Faculty Engineering Technology
Program Mechanical Engineering

UNIVERSITY OF TWENTE.

COLLOQUIUM

Group: **Engineering Fluid Dynamics**

As part of his MSc thesis assignment

G.J. Mourits

will give a presentation, entitled:

Development and Analysis of Engineering Methods for the Aerodynamic Design of Wind Turbines

Date: Friday December 12, 2014

Time: 10:00

Room: **Horst Building Room ZH-286**

Summary:
In the aerodynamic design process of wind turbines, several thousands of test cases need to be analysed. This involves for instance the evaluation of different blade geometries, wind speeds, yaw angles, inflow profiles and operational conditions. The aim of this project is to investigate, implement, compare and examine different aerodynamic methods for the application in wind turbine design. The work was performed at the CFD lab of the University of Liverpool.
The models implemented in this project involve a kinematic wake model, a blade element momentum method (BEM), a helical wake model, a Kocurek and Tangler prescribed wake model and a Free-Wake method. The required computational time associated with these methods is sufficiently small to allow the simulation of the thousands of cases within the design process of wind turbines. For the different wake models the induced velocity is determined by the Biot-Savart law regularised with a finite vortex core model. These models are coupled with a blade element method based on lifting line theory to interact between wake and rotor plane and to enable the methods to converge to a solution in which the rotor performance conforms with the wake.
The developed Free-Wake method is based on a time marching integration method. To account for the presence of the tower, the Free-Wake method is complemented with a panel method. A parameter study is performed to assess the stability and sensitivity of the method.
For the application and comparison of the different methods 5 different test cases were considered, ranging from a 4.5 m diameter wind tunnel model (MEXICO in DNW), to a proposed 206 m diameter 10 MW wind turbine design. The analyses of these rotors include comparisons with experimental data and full 3D CFD simulations. The experimental data incorporates pressure measurements at the blade surfaces, force measurements on the shaft and PIV and lidar measurements of the velocity field in the wake.
The comparison of the various methods showed that the developed Free-Wake method is capable of providing good estimations of the rotor performance and the near wake structure. The more limited but faster methods, like for instance BEM methods, were found to be able to predict the rotor loads to an acceptable level for the preliminary design stage. Furthermore it was demonstrated how ground effects, tower interference and non-uniform inflow profiles could be incorporated in these engineering methods.

Assessment committee: **Chairman,**

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Prof.dr.ir. H.W.M. Hoeijmakers (mentor)
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