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Modelling sound propagation in a waveguide containing multiple obstacles

Raymond Kirby
Brunel University, School of Engineering and Design, Uxbridge, UB8 3PH Middlesex, UK

Acoustic waveguides often include relatively short area changes and/or complex non-uniform obstacles. Understanding the propagation of sound within such waveguides requires a detailed knowledge of the scattering of sound at each obstacle and how these obstacles interact with one another. Mathematically modelling sound propagation in waveguides containing multiple non-uniform obstacles is challenging, especially if one assumes that the waveguide is relatively large. Accordingly, a computationally efficient hybrid numerical method is presented here that uses the standard finite element method to model non-uniform obstacles, and maps this onto a wave-based modal solution that is used for uniform duct sections only. The hybrid method has the advantage, moreover, of removing the need to numerically enforce a non-reflecting boundary condition downstream of the obstacles, which is often encountered in studies that rely solely on the standard finite element method. In this way, transmission loss predictions for relatively large ducts and multiple obstacles may be generated efficiently, and predictions are presented here for two cylinders placed in a two-dimensional waveguide.