VI International Conference on Adaptive Modeling and Simulation
ADMOS 2013
J. P. Moitinho de Almeida, P. Díez, C. Tiago and N. Parés (Eds)

DIRECT FEM-SIMULATION OF TURBULENT FLOW

J. HOFFMAN, J. JANSSON, N. JANSSON, R. VILELA DE ABREU and CLAES JOHNSON

Computer Science and Communication, KTH, SE-10044 Stockholm, Sweden.

Abstract. Turbulent fluid flow has been considered as the main unsolved problem of classical mechanics beyond theoretical description and also beyond computational simulation, because of thin no-slip boundary layers requiring trillions of mesh points to be resolved. In recent work we have discovered that using a slip boundary condition as a model of the small skin friction of slightly viscous turbulent flow, allows predictive simulation of mean value quantities such as drag and lift of turbulent flow with instead millions of mesh points. Basic aspects of turbulent flow from applications point of view thus show to be computable by stabilized finite element methods without turbulence modeling referred to as Direct FEM-Simulation, which opens large areas for exploration. As a key example the turbulent flow around a wing and complete airplane is computable and inspecting the solutions leads to a new theory flight essentially different from the accepted theory by Kutta-Zhukovsky-Prandtl developed 100 years ago.

REFERENCES

[1] J. Hoffman, J. Janson and C. Johnson, New Theory of Flight, submitted to J. Math Fluid Mech.

[2] J. Hoffman and C. Johnson, Computational Turbulent Incompressible Flow, Springer 2008.

[3] N. Jansson, J. Hoffman, J. Jansson, Framework for Massively Parallel Adaptive Finite Element Computational Fluid Dynamics on Tetrahedral Meshes, SIAM J. Sci. Comput., Vol. 34(1), pp. C24-C41, 2012.

[4] J. Hoffman, J. Jansson and R. Vilela De Abreu, Adaptive modeling of turbulent flow with residual based turbulent kinetic energy dissipation, Computer Methods in Applied Mechanics and Engineering, Vol.200(37-40), pp.2758-2767, 2011.

[5] J.Hoffman, J.Jansson, M.Stckli, Unified continuum modeling of fluid-structure interaction, Mathematical Models and Methods in Applied Sciences, Vol.21(3), pp.491-513, 2011.

[6] J.Hoffman and N.Jansson, A computational study of turbulent flow separation for a circular cylinder using skin friction boundary conditions, Quality in Large Eddy Simulation II, ERCOFTAC Series Vol.16, Springer, 2011.