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Session:

Detached-eddy simulation of a horizontal axis wind turbine

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Introduction

Wind energy is one of the most promising alternative renewable energy sources to fossil fuel energy. Small wind turbines, that can be integrated in urban areas, have gained interest recently. To analyse performance of the wind turbines, numerical simulations are often carried out using Reynolds averaged Navier-Stokes (RANS) simulations. However, RANS simulations do not give instantaneous information about the flow that can be further used for other analysis such as aeroacoustic predictions. Massive separation and flow around blunt bodies also cannot be correctly predicted by RANS models due to non-local effects. Because of its high computational cost, fully resolved large-eddy simulation (LES) is also not yet practical for wind turbine design purposes. On the other hand, detached-eddy simulation (DES), a hybrid LES-RANS model which is computationally much less expensive than LES, has been proven to be a reliable tool for aerodynamic simulations [1] and particularly for wind turbine applications and noise predictions [2,3].

In this study, as part of the EU FP7 SWIP project, we assess the performance of a 4KW wind turbine using the improved delayed DES (IDDES) [4] approach. The wind turbine has three blades with a radius of 3(m). It operates at a rotational speed of 128 (rpm). Cross sections of the

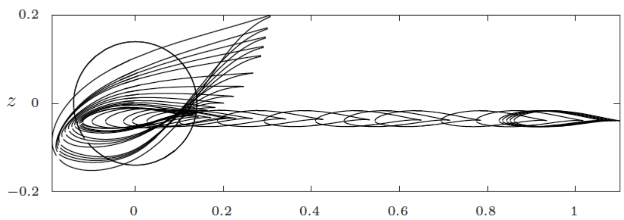

Fig. 1 Cross-

blade are give in Fig.1. The inflow velocity is 8(m/s). Simulations are carried out with and without turbulence content at the inlet to investigate the inflow turbulence effects on the aerodynamic performance of the blades.

Session:

Results

Contour plots of instantaneous vorticity magnitude at a vertical section and iso-surfaces of Q-criterion are given in Fig. 2. Figure shows the large vortical structures formed behind the turbine, which are convected further down stream. It highlights the trailing edge separation and the corresponding vortical structures. It also shows that the eddy-viscosity to kinematic viscosity ratio is less than 50. Other flow statistics, visualizations and a comparison between the two inflow cases will be presented and discussed.

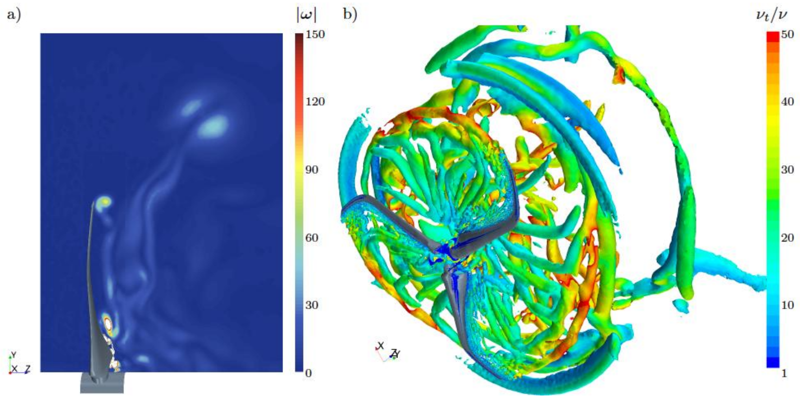

Fig. 2 Contour plot of instantaneous vorticity magnitude (a) and iso-surfaces of Q-criterion (b), coloured by the ratio of turbulent eddy- and kinematic viscosity.

References

[1] Spalart, P. (2009) Detached-eddy simulation. Ann. Rev. Fluid Mech., 41:181-202.

[2] Johansen, J., Sorensen, N, Michelsen, J.A. and Schreck, S. (2002) Detached-eddy simulation of flow around the NREL phase-VI blade, ASME wind energy symposium, American society of mechanical engineers, pp.106-114.

[3] Rasam, A., Botha J.D.M., Bolin, K., O'Reilly, J.O. Efraimsson, G. and Rice, H.J (2016) Aerodynamic noise prediction for a wind turbine using numerical flow simulations and semi-empirical modelling approaches. 22nd AIAA/CEAS Aeroacoustics conference. No. 2846.

[4] Shur, M.L, Spalart P.R., Strelets, M.Kh. and Travin A.K. (2008) A hybrid RANS-LES approach with delayed-DES and wall-modelled LES capabilities. Intl. J. Heat & Fluid Flow, 29, pp. 1638-1649.