Characterization of a gust generator for aerodynamic experiments: The Chopper

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Abstract

Wind turbines operate in the atmospheric boundary layer where the wind is naturally turbulent. As the turbulence is directly related to the loads acting on the turbine, turbulent conditions are taken into account when designing wind turbines. The design requirements are given by the IEC 61400-1 norm with respect to the conditions at a site, and one requirement is the turbine's survival of extreme gusts, i.e. a sudden, strong change of the wind velocity. These extreme events influence the behavior of the flow around the rotor blade. Experimental investigations on an airfoil in the wind tunnel in a controlled environment are one way to examine and understand the different aerodynamic effects. However, the generation of a strong gust in a wind tunnel is challenging. Here, a newly installed perturbation system for the generation of large velocity fluctuations, the chopper, is presented. It is installed in the aerodynamic wind tunnel of the Ecole Centrale Nantes in the Research Laboratory in Hydrodynamics, Energetics and Atmospheric Environment (LHEEA). The chopper consists of a rotating bar, the chopper blade, that cuts through the outlet of the wind tunnel with dimensions of (50 cm)2. Thus, the gust can be varied using different inflow velocities, rotational frequencies of the bar and bar widths. To characterize the gusts produced by the chopper, hot-wire measurements are conducted in the closed test section up 187 cm downstream the outlet. An array consisting of five hot-wires is used, and planes in stream-wise direction and perpendicular to the flow are measured to investigate the gust evolution. Two different rotational frequencies, 0.20 Hz and 0.02 Hz, are investigated for two chopper blades of width 10 cm and 20 cm at an inflow velocity of 25 m/s. First results show that the gust amplitude is approximately 20 m/s for a chopper blade of 20 cm width. The flow can be divided into a strongly turbulent gust and a regime where the flow recovers to its initial velocity. Looking at the gust, one can identify two scales that dominate the flow, namely the temporal duration of the gust as such and the integral length scale of the turbulence within the gust. In combination with the evolution of the mean gust velocity and the mean gust turbulence intensity, one finds that the flow field is asymmetric in the beginning but becomes more symmetric farther downstream when the gust disperses. The mean gust velocity increases downstream while the gust turbulence intensity decreases. In summary, the chopper, a perturbation system for the generation of large velocity fluctuations is characterized, and the results show the successful generation of a strong, sudden gust.

Keywords: gust genertion, turbulence

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