11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20–25, 2014, Barcelona, Spain

TOWARDS THE SIMULATION OF TURBULENT FLOWS VIA STABILIZED FINITE ELEMENT FORMULATIONS

Jordi Cotela-Dalmau[1,*], Riccardo Rossi[1,2] and Eugenio Oñate[1,2]

[1] Centre Internacional de Mètodes Numèrics en Enginyeria (CIMNE),
c/Gran Capità s/n, Edifici C1, 08034, Barcelona, Spain.
jcotela@cimne.upc.edu,rrossi@cimne.upc.edu,onate@cimne.upc.edu,
[2] UPC BarcelonaTech, c/Gran Capità s/n, 08034, Barcelona, Spain.

Key words: *Turbulence Modelling, Variational Multiscale Method, Finite Element Method.*

The simulation of turbulent flows of practical interest is a challenging problem which has been addressed using many different methods. One family of approaches to turbulence modelling, large eddy simulation (LES) is based on the introduction of a numerical filter, which separates the solution into a large-scale, resolved part, which is simulated, and a small-scale, unresolved part, whose effect on the large-scale solution is typically modelled by introducing dissipative terms, based on physical considerations or scaling arguments. When using LES models in the context of finite element formulations, challenges arise from the difficulty of defining the filter on unstructured meshes and the presence of stabilization terms, required in finite element formulations, which introduce additional numerical dissipation.

In the case of Variational Multi-Scale (VMS) formulations [1], the scale separation is naturally introduced by the stabilization, which gives hope that new LES-like formulations for finite elements could be derived from this framework, as shown, for example, in [2] for the low Mach number equations. We investigate this possibility by performing LES simulations of the turbulent channel flow problem at Reynolds number $Re_\tau = 395$ and compare the results to existing direct numerical simulation data [3]. The dissipative properties of the method will be analysed from the study of the turbulent statistics of the flow, and compared to those obtained using classical *physics-based* LES models.

REFERENCES

[1] T. J. R. Hughes. Multiscale phenomena: Green's functions, the Dirichlet-to-Neumann formulation, subgrid scale models, bubbles and the origins of stabilized methods. *Computer Methods in Applied Mechanics and Engineering*, Vol. **127**, 387–401, 1995.

[2] R. Codina, J. Principe and M. Ávila. Finite element approximation of turbulent thermally coupled incompressible flows with numerical sub-grid scale modeling. *International Journal for Numerical Methods for Heat & Fluid Flow*, Vol. **20**, 492–516, 2010.

[3] R. D. Moser, J. Kim and N. N. Mansour. *Direct numerical simulation of turbulent channel flow up to* $Re_\tau = 590$ Physics of Fluids, Vol. **11**, 943-945, 1999.