Research in Aeroelasticity EFP-2007-II

This report contains results from the EFP-2007-II project "Program for Research in Applied Aeroelasticity". The main results can be summed up into the following bullets:

- 2D CFD was used to investigate tower shadow effects on both upwind and downwind turbines, and was used to validate the tower shadow models implemented in the aeroelastic code HAWC2.
- Using a streamlined tower reduces the tower shadow by 50% compared to a cylindrical tower. Similar reductions can be achieved using a four legged lattice tower.
- The application of laminar/turbulent transition in CFD computations for airfoils is demonstrated. For attached flow over thin airfoils (18%) 2D computations provide good results while a combination of Detached Eddy Simulation and laminar/ turbulent transition modeling improve the results in stalled conditions for a thick airfoil.
- The unsteady flow in the nacelle region of a wind turbine is dominated by large flow gradients caused by unsteady shedding of vortices from the root sections of the blades.
- The averaged nacelle wind speed compares well to the freestream wind speed, whereas the nacelle flow angle is highly sensitive to vertical positioning and tilt in the inflow.
- The trailing edge noise model, TNO, was implemented and validated. The results showed that the noise was not predicted accurately, but the model captured the trends and can be used in airfoil design.
- The model was implemented in the airfoil design tool AIRFOILOPT and existing airfoils can be adjusted to maintain the aerodynamic characteristics, but with reduced noise in the order of up to 3dB in total sound power level and up to 1dB with A-weighting.
- 2D CFD simulations are performed to verify their capability in predicting multi element airfoil configurations. The present computations show good agreement with measured performance from wind tunnel experiments.
- The stochastic fluctuations of the aerodynamic forces on blades in deep-stall have an insignificant effect on the risk of stallinduced vibrations predicted by quasi-steady aerodynamic models, but more realistic models of deep-stall aerodynamics must be developed to finally conclude on the real risk of stallinduced vibrations at standstill.
- Finite element analysis shows that local blade cross section deformations caused by global blade deflection do not have significant influence on the aerodynamic performance.

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