Investigation of droplet erosion for offshore wind turbine blades

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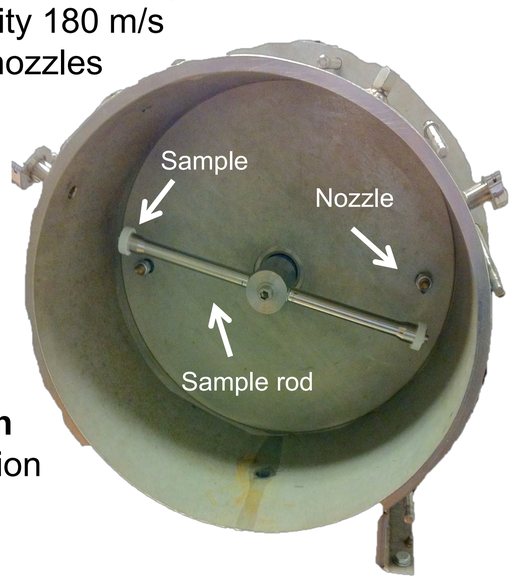
Introduction

Droplet erosion as one type of leading edge erosion on wind turbine blades, has been studied, in order to obtain a better understanding of the mechanisms and a resistance surface treatment. The target is to develop tools helping the industry to achieve a 20 year lifetime of blades.

Different coatings were investigated by erosion tests, material characterization and numerical modeling.

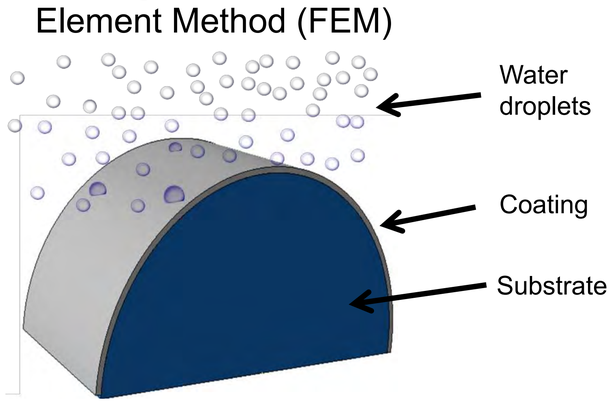
Methods and materials

Droplet erosion test facility
- Sample velocity 180 m/s
- Changeable nozzles



Characterization
- Nanoindentation
- Scratch test
- IFM
- SEM

Modelling of droplet impact
- Evaluation of a numerical model to simulate rain erosion
- Rain is modelled using the Smoothed Particle Hydrodynamics (SPH) formulation
- Coating is modelled with Finite Element Method (FEM)



Materials investigated

Dummy samples for erosion test facility
- HDPE
- PVC

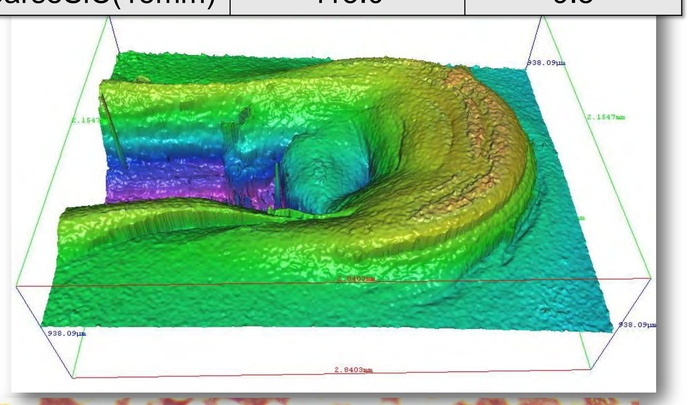
Protective surface coatings
- 3M™ Wind Protection Tape
- Polyurethane composite coatings
  - 100% PUR
  - PUR with SiC additives (15µm and 20nm)
  - PUR with FunzioNano® additives

Experimental Results

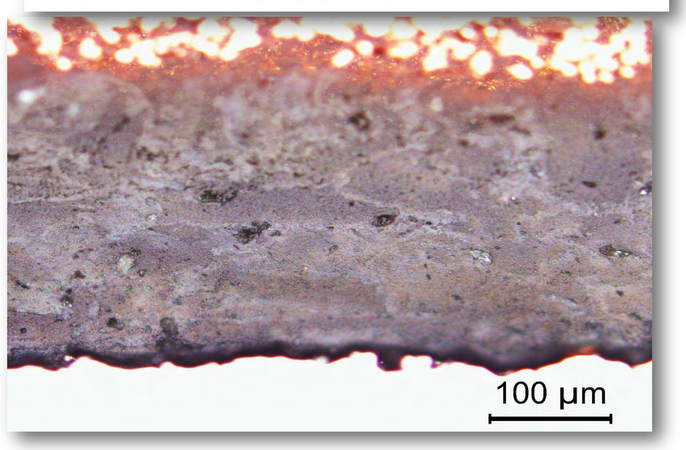
Characterization of TS Polyurethane
Nanoindentation, IFM of scratch test and cross sections.

