

COLLOQUIUM

Group: Engineering Fluid Dynamics

As part of his MSc thesis assignment

Tim Antony Plattel

will give a presentation, entitled:

Exploring the Opportunities of Extended Wind Turbine Airfoil Optimiser

Date: Friday December 14, 2012

Time: 14.00

Room: Horst Building ZH286

Summary:

At present the costs of producing energy out of wind are higher than the costs of energy out of fossil sources. A method to reduce the costs of wind energy is to increase the efficiency of wind turbines. The design of the blades of a wind turbine is a multidisciplinary challenge. In blade design not only the aerodynamics is important, also disciplines like structures, noise generation and manufacturability are to be considered. In the present study the design of airfoil sections for wind turbine blades is considered.

There are two types of design method currently widely applied: indirect and direct numerical optimisation. This study presents the further development of the second type of method that resulted in the Wind Turbine Airfoil Optimiser (WTAO). The WTAO determines the optimum of an objective function, subject to constraints, employing the gradient-based optimisation algorithm SNOPT coupled to the flow solver XFOIL. XFOIL is a 2D potential flow method coupled to an integral boundary layer method. The gradients of the objective function with respect to the design variables, required for the optimisation, are evaluated by a complex-step finite-difference method. The design variables for the optimiser are a number of control points which define the airfoil geometry, here described as the camber line and the half-thickness distribution, and the angle of attack of the airfoil.

This study extended the existing WTAO by defining a new objective function and by reformulating the constraints. Furthermore, the design space consists of less design variables and reduced ranges for the design variables are specified. This resulted in a WTAO with better convergence behaviour, reduced calculation time and improved stability. These extensions enabled the design of airfoils with improved aerodynamic efficiency.

The use of the WTAO for optimising a number of airfoils has led to a better understanding of wind turbine blade optimisation. Promising results have been achieved optimising for high lift starting the optimisation with an airfoil with low lift. The present optimisation effort provided significant improvements on frequently used wind turbine airfoils. Furthermore using the WTAO, the effects of constraints on the optimisation procedure and on the final airfoil geometry have become clear. One of the main findings is that in the design space the constrained objective function contains numerous local optima. Since the gradient-based optimiser converges to a local optimum the selection of an appropriate initial airfoil and the specification of a carefully selected set of constraints are essential in achieving a substantially improved airfoil design. It is found that constraints are instrumental in defining the feasible design space and that an optimisation route in which constraints are sequentially applied, is necessary for successful optimisation.

Assessment committee:

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