Time-domain broadband impedance model for computational aeroacoustics: application to shock-wave propagation in lined intakes

Soutenance de thèse – Loris CASADEI
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Devant le jury composé de :

Gwénaël GABARD
Sofiane KHELLADI
Éric LAMBALLAIS
Damiano CASALINO
Didier DRAGNA
Estelle PIOT
Hugues DENIAU
Thomas NODÉ-LANGLOIS
Cyril POLACSEK (Membre invité)
Yves DETANDT (Membre invité)

Résumé :

Rotor shock noise is one of the main noise sources of today's aircraft engines in take-off and climb flight conditions. The control and reduction of this noise source is of paramount importance for aircraft manufacturers for complying international regulations and improve passengers comfort. High fidelity simulation tools are required for its study, with inclusion of all 3D geometric and flow effects as well as the modelling of the acoustic treatments incorporated in the walls of the engine intake. Euler and Navier-Stokes solvers offer solutions to compute the nonlinear propagation of the high amplitude pressure fluctuations of the rotor shocks in the intake. However, modelling acoustic liners in these solvers remains a challenge of current state-of-the-art numerical acoustics, due to their natural belonging to the frequency domain. The present work focuses on the validation and extension of the Time-Domain Impedance Boundary Condition (TDIBC) based on the Oscillo-Diffusive Representation (ODR) and its implementation in an industrial CFD solver. The ODR already proved to be a powerful mathematical tool to translate the impedance (or scattering) operator in the time-domain. A numerical development in a Navier-Stokes Characteristic Boundary Condition (NSCBC) formalism allowed the implementation of this time-domain model in the finite-volume Navier-Stokes solver elsA. Validations of this methodology are carried out against acoustic benchmarks from the literature and industrial experimental measurements. They all demonstrated that the novel TDIBC is correctly implemented in the CFD solver and proved its efficiency in terms of computational time and numerical stability. Finally, an application to the propagation and attenuation of rotor shock waves in an aircraft engine intake is proposed.

Mots clés :

Time-domain impedance boundary condition, Oscillo-Diffusive Representation, Aircraft noise, Acoustic liner, Duct acoustics, Nonlinear propagation, Acoustic boundary condition, Buzz-Saw Noise, Computational Fluid Dynamics (CFD), Navier-Stokes Characteristic Boundary Condition (NSCBC).