Measurement and Understanding of Viscoelastic Wind Blade Erosion Coatings

Key focus: Leading Edge Erosion (LEE); Material Characterisation, and Viscoelasticity

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Background

Offshore wind turbine blades are expected to remain in operation with minimal maintenance for a service life of 25 years. However, it is now estimated that up to £1.3 million is spent on each turbine during its lifetime due to Leading Edge Erosion (LEE) from the impact of rain droplets. Erosion can be reduced by limiting blade tip speeds, but with reduced restrictions offshore, the current trend is for increasing the blade length and tip speeds to maximise the potential of wind turbine technology as a source of clean and renewable energy helping to tackle climate change. However as current polyurethane/polyurea based coating solutions for offshore wind turbines typically fail prematurely, the aerodynamic efficiency of blades is reduced, leading to significant decreases in energy capture.

Figure 1 - Example of severe erosion in an accelerated environment

Project description

This project aims to develop measurement techniques to quantify, and be used to develop understanding, of the viscoelastic response of the coatings in both accelerated Rain Erosion Testing (RET) and real wind turbine environments. Examples of this include studying the effect of high strain-rates, temperature, and recovery on material properties. Current rain erosion lifetime prediction models work generally well with homogeneous materials which undergo brittle failure. However, state-of-the-art models are incapable of accurately predicting the effect of rain erosion on the lifetime of highly viscoelastic materials which are currently being developed at industrial levels. This is due to a lack of understanding of the failure mechanisms and an inability to measure key material properties using standard methods. This work is part of a collaboration between ORE-Catapult, University of Bristol, University of Strathclyde, and two commercial coatings manufacturers; under the BLEER project which aims to further the understanding of damage mechanisms and improve current lifetime prediction models.

Research outcomes/impact

- Informing commercial coating manufactures and interested academic community of properties that influence the performance of materials used in current wind turbine leading edge protection solutions.
- Development of a suite of techniques into an overarching methodology to characterise current commercial products and compare their viscoelastic characteristics. This would allow for rapid, relevant, and cost-effective laboratory test methods for early erosion performance screening, reducing overall development time.
- Establishing a predictive capacity using lab testing and simulation to improve high-performance leading-edge rain erosion protection, using viscoelastic materials.
- Improved knowledge for designing better wind blade leading edge protection coatings, reducing erosion failure, and thus improving the current cost basis.

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