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# Airfoil prediction at high Reynolds numbers using CFD

Niels N. Sørensen[a], Frederik Zahle[a]

In connection with the newest generation of wind turbines with sizes above 10 MW and the future turbines that are already now being designed, several new challenges must be faced. From an aerodynamic perspective the two most obvious issues are the increase of the Reynolds numbers (Re) with increasing size and the possibility of increased Mach numbers in the tip region. While the Mach numbers can be controlled and kept sufficiently low by specific design choices, the increase of the Re with size is difficult to avoid. For the combination of high Re and low Mach numbers, the available measurements are very sparse and one will need to address and extrapolate the aerodynamic effects of high Re by modelling, as the experimental approach become prohibitive expensive in this range. In connection with the ongoing EU projects INNWIND and AVATAR, these activities are already addressed on a European level with a moderate effort on the experimental side and the main focus on the computational perspective.

In the present paper we investigate the capability of state of the art CFD models to handle airfoil aerodynamics at high Re, with specific focus on correct predictions of the transition process for incompressible flow. The investigations are based on the multi-block incompressible flow solver EllipSys2D, developed at DTU Wind Energy[1,2], based on the pressure correction method using Rhie-Chow[3] approach on a non-staggered grid. The turbulence is modelled using the k-omega SST model by Menter[4] while the transition process is model with either the correlation based model of Menter et al.[5] or the $E^n$ model as suggested by Drela and Giles[6] and originally implemented in EllipSys by Michelsen[7].

In the present work it will be demonstrated how the correlation based transition model, that has previously been shown to work well for a series of wind turbine aerodynamic cases at moderate Re[8] over-predicts the viscous drag due to premature transition at high Re caused by the limitations of the empirical correlation functions inherent to the model. In contrast it is demonstrated how the more fundamental $E^n$ model is capable of predicting transition in better agreement with available measurements for the full range of Re, and additionally is capable of predicting the correct drag trend with increasing Re.

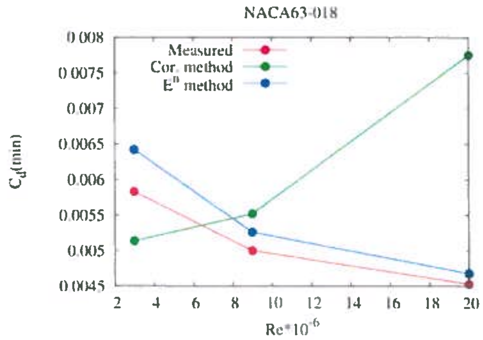


**Figure 1. Variation of the minimum drag with increasing Reynolds number for the NACA 63-018 airfoil.**

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