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Session:

Development of Alternative Shielding Functions for Detached Eddy Simulations

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Abstract

In the original formulation of DES97, the switching from RANS to LES was purely defined by the grid. If not carefully designed, guaranteeing that the filter width is larger than the boundary layer thickness, the detrimental invasion of LES leads to the well known model stress depletion problem and eventually to grid induced separation. In order to overcome the strong sensitivity on the grid, Delayed DES (DDES) was designed and is to date considered as the state of the art derivate for external aerodynamic problems.

The increasing computational power renders the employment of finer and finer grids possible. It could be shown by Ashton [1] and Menter [2] that the shielding function of DDES, which should protect the boundary layer from LES intrusion, collapses under grid refinement. This problem was already observed on moderately fine grids in conjunction with dynamically and highly loaded boundary layers [3]. A proprietary solution was developed by Menter [2] to eliminate any grid dependence on the RANS/LES interface.

In this paper the development of alternative shielding functions is presented for the DES module of the block-structured finite volume solver FLOWer [4]. The main requirements on the shielding are a grid independent shielding of attached boundary layers in combination with a self-destruction under resolved turbulent content as well as an entirely local formulation. For the basic purpose of the shielding - detecting the boundary layer edge - two different approaches were examined. The first is based on a local formulation of the Bernoulli principle, whereas the second employs the information of the wall normal velocity gradient. For destruction of the shielding under turbulent content, high pass filtering and velocity gradient operators are implemented.

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The final paper provides details on the model formulation and shows the application to canonical test cases (see Fig.1), as well as to a stalled airfoil with strong trailing edge separation (see Fig.2).

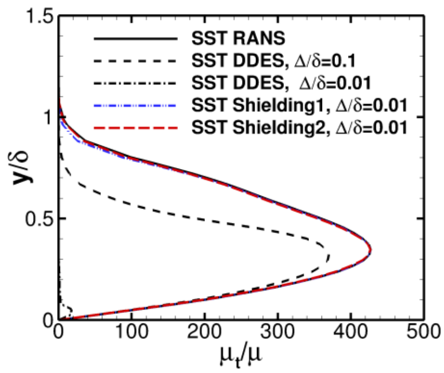

Figure 1: Eddy-viscosity ratio in a flat-plate boundary layer for different grid spacing to boundary-layer height ratios. Comparison of RANS, DDES and new shieldings

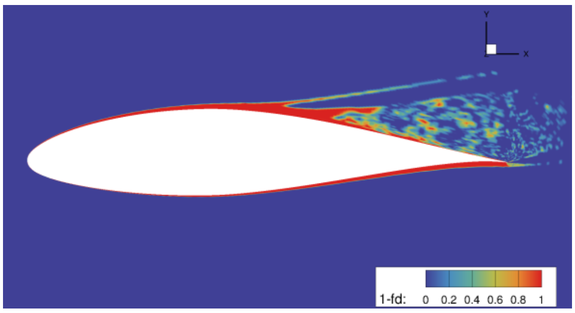

Figure 2: Application of the new shielding function to a stalled airfoil

References

[1] Ashton, Neil, Alastair West, and Fred Mendonça. "Flow Dynamics Past a 30P30N Three-Element Airfoil Using Improved Delayed Detached-Eddy Simulation." *AIAA Journal* (2016): 3657-3667.

[2] Menter, F. "Stress-Blended Eddy Simulation (SBES)—A New Paradigm in Hybrid RANS-LES Modeling." *Symposium on Hybrid RANS-LES Methods*. Springer, Cham, 2016.

[3] Letzgus, Johannes, et al. "Numerical investigations of Dynamic Stall on a Rotor with Cyclic Pitch Control." (2017).

[4] Weihing, Pascal, et al. "Hybrid RANS/LES Capabilities of the Flow Solver FLOWer—Application to Flow Around Wind Turbines." *Symposium on Hybrid RANS-LES Methods*. Springer, Cham, 2016.