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

On the Influence of Near-wall Grid Line Spacing on the Prediction of the Friction Resistance Coefficient

Eça L. *[1], Pereira F.S [1,2], G.Vaz[3] and M.Hoekstra [3]

[1] Instituto Superior Técnico, Av. Rovisco Pais 1, luis.eca@ist.utl.pt
[2] KSF MARIN Academy, P.O. Box 28 6700 AA Wageningen, filipemsoares@ist.utl.pt
[3] MARIN, P.O. Box 28 6700 AA Wageningen, G.Vaz@marin.nl, M.Hoekstra@marin.nl

Key Words: *Friction Resistance, Numerical Uncertainty, Grid refinement, Eddy-viscosity models.*

In many engineering applications at high Reynolds numbers, the solution of the Reynolds-Averaged Navier-Stokes (RANS) equations supplemented with eddy-viscosity turbulence models is still common practice. In some of these applications, the challenge is no longer the ability to obtain a solution, but to demonstrate that the numerical accuracy of the predictions may be reduced to negligible levels. In this paper, we focus on the prediction of the friction resistance coefficient in viscous flows. Our goal is to assess the influence of the near-wall grid line spacing and grid refinement level on the numerical uncertainty of the friction resistance coefficient of two statistically steady test cases:

1. The flow over a flat plate.

2. The flow around a tanker.

The first case is a simple academic exercise that contains most of the relevant features of an external viscous flow. On the other hand, the latter flow is a standard application of Computational Fluid Dynamics (CFD) in ship hydrodynamics.

The exercise is performed for three eddy-viscosity models: the Shear-Stress Transport (SST) version of the two-equation k-ω model [1]; the Spalart & Allmaras one-equation model [2] and the $k-\sqrt{k}L$ two-equation model [3]. The SST model as an awkward boundary condition at the wall (ω goes to infinity), whereas the other two models have all turbulence quantities equal to zero at the wall.

Two significantly different in-house codes (ReFRESCO and PARNASSOS) are used to perform grid refinement studies with sets of grids that contain the same number of cells, but different near-wall grid line spacing. The data available allows a reliable estimation of the numerical uncertainty of the predicted friction resistance coefficients. The results obtained with the two codes exhibit similar trends. It is clear that the turbulence model has a significant influence on the numerical uncertainty of the friction resistance prediction. When the grids are not too coarse, the near-wall grid line spacing is the most important parameter for the accuracy of the friction resistance prediction with the SST model. On the other hand, the other two models do not exhibit such dependence on the near-wall grid line spacing.

The present exercise represents one more example of the fundamental role of Solution Verification in CFD. A similar exercise performed with single grid calculations could lead to totally misleading conclusions.

REFERENCES

[1] Menter FR. Two-equation eddy-viscosity turbulence models for engineering applications. *AIAA Journal* 1994; Vol. 32 :1598–1605.

[2] Spalart PR, Allmaras SR. A one-equation turbulence model for aerodynamic flows. *AIAA 30th Aerospace Sciences Meeting*, Reno, January 1992.

[3] Menter FR, Egorov Y, Rusch D. Steady and unsteady flow modelling using the $k-\sqrt{kL}$ model. *Turbulence Heat and Mass Transfer*, *ICHMT*, vol. 5, Dubrovnik, Croatia, 2006.