LARGE EDDY SIMULATION OF THE SOURCE DIAGNOSTIC TEST TURBOFAN FOR BROADBAND NOISE PREDICTION

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Long Abstract

Extended abstract

The present study focuses on the SDT fan rig of the NASA Glenn Research Center which provides detailed aerodynamic and acoustic measurements, and has been used as a benchmark for turbofan broadband noise prediction [1-3]. The focus is put on the approach condition and the full model with nacelle, fan and Outlet Guiding Vanes (OGV) is simulated (Fig.1).

A detailed analysis of the mean and statistics of the turbulent flow is first performed on RANS and Large Eddy Simulation (LES) results of the fan-outlet guide vane stage. The RANS simulations are performed with the commercial code Ansys CFX and serve as initial solutions to the unstructured LES turbomachinery code TurboAVBP that couples with a Chimera method two instances of the basic LES solver AVBP jointly developed by Cerfacs and IFP-EN [4].

A good agreement with experiments is observed for both simulations, although the LES provides better results in the tip regions where large coherent structures appear. The shape of the wakes is also better predicted by LES yielding better wake parameters and more realistic impact on the downstream OGV. The transition to turbulence is also very different in the LES (Fig.2).

A Dynamic Mode Decomposition analysis of the LES unsteady results gives insights on the boundary layer development along the rotor blade span. The rotor-wake turbulence properties responsible for the main contribution to the stage broadband noise are also analyzed and compared with analytical models used to feed broadband noise models including both cascade and duct modes.

Finally, the acoustic is investigated using both Ffowcs Williams & Hawking's and Goldstein's analogies from the recorded LES noise sources. It provides levels close to the measurements although the results are influenced by too coherent rotor tip secondary flow.

Figure 1. Source Diagnostic Test test rig at NASA Glenn Low Speed Wind Tunnel

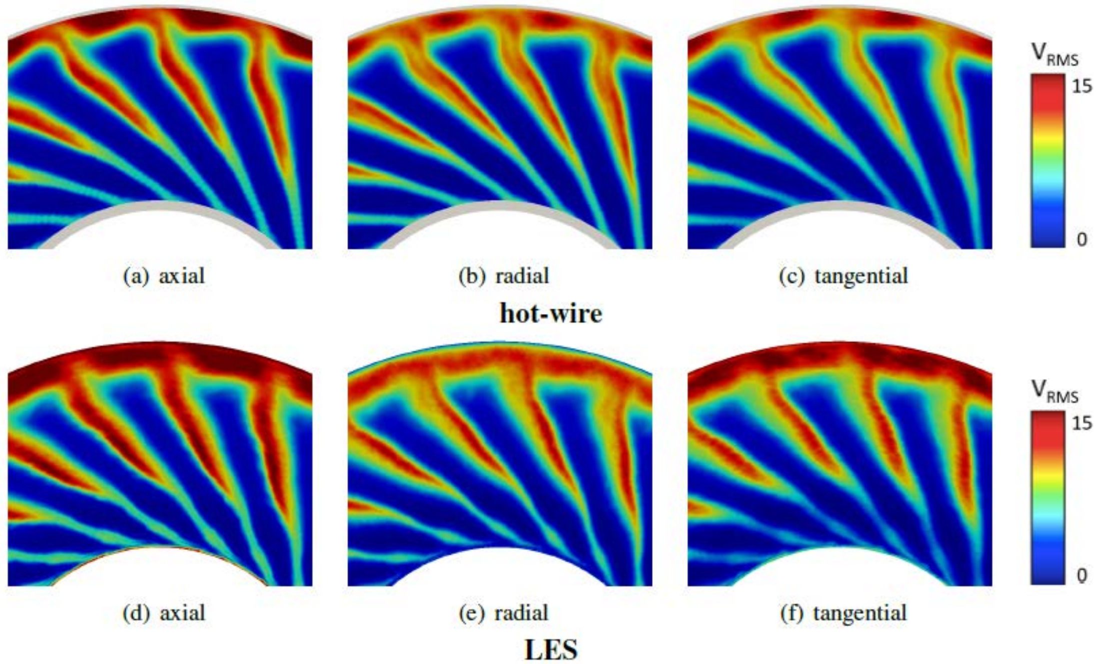

Figure 2. Three components of RMS velocity on an axial plane at mid-distance between rotor trailing edge and stator leading edge. Top: hot-wire measurements, bottom: LES

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