THICKNESS VARIATION EFFECT ON COMPOSITES SURFACE LAYER PROTECTION SYSTEM DUE TO RAIN EROSION DAMAGE IN WIND TURBINE BLADES

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1 General Introduction

In the immediate future, wind power will provide more electricity than any other technology from renewable and low-emission sources. There is a need to improve existing technologies, by increasing the size of offshore wind turbines to capture more wind energy. The use of composites has opened up great prospects in the design and manufacture of future wind turbine blades due to the versatility offered in the material optimization and design. Nevertheless, composites perform poorly under transverse impact (i.e., perpendicular to the reinforcement direction) and are sensitive to environmental factors such as heat, moisture, icing, salinity and/or UV. Blade manufacturers employ surface coatings to protect the composite structure from exposure to these factors.

2 Methodology

When considering the repeated impact of rain droplets, the high required tip speed is a key contributor to surface erosion damage on the leading edges of wind turbine blades. The Springer analytical model [1] has been widely referenced and validated to predict the erosion of coated materials under the previously untested material and operational conditions. The erosion lifetime prediction model has been computationally evaluated and implemented as a modelling approach to enable studies into the optimization of the coating mechanical properties. The methodology links the Springer model's lifetime prediction to the modulation of a coating's properties through analysis based on the uncertainties and induced effects of variation for a given material property (density, impedance, endurance limit, etc.). A complete map of the test conditions and material property input parameters required for the model [1, 2-4] is presented, Figure 1. In this work the analysis is developed in terms of evaluating the effect of a coating thickness layer variation due to its application process, Figure 2 and 3, on the erosion performance.

3 Results

The erosion performance depends on the interaction of the coating layers of the system and the impact / load conditions, as such, a parametric analysis was performed to examine the influence of the selected coating thicknesses on the erosion performance. This provides guidance in the selection and modulation of coating properties and should reduce the scope of testing to verify the rain erosion resistance of coating systems.
The modelling approach has then been applied to an industrial coating to determine its lifetime and the influence of the coating material configuration and testing uncertainties. Coating thickness analysis was developed with Ultrasonic measurements as the input material configuration data for the numerical modelling of erosion performance and to identify suitable coating and substrate combinations due to their acoustic matching optimization. To obtain the model inputs, mechanical tests were also performed along with erosion testing in a whirling arm rain erosion test rig until failure of the coating. The degree of uncertainty in the property measurements and rain erosion testing inputs (droplet size, impact velocity) was recorded. The framework was then used to

calculate a range in the lifetime of the coating based on the layer thickness input and to scrutinize the Springer model.

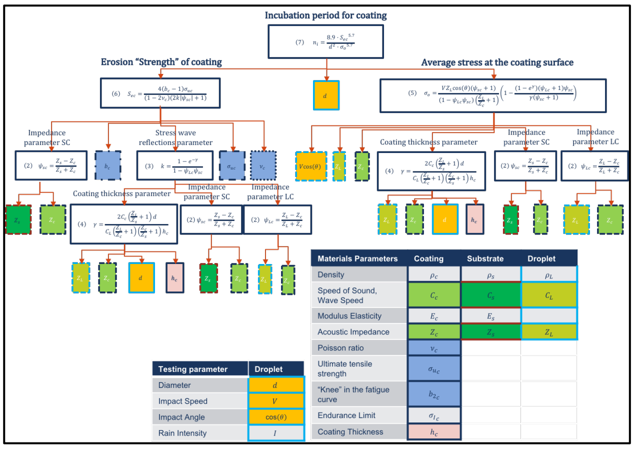

Fig.1. Diagram of material and testing parameters affecting rain erosion performance for used Springer [1] modelling.

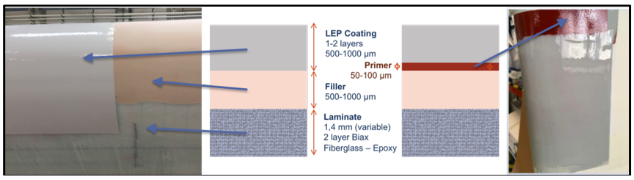

Fig.2. Leading Edge Protection (LEP) system configuration on the blade surface as a post-mould application multilayer system.

Fig.3. Leading Edge Protection (LEP) system application in field and in manufacturing plant.

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