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AEROACOUSTIC SIMULATIONS OF A BLUNT TRAILING EDGE WIND TURBINE AIRFOIL

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Utilizing blunt trailing edge airfoil is an important consideration in the design of large wind turbine root blade for structural requirement. However, an efficient tonal airfoil self-noise is generated from the blunt trailing edge. In this study we demonstrate the effectiveness of semi-empirical Brooks, Pope and Marcolini (BPM) model and hybrid large eddy simulations (LES) in calculating the blunt trailing edge wind turbine noise at higher Reynolds number conditions. The finite volume code FLUENT was used with 4 million element hybrid meshes of DU97-W-300 and flatback version airfoils at a Reynolds number of 3.2 million and an angle of attack of 4 degrees. The blunt trailing edge noise is computed using Ffowcs-Williams and Hawkings equation with acoustic pressure signals obtained from hybrid LES. The predicted airfoil self-noise by the modified BPM model with a low frequency directivity function is compared to the experiments. The results show a close agreement between the hybrid LES calculations and experiments for the far-field acoustics. However, the modified BPM model shows some discrepancies at the noise peak frequency.

1. Introduction

The root blade of large wind turbine requires blunt trailing edge airfoil to meet structural requirements. The blunt trailing edge airfoil has some benefits such as structural improvement, high sectional lift coefficient and a reduction of sensitivity to leading edge surface soiling.

However, blunt trailing edge airfoil increases pressure drag and generates trailing edge vortex shedding noise. The wake of blunt trailing edge airfoil is affected by unstable pairs of counter-rotating streamwise vortices connecting the von Karman vortices. These three-dimensional instabilities are dependent on the airfoil's Reynolds number, free stream turbulence and the turbulent layer boundaries at the two ends of the blunt trailing edge of the profiled body[1]. This vortex shedding generates efficient tonal noise from the blunt trailing edge. Although aerodynamic noise radiated from wind turbines and wind farms is low compared to other community noise sources, wind turbine noise can annoy residents near wind farms[2-4].

The flow at and behind the blunt trailing edge of the body is very complex and cannot be reliably simulated by using Reynolds-averaged Navier-Stokes (RANS) models[5]. On the other hand, large eddy simulation (LES) is known as a useful tool to predict practical turbulence problems. However, when increasing the Reynolds number in the near-wall region, the number of LES grid points increases drastically and the computational effort is similar to that of a direct numerical