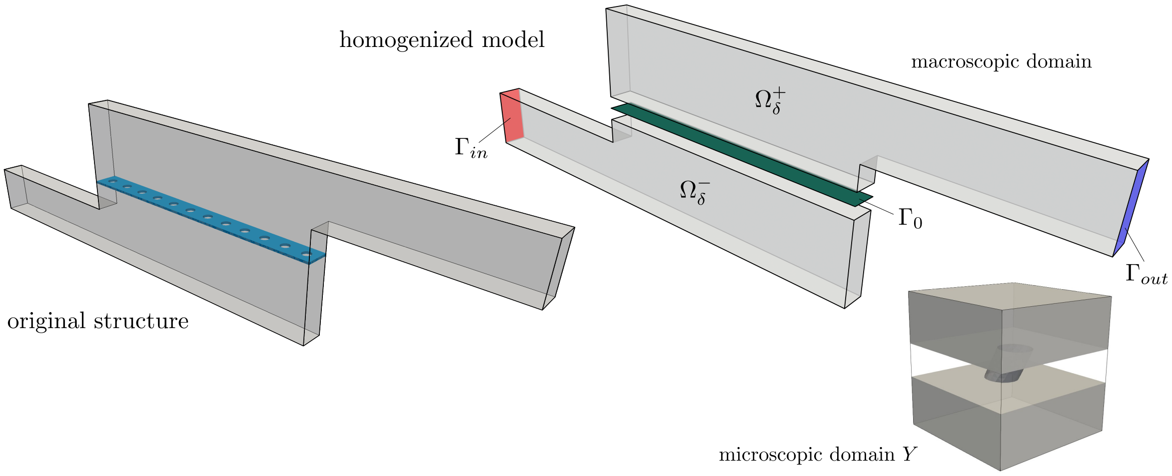

Fig. 1. *Left:* original structure. *Right:* homogenized macroscopic model and reference cell

Homogenization of the potential flow model leads to a set of subproblems defined in Y and to a macroscopic model of the homogenized layer Γ_0, which replaces the original perforated structure. This homogenized model constitutes the transmission condition coupling the separated domains Ω_δ^+, Ω_δ^-. The solution of the local subproblems in the reference cell Y gives the so called corrector functions that are used to evaluate homogenized flow coefficients appearing in the transmission condition. The global macroscopic solution provides the flow velocity field in the homogenized layer Γ_0 and in Ω_δ^+, Ω_δ^-. The reconstruction based on the corrector func-

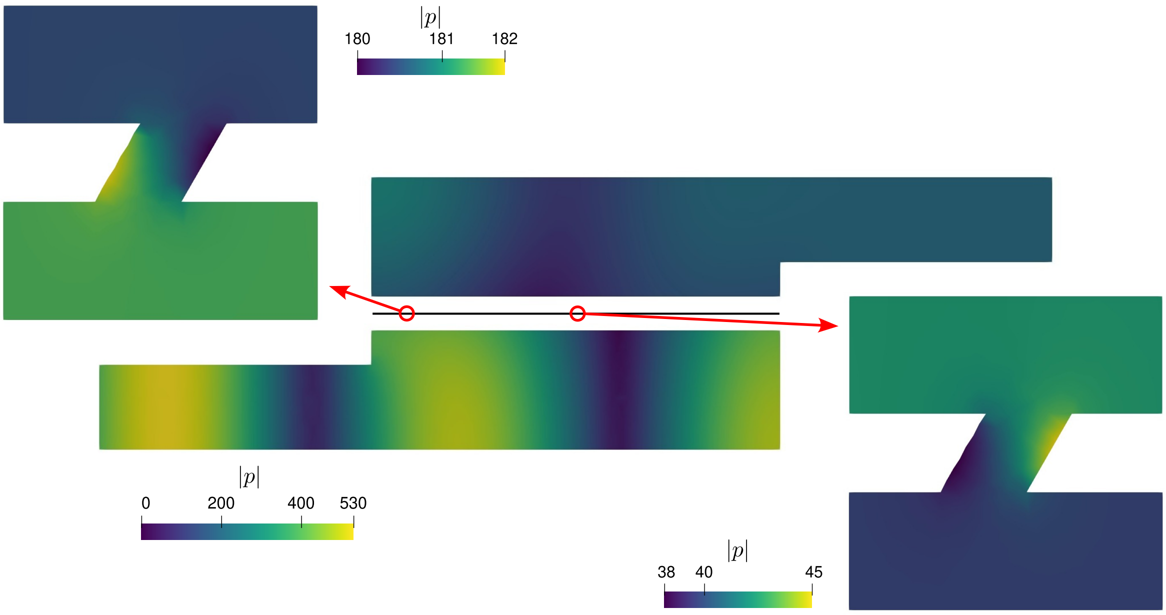

Fig. 2. Computed acoustic pressure in the waveguide and reconstructed pressure fields in two distinct macroscopic points

tions and the macroscopic solution must be performed to get the flow velocities in Y for given macroscopic locations, which will be required in the following calculations.

The extended Helmholz equation describing the acoustic waves interacting with an inviscid fluid is treated similarly to the flow problem above. It again leads to the local subproblems in Y and the homogenized transmission condition related to the acoustic problem. Because the local subproblems, and also the homogenized acoustic coefficients, now depend on the flow velocities that vary in space across the perforations, they must be solved for all given macroscopic points, usually corresponding to element centers or integration points of the finite element discretization of Γ_0. The space dependent homogenized coefficients enter the macroscopic simulation, which results in the global acoustic pressure fields in Γ_0, Ω_δ^+, and Ω_δ^-.

Fig. 2 shows the distribution of the macroscopic pressure in the waveguide and the reconstructed pressures in two distinct perforations. As stated above, the fluid flow influences the homogenized acoustic coefficients that affect the global acoustic pressure distribution. This is

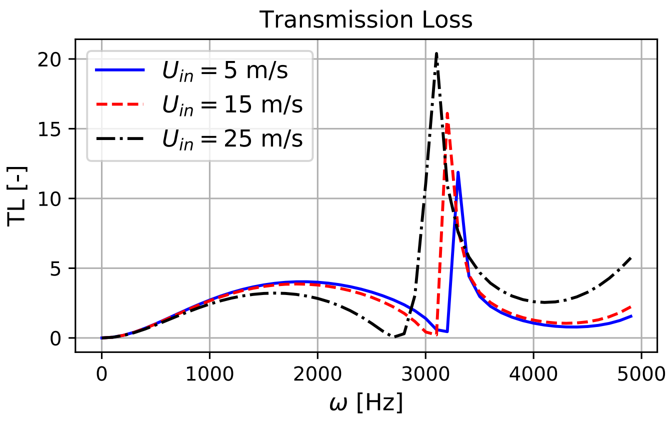

Fig. 3. Transmission loss curves calculated for different velocities $U_{in} = -U_{out} = 5,\ 15,\ 25$ m/s

illustrated in Fig. 3, where the transmission loss curves are calculated for different inlet and outlet velocities applied to the waveguide boundaries Γ_{in} and Γ_{out}, see Fig. 1.

Acknowledgement

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