Numerical prediction of SDOF-Perforated Plate Acoustic Treatment Impedance. Part 1: Linear domain

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A new numerical prediction tool has been developed in order to improve acoustics impedance predictions for typical Nacelle SDOF with perforated-plate liners, accounting for realistic geometry and flow. This method is based on domain breakdown and Linearized Compressible Navier-Stokes equations in the holes. Numerical Results are successfully compared to analytical predictions and measurements in the linear domain without flow. Next steps are non-linear effects and the influence of grazing mean flow.

Nomenclature

\[ c_0 = \text{Sound velocity, m.s}^{-1} \]
\[ d = \text{Holes diameter, m} \]
\[ d_1, d_2 = \text{Elementary period sizes, m} \]
\[ D = \text{Cavity lateral size, m} \]
\[ e = \text{Plate thickness, m} \]
\[ e' = \text{Corrected thickness, m} \]
\[ f = \text{Frequency, Hz.} \]
\[ h = \text{Cell depth, m} \]
\[ k=\omega/c_0 = \text{Wave number, m}^{-1} \]
\[ p = \text{Acoustics pressure, Pa} \]
\[ p_{\text{inc}}, p_{\text{sc}} = \text{Incident, scattered pressure, Pa} \]
\[ R = \text{Reduced Resistance} \]
\[ V = \text{Acoustics velocity, m.s}^{-1} \]
\[ x_1, x_2, x_3 = \text{Spatial coordinates, m} \]
\[ Z = \text{Reduced Impedance} \]
\[ Z_{\text{cav}}, Z_{\text{res}} = \text{Impedance of the cavity, of the resistive sheet} \]
\[ \lambda = \text{Wavelength, m} \]
\[ \sigma = \text{Porosity (POA), } \% \]
\[ \nu = \text{Kinematic viscosity, m}^2\text{s}^{-1} \]
\[ \rho_0 = \text{Air density, kg.m}^{-3} \]
\[ \Sigma = \text{Rigid surface} \]
\[ \Sigma', \Sigma'' = \text{Interfaces between holes and Euler domain} \]
\[ \omega = 2\pi f = \text{Wave pulsation, s}^{-1} \]

I. Introduction

I. Noise represents half of Aircraft Noise at both landing and take-off conditions. This noise source is mainly reduced thanks to Acoustic treatments installed inside nacelle inlet and bypass ducts. These treatments allow decreasing the overall Aircraft Perceived Noise Level by 4 to 5 dB at take-off and 2 dB at approach. In the last decades, Airbus invested a lot in the development of nacelle low noise technologies and associated optimisation.

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