NUMERICAL SIMULATION OF AERODYNAMIC NOISE IN LOW MACH NUMBER FLOWS

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The evaluation of the noise produced by flows has reached a high level of importance in the past years. The physics surrounding flow-induced noise is quite complex and sensitive to various flow conditions like temperature, shape. Empirical models were built in the past for some special geometries but they cannot be used in a general case for a shape optimization for instance. Experimental aeroacoustic facilities represent the main tool for acoustic analyses of flow fields, but are quite expensive because extreme care must be exercised not to introduce acoustic perturbations in the flow (silent facilities). These tools allow a good analysis of the physical phenomena responsible for noise generation in the flow by a comparison of the noise sources and the flow characteristics (pressure, turbulence,...). Nevertheless, the identification and location of noise sources to compare with flow structures requires quite complex methods.

The numerical approach complements the experimental one in the sense that the flow characteristics are deeply analyzed where experiments suggest noise production. For the numerical approach, the turbulence modeling is quite important. In the past, some models were appreciated for their good prediction of some aerodynamic parameters as lift and drag for instance. The challenge is now to tune these models for a correct prediction of the noise sources. In the low subsonic range, the flow field is completely decoupled from acoustics, and noise sources can be computed from a purely hydrodynamic simulation before this information is transferred to an acoustical solver which will compute the acoustic field at the listener position. This post processing of the aerodynamic results is not obvious since it can introduce non-physical noise into the solution.

This project considers the aspect of noise generation in turbulent jets and especially the noise generated by vortex pairing, as it occurs for instance in jet flows (see example shown on figure 1, computed using the SFELES code (http://www.sfeles.org)). The axisymmetric version of the flow solver SFELES has been part of this PhD research, and numerical results obtained on the jet are similar to the experimental values of C. Schram (former PhD at von Karman Institute). Analyses performed on the numerical results are interesting to go to complete turbulence modeling for aeroacoustics since vortex pairing is one of the basic acoustical processes in vortex dynamics.

The commercial software ACTRAN delivered by Free Field Technologies company is used for the computation of sound propagation inside the acoustic domain. Results on jet flow simulations show the pertinence of hybrid CAA approach for low Mach number applications. The combination SFELES/ACTRAN shows a nice agreement between experimental and published literature results. In particular, the amplitude of the sound as well as the directivity are correctly evaluated for jet flow. Correct directivity is a challenge for jet flow CAA simulations since these require particular techniques to remove the spurious sound due to the unavoidable spatial truncation of the acoustic source field. These results are presented in the PhD thesis entitled “Numerical Simulation of aerodynamic noise in low Mach number flows”

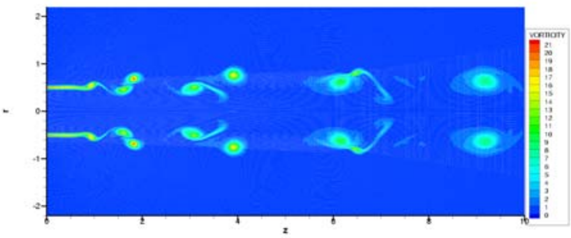

Figure 1 : Module of vorticity vector in a plane for a Re=14000 jet flow simulation