Implementation and validation of $\gamma - Re_{\theta t}$ transition model in OpenFOAM

Introduction

Laminar-turbulent transition phenomenon occurs often in many different applications, such as in gas turbine engine, helicopter blades and wind turbines. Based on different flow mechanism, normally transition is categorized as natural transition, bypass transition and separation induced transition. Figure 1 illustrates the natural transition process from laminar to turbulence. The effects of transition influence the wall shear stress, heat transfer, separation behavior in the boundary layer, and even overall aerodynamic performance.

One challenge in CFD modeling for wind turbine aerodynamics is to consider transition effect in the RANS (Reynolds-averaged Navier Stokes) simulations. By applying transition model, the aerodynamic characteristics (L/D) of 2D wind turbine airfoils can be predicted more accurately at the design process, see Figure 2. Moreover, more boundary layer flow physics can be investigated, which cannot be obtained by traditional fully turbulence models. Some researchers also found the transition model improves significantly the torque prediction in wind turbine flows involving separation.

OpenFOAM, an open source CFD code, solves the Navier-Stokes equations in the finite volume approach. This code is written in C++ language, easy to customize. This code is used widely in the areas of engineering and science.

![Figure 1: The natural transition process (Schlichting, 1979)](image1)

![Figure 2: Lift prediction with and without transition model](image2)

Objective

The objective of this project is to implement and validate a $\gamma - Re_{\theta t}$ transition model in OpenFOAM. This local correlation-based transition model proposed recently by Langtry et al. solves intermittency equation ($\gamma$) and transition onset Reynolds number equations ($Re_{\theta t}$) in addition to the SST $k-\omega$ turbulence model. First of all, this implemented transition model is to be validated with simple test cases. After that, it can be validated and used for two dimensional wind turbine airfoil flows.

Requirement

- Experience with C++ language programming

References