Sample	Modulus (MPa)	Hardness (MPa)
100% PUR	273.5	20.8
2.5% FunzioNano	108.8	9.8
2.5% nanoSiC(20nm)	122.3	10.9
5.0% coarseSiC(15mm)	115.0	9.8

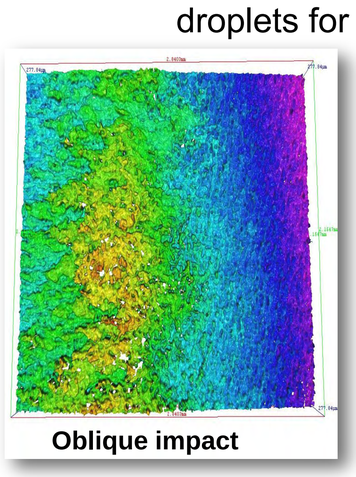
Scratch by cone-shaped pin (60N)

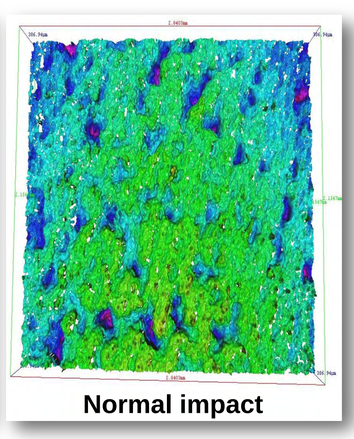


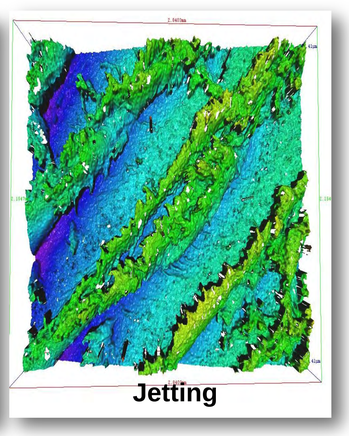
Cross section of TS PUR 2.5% SiC



Erosion test
Erosion pattern obtained at 180 m/s with rain droplets for HDPE.

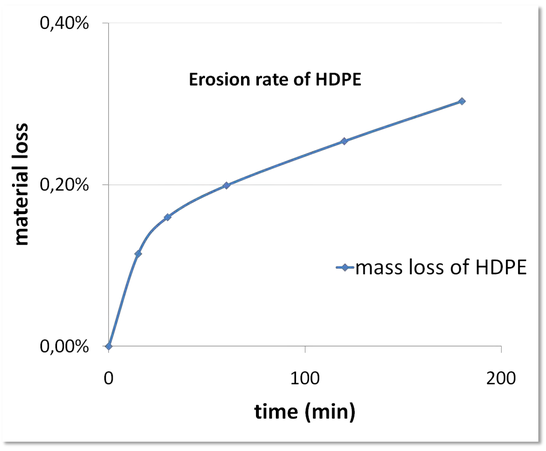

Oblique impact


Normal impact


Jetting

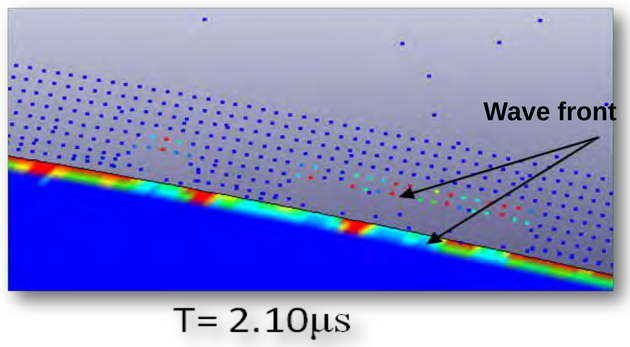
Erosion rate
The erosion resistance of the sample is evaluated through the erosion rate (loss of mass per time).


HDPE sample after 3 hours of erosion test



Numerical results

The discretisation of the rain field into particles moving independently is limited by the SPH formulation. The particle field is still considered as a continuum medium despite minimized interaction between particles.



After the first impact, a shockwave propagate inside the particle field, disturbing it, spoiling the results.

Conclusions

Experimental
- Test facility provides suitable conditions to perform droplet erosion.
- Thermal sprayed Polyurethane composite coatings shows promising mechanical properties as a protective coating.
- Further characterization of materials are required.

Modelling
- Discrete Element Method (DEM) must be considered as an alternative formulation to simulate the droplets flow.
- A study of single droplet impacts, comparing the stress and pressure distribution with theoretical data to rank the coatings susceptibility to wear can be an alternative study.

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