Improvement of model for vortex generator on wind turbine blade zEPHYR Marie Skłodowska-Curie project: towards a more efficient exploitation of on-shore and urban wind energy resources

Nishchay Tiwari*, Pawel Flaszynski, Oskar Skulc
Email* : nishchay.tiwari@imp.gda.pl
Aerodynamics Department, Institute of Fluid-Flow Machinery, Polish Academy of Sciences, Gdansk, Poland

CONTEXT

Energy production in a Wine Turbine can be enhanced by increasing wind turbine and rotor sizes. However, large rotors present in **non-uniform inflow conditions**, if left uncontrolled, lead to **increased flow separation**. As a consequence, the airflow on the blade is detached leading to increased :

- **Aerodynamic losses**
- **Noise generation**
- **Fatigue loads**

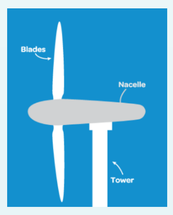

Fig 1. Wind Turbine components

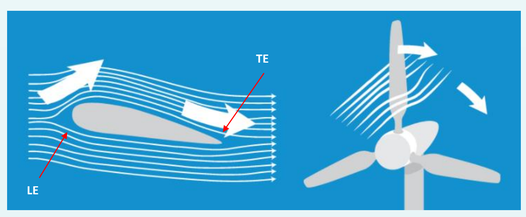

Fig 2. Wind Turbine Aerodynamics

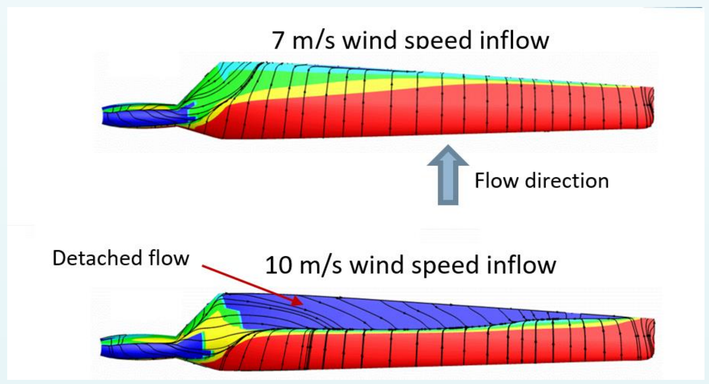

Fig 3. Changes in Boundary Layer at different Velocities [1]

FLOW CONTROL DEVICES

- The flow control device proposed to mitigate flow separation and/or blade loading are **vortex generators**.
- **Vortex generators** are designed to create stream-wise vorticity along the blade surface, which entrain high momentum fluid from zones with higher velocity in the upper part of boundary layer and transport it near the surface, deep into the boundary layer, resulting in a velocity profile less prone to separation.
- The Flow Control Device on focus is **ROD VORTEX GENERATORS.**

Fig 4. Vane type VGs in DTU Wind Turbine Blade[2]

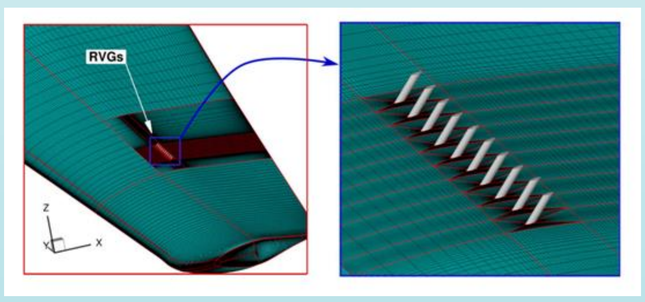

Fig 5. RVGs proposed on WT blade [1]

