Journal: WES
MS No.: wes-2021-124
Title: “Experimental investigation of Mini Gurney Flaps in combination with vortex generators for improved wind turbine blade performance ”
Author(s): Jörg Alber, Marinos Manolesos, Guido Weinzierl-Dlugosch, Johannes Fischer, Alexander Schönmeier, Christian Navid Nayeri, Christian Oliver Paschereit, Joachim Twele, Jens Fortmann, Pier Francesco Melani[5], and Alessandro Bianchini

General comments:

This paper present wind tunnel investigations on the effects of Mini Gurney flaps (MGFs) and their combination with vortex generators (VGs) on the performance of airfoils and wind turbine rotor blades.

This paper present high quality experiments with a lot of details on how to design the combined configurations of MGF and VG. Output results on the efficiency of passive devices should however be taken with caution because of two main reasons:
- the zztape effects are more important than passive device effects which is certainly an important issue for real blades that have generally LE erosion during operation. Same studies with different LE roughness should certainly be performed as pointed out by the authors.
- experiments were performed in a low turbulent intensity wind tunnel facility, which is far from the environment of operated blades and may lead to a decrease of actuator efficiency.

An important output of the present paper is the new design opportunities (chord length significantly reduced) that is provided using these passive devices. This study explains to do such a new blade design (the first detailed paper on that matter from my knowledge).

It has however some issues that need to be corrected. The major issues concern :
- the scientific objective that is unclear regarding the available literature of section 1.5.
- the hypothesis on the design of MGF and Vgs that are not always formulated, especially when using Xfoil to design actuators at high angle of incidence.

I thus recommend the publication of the paper with corrections detailed below.

MAJOR ISSUES:

Q1: P6L137 How the present study is original from the existing literature of section 1.5 ?

Q2: p8L190: “relative strong turbulence intensity of Ti=0.3%”
For atmospheric flows in which wind turbine operates, the turbulence intensity is rather around 10%, please remove strong and put it in the context of wind tunnel facilities.

Q3: P9L216: this “The model revealed a non-proportional dependency on the GF height” contradict this “diminishing HGF, dCL/hGF increased, whereas dCd/hGF decreased.
Also, from equation 6: Cl/Cd ~ dCl/Cd , which also contradicts the non-proportional dependency …

It is not clear what is non-proportional to what ?

Q4: P9L221: hGF is defined relatively to the blade chord while the conclusion is “GF needs to be submerged deeply into the local BL”
The height of the device should be expressed relatively to the boundary layer thickness to do that conclusion. Also, it can’t be reduced to the boundary layer thickness dependency only, as the boundary layer is never in equilibrium on blades but subjected to different pressure gradient history depending on the blade shape. The conclusion of Alber et al (2017) study is therefore limited to the tested configurations.

Q5: P9L224: “ratio between the GF height and the BL displacement thickness at the TE”
Why at the TE ?
This is rather at the location of the GF. The effect of GF location is certainly another parameter that needs to be explored.

Q6: P9L225: It is not clear here why MGF is designed at the optimal angle of incidence ? It is certainly the angle of incidence corresponding to the maximum TE boundary layer thickness, so the MGF design is detrimental to other angles of incidence ?
Please explain.

Q7: P10L2: “hMGF < delta*”, the impact of MGF on the airfoil performance becomes insignificant.
Even if it seems obvious that the MGF size has some low limitation, how do you end-up with this value ?

Q8: p10L228: “hMGF ~ 0.25 delta”
Why chosing ¼ while 2/3 would lead to an higher aerodynamic impact and is stil compatible to eq. 8 ?

Q9: p10L234: “0.1%c < hMGF < 0.7%c”
According to table 3, the minimum value of delta is 0.82%c, leading to hMGF=0.2%c (according to equation 9). Please correct.

Q10: P10L239: “All tested … in relation to the size of GF”, this sentence is not clear, is the GF height varying from 0.3mm to 0.6mm ? It does not seems so for the smallest MGF as the chord is c=0.6m and hMGF=0.25%c=0.15mm. Please make it clearer.

Q11: P10L241: on the vortex generators design
The BL transition can be extracted from Xfoil. However, Xfoil is known to be limited to attached flow configurations with difficulties to correctly predict forces when there exist flow separation and especially at Clmax. I also don’t know any Xfoil output on the mean separation line.

It is therefore not clear here how the location of the mean separation line is obtained ?

Please be clearer.

Q12: Also, once the flow is separated, there is not anymore a boundary layer flow, so the standard boundary layer thickness definition fails. Please specify how do you define it ?

