SENSITIVITY ANALYSIS OF ANALYTICAL MODELS FOR THE PREDICTION OF TRAILING-EDGE NOISE

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Airfoil self noise occurs when an airfoil is placed in a disturbed or uniform and steady fluid flow. As in most aeroacoustic noise generation situations, noise is generated by flow unsteadiness. In the case of airfoil self noise, it is the interaction of flow unsteadiness, in form of fluid turbulence, with the airfoil surface leading to broadband noise. Though less painful than tonal noise, broadband noise is a matter of great interest in technologies that utilize airfoils and airfoil-like shapes. It may become the major contribution either because tonal noise is hidden due to its low level, or because tonal noise escapes the range of human hearing. Moreover broadband noise is the only remaining contribution for surfaces in non accelerated motion, such as structures in the wind.

There are mainly two broadband noise-generating mechanisms, namely the interaction with upstream turbulence, the *turbulence-interaction noise*, involving the breakdown of oncoming vortices on the leading edge of the airfoil, and the boundary-layer turbulence scattering at the trailing edge, referred as *trailing-edge* (TE) *noise*. Turbulent eddies are formed within the boundary layer and it is the interaction of these eddies with the TE that generates broadband aerodynamic noise. In acoustic terms, the edge presents itself as a sharp impedance discontinuity, scattering acoustic waves generated by fluid turbulence and creates an intensified radiated acoustic field.

The focus of the present work in on TE noise generation and its prediction. Calculating TE noise is made difficult due to the complexity of the noise source, which is a turbulent flow. Numerical approaches based on direct simulations or hybrid techniques are aimed at understanding the tiniest details of the sound generating mechanism. This is achieved at a price of time-consuming computations. On the other side, analytical methods, based on acoustic analogy and wave scattering theory, are not devoted to reproducing the details of noise generating mechanisms, but rather to provide acceptable order of magnitude of the generated sound with fast and inexpensive calculations. They provide the right trends and scaling laws which are needed for the assesment of low-noise airfoil design.

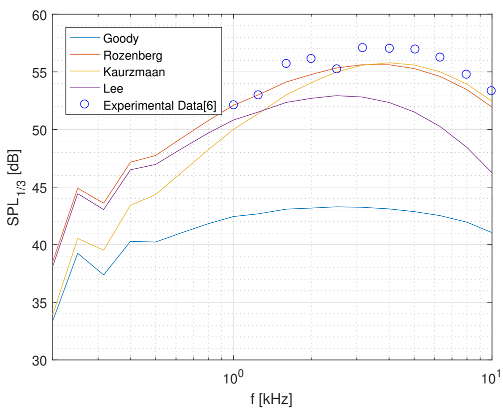

Figure 1. Pressure spectrum (NACA0012 airfoil, $\alpha = 0\,deg, U_\infty = 71.3\,m/s$)

The TE noise radiated by aNACA0012 airfoil, at zero incidence, is studied. The mean turbulent flow past the airfoil is calculated solving the Reynolds Averaged Navier-Stokes equations with the Spalart-Allmaras turbulence model. The boundary-layer thickness at the TE, an empirical wall pressure spectral density and the correlation length, calculated introducing the Corcos hypothesis, as function of the frequency, are the inputs for the analytical models describing the acoustic radiation.

The most popular models, proposed in the literature, are compared. Namely the models of Amiet [1], Goody [2], Rozenberg [7], Kamruzzaman [5] and Lee [3]. The predicted pressure spectra are compared with the experimental data [6, 4] in Figure 1.

A sensitivity analysis will be carried out in order to understand how the output of each acoustic model is influenced by the boundary-layer parameters predicted by the RANS simulations. In particular, a Monte Carlo method will be adopted to estimate the uncertainty propagation for the different analytical models.

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