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Numerical Aeroacoustics Investigation of Eroded and Coated Leading Edge of NACA 64- 618 Airfoil

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Abstract : Long term surface erosion of wind turbine blades, especially at the leading edge, impairs aerodynamic performance; therefore, lowers efficiency of the blades mostly in the high-speed rotor tip regions. Blade protection provides significant improvements in annual energy production, reduces costly downtime, and protects the integrity of the blades. However, this protection still influences the aerodynamic behavior, and broadband noise caused by interaction between the impinging turbulence and blade's leading edge. This paper presents an extensive numerical aeroacoustics approach by investigating the sound power spectra of the eroded and coated NACA 64-618 wind turbine airfoil and evaluates aeroacoustics improvements after the protection procedure. Using computational fluid dynamics (CFD), different quasi 2D numerical grids were implemented and special attention was paid to the refinement of the boundary layers. The noise sources were captured and decoupled with acoustic propagation via the derived formulation of Curle's analogy implemented in OpenFOAM. Therefore, the noise spectra were compared for clean, coated and eroded profiles in the range of chord-based Reynolds number (1.6e6 ≤ Re ≤ 11.5e6). Angle of attack was zero in all cases. Verifications were conducted for the clean profile using available experimental data. Sensitivity studies for the far-field were done on different observational positions. Furthermore, beamforming studies were done simulating an Archimedean spiral microphone array for far-field noise directivity patterns. Comparing the noise spectra of the coated and eroded geometries, results show that, coating clearly improves aerodynamic and acoustic performance of the eroded airfoil.

Keywords : computational fluid dynamics, computational aeroacoustics, leading edge, OpenFOAM
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