Hybrid simulation of high-Reynolds number flows relying on variational multiscale model

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The proposed communication presents an investigation which is motivated by the simulation of medium and high-Reynolds number (Re>10K) massively separated flows. In the present work, the spatial discretization is based on a mixed finite element/finite volume formulation on unstructured grids. The numerical dissipation of the upwind scheme is made of sixth-order space derivatives in order to limit as far as possible the interactions between numerical and subgrid scale dissipation. The turbulence model is based on a hybridization strategy which blends a variational multiscale large-eddy simulation (VMS-LES) and a RANS model. A particular attention is paid to the VMS-LES approach used in this work. The separation between the large and the small resolved scales is obtained through a variational projection operator based on spatial average on agglomerated cells [1].

The dynamic procedure (Germano) allows the adaptation of the constant of the SGS model to the spatial and temporal variation of the flow characteristics, while the VMS formulation restricts the SGS model effects to the smallest resolved scales [2]. We have found that the combination of the dynamic procedure with the VMS approach is interesting, as, for example, for the accurate prediction of turbulence intensity in wake (Figure 1a). The RANS component is a two-equation model (k-ε). The improvement brought by a Bradshaw SST-like limitation will be discussed (Figure 1b). The hybridization strategy uses a blending parameter, such that a VMS-LES simulation is applied in region where the grid resolution is fine enough to resolve a significant part of the turbulence fluctuations, while a RANS model is acting in the regions of coarse grid

resolution [3]. For instance, near the body surface, it is used under two forms, either as a statistical model for the turbulent boundary layer or as a (thinner) wall law for the LES part of the flow.

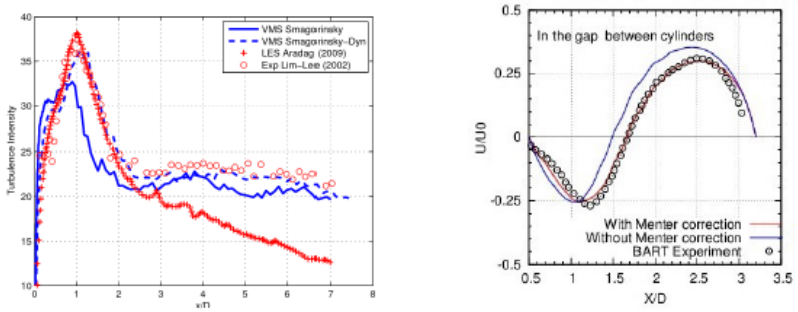

Fig. 1 (a) Improvement of turbulence intensity prediction in the wake when VMS and Dynamic are combined (cylinder at Re=20K), **(b)** improvement of velocity between two cylinders when Menter's correction is introduced (tandem cylinders at Re=166K).

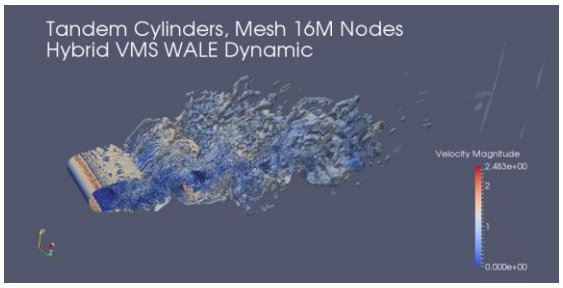

Fig. 2 Tandem cylinders at Re=166K: instantaneous iso-surfaces of Q-criterion field colored by velocity magnitude (Hybrid VMS Dynamic).

References

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