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Comment on wes-2021-115

Anonymous Referee #1

Referee comment on "CFD-based curved tip shape design for wind turbine blades" by Mads H. Aa. Madsen et al., Wind Energ. Sci. Discuss.,
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Review: CFD-based curved tip shape design for wind turbine blades – Madsen, HA et al.

Opening Comments:

This manuscript presents an optimization framework for tip designs in wind turbines using CFD. The authors are attempting to come up with a load neutral tip shape for wind turbines using a direct high-fidelity CFD based approach. Only aerodynamic effects are considered. The authors begin with an extensive literature review that places the current work in context with archival literature. They divide recently published literature into parametric studies and optimization studies. They point to the need for higher model fidelity as cited by several previous studies, as well as the need for optimizations with unifying design optimization problems. These are the drivers for this study.

The optimization method involves a straightforward process of determining design variables, calculating a deformed surface mesh, subsequently calculating a flowfield, functions of interest and constraints using EllipSys3D. This cycle is repeated until an optimized shape is obtained. The IEA 10MW is used as the baseline, and the design optimization problem is performed on this turbine. The results are presented in terms of optimal step size, and finally the optimized tip shape compared to the baseline. The authors conclude by pointing out that mesh deformation and setting up the finite difference method carefully are critical in a CFD based approach, but ease of use may mean surrogate based approaches may be more viable currently.

There are a few specific concerns with methods and results that have been outlined below:

Specific concerns:

- The complex step method is used to compute reference gradients. However, it is also mentioned that there is a lack of robustness in the authors' implementation of the complex step method. This statement will need to be clarified to build confidence on the accuracy of reference gradient and the results presented here.
- The variables in the design optimization process are not clearly explained. I assumed $\theta_{1,2,3,4}$ and $c_{1,2,3,4}$ are twist and chord for four points along the span in the tip region (outer 10%), but this is not stated clearly and locations not given.
- It is not clear how c is scaled. Is it with respect to chord at $0.9r/R$?
- Recommend using the term merit function when discussing design optimization problem for consistency, rather than just in the results.
- An iso-view of the blade in comparison to Zahle (2018) may be more informative than current tile 3 of figure 15.

Technical concerns:

While this manuscript has been written well for most part, there are areas where typing errors have crept in or word choices cause confusion. A few examples: line 75 (also), line 241 (I'm not sure unimodal is the right word here), line 309, line 348, line 479, line 629, line 819 and so on. Recommend careful proofreading once again and rewording the unclear sentences.

Closing comments:

In general, this is a well-written and researched paper and will advance the literature on CFD based design approaches for blade tip devices. The current study can be considered a companion study to the ones by Zahle et al. (2018) and Barlas et al. (2021) where the authors also tackle the problem of load neutral blade tip extensions. The paper addresses questions relevant to the scope of WES and presents a framework for using a CFD based design optimization process. I recommend that with minor revisions (addressing the concerns listed above), the paper be accepted for publication in WES.