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[Extended Abstract]

3D RANS Simulation of NREL Phase-VI and MEXICO Wind Turbines

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Introduction

In the recent years, efforts have been given to perform experimental investigations on wind turbine models to facilitate a database for better understanding the aerodynamic effects of the different design aspects, and benchmark testing of the numerical model of wind turbine flow simulations. The authors present the result of 3D RANS simulations of two test cases, namely the Phase-VI [1] of NREL's measurement campaign conducted under the (Unsteady Aerodynamic Experiments) UAE, and the EU project (Modelled Experiments in Controlled Conditions) MEXICO [2] under the IEA Wind Task 29, Mexnext phase III. The commercial software FINE™/Turbo is used for this purpose. The results from the simulations are compared to the measurement data available from the experimental investigations. The results will serve as a benchmark test for the numerical code, and will allow a better understanding of the development of flow field structures along the radial positions, specially near the tip region of the blade, thus facilitating improved design philosophies.

Computational Test Case NREL Phase-VI

For the first test case, the NREL Phase-VI wind turbine is simulated with help of the commercial software FINE™/Turbo. The computational domain is defined to cover 10 times the blade radius along both the upstream and the downstream directions, and 5 times the blade radius along the radial direction. Owing to the blade periodicity, and the omission of the tower, one blade passage is simulated covering 180° in the circumferential direction. The computational domain is discretized using 3.6×10^6 cells. Steady state viscous simulations are carried out using $k-\epsilon$ turbulence model. The simulation time was over 7.5 hours using Linux based IBM PC with dual Intel Core i7 990X CPU and 16 GB RAM.
The comparisons of the coefficient of pressure c_P distribution along the airfoil sections at different radial positions are depicted in figure 1. The experimental results are depicted in red, and the results from the numerical simulations are depicted in blue. The comparisons attest the effectiveness of the simulation software in reproducing the results from the experiment. There is however clearly visible difference between the simulation and the experimental results

along the inboard section. This can be caused by the fact that the hub profile of the NREL Phase-VI was not modeled in the simulation.

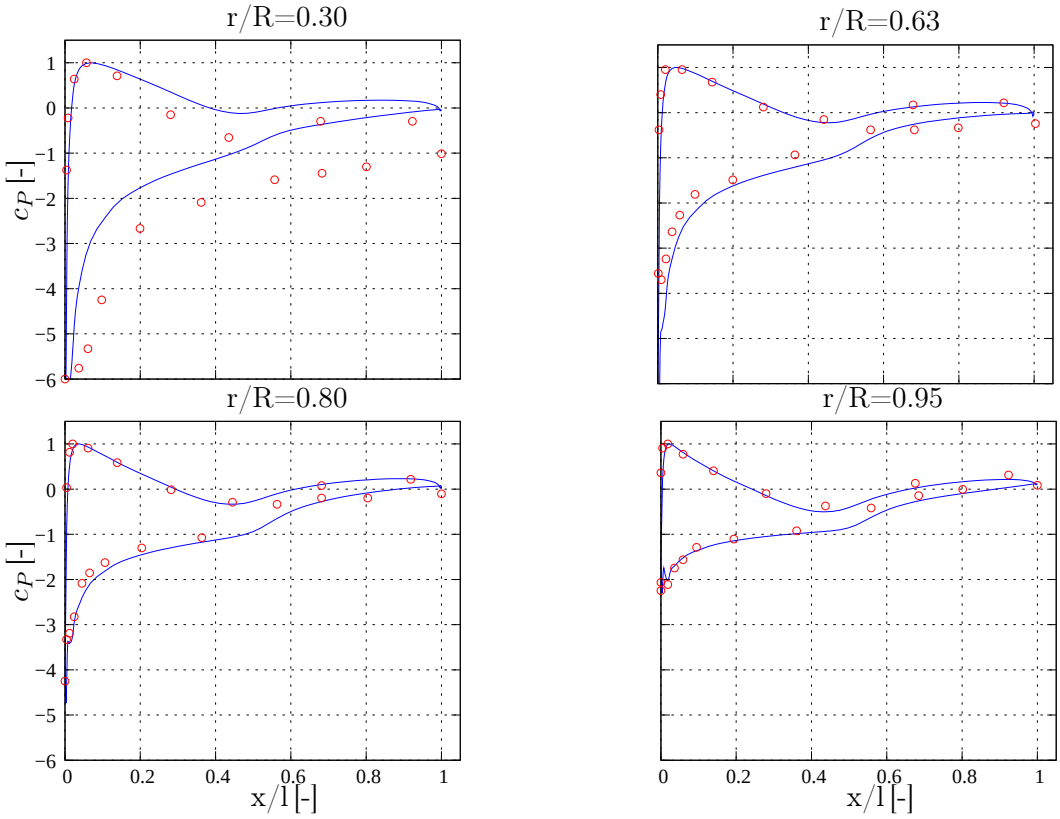

Figure 1. Comparison of c_p distribution for inflow velocity of 10.1 m/s [3]

The radial distributions of the normal force coefficient c_N is depicted in figure 2. The comparison mirrors the tendency observed in figure 1. The simulation results differ from the experimental results for the inner section of the blade. In fact, the flow was observed to be separated for the mid-span section during the experimental investigations, which could not be reproduced in the simulations.

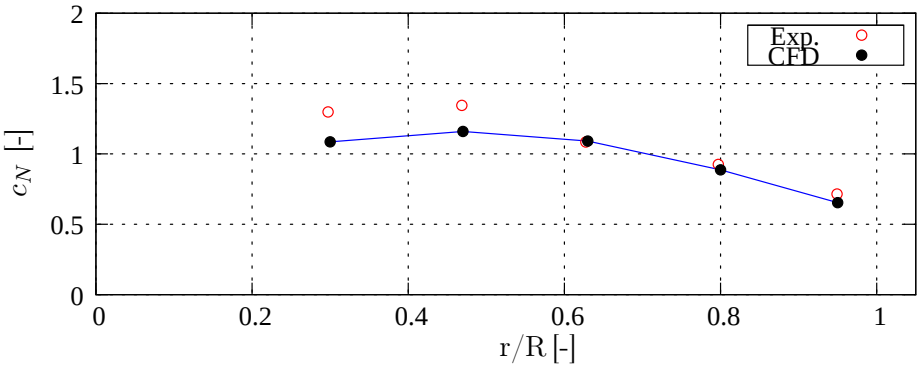

Figure 2. Comparison of radial distribution of c_N for inflow velocity of 10.1 m/s [3]

Further Works

Based on the results obtained so far, it is planned for a reiteration of the numerical effort for the NREL Phase-VI wind turbine with a more plausible hub section to obtain a better radial distribution of the flow field. Furthermore, the simulation of the MEXICO wind turbine is under pre-processing, and will be included in the final paper.

References

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