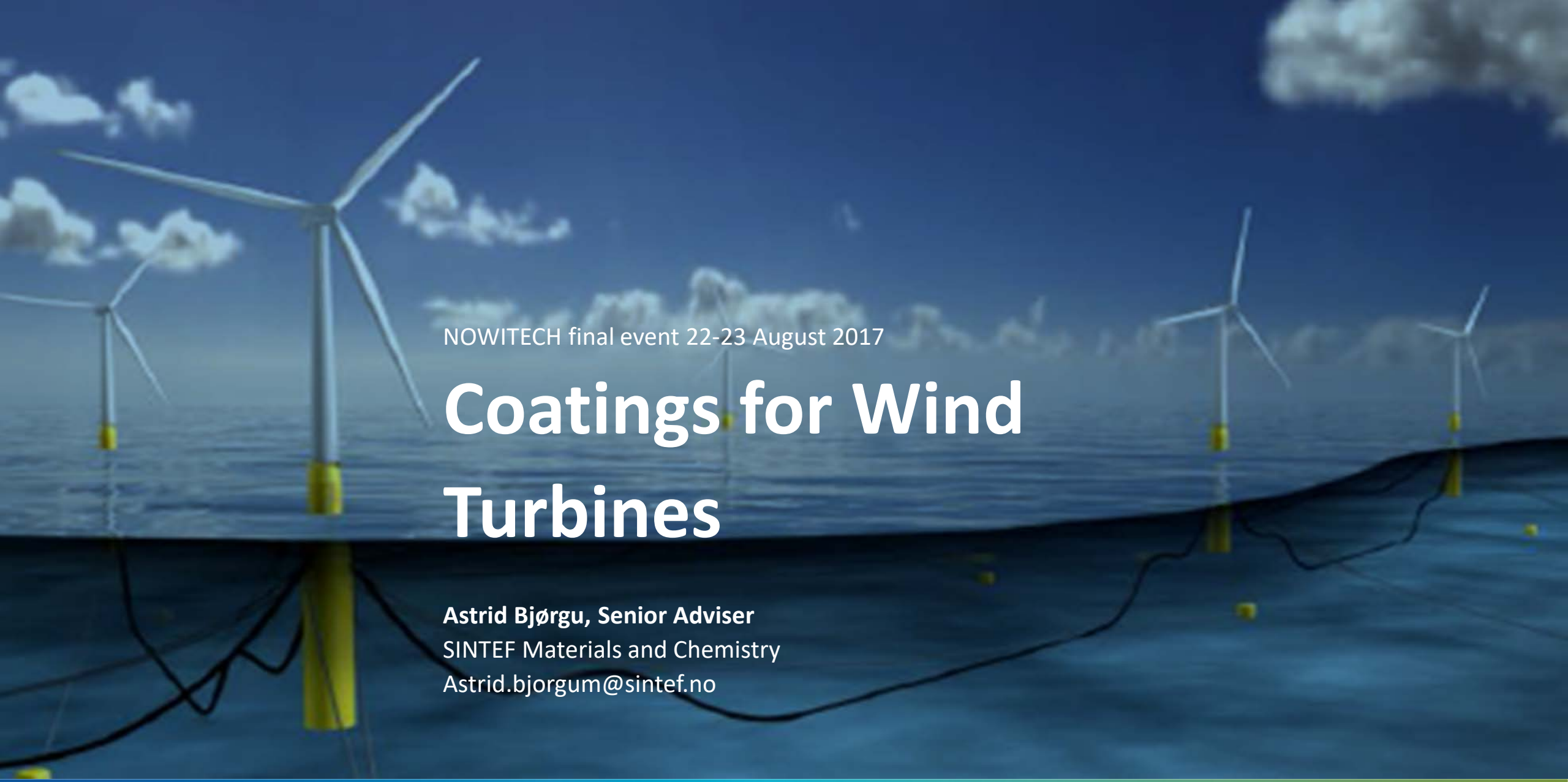


NOWITECH final event 22-23 August 2017

Coatings for Wind Turbines

Astrid Bjørgu, Senior Adviser
SINTEF Materials and Chemistry
Astrid.bjorgum@sintef.no

Challenges for offshore wind farms

http://www.renewableenergyworld.com/rea/images/float-on-floating-offshore-wind-opens-up-the-deep-52031/47238

- Harsh environmental conditions
- Corrosion and leading edge erosion are proven to be detrimental treats
  - Construction integrity
  - Economy of offshore wind energy production

