A zonal RANS/LES method for rotor-stator wakes

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To meet the societal demand for environmentally friendly technology, stationary and flight gas turbines require further efficiency control development. Numerical simulations provide valuable insight into the complex unsteady turbulent flow fields at high Reynolds numbers. However, the simulation of such complex flow problems is challenging even with current computing capabilities. Reynolds-averaged Navier-Stokes (RANS) models offer reduced computational cost due to lower resolution requirements. However, these models are not well suited for unsteady flows often present in separated flows.

A promising method to efficiently simulate separated flows is the zonal RANS/LES concept, which promises to provide accurate results at reduced computational cost. These methods use turbulence-resolving LES in regions where resolutions beyond the integral length scale are necessary which are, e.g., embedded in a RANS region. The main challenge lies in the RANS-LES coupling which has to ensure a smooth transition between non-turbulence and turbulence-resolved domains.

In this work, a wall-parallel RANS/LES interface formulation is presented for rotor-stator wake flows. The interface allows an exiting and entering mass flux over the surface determined by the surrounding RANS domain. This ensures the correct mass flux in the embedded LES domain. This interface is coupled with wall-normal inflow and outflow boundaries of the embedded LES domain resulting in a further reduction of the size of the embedded LES domain. First, the zonal RANS/LES method is used to simulate the separating flow of a periodic hill. The reformulated synthetic turbulence generation (RSTG) by Roidl et al. [1] is used at the upstream RANS-to-LES interface to reconstruct the turbulent kinetic energy at the inflow of the embedded LES domain. At the outflow of the embedded LES domain, the zonal interface fomulated by König et al.[2] is used which is reformulated as a characteristic boundary condition. Second, a generic rotor-stator interaction is simulated.

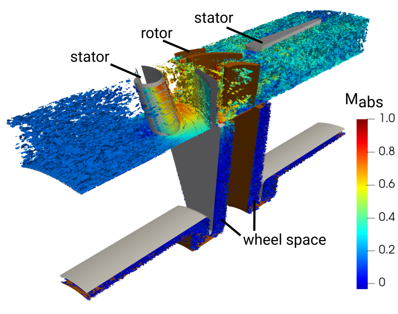

Figure 1: Vortex structures of the Q criterion colored with the absolute Mach number for an 1.5-stage axial turbine.

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[1]Roidl et al., *Computers & Fluids* **67**,1 (2011).

[2]König et al., *Journal of Turbulence* **11**,7 (2010).