IEA Wind Task 46

Erosion of wind turbine blades

Review and assesment of erosion damage models based on fundamental material properties and DNV-GL-RP0573

Technical report

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iea wind

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Review and assesment of erosion damage models based on fundamental material properties and DNV-GL-RP0573

Prepared for the

International Energy Agency Wind Implementing Agreement

Prepared by

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Purpose

Leading edge erosion (LEE) of wind turbine blades has been identified as a major factor in decreased wind turbine blade lifetimes and energy output over time. Accordingly, the International Energy Agency Wind Technology Collaboration Programme (IEA Wind TCP) has created the Task 46 to undertake cooperative research in the key topic of blade erosion. Participants in the task are given in Table 1.

The Task 46 under IEA Wind TCP is designed to improve understanding of the drivers of LEE, the geospatial and temporal variability in erosive events; the impact of LEE on the performance of wind plants and the cost/benefit of proposed mitigation strategies. Furthermore Task 46 seeks to increase the knowledge about erosion mechanics and the material properties at different scales, which drive the observable erosion resistance. Finally, the Task aims to identify the laboratory test setups which reproduce faithfully the failure modes observed in the field in the different protective solutions.

This report is a product of Work Package 5 Damage models based on fundamental material properties.

This report aims to describe the methodology of using the Springer model as an appropiate damage model for accumulative droplet impact erosion attending initiation of the wear damage. The report pretends also to identify its modiffied application with the DNV-GL RP0573 and its and validation with observed in-field blade inspections.

Table 1 IEA Wind Task 46 Participants.

Country	Contracting Party	Active Organizations
Belgium	The Federal Public Service of Economy, SMEs, Self-Employed and Energy	Engie
Canada	Natural Resources Canada	WEICan
Denmark	Danish Energy Agency	DTU (OA), Hempel, Ørsted A/S, PowerCurve, Siemens Gamesa Renewable Energy
Finland	Business Finland	VTT
Germany	Federal Ministry for Economic Affairs and Energy	Fraunhofer IWES, Covestro, Emil Frei (Freilacke), Nordex Energy SE, RWE, DNV, Mankiewicz, Henkel
Ireland	Sustainable Energy Authority of Ireland	South East Technology University, University of Galway, University of Limerick
Japan	New Energy and Industrial Technology Development Organization	AIST, Asahi Rubber Inc., Osaka University, Tokyo Gas Co.
Netherlands	Netherlands Enterprise Agency	TU Delft, TNO
Norway	Norwegian Water Resources and Energy Directorate	Equinor, University of Bergen, Statkraft
Spain	CIEMAT	CENER, Aerox, CEU Cardenal Herrera University, Nordex Energy Spain
United Kingdom	Offshore Renewable Energy Catapult	ORE Catapult, University of Bristol, Lancaster University, Imperial College London, Ilosta, Vestas
United States	U. S. Department of Energy	Cornell University, Sandia National Laboratories, 3M

Executive Summary

The aim and scope of the *Working Package 5 Damage models based on fundamental material properties* considers to review and apply appropriate modelling techniques and material properties characterization methods to be defined and used to understand erosion mechanics for LEP system technologies and to quantify the influence on the erosion performance. Its activity includes literature reviews and alternative or complementary studies including partner's experiences.

The report is focused on better understanding of 3 key factors: damage mechanisms, influence of material behavior, and lifetime performance analysis.

Since raindrop impact wear can be seen as a fatigue process, Springer developed a widely-cited analytical and empirical model for rain impact resistance. This model is used to predict erosion lifetime and assess blade erosion risk in relation to atmospheric conditions. It has been effectively applied to wind turbine blades under accelerated rain erosion test conditions. As a result, the industrial wind sector defined DNVGL-RP-0573, 2020 to quantify erosion lifetime, suggesting the use of lab-based rain erosion test results and DNVGL-RP-0171, 2018 to determine material strength parameters.

Quantifying erosion severity in wind turbine blades is complex due to factors like meteorology, aerodynamics, materials, and turbine dynamics. Lab testing provides initial performance data that can be extrapolated for field evaluations. This review examines the Springer model's application to estimate rain erosion in wind turbine blade protection systems and analyzes DNVGL-RP-0573's industrial use. Practical cases show that model predictions align well with in-field inspection data, validating the models with reference coating materials.

The work is compiled as a research journal paper than can be found for public dissemination in next reference:

Sánchez, Fernando and Hao, Hao and Domenech, Luis and Hardalupas, Yannis and Dyer, Kirsten and García, Víctor and Charalambides, Maria and Ibáñez-Arnal, Manuel and Sergis, Antonis and Taylor, A. M. K. P., A review and assessment of the rain erosion damage initiation of wind turbine blades leading edge protection systems based on laboratory testing data and industrial recommended practice DNVGL-RP-0573 (March 04, 2025). Available at SSRN: https://ssrn.com/abstract=5165106 or http://dx.doi.org/10.2139/ssrn.5165106