

The Royal Academy
of Engineering

Global Research Award

Unsteady effects in wind turbine aerodynamics

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Host: Institute of Turbomachinery, University of Hannover

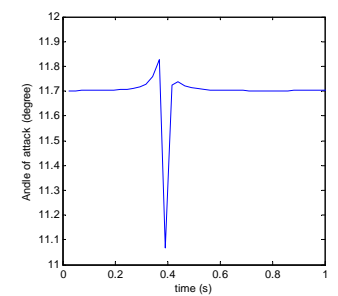


Background



Arklow Bank, Ireland
GE 3.6MW turbine

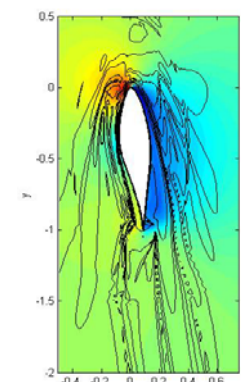
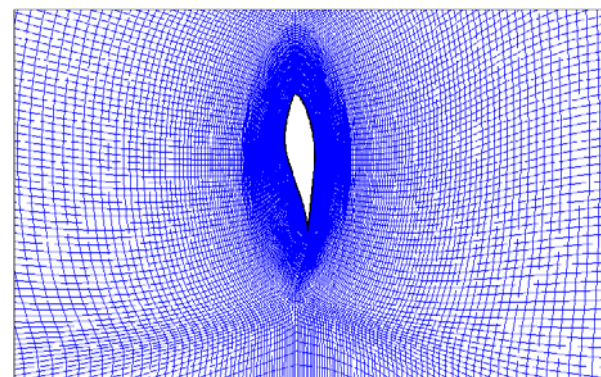
- With a rotor diameter of over 100m, new wind turbines experience very large forces due to unsteady wind conditions
- Wind turbines often operate near stall conditions and at sizes and speeds comparable with the spatial and temporal fluctuations of the wind in the atmospheric boundary layer.
- The turbine tower affects the flow upstream, which leads to a brief change in the wind speed and angle of attack.
- Such a pulse leads to sudden load fluctuations with implications for structural vibrations and material loading



Change of the angle of attack as the blade passes in front of the tower

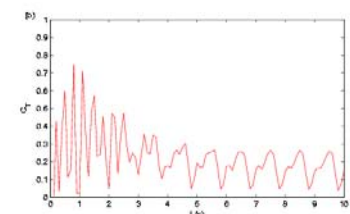
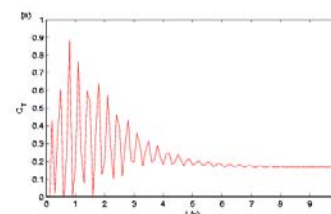
Computational modelling of tower influence

- Use of a 2D Computational Fluid Dynamics (CFD) code (Close-up of aerofoil section and mesh)
- First find solution without tower effect for a range of angle of attack
- Then prescribe time-varying boundary conditions based on ideal flow induced by down-wind turbine tower



Colour: pressure
Contours: vorticity

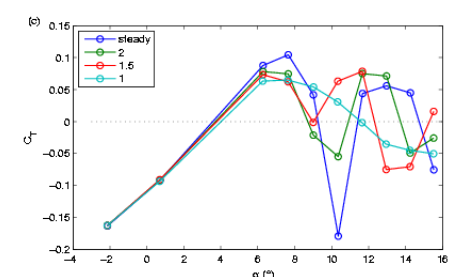
- Comparison of torque coefficient without tower (left) and with tower (right) (first 4 seconds show initial settling period)



➤ Tower effect leads to pronounced variation in torque (and therefore power output and forces on blade)

- Time averaged torque coefficient without tower and with tower at three distances between rotor and tower:

➤ The average torque coefficient is reduced by tower
➤ but stall is delayed if tower is sufficiently close



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