ACOUSTICS2008/1049
Modeling of sound propagation in nonuniform waveguides

Wenping Bi[a], Vincent Pagneux[a], Denis Lafarge[b] and Yves Aurégan[b]
[a]Laboratoire d'Acoustique de l'Université du Maine, UMR CNRS 6613, AV. O. Messiaen, 72085 Le Mans, France
[b]Laboratoire d'Acoustique de l'Université du Maine, Avenue Olivier Messiaen, 72085 Le Mans, France

Sound propagation in waveguides is modeled by a Multimodal Method. The waveguides geometries may involve bends, variable cross-sections, or their combinations. The waveguide boundaries may involve axially or circumferentially nonuniform impedance conditions or acoustically rigid conditions. Uniform flow may also be included for a simple uniform geometry.
The pressure (displacement potential for uniform flow) is expanded in terms of the modes of acoustically rigid waveguides and an additional function that carries the information about the impedance boundary. The rigid waveguide modes and the additional function are known a priori so that calculations of the true modes of waveguides with impedance boundary, which are difficult, are avoided. By matching the pressure and axial velocity (displacement potential and axial derivative for uniform flow) at the interface between different axially uniform segments, scattering matrices are obtained for each individual segment; these are then combined to construct a global scattering matrix for multiple segments. After calculating the scattering matrix, the transmitted and reflected sound fields or intensities may be obtained for any kind of modal sources. The method allows modeling sound propagation in waveguides with axially and circumferentially nonuniform impedance boundaries up to dimensionless frequency K=70 in just hours on a personal computer, which advantageously compares with other techniques.