APPLICATION OF HYBRID METHODS TO HIGH FREQUENCY AEROACOUSTICS

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Nowadays, flow-generated sound is a serious problem in many engineering applications, from transport industry (noise emitted by landing gear, wings and high-lift devices in aeronautical applications or sound produced by cooling fans in automotive industry) to wind turbines noise. Among computational techniques available in literature, indirect methods (hybrid methods) to estimate the radiated noise in the acoustic far-field have proved their interest compared to direct methods (in which the flow and sound fields are computed altogether). In such hybrid methods, the computation of the flow is decoupled from the computation of the sound: a) firstly, near the noise source, the flow field is obtained from an unsteady computation reproducing the more energetic contents of the turbulent flow; b) secondly, the acoustic source radiation is computed in the far-field by the use of an analogy. This methodology is based on the substitution of the real flow by equivalent sources, computed as post-processing of the flow data. At the end, the total computational cost to obtain the acoustic field is highly reduced by using an hybrid method than a direct method when both high Reynolds number and low Mach number are considered.

Although hybrid methods have proved their efficiency for low Helmholtz numbers – i.e. compact source regions, this work proposes to explore the numerical accuracy of the CFD modeling required to obtain good acoustic predictions and limitations of hybrid methods for higher frequencies and to develop new acoustic techniques based on hybrid methods to reach these higher frequencies. This study encompasses two important aspects. On one side, we consider the optimisation of important parameters of the CFD modeling with regard to the frequency range of application and computational cost. On the other side, non-compactness must be taken into account in the prediction of the acoustic field (diffraction effects), which is usually not the case with conventional hybrid methods. This is considered through development and optimisation of interface methodologies between flow computation and acoustic simulation.

This study proposes to investigate two cases related to two different major sources of noise : 1) the interaction of an infinite span airfoil placed in the turbulent region of a round jet (Figure 1) related to interaction noise produced by the impact of coherent structures on the leading edge, 2) a infinite span controlled-diffusion airfoil placed in a uniform flow (Figure 2) related to trailing edge noise produced by the scattering of the boundary layer disturbances at the trailing edge. On both cases, the limitations of the hybrid methods are investigated through the source modelisation (mesh influence, LES subgrid models,…) and the acoustic propagation. Furthermore, specific methods (Amiet’s theory, Ffowcs-Williams and Hall analogy) taking into account explicitly diffraction effects and being then high frequency oriented are investigated and developed. The combination of those two kinds of methods shows the possibility to predict correctly the sound propagated in the far-field for the entire frequency spectrum, the classical analogies being limited and used for the low frequency range while specific methods are used to complete the high frequency part of the noise spectrum.

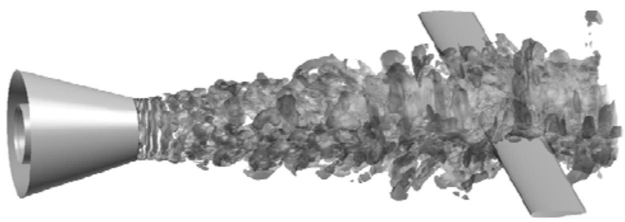

Figure 1: Instantaneous flow field of the jet-airfoil interaction case, coherent structures visualized Q=30000 colored by velocity amplitude

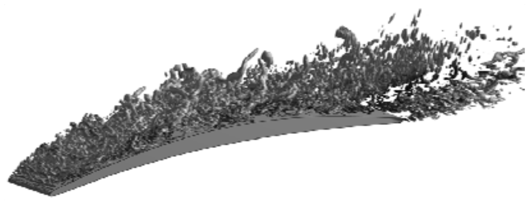

Figure 2: Instantaneous flow field around a CD-airfoil at 15° of angle of attack in uniform flow, coherent structures visualized Q=1000 colored by velocity amplitude