Effects of inlet/outlet boundary conditions on acoustic behaviour of a swirled burner

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Abstract :

Large Eddy Simulation LES has become today an important tool for the simulation and posteriori analysis of turbulent flows. Within the field of acoustics, LES offers the best promise in the foreseeable future for the estimation of noise in both open and closed systems in flows at Reynolds Numbers of interest. In aeroacoustics, LES plays an important roll in the study of aerodynamical generated noise of numerous practical cases that can go from air jets, airfoils or landing gears in an aircraft to the rear-view mirror of a car or the fan of a wind mill. Thermoacoustics is, on the contrary, less understood than aeroacoustics. This is due to the different physical phenomena implied such as the addition of unsteady combustion and heat release to the already turbulent flow. However, until today LES has been successfully applied in numerical simulations of partially premixed and non-premixed open flames [1], as well as in more complex cases such as gas turbine combustors [2]

Computational techniques for the estimation of sound can be classified into two broad categories : direct computation and indirect, or hybrid, computation. LES is well presented in these two categories. Direct computation resolves the flow field together with the sound radiation. A compressible LES code is therefore required in addition to high-resolution numerical schemes in order to minimize both dispersion and dissipation. Moreover, the computational domain must be large enough to include the sources of noise as well as part of the acoustic near field [3]. Especially in thermoacoustics, very expensive computational costs can arise : in order to solve the problem of compressible multicomponent reactive flows, the transport equation of each species have to be considered.

This article describes the procedure of the evaluation of noise due to combustion of a swirling premixed combustor [5] performing a LES computation. AVBP, developed by CERFACS, is the numerical tool utilzed for the LES numerical simulations [4]. In this code, the spatial discretization is based on the finite volume method with a cell-vertex approach, combined to a numerical scheme derived from the Lax-Wendroff scheme. Time is explicitly discretized by means of the Runge-Kutta scheme. The experimental study on the test rig is carried out in the laboratory EM2C (École Centrale Paris). The combustor consists in two identical geometrical stages for air-fuel injection, a premixer and a plenum chamber. The flame is controlled by the Fuel-Air ratio imposed in each of the two stages and stabilized by swirling in the premixer.

Self-excited acoustic oscillations are also studied in addition to combustion noise. Inlet acoustic impedance is measured experimentally and the sensibility of cavity acoustic mode frequencies to the inlet and outlet boundary conditions is investigated numerically by the use of an Helmholtz solver. Strong effect of the inlet impedance is observed on the frequencies of the acoustic cavity modes.

Mots clefs : **Large-eddy Simulation, Combustion Noise**

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