SmartANSWER

Novel Experimental Diagnostics for the Reduction of Trailing Edge Noise

L. T. Lima Pereira[1], F. Avallone[2], D. Ragni[3], F. Scarano[4]

[1]PhD Candidate, [2]Assistant Professor, [3]Associate Professor, [4]Professor, Aerodynamics, Wind Energy and Propulsion Department
Faculty of Aerospace Engineering, Delft University of Technology

Smart Mitigation of flow-induced Acoustic Radiation and Transmission for reduced Aircraft, surface traNSport, Workplaces and wind enERgy noise

Host institution: TU Delft

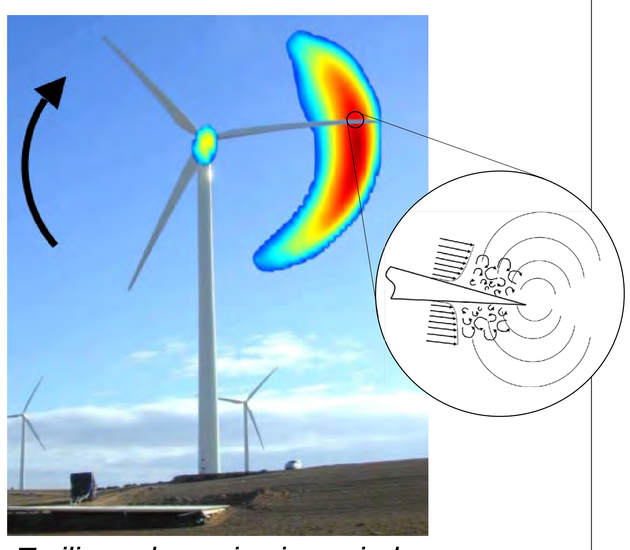
Partnership: SIEMENS Gamesa RENEWABLE ENERGY

RESEARCH OBJECTIVES

- Improve understanding and predictions of the trailing-edge noise reduction from serrations in wind turbines;
- Explore novel techniques to measure the unsteady flow close to the trailing edge.

WIND TURBINE NOISE

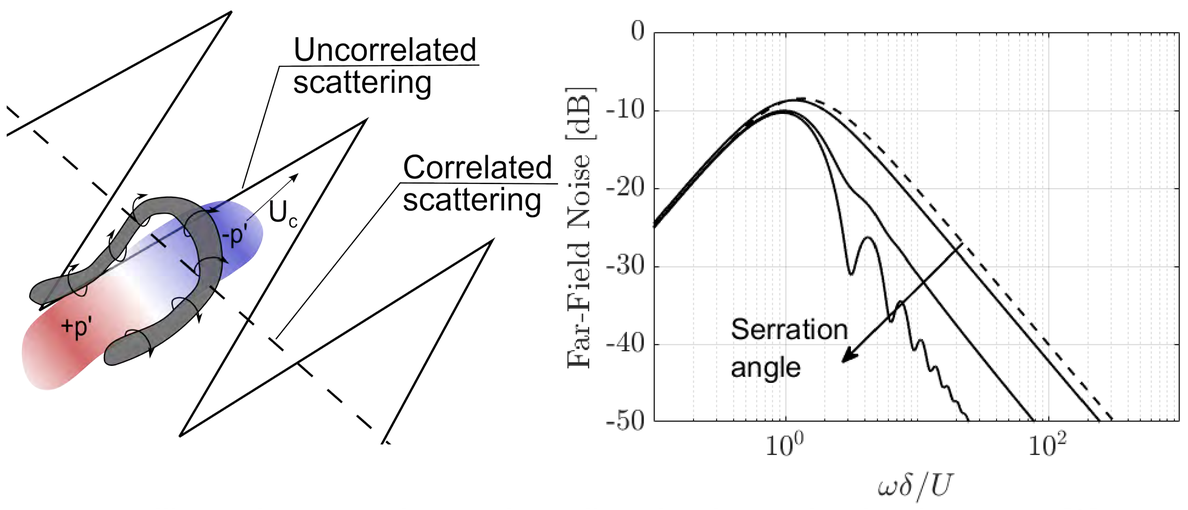
Noise on a wind turbine is dominated by the scattering of pressure fluctuations at the sharp trailing edge (TE) geometry, where the fluctuations can be associated with **Turbulent Boundary Layer** conditions over the blade surface **[1]**.



Trailing edge noise in a wind turbine, [1] and [2].

TRAILING EDGE SERRATIONS

TE noise can be significantly reduced by the use of **serrations**, where the sound generation is **uncorrelated** by shaping the trailing edge in a sawtooth-like geometry.



Trailing edge serration and predicted noise reduction by Howe [3].

Modeling Noise Reduction

Aerodynamic → **Acoustic**

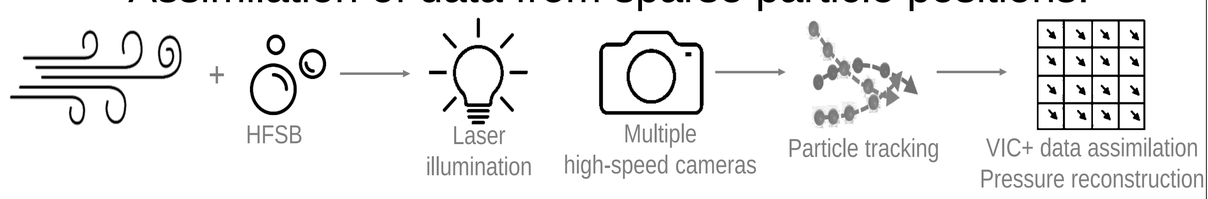
- **Frozen turbulence assumption (serration geometry not considered);**
- **No effect from blade loading.**
- **Turbulence levels**
- **Coherence length**
- **Convection velocity**
- **Models do not predict a limit for serration angle;**
- **Aerodynamic data on stream and spanwise wavenumbers required.**

Models are affected by the lack of experimental data of **unsteady flow** within the **boundary layer. No considerations of real life applications,** e.g. loading of the serrations or installation effects.

