Aerodynamic and Aeroacoustic Prediction of Wind Turbine Rotor for a 2MW Horizontal-Axis Design under the Rated Condition

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Rotor blades are the most important component of a wind turbine to recover energy from a flowing air stream. The aerodynamic design of rotor blade not only determines the efficiency of energy conversion from the kinetic energy of incoming wind into the mechanical energy of rotating rotor, but also involves the structure requirement of rotor blades to ensure a technical operation following engineering safety. In addition, the aeroacoustics issue of rotor blade during wind turbine operation is of great importance as well, especially for those installed in the vicinity of residential areas. This paper is to investigate the aerodynamic as well as aeroacoustic performance of rotor blades under the rated condition of a 2 MW horizontal-axis wind turbine of. The continuity and momentum equations incorporated with a SST $k-\omega$ turbulence model is employed to describe the turbulent flow around the studied wind turbine with a rotor diameter of 87m and a hub height of 78 m. The flow field is computed via a numerical approach, where the dependence of rated aerodynamic loadings on blade, such as pitch moment and bending moment, as well as axial moment of rotor contributed by rotating blades, on the azimuthal angle of rotor blade is predicted. The pressure induced noise field is modelled by the Ffowcs Williams and Hawkings model, where the sound pressure is predicted using the flow and pressure fields obtained from the previous flow computation. The noise spectrum of several ground locations around the wind turbine is estimated and compared to disclose the sound pressure characteristics in the neighbourhood of wind turbine. The dependence of sampling points number on the total sound pressure is also studied to estimate the prediction error of total sound pressure caused by limited number of sampling points.

Keywords: wind turbine, rotor blade, aerodynamics, aeroacoustics