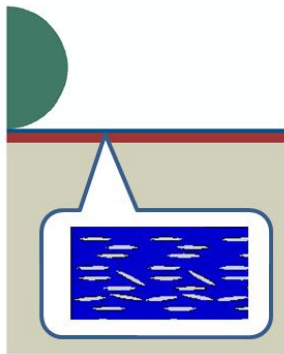




International Symposium on

Leading Edge Erosion of Wind Turbine Blades



February 4-6, 2020 Roskilde, Denmark

Organized in the framework of two Innovation Fund Denmark projects “DURALEEDGE: Durable leading edges for high tip speed wind turbine blades” and “EROSION: Wind Turbine Blade Erosion-Reducing the largest uncertainties”

Programme

Overview and Objectives

Leading edge erosion of wind turbine blades is one of rather critical problems of the wind energy development. It can lead to more than 5% reduction of annual energy production for wind turbines. The objective of this Symposium is to discuss ways to predict, control and prevent leading edge erosion of the wind turbine blades, ensuring high reliability of the wind energy generation. The Symposium will bring together experts in the areas of wind energy, meteorology, materials and coating development, aerodynamics. Further, industrial solutions and products for the wind turbine blade blade protection and testing will be presented.

The symposium is organized in the framework of the Innovation Fund Denmark (IFD) projects “*DURALEEDGE: Durable leading edges for high tip speed wind turbine blades*” and “*EROSION: Wind Turbine Blade Erosion-Reducing the largest uncertainties*”. The symposium is organized in collaboration with IEA Wind task 11, Topical expert meeting # 98 on Erosion of Wind Turbine Blades, which takes place at February 6 and 7, 2020. The symposium is also supported by US-Danish network “*Structural health monitoring and maintenance of wind turbine blades*”.

Symposium Topics

- Leading edge erosion mechanisms
- Prediction of erosion
- Meteorology
- Aerodynamics
- Solutions
- Computational modelling
- Coatings and protection
- Sensing and control

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Organizing Committee

- Kenneth Thomsen (Head of Program Materials and Structures, DTU)
- Bent F. Sørensen (Professor, Dr.techn., DTU)
- Ignacio Martí (Head of Program Offshore Wind Energy, DTU)
- Kim Branner (PhD, Senior Researcher, DTU)
- Christian Bak (PhD, Senior Researcher, DTU)
- Peggy Friis (Senior Advisor, DTU)
- Yukihiro Kusano (Senior Researcher, Dr. techn., DTU)
- Jakob I. Bech (PhD, Senior Development Engineer, DTU)

Related Projects

IFD project “DURALEEDGE: Durable leading edges for high tip speed wind turbine blades”.

The objective of the DURALEEDGE project is to improve the lifetime of wind turbine blades, and to reduce service and maintenance costs during the operation of the turbines by predicting, modelling and understanding the leading edge erosion mechanisms and by developing new highly durable protective coatings and guidelines for the coating development. Computational (finite element) micromechanical modelling of degradation protective systems of wind turbine blades will be carried out in this project, and lead to the development of new highly durable coatings. The protective systems which counteract the damage mechanisms, by toughening the material and arresting microcracks, increasing damping properties of polymers, using additional stiff and soft layers will be developed. The project began on November 1, 2019 and runs until October 30, 2021. Web: <http://www.duraledge.dk>. Partners: DTU Wind Energy, Vestas, Siemens Gamesa, LM Wind Power, Hempel AS and Covestro Deutschland.



IFD project "EROSION: Wind Turbine Blade Erosion • Reducing the largest uncertainties"

The objective of EROSION is to enable longer lifetime of wind turbine blades at multi-MW machines. The overall aim is to investigate the combined environmental conditions in the marine atmospheric boundary layer with regard to winds and precipitation in the Northern European seas where offshore wind farms are located based on novel remote sensing observations on the ground and from space and atmospheric modelling. Finally a new prototype instrument will be developed in order to measure rain at wind turbines for making decision on control, to set 'erosion safe mode' with regulation of turbines based on the assumption that lower tip speed during heavy rain event will enable much longer lifetime of wind turbine blades at multi-MW machines. Web: <http://www.rain-erosion.dk/>. The project began on April 1, 2017 and runs until December 31, 2020. Partners: DTU Wind Energy, DMI, E.On, R&D AS, Vattenfall and Vestas.



