11th. World Congress on Computational Mechanics (WCCM2014)
5th. European Conference on Computational Mechanics (ECCM V)
6th. European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

DIFFERENTIAL REYNOLDS STRESS MODELING FOR SEPARATING FLOWS IN INDUSTRIAL AERODYNAMICS

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Key words: Turbulence, Reynolds stress modeling, flow separation.

ABSTRACT

The methods of Computational Fluid Mechanics have been so successful that there are visions for future aircraft design almost entirely relying on numerical simulation data. This requires reliable simulations not only for the design point, but also for off-design conditions. In particular at the borders of flight these are characterised by various types of flow separation.

Unfortunately, the accurate prediction of flow separation is one of the most difficult tasks in Computational Fluid Dynamics (CFD), where the treatment of turbulence appears to be the crucial point. In principle, scale resolving methods, like Direct Numerical Simulation (DNS) or Large Eddy Simulation (LES), should be able to handle the phenomenon correctly. However, the associated effort increases rapidly with the Reynolds number, making such techniques unsuitable for application in aircraft design for the next decades.

In contrast, modelling approaches based on the Reynolds-averaged Navier-Stokes (RANS) equations do not have any limitation concerning the Reynolds number. For this reason they are currently the backbone of CFD methods for engineering applications. In particular, so-called eddy-viscosity models (EVM), modelling the effects of turbulence simply by a flow-dependent increase in viscosity, have contributed to the success of CFD methods and are, therefore, in widespread use. Nevertheless, EVMs have shown to lack the required accuracy for predicting flows with separation, due to their relative simplicity.

Improvement is expected by so-called differential Reynolds stress models (DRSM), employing individual transport equations for the turbulent stress components instead of assuming an eddy-viscosity. This approach correctly represents the production of turbulence and allows accounting for the anisotropy of the turbulent normal stresses near walls. It has shown to be applicable to industrial problems of high geometrical complexity, while increasing the computational requirements only moderately.

The Minisymposium addresses recent progress in the development of DRSMs, focussing on the prediction of separating flows that are relevant for industrial problems in aerodynamics. This includes pressure-induced trailing-edge as well as shock-induced and corner flow separation.