ECN Wind Energy Industrial Support

EWIS

Being one of the leading institutes on wind energy research, ECN has established the new EWIS (ECN Wind Industrial Support) group in 2009 to better bring the R&D results to the market. During the last three decades, ECN has developed expertise on aerodynamics, structural analyses, turbine control, offshore operation and maintenance, and grid connection. With the growing wind industry, ECN received more requests for assistance and EWIS has become the vehicle to support the wind energy industry in their product developments.

EWIS's focus is on the high end of the market which means that we will make use of tools and knowledge that have been developed in-house and include the latest R&D results!

The EWIS team is a mixture of young professionals and experienced researchers which ensures a fast response and high quality.

More information
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Blade Optimisation Tool

The software

The ECN Blade Optimisation Tool (BOT) has been developed to study and optimise the aerodynamic performance of wind turbine rotors. The program is used to determine the optimal chord, twist and thickness distribution, the optimal pitch settings, and the optimal tip speed ratio of rotor blades. Either active pitch or passive stall regulated wind turbines, both with constant, double, or variable rotor speed can be modeled in BOT. The chord and twist distributions are optimised for maximum CP or for maximum annual energy yield for a given wind speed distribution. Constraints for chord, twist and thickness values can be applied at any radial position, which are then excluded from the optimisation process. In this way a maximum chord (for transportation purposes), an adapted twist at the tip (for noise reduction), or a prescribed thickness distribution (for the structural requirements) can be easily applied. The rotor speed and pitch angles may be specified for individual wind speeds. For non specified values, BOT automatically calculates the optimal rotor speed and pitch setting.

The model

The calculations in BOT are performed by an aerodynamic model based on the blade element - momentum theory. The aerodynamic forces on the blade elements are calculated by means of two dimensional characteristics (lift and drag) for stationary axi-symmetric flow conditions. The lift and drag coefficients for the chosen airfoils need to be supplied by the user. For this purpose another ECN-tool, the Aerodynamic Table Generator (ATG), may be applied. For each element the aerodynamic coefficients are interpolated to the local airfoil thickness and to the current Reynolds number. From the BEM equations a system of two non-linear equations for the axial and tangential induction factors are solved by an iterative Newton-Raphson method. A polynomial extrapolation method is used to improve the rate of convergence significantly. In the optimisation process, the optimal chord and twist values are found by successively narrowing the range of values (golden section search).

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Specifications

Description of software:	- BOT.xls (Excel 2003 workbook) - User manual
Designated sites:	single user
Licence fee:	€ 8.000,--
Licence term:	unlimited use
Services:	one day technical and software support (by telephone and/or e-mail, not on-site)
Maintenance services:	not applicable
Additional options:	one day training in aerodynamic wind turbine rotor design given by ECN experts

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Two corrections to the blade element - momentum theory are implemented in BOT. The correction method of Snel, Houwink and Bosschers is used to model 3D rotational effects and the Prandtl hub and tip-loss factor is used to account for the effect of discrete number of blades on the average induction. These corrections can be turned off. As a function of the wind speed, the following output parameters are stored in a table:

- power (mechanic and electric)
- pitch angle
- rotor speed
- tip speed ratio
- power and thrust coefficient
- axial force and blade root moment

For detailed analysis of the aerodynamic performance, BOT additionally generates the following 2-dimensional tables (blade element vs. wind speed):

- torque and thrust contribution
- angle of attack
- lift and drag coefficient
- additional lift coefficient (rotational effects)
- axial and tangential induction factor
- annulus averaged induction factor (Prandtl tip-loss factor)
- circulation
- relative velocity
- local speed ratio
- Reynolds number
- number of iterations needed to find the solution of the BEM equations

The ECN Blade Optimisation Tool is implemented in an Excel 2003 workbook. The combination of input and output, including several graphs, in a single workbook makes the program very user friendly.

The Experience

ECN has sold licenses of the Blade Optimisation Tool to leading wind turbine and blade designers world wide. Although there is no need for training to get started with BOT as a typical process is explained step by step in the manual, training in aerodynamic wind turbine rotor design can be obtained at ECN.