



Programme

Composites for Wind Energy: Manufacturing, Operation and End-of-life

4 - 7 September 2023



Department of Wind and Energy Systems
Technical University of Denmark

Composites for wind energy: Manufacturing, Operation and End-of-life

The focus of the 43rd Risø Symposium is on composites for wind energy. This symposium takes a life cycle perspective and addresses manufacturing, performance during operation and end-of-life of composites for wind energy. Over the last 40 years, wind turbine blades have grown an order of magnitude. Today, the longest blades are exceeding 100 meters and weighing 50 tons. Because of this growth in blade size, the cost of wind energy can now compete with fossil-based energy sources on market terms.

As society is thriving towards a zero-emission future, the wind energy sector is foreseen to further expand. Longer wind turbine blades with improved overall lifetime, reliability, recyclability, sustainability, operability and maintainability are some of the objectives set on this component. To address these upcoming and ambitious requirements, the symposium welcomes contribution dedicated to the manufacturing, the operation and performance, as well as end-of-life strategies for wind turbine blades.

Acknowledgement:

The 43rd International Risø Symposium on Materials Science is organized by the Division of Wind Energy Materials and Components at the Department of Wind Energy, Technical University of Denmark (DTU). We want to thank all those at DTU who have assisted in the preparations for the symposium, and we gratefully acknowledge the financial support from the following foundations: Danish Center for Applied Mathematics and Mechanics, Otto Mønstedts Fond and Knud Højgaards Fond.

Links in program:

Links on presenter names: [Link to presenter video](#)

Links on titles: [Link to paper](#)

Link to Pictures:

<https://drive.google.com/drive/folders/1A15Kx78k1uuxQ94eZcYgrv8B-1b2ir5P?usp=sharing>

Link to program: <https://www.conferencemanager.dk/43rdsymposium/program>

Link to Proceedings: <https://iopscience.iop.org/issue/1757-899X/1293/1>

Quick Overview and Symposium Topics

Color coding

Manufacturing

Operation

End of life

	Monday, 4 September	Tuesday, 5 September	Wednesday, 6 September	Thursday, 7 September
9:00-10:10	Arrival 10:15 Opening Session and Welcome	Session M3: Large scale manufacturing	Session E2: Recyclable blades	Session O8: Image analysis
10:10-10:30			Break	
10:30-11:30	Session M1: Materials and flow in manufacturing	Session M4: Curing and Residual stresses	Session E3: Planning	Session M5: Flow and cure
11:30-11:50			Break	
11:50-13:00	Session M2: Test methods	Session O3: Simulation	Session O5: Blade maintenance	Session E4: Recycled materials
13:00-14:00		Break, lunchtime		
14:00-15:00	Session O1: Leading edge erosion	Session O4: Fatigue	Session O6: Fatigue	
15:00-15:20	Break		Break	
15:20-16:00	Session O2: Fatigue	15:00 Group photo 15:15 Bus	Session O7: Adhesives	
16:30-16:50	Break			
16:50-18:10	Session E1: Recycled materials	16:00 Social event 18:15 Conf. dinner 21:15 Bus	16:30 Lab tour 18:00 Networking and finger food	

Monday, 4 September

09:30-10:15 *Arrival and coffee*

10:15-10:30 **Opening Session and Welcome**

10:30-11:40 **Session M1: Materials and flow in manufacturing** **Chair: Lars**

10:30-11:00 [Véronique Michaud](#) (EPFL), [LCM of thermoset-based fiber reinforced composites for large-scale applications: are process kinetics and structural properties antagonistic?](#)

11:00-11:20 [Robert Pierce](#) (DTU Wind), [Challenges in permeability characterisation for modelling the manufacture of wind turbine blades](#)

11:20-11:40 [Douglas Cairn](#) (Montana State University), [Stretch Broken Carbon Fiber for Primary Wind Turbine Structure](#)

11:40-12:00 **Break**

12:00-13:00 **Session M2: Test methods** **Chair: Lars**

12:00-12:20 [Heloisa Guedes Mendonça](#) (Vestas), [Manufacturing methods for assessing the impact of wrinkles in wind turbine blades](#)

12:20-12:40 [Rajnish Kumar](#) (DTU Wind), [Experimental testing method to characterise the drapability of a fabric](#)

12:40-13:00 [Kristine Munk Jespersen](#) (DTU Wind), [Mode mixity for the fracture toughness obtained by climbing drum peel tests](#)

13:00-14:00 **Break, lunchtime**

14:00-15:00 **Session O1: Leading edge erosion** **Chair: Wim**

14:00-14:30 [Todd Griffith](#) (University of Texas at Dallas), [Composite Materials in Wind Energy: Design, Manufacturing, Operation, and End-of-Life](#)

