Sixth HRLM Symposium, 26-28 September 2016, Strasbourg University, France

Session:

Assessment of Scale-Resolving Simulations for Turbomachinery Applications

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The accurate representation of turbulence in turbomachinery CFD is of ever-increasing importance. Owing to the fact that even the most elaborate RANS models fail to accurately predict unsteady phenomena such as tip-gap vortices, corner separation and stall, and with the deficiencies of URANS in mind, the attention is turned towards scale-resolving methods such as the hybrid DES and SAS as well as the classic LES approaches.

Various scale-resolving methods are available in the DLR solver for turbomachinery applications, TRACE, comprising DES/DDES/IDDES based on the Wilcox and Menter SST k-ω models, SAS-SST k-ω and LES with Smagorinsky and WALE subgrid-scale models. Furthermore, a variety of RANS models ranging from the Spalart-Allmaras one-equation to the elaborate Hanjalic-Jakirlic Reynolds-stress model are available for comparison. TRACE is a compressible hybrid multi-block finite-volume solver which has been developed for over 20 years to meet the special requirements of turbomachinery applications [1].

Three test cases are presented. The first case is a circular cylinder in a square channel at Re=140,000, for which detailed measurements and simulation results exist (see e.g. [2]). Comparisons are presented for RANS vs. URANS vs. SRS. The second case is the classic 2D streamwise-periodic channel with one wall having hill-shaped features [3], for which DES is compared to LES with and without wall functions. Finally, a low-speed compressor cascade at M=0.07 and Re=400,000, for which extensive measurements are available and which has been thoroughly investigated in a RANS context by the authors [4] is considered, see Figure 1. The low-aspect ratio cascade consists of GE Rotor B section blades with a tip gap size of 1.66% of the blade height. LDV measurements are available in the tip gap [5], whereas the passage flow was investigated with a hot wire probe [6]. The numerical investigation in this study focusses on the assessment of the ability of scale-resolving methods to improve the deficiencies found in the RANS predictions as reported in [4], where the improved representation of turbulent quantities would only partially lead to equally pronounced improvements in the mean velocity components.

Session:

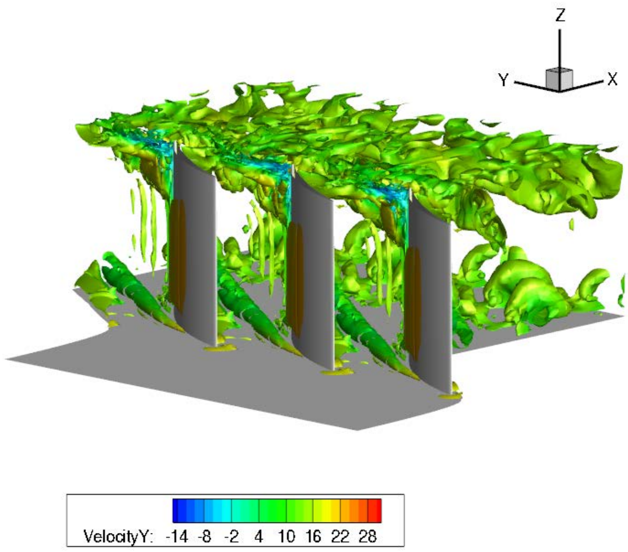

Fig. 1 Q-criterion iso-contours of a DDES of the low-speed compressor cascade (top sidewall removed for clarity)

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