Influence of Turbulence Modeling on Airfoil Unsteady Simulations of Broadband Noise Sources

In the process of simulating the trailing edge noise of an airfoil, performing the unsteady simulations of these broadband noise sources cheaply and accurately remains a major challenge. In the present study, two different fine turbulent unsteady simulations are tested on a thin controlled diffusion airfoil at low speed and low angle of attack. The flow conditions correspond to a recent aeroacoustic experiment run in the large ECL anechoic open-jet wind-tunnel for which detailed wall pressure and wake velocity measurements are available at the same time as the far field acoustic sound. The first turbulence model used is a Large Eddy Simulation with the standard Smagorinsky sub-grid scale model, the second one is a k--based Detached Eddy Simulation with the same sub-grid scale model. In order to stick with our objective of a simulation on a single fast PC workstation, several grid refinements in all directions have also been tested. The present final topology has up to six different grid levels. The major flow features are captured by the Large Eddy Simulation and the mean flow quantities compare favorably with the measurements. Significant differences are observed with the Detached Eddy Simulation which fails to capture the experimental short laminar separation bubble at the leading edge and consequently misses the transition point. The Large Eddy Simulation overpredicts the size of this separation bubble and the use of the MARS scheme necessary for stability reason on all the grids tested,also prevented a good prediction of the wall pressure fluctuations close to the trailing edge and therefore consequent noise predictions. This study therefore stresses the high sensitivity of such simulations of low speed transitional flows over thin airfoils.

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