February 4, 2020

9:00- 9:30 **Registration**

OPENING SESSION

Chairman: Kenneth Thomsen (DTU)

9:30- 10:00 Opening, Peter Hauge Madsen. (Director, DTU Wind Energy, DK)

10:00- 10:10 Welcome, Charlotte Hasager and Leon Mishnaevsky Jr. (DTU, DK)

Session: STATE OF ART

10:10-10:30 Nikolai Bak Grishauge (Siemens Gamesa, DK). Rain Erosion: further research needs seen from an industry perspective

10:30-10:50 Christian Bak (DTU, DK). Influence of leading edge roughness on aerodynamic performance

10:50-11:10 Arne Junike (Innogy, DE) LEP – what can go wrong? Examples from the field

11:10-11:40 **Coffee**

SESSION: RAIN DATA

Chairman: Christian Bak (DTU)

11:40-12:00 Charlotte Bay Hasager (DTU, DK) Project "Erosion": Concept and main results

12:00-12:20 Rebecca J. Barthelmie (Cornell University, USA). Experimental investigations of blade leading edge erosion potential

12:20-12:40 Sara C. Pryor (Cornell University, USA). Use of dual-polarization RADAR and WRF to characterize blade leading edge erosion potential

12:40-12:55 Witold R. Skrzypiński (DTU, DK) Erosion-safe turbine operation

13:00-14:00 **Lunch**

SESSION: MATERIALS AND MODELLING

Chairwoman: Charlotte Bay Hasager (DTU)

14:00-14:20 Fernando Sánchez López (Universidad CEU Cardenal Herrera, ES). Material characterisation of wind turbine blade coatings, and the effect of interphase coating–laminar adhesion on rain erosion performance

14:20-14:40 Leon Mishnaevsky Jr. (DTU, DK). Computational modelling of leading edge degradation: Materials science aspects

14:40-15:00 Benjamin Buchholz (Fraunhofer IWES, DE). Droplet impact detection in a rain erosion tester – results and validation

15:00-15:20 Søren Fæster (DTU, DK). X-Ray analysis of leading edge erosion mechanisms

15:20-15:50 **Coffee**

SESSION: TESTING METHODS AND ANALYSIS

Chairman: Bent F. Sørensen (DTU)

15:50-16:10 David Maniaci (Sandia National Laboratory, USA). Predicting Leading Edge Erosion

- Performance Degradation Through Experimental Measurement and CFD Modeling of Wind Turbine Airfoils
- 16:10-16:30 Kirsten Dyer and Robbie Herring (ORE Catapult, UK). From the test rig to the offshore environment
- 16:30-16:50 Nick Hoksbergen (University of Twente, NL). Leading edge erosion damage modeling and experimental validation
- 16:50-17:10 Prieto Raul (VTT, FIN) Fighting blade erosion with data science: WBEAtlas
- 17:20-18:20 **DISCUSSION:** Research on leading edge erosion: Mechanisms. Testing. Modelling. Moderation: Povl Brøndsted (BMC)
- 19:00-22:30** ***Dinner in Snekken Trattoria***, Vindeboder 16, 4000 Roskilde

February 5, 2020

SESSION: SOLUTIONS

Chairman: Pablo Bernad (Hempel)

- 9:00-9:15 Andrew T Woods (Doncasters, UK). From aerospace to renewables - electroforming and leading edge erosion protection
- 9:15-9:30 Lars Ischtschuk (SaertexGmbH, DE) and Michael Brink (Uni Bremen, DE). A new hybrid solution for LEP-Systems
- 9:30-9:45 Martins Ummers (Aerones, LV). Surroundings which accelerates LE wear off and solution to maintain longer durability
- 9:45-10:00 Mark Powell (Armour Edge Solutions, UK). Armour edge solutions; durable and aerodynamically optimal leading edge solution
- 10:00-10:15 Jamal Zanjani (University of Twente, NL). Leading edge protection by thermoplastics
- 10:15-10:30 Poul Anker Lübker (Ventus Engineering GmbH, AT). TripleCMAS rotor monitoring system. System for dynamic blade pitch measurement
- 10:30-11:00** ***Coffee***