Main activities on coatings

- Coatings used as protection against corrosion and leading edge erosion

Corrosion protection by coatings

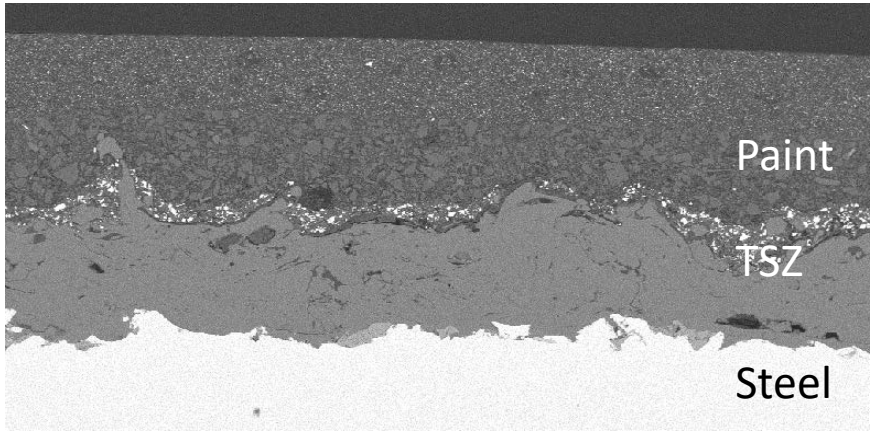
- Design lifetime for offshore wind is typically 25 years
- Protective coating systems meets following challenges
  - Limited accessibility
  - High repair- and maintenance costs for coatings offshore
  - Coating systems aim to be maintenance free for the entire lifetime
- Long life coating systems exists
- 3-coat paint systems used in atmospheric zone need maintenance after less 10 years or less

http://www.abfad.co.uk/project/monopile/

We have focused on finding cost effective coating systems with long lifetime and minimum need for maintenance

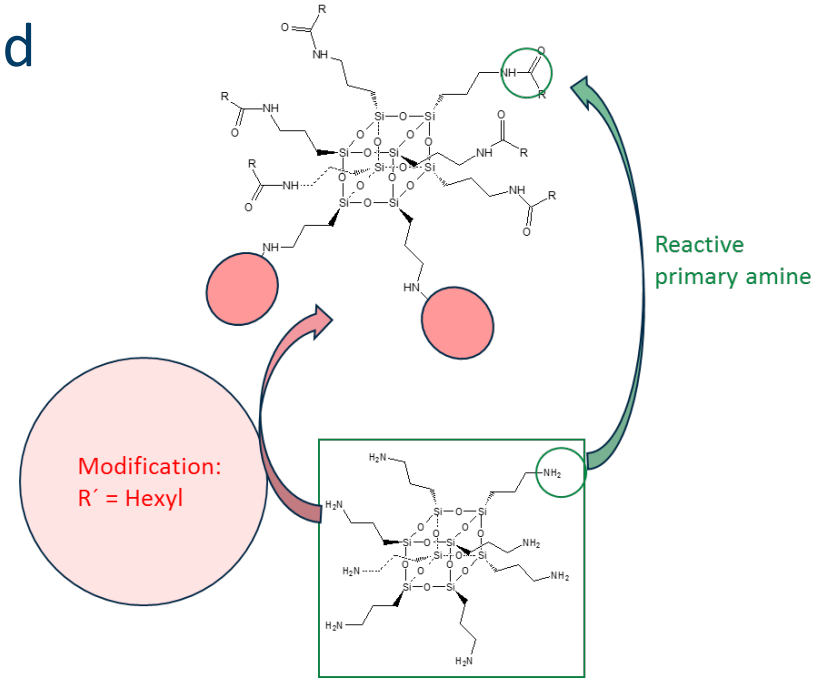
Duplex coatings

- Offshore wind towers are often protected by duplex coating systems
  - Metallized zinc (TSZ) and a 3-coat paint system.
  - Regarded as maintenance free even in harsh marine environments
- Sub-structures are often protected by regular 3-coat paint systems
  - Costly maintenance needed