14:30-14:50 [Antonios Tempelis](#) (DTU Wind), [Complex damage mechanisms and roughness evolution of wind turbine blade surface: Multiphysics and stochastic effect modelling](#)

14:50-15:10 [Matt Korey](#) (Oak Ridge National Laboratory), [Development of Wind Turbine Blade Recycling Baselines in the United States](#)

15:10-15:30 **Break**

15:30-16:30 **Session O2: Fatigue** **Chair: Wim**

15:30-15:50 [Arturo Gomez](#) (DTU Construct), [A multi-scale level approach for damage assessment of wind turbine blade shear web joints under fatigue loading](#)

15:50-16:10 [Arturo Gomez](#) (DTU Construct), [Cohesive zone modelling to predict crack growth under fatigue loading](#) - ONLINE

16:10-16:30 [Tamas Nagy](#) (DTU Construct), [Large-scale fatigue testing of a retrofitted 3RD shear web in a 34m wind turbine blade section](#)

16:30-16:50 **Break**

16:50-18:20 **Session E1: Recycled materials** **Chair: Justine**

16:50-17:20 [Larry Lessard](#) (McGill University), [Proposed holistic strategy for mechanical recycling of wind turbine blades for 3D printing and compression molding](#)

17:20-17:40 [Essi Sarlin](#) (Tampere University), [Viability of recycled fibres extracted from end of life composites](#)

17:40-18:00 [Rafael Carnicero](#) (Centre for the Development of Renewable Energy), [Analysis of a Small Recyclable Wind Turbine Blade](#)

Tuesday, 5 September

08:45-09:00 *Arrival and coffee*

09:00-10:10 **Session M3: Large scale manufacturing** **Chair: Rob**

09:00-09:30 **Michael Wenani Nielsen (LM Wind Power), Large scale blade manufacturing and the challenges posed by composites**

09:30-09:50 [Kaveh Rashvand \(DTU Wind\), Parametric and numerical Finite Element simulation of wind turbine blades subjected to thermal residual stresses](#)

09:50-10:10 [Malo Rosemeier \(Fraunhofer IWES\), Quantification of process-induced effects on fatigue life of short-glass-fiber-filled adhesive used in wind turbine rotor blades](#)

10:10-10:40 *Break*

10:40-11:20 **Session M4: Curing and Residual stresses** **Chair: Rob**

10:40-11:00 Yixing Wang (Leibniz University Hannover), [Residual stresses in thick composites considering through-thickness temperature gradients during manufacturing](#)

11:00-11:20 [Ulrich Mortensen \(LM Wind Power\), How epoxy cure profiles \(may\) impact performance of non-crimp fabric composites](#)

11:20-11:50 *Break*

11:50-13:00 **Session O3: Simulation** **Chair: Kristine**

11:50-12:20 [Wim Van Paepegem \(Ghent University\), Building blocks towards progressive fatigue damage modelling of a whole wind turbine blade](#)

12:20-12:40 [Pierre-Yves Mechin \(Dassault Systèmes\), Multi-scale simulations for effect of defects and life fatigue prediction applied to wind turbine blade composites structures](#)

12:40-13:00 Xiao Chen (DTU Wind), High-performance virtual testing beyond coupons: applications to large-scale composite structures

13:00-14:00 *Break, lunchtime*

14:00-15:00 **Session O4: Fatigue** **Chair: Kristine**

14:00-14:20 [Berin Seta \(DTU Construct\), Numerical modelling of fiber orientation in additively manufactured composites](#)

14:20-14:40 [Ruben Erives \(DTU Wind\), Design of an element test specimen for fatigue delamination growth of a thick laminate](#)

14:40-15:00 [Bent F. Sørensen \(DTU Wind\), J integral strain-curvature approach for multilayer fracture specimens with unknown thickness and stiffness of layers.](#)

15:00 *Group photo*

15:15 *Bus to Sagnlandet*

16:00 *Visit of Sagnlandet*

18:15 *Dinner at Herthedalen*

21:15 *Bus to Roskilde Station*

Wednesday, 6 September

08:45-09:00 *Arrival and coffee*

09:00-10:10 Session E2: Design for recycling of blades **Chair: Bo**

09:00-09:30 [Francisco Javier Hierro-Olabarria Salgado](#) (Siemens Gamesa Renewable Energy), [Wind blades circularity - Resins development for improved sustainability](#)

09:30-09:50 Kathrin Kramer (Leuphana University of Lüneburg) [Review existing strategies to improve circularity, sustainability and resilience of wind turbine blades – A comparison of research and industrial initiatives in Europe](#)