SESSION: MATERIALS AND MODELLING

Chairman: Lars P. Mikkelsen (DTU)

- 11:00-11:20 David H Nash (University of Strathclyde, UK). Creation of a single water droplet FEA model for rain erosion and observations of coating property changes during rain erosion testing
- 11:20-11:35 Mohamed Ibrahim (Concordia University, Canada). Prediction of threshold conditions in water droplet erosion
- 11:35-11:50 Nicolai Frost-Jensen Johansen (DTU, DK). Temperature effect in leading edge erosion
- 11:50-12:05 Tomi Suhonen (VTT, FI) Machine learning driven design of coatings to combat erosion in wind turbine blades
- 13:00-14:00** ***Lunch***

SESSION: MATERIALS AND MODELLING

Chairman: Jan Sütterlin (Covestro)

- 14:00-14:20 Bent F. Sørensen (DTU, DK). Reliability of coatings and multilayers: Role of interfaces
- 14:20-14:35 Saeed Doagou Rad (DTU, DK). Multiaxial high cycle fatigue model of rain erosion of wind turbine blades
- 14:35-14:50 Amrit S. Verma (TU Delft, NL). A summary of recent work on leading edge erosion of wind turbine blades at the WINDCORE project, TU Delft
- 14:50-15:10 Luis Bartolome (TU Delft, NL). Surface roughness progression as the initiation of the erosion on the leading edge of wind turbine blades

15:10-15:40 *Coffee*

SESSION: MONITORING AND EXPERIMENTS

- 15:40-16:00 Rasmus Refshauge (R&D, DK) Rain Erosion Test Facility by R&D Test Systems
- 16:00-16:20 Jakob Ilsted Bech (DTU, DK), SPIFT testing of leading edge protection
- 16:20-16:35 Ozlem Ceyhan Yilmaz (SIRRIS, BE) Leading edge erosion detection of wind turbines by aero-acoustic noise
- 16:30-16:50 Hans Laurberg (Rope Robotics ApS, DK) Robot performing leading edge repair
- 16:50-17:10 Patricia Tencaliec (Ventus Engineering GmbH, AT). Leading edge erosion and how to use rotor sensor technology for wind turbine condition monitoring
- 17:10-18:00 **DISCUSSION:** Solutions for wind blade protection? Moderation: Nicolas Quievy (Engie)

18:30-22:00 *Beer and wine get together, in the DTU Risø Campus canteen*

February 6, 2020

SESSION: EROSION AND WIND TURBINE PERFORMANCE

Chairman: Søren Fæster (DTU)

- 09:00-9:15** Sergio Campobasso (Lancaster Uni, UK). Machine learning-aided assessment of wind turbine energy losses due to blade leading edge damage
- 09:15-9:30** Motofumi Tanaka (Fukushima Renewable Energy Institute, Japan). Erosion protection with a leading edge plasma device for flow control
- 9:30-9:45** Beatriz Mendez Lopez (CENER, Spain) Experimental and numerical investigation of surface roughness effects on wind turbine performance
- 9:45-10:00** Anna-Maria Tilg (DTU, DK). Disdrometer data used for Erosion safe mode control
- 10:00-10:15** Josué Enríquez (Instituto Tecnológico de Tuxtla Gutiérrez, Chiapas Mexico). Aerodynamic and modal analysis of wind turbine blade caused by the effect of erosion

10:15-10:50 *Coffee*

11:00-12:00 **DISCUSSION:** What are next steps? Moderation: Christian Bak, Charlotte Hasager, Leon Mishnaevsky Jr.

CLOSING SESSION

12:00-12:30 Closing Remarks, Charlotte Hasager and Leon Mishnaevsky Jr. (DTU, DK)

13:00-14:00 *Lunch*