Cost effective coating systems

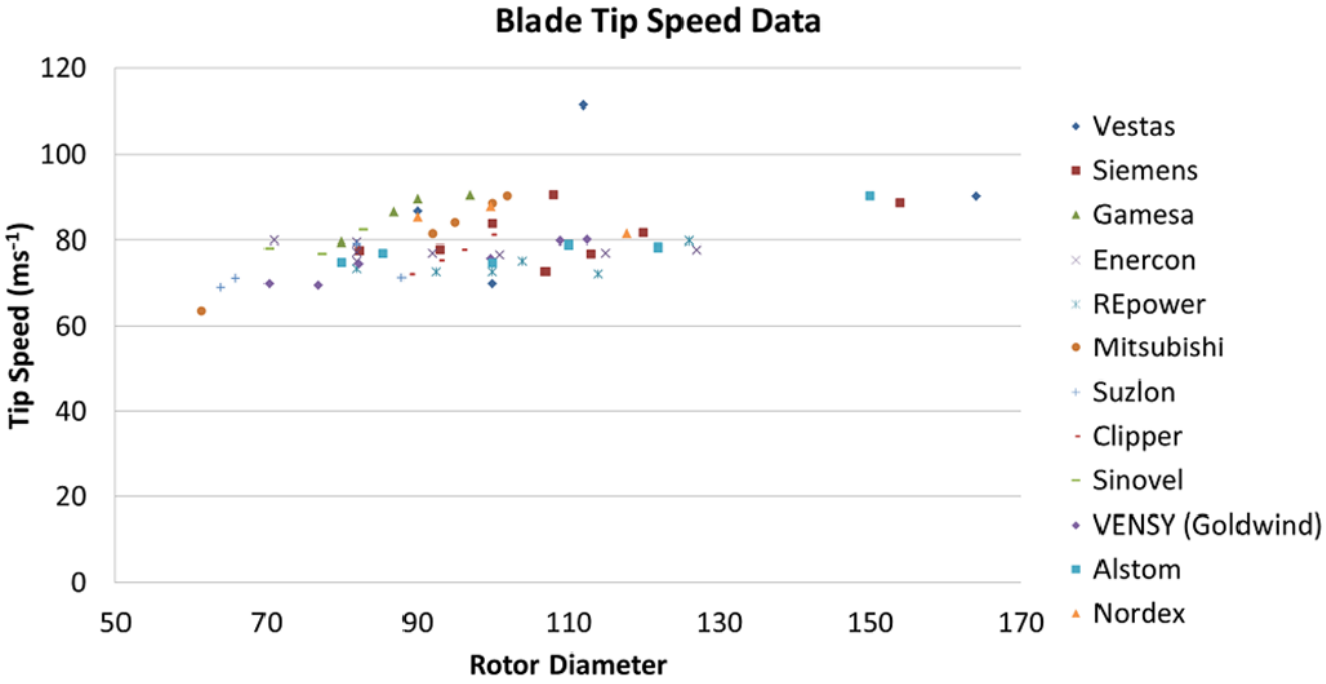
- Different coating systems are compared by lab and field testing
  - Metallizing combined with a simplified paint system
    - TSZ (85% Zn/15 % Al) – 100 µm
    - One-coat paint systems
  - Commercial paints
    - Unmodified
    - Modified by adding FunzioNano™
- Results show that TSZ perform excellent in the field, even with a simple 1-coat paint system on top



FunzioNano™ derivates (HAPS)
added to improve coating properties

Leading edge erosion

- Tip speeds in excess of 80 m/s are common for large wind turbine – increasing tip speed with increasing rotor diameter
- Impact of rain, hailstones and other particulates on the leading edge - incoming velocity may also play a role
- A typical wind turbine may be operating continuously for approximately 15 years over its service – a long time compared to e.g. modern automobiles that may only operate continuously for around 9 months



Ref: On erosion issues associated with the leading edge of wind turbine blades. M H Keegan, D H Nash and M Stack. J. Phys. D: Appl. Phys. 4**6** (2013) 383001 (20pp)