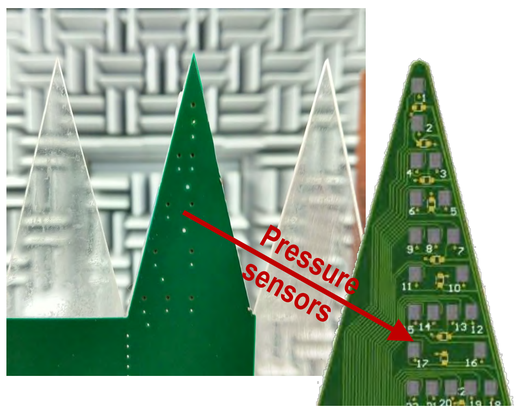
MEASUREMENT TECHNIQUES

Wind-tunnel measurement techniques:

- Time-resolved 3D-PIV + pressure reconstruction using Helium Filled Soap Bubbles (HFSB):
  - Large volumes and high Reynolds numbers;
  - Assimilation of data from sparse particle positions.

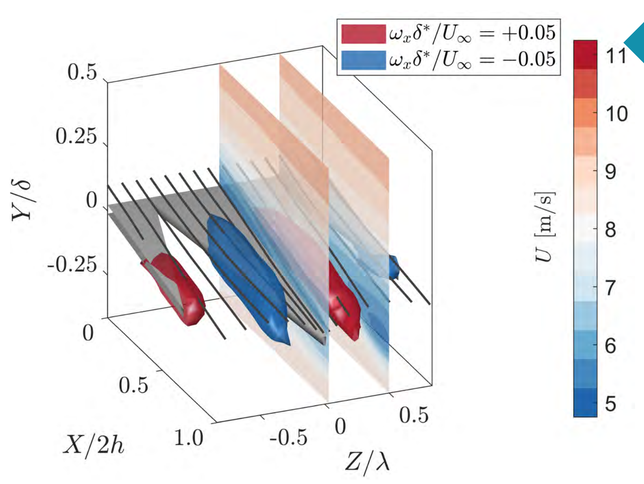


- Surface mounted pressure sensors:
  - Printed Circuit Board (PCB) assembly;
  - Non-intrusive unsteady wall pressure reference.



RESULTS

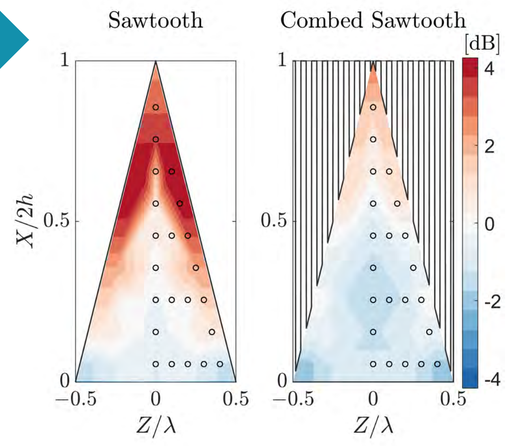
Flow Field



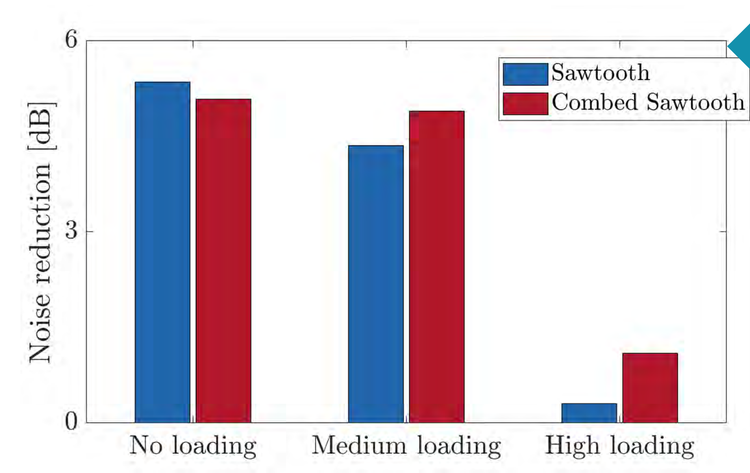
The **flow field** is significantly **altered by the serrations**. The effect is stronger when the serrations are submitted to aerodynamic loading.

Wall-Pressure Fluctuations

The changes will **increase the pressure fluctuations near the TE**. **Different geometries**, e.g. combed sawtooth [3], can avoid the flow distortions and **reduce the pressure fluctuations**.



Far-field Noise



Noise reduction is directly **impacted by the flow conditions**. Optimized trailing-edge geometries can reduce more noise under loading.

REFERENCES

[1] Oerlemans, S., Sijtsma, P., and Lopez, B. M., "Location and quantification of noise sources on a wind turbine". Journal of sound and vibration, 2007.
[2] Barone, M. F. , and Franklin, M. "Survey of techniques for reduction of wind turbine blade trailing edge noise". Technical Report, 2011.
[3] Asheim, M.J., Ferret Gasch, O., Oerlemans, S. "Rotor blade with a serrated trailing edge". US Patent 2017.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement No 722401.