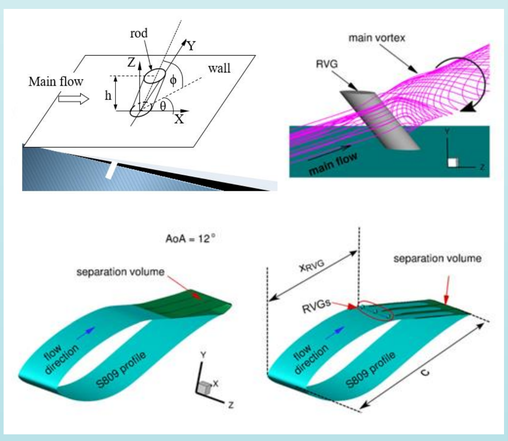

Fig 6. Geometry of RVG, stream-wise vortices created by it and the effects on separation volume [1]

PROBLEM DEFINITION

We need a different model from Grid Resolved CFD. Because:

- The simulations of **grid-resolved** rod vortex generators (RVGs) require **high computational cost and time**.
- The computational mesh topology must be adjusted to different ROD geometries.

Fig 7. Specimen for RVGs mounted on a blade

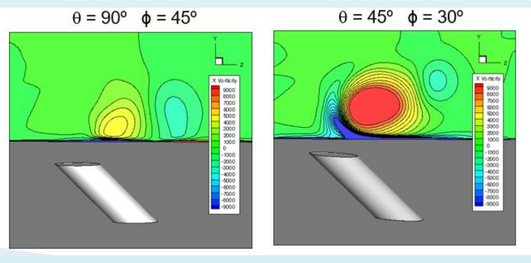

Fig 8. Grid Resolved RVGs solution for different inclination angles [1]

In order to achieve this, a model has to be defined taking in account the previous investigations done with models like **BAY model** (built on lifting line theory).

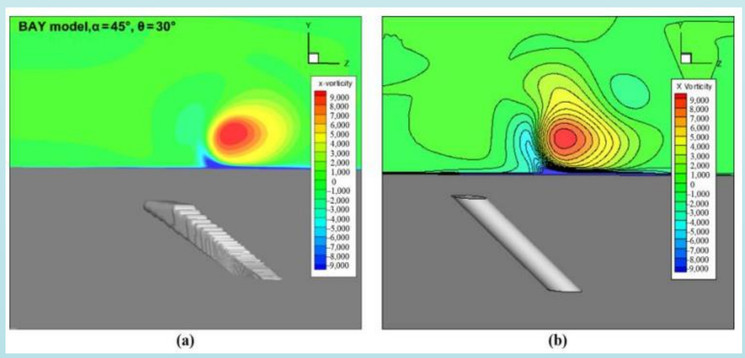

Fig 9. Stream-wise vorticity component at plane 50 mm (50D) downstream BAY model (a) and grid resolved RVG a = 45° and u = 30° (b) [3]

OBJECTIVES

- To develop a model for Rod Vortex Generators on a Wind Turbine blade.
- To carry out **sensitivity study** and provide guidelines for it's application to various Wind Turbine geometries.
- To study the **3D effects** of Rod Vortex Generators on the performance and possible noise regeneration using 3D CFD simulations.
- To evaluate the applicability and potential benefits of RVGs for **automotive** applications.

METHODOLOGY AND EXPECTED RESULTS

The computational results of the new model will be validated against **experimental data** and **numerical simulation results** for grid resolved rod.

Expected Results:

- 3D CFD simulation procedure to quantify the performance improvement of RVGs.
- Sensitivity analysis and guideline for HAWT configurations.

[1] Javier Martinez Suarez, Pawel Flaszyński, Piotr Doerffer, (2018) "Application of rod vortex generators for flow separation reduction on wind turbine rotor", Wind Energy, DOI: 10.1002/we.2224
[2] http://powercurve.dk/our-technology/
[3] Tomasz Kwiatkowski, Pawel Flaszyński, Jerzy Zoltak, (2018) "Source term model for rod vortex generator", Aircraft Engineering and Aerospace Technology, https://doi.org/10.1108/AEAT-01-2018-0072

The project as received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 860101

INSTITUTE OF FLUID FLOW MACHINERY
POLISH ACADEMY OF SCIENCES