Review paper WES entitled :

Blade surface pressure and drag measurement of a blade section on a 4.3 MW turbine with trailing edge flaps

from :
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Resume :

Authors present an original way of measuring drag on field test measurements. This can be used to evaluate drag with and without a control/perturbation device (trailing edge flaps, Vgs, zztape). This method is well known for wind tunnel tests, but has not been used yet on field tests.

Evaluating efficiency of control or perturbation device on field tests is an important challenge. These measurements are thus rare and essential to help modeling aerodynamics in real operating conditions. This is also really complex measurements to perform. This study is therefore highly valuable. However, there is many major issues that needs to be tackled before publication.

Summary of major issues :

The paper present an important work with wind tunnel, tests ring and field test measurements, that are however most of the time not sufficiently described, not sufficiently justified and analyzed. This is also difficult to make a link between wind tunnel tests/ test ring and wind turbine tests as there is either no quantitative results, only the Cl/Cd curve or only the Cl/Cd time series …
I recommand authors to maybe focus more on one set of tests and to provide a more detailed analysis.

Major issues : some details

1-Introduction :
Authors underline the lack of knowledge on blade aerodynamics on solely three mechanisms : high Reynolds numbers, roughness state at the surface of the blades, outer-flow state (turbulence inflow) that acts on the laminar to turbulent transition on the airfoil surface.

However, differences between wind tunnel and field tests can come from more than these 3 mechanisms. Indeed, wind tunnel turbulent inflow do not necessarily match inflows encountered in blade real operating conditions and not only regarding turbulence level. Mean inflow velocity gradients combined with different turbulent inflows may lead to different operating AoA. This can induce important load variations and even flow separation (even small) which induces 3D and unsteady flow over the airfoil and thus load variations. When the flow separates other aspects such as the airfoil aspect ratio, and the centrifugal forces play an important role in differences with wind tunnel measurements. Centrifugal forces are reproduced by the rotating test ring, however, the aspect ratio is very low (2) on both wind tunnel and rotating test ring.

Please reformulate hypothesis of this study in the introduction :
- The author place themselves in the hypothesis with no inflow inhomogeneity (mean or turbulent) along the blade in real operation (there is no inflow measurements able to measure the presence of any mean or unsteady velocity gradient). Only two points are measured in the near blade inflow (in the blade induction zone?) using the 5 hole pressure sensors.

- The AoA is sufficiently low for the flow to stay attached.

2 - Experimental set-up :

- Figure 1 is unclear. It is very difficult to see how the rake is installed relatively to the blade.

Please provide a clearer view (maybe add a sketch).

- Due to all the instrumentation (wake rake plus 5 hole pressure sensors), the flow over the airfoil might be 3D even if not separated (low AoA). This could happen especially due to the low aspect ratio (equal to 2).

How the two dimensionality is checked (wood tuft ? Visualization??) ?

- The wake rake composition is not given clearly in section 2.2. A picture appears only in L120, with no explanation on the location of « static tubes », « total pressure tubes » or « head of pitot tubes » that seems to compose the wake rake as given from L116 to L119.

Please provide a clear description/composition of the wake rake (on figure 2), at section 2.2. Please justify the choice of this composition.

- The geometry of the airfoil section is not given. This is a very important matter as the state of the flow over the airfoil depends largely on the airfoil geometry. 15° is certainly a separated state, and depending on the airfoil geometry (thickness, curvature), this correspond to a deep stall or a slight trailing edge flow separation …
  Also, there is no means to evaluate the drag without the wake rake (no reference case). This could be a an xfoil simulation (valid only at low AoA) or drag measurements using a balance system.

Please provide the airfoil geometry that is tested, and at least a reference case with measurement of Cl, Cd versus AoA.

- L110-114 : « measurement is only slightly affected by ».

How can you conclude on this as there is no « reference case » ? Also, please provide a more quantitative description.

- L113 « The cd is only slightly affected by the pressure orifices, but largely affected by the five-hole Pitot tube connection »

This is to me a major issue for drag measurement. Please develop more for which configurations this sentence applies ? Please provide a quantification of this impact. At last, justify more why using 5 hole pressure sensors, and give possible solutions for future work.

- Nothing is said on impact of AoA (8° and 15° were tested) on drag measurements

Please provide Cd error quantification for both AoA.

Section 2.2.2

- L136 « Detailed tests were carried out in different wind conditions ... »

Please provide detailed informations on tested configurations (give values of velocity, pitch and flap angles, together with calculated AoA – and provide method used to compute AoA).

- P6 L137 : There is no description of the VG and of the surface roughness (shape, location on the blade, wind tunnel tests etc …) used for figure 4. Also this figure is out of the main paper subject.

Either the authors give more information on these tests, or the figure should be removed.

Also, why not providing a comparison between wind tunnel drag measurements and test ring measurements (and then field tests measurements) ? Isn't is the purpose of the paper ?

Section 2.2.3

- *L144 « it was decided to design and manufacture a new frame for attachement of the wake rake on the full scale blade »*

I do understand this difficulty, however, do you have reproduced this set-up in wind tunnel (at least once) to evaluate this impact of this new mounting system ? If not, how do you expect this mounting to change results ? Please give more details.

Minor comments :

- L21-22 : « This is due to … 2D wind tunnel flow and unsteady, turbulent 3D flow experienced on the wind turbine blade »

I agree that there exist major differences from wind tunnel experiments and field measurements, but I won't say that the inflow is 2D in wind tunnels. In wind tunnels the flow is homogeneous and with low turbulence intensity, unless customized differently (passive or active grids, gust or other generated perturbations …).

please be more specific

- L54 : « This is commonly measured ... »

This is not clear what « This » refers to. One could think that the wake rake measure only the viscous drag.

Please reformulate.

- « Experimental set-up » section :

The description of experimental set-up is made of bullet points, which is unusual and rather adapted to technical reports.

Please provide sentences rather than bullet points.

- P6L133 : « in standar procedure from inside »

Please develop.