A novel full scale experimental characterization of wind turbine aero-acoustic noise sources

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Over the last 10 years DTU has worked on experimental characterization of the aero-acoustic noise sources of wind turbines. In particular the trailing edge (TE) noise; the turbulent inflow (TI) noise and the stall (ST) noise have been explored as they are the dominant noise sources for wind turbines. The basic source of all three noise types are the high frequency pressure fluctuations (HFPF) in the boundary layer on the blade. Therefore the measurement technique has been focused on measuring HFPF on 2D airfoils in wind tunnels as well as measurements carried out in the DANAERO project in 2009 [1], [2], [3] on a full scale 38.8m blade on a 2MW turbine. Due to the unsteady inflow to the blade on a turbine operating in the atmospheric boundary layer it is important to correlate the HFPF with the exact inflow to the blade section in order to characterize the noise. This has been done with five hole pitot tubes from which the inflow velocity to the blade section and the angle of attack AoA can be derived. Based on this experimental set-up it has been possible to derive the general characteristics of the above mentioned noise sources [4] and details like the mechanism and causes of amplitude modulation (AM) of noise [5] and stall noise [6].

A limitation of the previous experimental set-up has been that the noise on the ground close to the turbine has not been measured which e.g. means that it has not been possible to derive the directivity characteristics of the noise sources. Further it has not been possible in general to explore how the HFPF on the blades of a turbine correlate with the noise in the near field of the turbine. These short-comings in the previous experiments have led to a new set-up where the measurements of HFPF on the blades and the inflow measurements from a five hole pitot tube are conducted simultaneously with measurements from 8 microphones on plates on the ground as sketched in the figure below. The six surface microphones on the blades are of manufacturer G.R.A.S. and positioned at the leading edge and trailing edge, respectively. They will be glued to the blade surface. The microphones at the leading edge will be in the laminar boundary layer and will be used to characterize the HFPF linked to TI noise whereas the microphones at the trailing edge will be in the turbulent boundary layer and correlate with TE and ST noise. The turbine is a constant speed 500 kW stall regulated turbine which means the AoA will increase with increasing wind and at around 12m/s trailing edge stall will start to develop. A wide range of AoA variations will thus be available for a reasonably wind speed interval and facilitate a characterization of the noise sources in a wide range of conditions.

In the final paper the measurement set-up will be described in details and initial measurements presented.

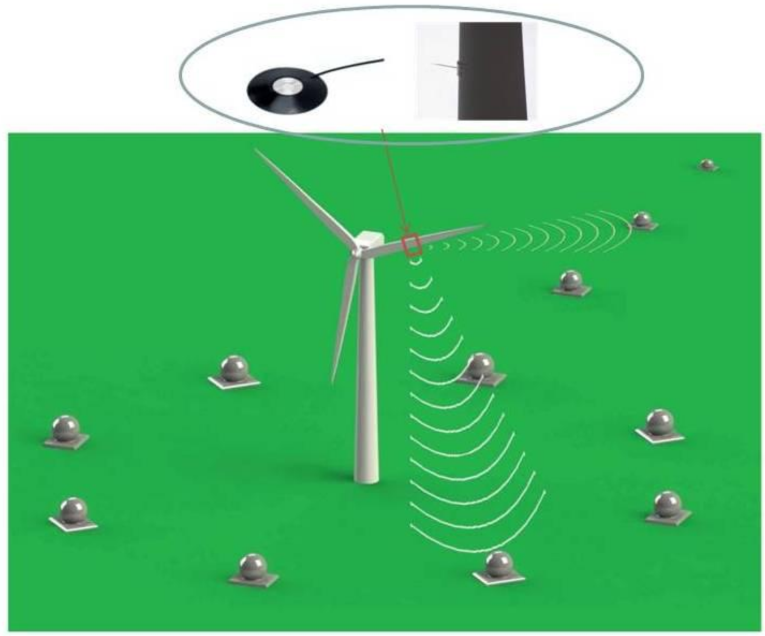

Figure 1: The experimental setup comprises a 500 kW turbine; 8 microphones on the ground in a circle around the turbine; 6 surface mounted microphones on the blade; one pitot tube on the blade and a meteorological mast.

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