Erosion on wind turbine blades

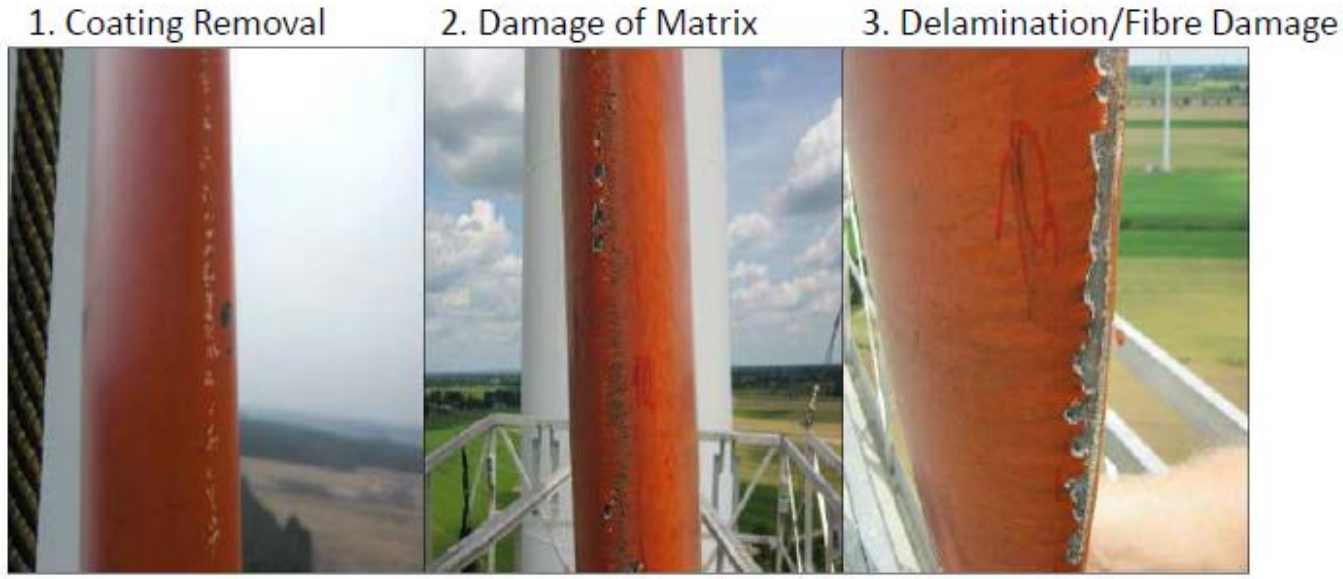
- Starting at the blade tip – highest speed
- Different stages:

From:

- Minor cosmetic damages
- ….

To:

- Blade failure (including full stop of the turbine)

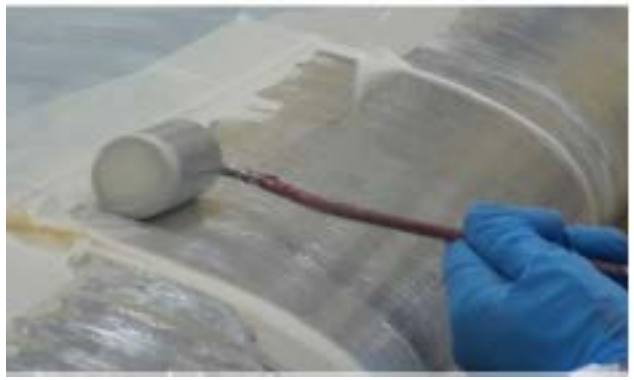


Source: Latest protection methods against leading edge erosion for increased tip speeds. Christian Claus. 3M renewable Energy Division

How to protect the blades

- Coatings are used for minimizing the erosion on the leading edge
- Application procedure might affect the erosion resistance of the system

Spray



Roller

Trowel

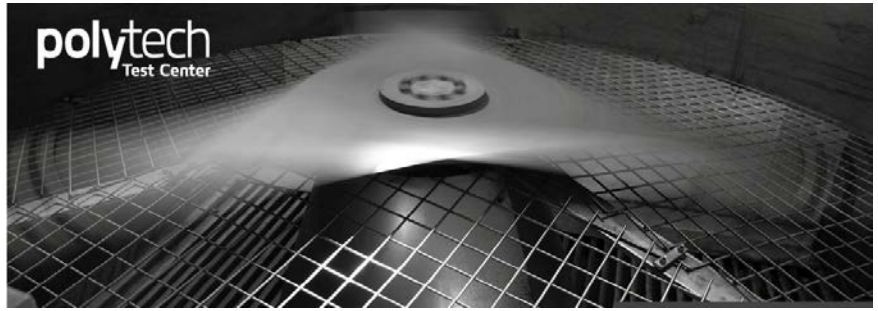
Source:On the rain erosion damage modelling of wind turbines blade coatings. A material and process approach. E.Corés et al. Wind Turbine manufacture 2016.

Testing methods

- Most of the testing methods are based on the helicopter test:
  - The "rain rig" has been the national and international standard for testing the rain erosion resistance of a variety of aerospace materials since 1967
  - Different tests exist today based on the helicopter test:

SAAB Rain erosion test facility

R&D Test Systems A/S test rig



Polytech test center

Continuation of this work:

Coatings for Leading edge erosion - CoatLee

- IPN – project partly financed by the Norwegian Research Council
- Participants: Carboline Norway, Statoil, Gamesa, SINTEF, and NTNU
- The project aims are to work toward solving one of the biggest wind turbine maintenance challenges (LEE) by:
  - Building a reliable erosion data base based on real field data
  - Increase the leading edge erosion resistance by developing new protective coatings
  - Developing more suitable accelerated multi-degradation testing tools that better duplicate real-life LEE