Scale-Resolving Simulations in Industrial CFD - Models and Best Practice

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ABSTRACT

Historically, industrial CFD simulations are based on the Reynolds Averaged Navier-Stokes Equations (RANS). For many decades, the only alternative to RANS was Large Eddy Simulation (LES), which has however failed to provide solutions for most flows of engineering relevance due to excessive computing power requirements for wall-bounded flows. On the other hand, RANS models have shown their strength essentially for wall-bounded flows, where the calibration according to the law-of-the-wall provides a sound foundation for further refinement. For free shear flows, the performance of RANS models is much less uniform. For this reason, hybrid models are under development , where large eddies are only resolved away from walls and the wall boundary layers are entirely covered by a RANS model (e.g. Detached Eddy Simulation – DES (6, 7) or Scale-Adaptive Simulation – SAS (2,4)). A further step is the application of a RANS model only in the innermost part of the wall boundary layer and then to switch to an LES model for the main part of the boundary layer. Such models are termed Wall Modelled LES (WMLES). Finally, for large domains, it is frequently only necessary to cover a small portion with Scale-Resolving Simulation (SRS) models, while the majority of the flow can be computed in RANS mode. In such situations, zonal or embedded LES methods are attractive (1,3). Such methods are typically not new models in the strict sense, but allow the combination of existing models/technologies in a flexible way in different zones of the simulation domain. Important elements of zonal models are interface conditions, which convert turbulence from RANS mode to resolved mode at pre-defined locations. In most cases, this is achieved by introducing synthetic turbulence based on the length and time scales from the RANS model.

The paper will provide an overview of hybrid RANS-LES methods currently used in industrial flow simulations and will evaluate the models for a variety of flow topologies. It will be shown why numerous different concepts are currently needed to cover the wide range of industrial flow simulations. The different methods will be compared from a theoretical as well as from a practical standpoint. Special attention will be devoted to the aspect of global vs. zonal approaches and aspects related to interfaces between RANS and LES zones. Numerical aspects will be included in the discussion. Numerous examples will demonstrate the best use of the available methods for different applications. Testcases will be shown for a wide range of validation and industrial flows.

The paper will include numerous simple to complex validation studies from different application areas, ranging from aerodynamics to nuclear safety. No results are included in this abstract, as the

paper will focus on the latest validation studies being currently performed – mostly as contributions to workshops on different subject areas. These simulations are still in progress.

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