Acoustic Scattering Through a Circular Orifice in Low Mach-Number Flow

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Abstract

The acoustic scattering through a circular orifice plate in a duct with low Mach number flow (M=0.1) is computed using the Linearized Navier-Stokes physics interface of COMSOL Multiphysics®. The work by Kierkegaard et al. [1] is extended to account for higher order acoustic modes, i.e., behind the cut-on frequency of the first radial duct mode. The flow field is computed using a k-omega stationary RANS computation in COMSOL® and the solution is interpolated to the acoustic mesh for the linearized Navier-Stokes solver. Orifice flows tend to create a sharp separation zone at that hydrodynamic energy is transformed into acoustic energy and vice versa. At characteristic Strouhal numbers, a recirculation zone inside the orifice creates an acoustic feed-back loop which courses very strong amplifications of distinct tones, so called "whistling" tones. Capturing this amplification is highly demanding as the separation zone has to be computed in great detail and the acoustic mesh has to resolve the areas of energy transmission. A computation is conducted for frequencies behind the plane-wave range and compared to measurements. The data is post-processed with advanced procedures in order to map mode-shapes (eigen-solutions of the convective wave equation) on the acoustic field which results in clean data, i.e., with reduced noise and abated internal reflections at the boundaries of the computational domain.

Reference

[1] A. Kierkegaardet al., Simulations of Whistling and the Whistling Potentiality of an In-Duct Orifice with Linear Aeroacoustics, Journal of Sound and Vibration, Vol. 331(5), p. 1084 (2012)