A Numerical Analysis on the Effect of Wind Turbine Blade Erosion on Change in Performance Curve and Energy Production

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Abstract

Outboard airfoils that determine the performance of wind turbine blades have higher surface sensitivity than inboard airfoils. Outboard airfoils are easily exposed to contamination and erosion due to relatively fast angular velocity and the sensitivity of their aerodynamic characteristics to surface roughness, thereby degrading the output performance of the wind turbine and increasing load. Increases in blade diameter have led to the rapid rise of erosion, in line with rising demand for the development of onshore wind farms in low wind speed regions and large offshore wind farms. This in turn has spurred interest in improving the output performance and maintenance of wind turbines. Through studies using computational fluid dynamics (CFD) code, which boasts advantages over experimental studies in terms of time and cost due to higher reliability of numerical analysis, many researchers are presenting analysis results on the effect of wind turbine blade erosion on output performance and structural stability. However, the majority of these studies have estimated change in output performance based on analysis of airfoil cross sections without accounting for three-dimensional flow phenomena. As a result, they could not accurately predict the flow separation point. To address this limitation, this study applied the abrasion pattern of a blade discarded after 20 years of operation to a 5MW wind turbine designed for research at the National Renewable Energy Laboratory (NREL) and conducted a CFD analysis. The calculation of wind turbine output through CFD analysis demonstrated that output decreased by a maximum of 2.5% when erosion of the leading edge developed in the blade at the rated wind speed, and that estimated annual energy production decreased by a maximum of 4%.

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Keywords: *Wind turbine blade, leading edge erosion, CFD, power curve, annual energy production*

Biography

Bumsuk Kim received his PhD in mechanical engineering in 2005 from the Korea Maritime and Ocean University (KMOU).
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