Q13: P11L1: “at stall, delta is similar in both the clean and tripped cases”
Stall configuration refers to a full flow separation over the blade suction side, so no delta can be measured (as there no boundary layer anymore).

Please reformulate to be clearer.

Q14: P17L377: From

Dan H. Neuhart and Catherine B. McGinley “Free-Stream Turbulence Intensity in the Langley 14- by 22-Foot Subsonic Tunnel” NASA report NASA/TP-2004-213247, Langley Research Center, Hampton, Virginia

The turbulent intensity is one order of magnitude higher, between ~0.07% to 0.08%.

There is certainly a mistake in the reported Ti (0.005%), please correct.

Q15: The drag signal is acquired at 10kHz and the lift is acquired at 5kHz, it is therefore possible to plot the standard deviation with the AOA. Please add this quantity that will help to evaluate further the actuator efficiency.

Conclusion:
The ZZ tape has more impact on the L/D ratio than the actuators themselves. Therefore authors raise naturally the question of the blade roughness impact on their conclusion, but should also raise the question of the turbulent intensity impact, that has the ability to enhance the mixing rate of separated shear layers near the maximum lift values (or near stall).

MINOR ISSUES:

Q1: This citation is not a peer review journal nor a conference paper:

Schatz, M., Günther, B., and Thiele, F.: Numerical Simulation of the Unsteady Wake behind Gurney-Flaps, available at:
https://www.cfd.tu-berlin.de/research/flowcontrol/gurneys_en/ (last access: 17 October 2020), 2004a.

Q2: L93: “the unsteadiness vanished as the AoA is increased from 0 to 4°”
why only until 4° ? It increases again afterwards ?

Q3: P2L37: what PFC stands for ?

Q4: P12L267: what is the purpose of the “airfoil box” ?

Q5: P12L274: from the static pressure difference between the inlet and outlet of a duct you only get the pressure losses, not the dynamic pressure used to measurement the inflow velocity. Please correct the sentence.

Q6: P12L276: How the blade is attached to the balance system ?

Q7: P12L277: What are the wind tunnel boundary layer thickness value ? And what are the end plates dimensions and how they were chosen ?

Q8: P12L277-278: The flow in the bypass region is certainly very complex with interaction between the facility boundary-layer and the end plate boundary layer. Why using that location as a reference velocity ? Is the prandtl tube in front of the blade sufficiently insufficient ? Is there blade induction effects at this location ?

Q9: P14L1: what is the origin of x ? because x=c from figure 4a is at the trailing edge … I guess you mean x/c=2 ?
Please correct.
Idem p25L494: 100%c → x/c=2

Q10: P14L2: what do you mean by "return to static pressure level in the wind tunnel" ?
If the pressure is measured in the blade wake area at high angle of incidence, 1D is certainly not sufficient to return to the static pressure level in the wind tunnel. Please be more specific.

Q11: P14L311: "two Prandtl tubes that are installed inside the downstream plane of the rake, one on top and one below the casing"
This sentence is not clear as Prandtl tubes measure the dynamic pressure (difference between static and total pressure). Please be clearer.

Q12: P14: careful on the notations: deltapP(yi)=deltaPi of equation 11 ?
Ptotal = Pbar total (the question behind is: how long the signal was acquired and does the bar mean averaged over that signal ?)
Pstatic=Pbar static (idem)?

Q13: P14L330: please explain (quickly) where the relation 14 comes from.

Q14: P14L340: About Lambda: is it related to the airfoil thickness (and so dependent on each airfoil), or is it the height of the test section (and so a fixe value). Please make it clearer.

Q15: Please provide the raw lift and drag curves to see the improvement when applying the wind tunnel correction.

Q16: P18L396: Next, figure 12a … isn't it figure 11a ?
Please check.

Q17: P18 legend of figure 11 on p19.
Please correct

Q18: p21L1-2: it should also be noted that there is only marginal L/D improvement between GF cases.

Q19: P26L506: normalizing the vertical position with the chord and locate the center relatively to the blade will help to evaluate the wake extend and thus conclude on the flow separation extend, that is not necessarily going up to the trailing edge - stalled (in figure 15a: the baseline zz case indicates that the flow separation do not occurs at the leading edge).

Q20: P26L509: please replace "suppress" by "delay"

Q21: p27 Figure 19: I don't see the benefit of adding GF (or MGF) compared to VG alone, and it is not commented in the article.
Please explain why MGF+VG is better than VG alone for that configuration ?

Q22: P30: legend of figure 20 is misplaced.