The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

ON THE ALGEBRAIC MODIFICATIONS OF TRADITIONAL TURBULENCE MODELS TO PREDICT BY-PASS AND SEPARAION-INDUCED TRANSITION

Alessandro Colombo[1], Andrea Crivellini[2], Antonio Ghidoni[3], Alessandra Nigro[2] and Gianmaria Noventa[3]

[1] University of Bergamo, Department of Engineering and Applied Sciences, Viale Marconi 5, 24044 Dalmine (BG), Italy

[2] Marche Polytechnic University, Department of Industrial Engineering and Mathematical Science, via Brecce Bianche 12, 60131, Ancona, Italy

[3] University of Brescia, Department of Mechanical and Industrial Engineering, via Branze 36, 25123 Brescia, Italy

Key Words: *discontinuous Galerkin, RANS equations, Transition models*

Many reliable and robust turbulence models are nowadays available for the Reynolds Average Navier-Stokes (RANS) equations to accurately simulate a wide range of engineering flows. However, turbulence models are not able to correctly predict flow phenomena with low to moderate Reynolds numbers, which are characterized by strong transitions. Laminar-turbulent transition is common in aerospace, turbomachinery, maritime, automotive, and cooling applications. Therefore, numerical models able to accurately predict transitional flows are mandatory to overcome the limits of turbulence models for the efficient design of many industrial applications.

A modified version of the $k - \widetilde{\omega}$ [1] and Spalart-Allmaras [2] turbulence model is proposed in order to predict transition due to the by-pass and separation-induced modes. The modifications here proposed are based on the $\gamma k - \omega$ by Holman and Furst [3] and the SA-BCM by Cakmakcioglu et al. [4]. Both the models are correlation-based algebraic transition models that relies on local flow information and include an intermittency function instead of an intermittency equation. The basic idea behind the models is that, instead of writing a transport equation for intermittency, an intermittency function multiplies the production terms of the classical formulation of the turbulence models. In particular, the turbulence production is damped until it satisfies some transition onset requirements.

The proposed models are implemented in a high-order discontinuous Galerkin (DG) solver and validated on different transitional benchmark cases from the ERCOFTAC suite, with by-pass (T3A, T3A- and T3B) and separation-induced (T3Lx) transition.

REFERENCES

[1] Bassi F. and Botti L. and Colombo A. and Crivellini A. and De Bartolo C. and Franchina N. and Ghidoni A. and Rebay S., *Time integration in the discontinuous Galerkin code MIGALE - steady proble*ms, Notes on Numerical Fluid Mechanics and Multidisciplinary Design, Springer International Publishing (2015).

[2] *Spalart, P. R. and Allmaras, S. R., A One-Equation Turbulence Model for Aerodynamic Flows, AIAA Paper (1992).*

[3] Holman J. and Furst J., *Numerical simulation of separation induced laminar to turbulent transition over an airfoil,* J. Comput. Appl. Math. 394 (2021).

[4] Samet C. Cakmakcioglu and Onur Bas and Riccardo Mura and Unver Kaynak, *A Revised One-Equation Transitional Model for External Aerodynamics*, AIAA AVIATION 2020 FORUM, 10.2514/6.2020-2706 (2020).