Benchmarking of non-linear wake interaction of eddy viscosity model

Uzunoglu, B.; Hansen, Kurt Schaldemose; Ivanell, S.

Publication date:
2012

BENCHMARKING OF NON-LINEAR WAKE INTERACTION OF EDDY VISCOSITY MODEL

B.Uzunoglu, K.Hansen and S.Ivanell

Gotland University,
Cramergatan 3 621 57 Visby, Sweden
e-mail: bahri.uzunoglu@hgo.se
e-mail: stefan.ivanell@hgo.se

†Department of Wind Energy
Technical University of Denmark
Nils Koppels Alle Building 403, room 218
2800 Kgs. Lyngby Denmark
e-mail: kuhan@dtu.dk

Key words: Eddy Viscosity Model, Nonlinear Wake, Lidar, Reduced

Abstract. *Modelling of wake losses is an important part of the production estimation for wind farms. The eddy viscosity model is widely adapted by industry for wind farm wake calculations and energy output predictions* [1]*. Their practical implementations for linear wind resource grid generation tools and their ability to provide better accuracy in non-linear terms and turbulence terms* [1,2,3,4] *created easy market penetration. As a result, the eddy viscosity wake models and their variants have found wide spread application in commercial wind farm design softwares.*

Compared to algebraic wake models, eddy viscosity model has intermediate complexity in physics. The referred model can be derived by simplification of Reynolds Averaged Navier-Stokes equations. This derivation reduces the complexity of the model compared to full CFD models [5]*. The eddy viscosity model is derived by employing velocity deficit field using the thin shear layer approximation in axi-symmetric coordinates.*

The eddy viscosity model's wake comparison has been limited to either CFD results comparison or to wind tunnel tests to this day [2,14]*. By introduction of more advanced spatial measurements techniques such as Lidar, it is now possible to have more detailed field comparison and validation to actual wind turbine measurements recently* [1]*.*

In this work, eddy-viscosity will be benchmarked to non-linear models such as actuator disc model in two turbine settings and to recently available Lidar data [1]*. This gives us further insight into the application envelope of the eddy viscosity model. The impact of different parameters on velocity deficit and turbulence approaches will be investigated. Power deficit as a function of ambient turbulence intensity will be validated. The impact of central speed deficit created by shadowing will be implemented to initial profile*[1]*.*

REFERENCES

[1] The impact of turbulence intensity and atmospheric stability on power deficits due to wind turbine wakes at Horns Rev wind farm *Wind Energy*, **Special Issue**, 2011.

[2] Windfarmer, The wind farm design software, Theory Manual (11/2006) *Garrad Hassan and Partners LTD.*.

[3] Openwind, Theoretical basis and validation Version 1.3 (04/2010) *AWSTRUEPOWER LLC*.

[4] WindPRO / PARK, Introduction to Wind Turbine Wake Modelling and Wake Generated Turbulence (04/2005) *EMD International A/S*.

[5] B.Lange, H.P.Waldi, A.G.Guerrero, D. Heinemann and R. Barthelmie Modelling of Offshore Wind Turbine Wakes with the Wind Farm Program FLaP *Wind Energy*, **37**, 87–104 (2003).

[6] J.F.Ainslie Calculating the velocity field in the wake of wind turbines. *Journal of Wind Engineering and Industrial Aerodynamics*, **27**, 213–224 (1988).

[7] S.Ivanell Numerical computation of wind turbine wakes. *PhD thesis, ISSN 0348-467X, KTH.*, (2005).

[8] F.Zou Estimation of wind energy production for Offshore wind farm. *MSc thesis, KTH.*, (2011).

[9] WindSim. History. http://windsim.com/about-windsim/history.aspx. Accessed: 2010-07-15.

[10] Windfarmer 4.1, Validation report (11/2006) *Garrad Hassan and Partners LTD.*.

[11] B.Uzunoglu Reduced modelling and controller design for boundary element discretized flow around cylinders. *PhD thesis, University of Southampton.*, (2001).

[12] C.Sanz A note on k ϵ modelling of vegetation canopy air-flows. *Boundary-Layer Meteorology*, **108**, 191-197 (2003).

[13] A.Sogachev A note on two-equation closure modelling of canopy. *Boundary-Layer Meteorology*, **130**, 423-435 (2009).

[14] B.Uzunoglu, F.Zou and S.Ivanell Benchmarking of eddy viscosity model with nonlinear wake models *CFD Optimization 2011*, **071**, 23-25 May 2011, Antalya Turkey.