IMPLEMENTATION OF THE PERMEABLE SURFACE TECHNIQUE FOR AN AEROACOUSTICAL HYBRID METHOD

Julien Christophe , Belgium
Supervisors: J. Anthoine & P. Rambaud

The objective of this research was to continue and validate the development of an acoustic post-processing module for CFD computation dealing with the permeable surface technique. The numerical investigation of the aerodynamic noise sources is treated using an hybrid method consisting in two different steps :

- Around the noise source, the dynamic quantities (flow field) are obtained from a CFD computation performed using the commercial code FLUENT.
- In the far field, the sound radiation is computed using the Kirchoff-Ffowcs-Williams and Hawkings (KFWH) integral method. This aeroacoustical analogy allows to predict the noise produced by all the sources of sound (monopole, dipole and quadrupole) enclosed inside a permeable control surface. This method is implemented as a post-processing module in the general solver FLUENT through a User Defined Function (UDF).

The acoustic module can be used in its impermeable version, implemented last year, by placing the control surface on a rigid solid body, taking then into account only the sound produced by solid surfaces immersed in an unsteady flow field, namely the dipole source. This impermeable module has been used this year to investigate the convergence of noise predictions (obtained after 50 integral time scales, see figure 1(c) for a complex case of a wing placed inside a round turbulent jet (Re_D=36000, Ma=0.04) simulated with LES computation. The coherent structures impinging on the wing are shown in figure 1(a). The directivity of the Sound Pressure Level (SPL) is illustrated in figure 1(b), showing the null region in the vicinity of ± 90 degrees (typical of the acoustic radiation of a dipole) and the good agreement between the impermeable acoustic module of FLUENT (bullet) and the VKI implemented acoustic module (plain line).

The permeable version of the acoustic module has been fully developed this year by implementing all the surface terms of the KFWH integral method. This version has been investigated on a transversally oscillating sphere reproducing a pure dipole, the flow being computed with an incompressible inviscid solver. Figure 2(a) illustrates the corresponding instantaneous pressure field and figure 2(b) the directivity pattern related to a pure dipole. The influence of the permeable control surface position has been investigated (figure 2(c)) and has revealed that, depending on the frequency, holes appear where the control surface can't be placed (around *r/?*=0.85$) without having leakages in noise prediction. The holes presence and position have been analysed through the influence of different parameters : the viscosity, the length of the computational domain, the shape of the control surface and the mesh refinement. Because these holes can't be removed, a tool has been developed to place correctly the control surface : this one must be placed before 0.7 wavelength from the source of sound to have noise prediction with a maximum deviation of 4 dB (figure 2(c)).

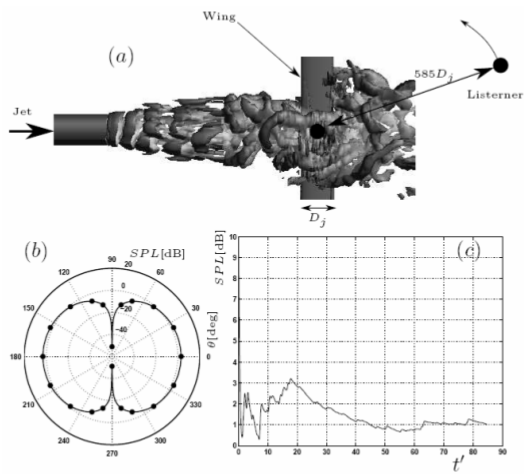

Figure 1: Impermeable technique: Coherent structures impinging on the wing (a), directivity of the SPL (b) and convergence of SPL for a angle of 0 degree (c)

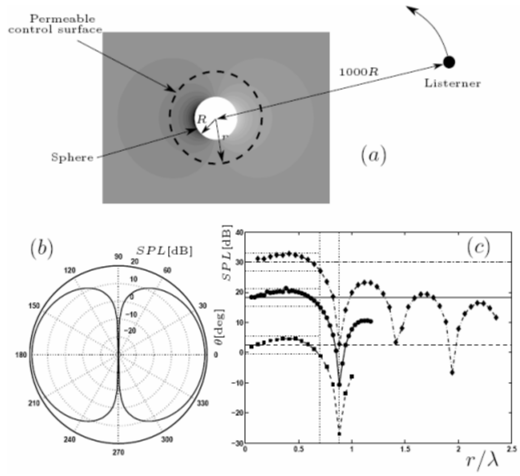

Figure 2: Permeable technique: Instantaneous pressure field for a oscillating sphere (a), directively of the corresponding SPL (b) and evolution of the SPL with the control surface position (c)