Large scale experimental aerodynamics – status and perspectives

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BACKGROUND

Background <u>1976-83 at Risø</u>: Wind turbine tests



DTL



In 1970'-80's NASA made wind turbine tests





In 1990's: Aerodynamic tests on rotors



- We got important knowledge about e.g. 3D effects
- Challenge
 - Measuring the inflow?
 - Too much wind
 - The weather:
 - Rain
 - Lightning

– Cost



In 2000's: More frequent use of wind tunnels





In 2009: Test on NM80 rotor (DANAERO)





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Today

Turbines are very big: Blades up to 107m length and towers up to 150m









Today Challenges

- Reynolds number (=size)
- Transition from laminar to turbulent
- Turbulence
- Increasing Mach number (=increasing tip speed)
- Stall
- Thick airfoils
- Tip shapes
- ...

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Challenges Reynolds number



1.6

Challenges Transition from laminar to turbulent + turbulence



Challenges **Increasing Mach number**







LARGE SCALE TESTS IN THE FUTURE

Test section, control room, workshops, meeting room

Large wind tunnel The Poul la Cour Tunnel

Fan, cooling surface





Large wind tunnel The different components





The fan upstream

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The contraction and screens







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Full scale wind turbine An example: DTU research wind turbine



• The turbine

-Vestas V52 (P_{rated} =850kW, D_{rotor} =52m, H_{hub} =44m)

• Sensors

- Blade and tower moments
- Power, pitch, rotational speed
- Yaw angle
- Wind speed and wind direction
- Test possibilities
 - Aerodynamics new designs, devices etc
 - Aeroelastics and control

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In between wind tunnel and rotor Rotating rig

- Aerodynamic measurements incl rotation:
 - A rotating rig (one boom forced in rotation by a motor)
 - A wing section corresponding to one to be tested in the Poul la Cour Tunnel
 - Advantage (and in the same time challenge):
 - Rotational effects
 - Atmospheric flow
 - Unsteady conditions



In between wind tunnel and rotor **Rotating rig**

 CI/Cd-aoa measured data vs wind tunnel tests









A chain of test From wind tunnel to full scale













Experiments connected to modeling



Models validated by
measurements



 Experiments analyzed by computations









Perspectives for experimental aerodynamics

- Further analysis of the transfer function from wind tunnel to rotor
- Development of measurement techniques for full scale rotors
- Develop the rotating test rig

Thank you



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