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AERODYNAMIC EROSION DAMAGE MODELLING ON WIND TURBINE BLADES

AIRTUB FINAL DELIVERY & DEMONSTRATION EVENT | 24 NOVEMBER 2022 KISHORE VIMALAKANTHAN | GERARD SCHEPERS | HARALD VAN DER MIJLE MEIJER

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LEADING EDGE EROSION (LEE) THE PROCESS

- > The process LEE 'water droplet impact erosion'
 - > Problem with the high tip speeds (up to 90m/s)
 - Fatigue related, brittle cracking related or a combination
- > LEE damage of wind turbine blades results in
 - High O&M costs, downtime, reduction AEP











24 November 2022 | Aerodynamic erosion damage modelling on wind turbine blades

AERODYNAMIC EROSION DAMAGE MODELLING ON WIND TURBINE BLADES

) Goal

Erosion modelled on blade section level corresponding loss in AEP through a standard BEM code

> First part "LEE damaged surfaces"

- Aerodynamic performance of scanned eroded wind turbine blade sections using RANS CFD
- Focused on modelling the actual shape change (10 20 mm) at the blade leading edge due to erosion
- Second part: "roughened surfaces"
- Development and calibration of transport equation based boundary layer transition model for surfaces with distributed roughness
- Focused on modelling the textural differences (0.10 0.20 mm) at the leading edge due to blade erosion or contamination





PERFORMANCE MODELLING OF DAMAGED LE USING CFD AIRTuB

- > 3D scanned LE into watertight mesh model
- Performance modelling of damaged blade profile
- CFD modelling at moderate Reynold numbers
 Re no ~3 million



LE of Airfoil: NACA64-618, NREL 5MW (tip section)

Clean

Eroded 2x

Eroded 3x

0.1

Eroded (measured)

0.08

0.08

0.06

0.04

-0.02

0.02

0.04

0.06

x/c



PERFORMANCE MODELLING OF ROUGHENED LE USING SSTLM METHOD AIRTUB



> Result:

- Roughness heights of 140um and 200um : very good agreement between the modelled and the experimented drag for the large
- Roughness height 100 um roughness no correlation



CONCLUSION

- > Shape change due to erosion damage
 - Significant damage at the tip section
 - AEP reduction in the range of 0.86-1.24% is realised when the LE shape is eroded by >0.8% of the chord length
- > Modelling transition for rough blade surfaces
 - Very good agreement with the measurement for leading-edge roughness heights in the order of 140-200um
 - For smaller roughness height of 100um, the model fails to accurately predict the measured drag forces





PUBLICATION WIND ENERGY SCIENCE

 Please see our publication for more discussion and details on the results

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NO, Westerduinweg 3, 1755 LE Petten, Netherlands ecceived: 15 Jul 2022 – Discussion started: 22 Jul 2022 stract. Leading edge erosion (LEE) is one of the most critical degradat rodynamic performance due to the damaged leading edge (LE) is paper agnituc r of 0, 1. ewith L b) CFD r the first //namic	tion mechanisms that occur with wind turbine blades nderstanding of the LEE process and the impact on set the most appropriate Leading Edge ing tools is therefore essential. •D) modeling approaches for different order: for eroded surfaces with roughness in the esolution scanned LE surfaces from an actu face resolved Reynolds Average Navier Stok Reynolds number range of 3-6 million



THANK YOU FOR YOUR TIME!

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