09:50-10:10 [Israel Carrete](#) (Delft University of Technology), [Circular applications through selection strategies \(CATSS\): a methodology for identifying reuse applications for end-of-life wind turbine blades](#)

10:10-10:30 *Break*

10:30-11:30 Session E3: Planning **Chair: Bo**

10:30-10:50 [Evan Sproul](#) (Sandia), [Life Cycle Assessment of Wind Turbine Blade Recycling Approaches in the United States](#)

10:50-11:10 Kyle Pender (National Composites Centre), [A strategic approach to wind turbine blade recycling: Using life cycle assessment to enable data driven decision making](#)

11:10-11:30 [Aeva Silverman](#) (Georgia Institute of Technology), [Mass determination and model prediction of retired blades from wind turbine repowering or dismantling using a GIS database](#)

11:30-11:50 *Break*

11:50-13:00 Session O5: Blade Maintenance **Chair: Bent**

11:50-12:20 [Find Mølholt Jensen](#) (Bladena), [Torsional Effects on Wind Turbine Blades and Impact on Field Damages](#)

12:20-12:40 Vipin Kumar (Oak Ridge National Laboratory), [Non-metallic lightning strike protection coating for wind-turbine blades](#) - ONLINE

12:40-13:00 Claudio Balzani (Leibniz University Hannover), [Impact of shell structure stiffness on aero-structural coupling in wind turbine rotor blades](#)

13:00-14:00 *Break, lunchtime*

14:00-15:00 Session O6: Fatigue **Chair: Bent**

14:00-14:20 Felix Klaenfoth (Fraunhofer IWES), [Constraining effect of load frames during full-scale rotor blade fatigue testing](#)

14:20-14:40 [Mitsuki Otsubo](#) (Waseda University), [Effect of span/thickness ratio on fatigue properties of thick quasi-isotropic CFRP laminates subjected to three-point bending loading](#)

14:40-15:00 Ashish Kumar Bangaru (DTU Wind), [Prediction of crack growth at trailing edge bondlines of a wind turbine rotor blade for the assessment of remaining service life](#)

15:00-15:20 *Break*

15:20-16:20 Session O7: Adhesives **Chair: Lars**

15:20-15:40 [Abdul Wasay Khan](#) (Leibniz University Hannover), [Generative AI and Image Based Numerical Mechanics in Wind Blade Adhesive Composite](#)

15:40-16:00 Claudio Balzani (Leibniz University Hannover), [Characterization of a short fiber-reinforced adhesive designed for wind turbine rotor blades](#)

16:00-16:20 Kristofer Gamstedt (Uppsala University), [Material aspects of wooden towers for offshore wind turbines](#)

16:30-18:00 *Lab Tour*

18:00 *Finger food and beer in the canteen*

Thursday, 7 September

08:45-09:00 *Arrival and coffee*

09:00-10:10 **Session O8: Image analysis** **Chair: Veronique**

09:00-9:30 [Lars Pilgaard Mikkelsen](#) (DTU Wind), [Imaging techniques analysing composite materials for wind energy](#)

09:30-09:50 Azat Slyamov (Xnovo), [Defect detection in carbon fiber-reinforced composites using directional dark-field imaging and tomography](#)

09:50-10:10 [Lars Pilgaard Mikkelsen](#) (DTU Wind), [Compressive strength prediction of fiber-reinforced composites with realistic volumetric fiber orientations.](#)

10:10-10:30 *Break*

10:30-11:30 **Session M5: Resin flow and cure** **Chair: Rob**

10:30-10:50 [Jesper Kjær Jørgensen](#) (DTU Wind), [Cure characterisation and prediction of thermosetting epoxy for wind turbine blade manufacturing](#)

10:50-11:10 Nikos Pantelelis (Synthesites), [Online Tg estimation for blade manufacturing](#)

11:10-11:30 M. Elkington (National Composites Centre), The effect of gaps between sandwich core sections on large scale infusions

11:30-11:50 *Break*

11:50-12:30 **Session E4: Recycled materials** **Chair: Bo**

11:50-12:10 [Justine Beauson](#) (DTU Wind), [Polymer composites with short recycled glass fibres manufactured by vacuum infusion](#)

12:10-12:30 [James Ezhilan](#) (Easwari Engineering College), [Study on recycling wind turbine blades into reinforcement for filaments used in 3D printing](#)

12:30-12:50 [Tristan Hamers](#) (DTU Wind), [Fatigue S-N curve approach for impact loading of hyper- and visco-elastic leading edge protection systems of wind turbine blades](#)

12:50-13:00 [Closing comments](#)

13:00-14:00 *Break, lunchtime*

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<https://www.conferencemanager.dk/43rdsymposium>