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Comment on wes-2021-115

Malo Rosemeier

Community comment on "CFD-based curved tip shape design for wind turbine blades" by Mads Holst Aagaard Madsen et al., Wind Energ. Sci. Discuss., https://doi.org/10.5194/wes-2021-115-CC1, 2021

This academic study presents well a blade tip shape design optimization from a purely aerodynamic point of view using the IEA 10 MW reference blade. The optimization is constrained not to exceed the flap-wise design bending moment at 90% rotor radius. The final tip shape extends the reference blade by 1% of the relative radius (r/R) while introducing a luvward prebent and a backward sweep of 2% r/R, respectively. The AEP increases by 1.12%.

In the introduction, the business case for tips as optimized in this study is stated to be a load neutral AEP increase for already existing blades in field. The optimized blade tip shall be mounted as a retrofit, which could look as illustrated in the work by Rosemeier and Saathoff (2020), for example. Now, the principle of the work is applied to the final tip shape of this study: A new blade tip of, e.g., 10% r/R, is newly manufactured, a piece of the original blade tip must be cut away (due to the curved shape of the tip extension) in field at the installed rotor, and the new tip is pulled over the existing blade and is re-mounted. A structural connection between the existing blade and the tip is achieved through a bonding connection within an overlap region. This extended and curved blade tip itself, the overlap, and additional adhesives or ribs are expected to increase the mass at the blade tip when compared to the reference. Additional mass at the tip introduces an increase of the design-dimensioning lead-lag bending moment at the blade root. The lead-lag load collective is driven by the number of rotor revolutions during the lifetime of say 20 years. To compromise the load increase, the lifetime would need to be reduced. The reduced lifetime decreases the total energy yield, which would need to be outweighed with the AEP increase of the optimized tip shape. These aspects are part-wise highlighted in the work by Rosemeier and Saathoff (2020), wherein it was concluded that the tip retrofit's AEP increase minus the additional cost for development, certification, mounting, and manufacture need to be opposed to an easy to "implement" lifetime extension of the turbine at a wind site that is weaker than assumed during the design.

In the conclusions, you mentioned another possible business case, i.e., the implementation of site-specific blade tips in the framework of a modular blade design. This means that for a new blade design, a standard root segment and a variety of different tip sigments optimized to site-specific condition categories is manufactured. If not manufactured from one mould, the blade root and tip segment would need to be joined. Such a joint adds mass to the blade and the standard root segment would need to be designed to carry the loads of tip segment with the largest load envelope. Finally, the modular blade root segment is expected to be increased in mass compared to the non-modular reference. The consequences are similar to what is decribed in the previous paragraph.

Having these thoughts in the back one's mind your described business cases in the introduction/conclusions should be overthought or reformulated to address the above. Moreover, the practical relevance of such purely aerodynamic optimizations can be increased if they would consider the additional impact of mass loads, e.g., by constraining the bending moment at 90% r/R to be also mass load neutral. The additional mass could be modeled as a function of volume and a "smeared" density, for example, plus some constant masses for the overlap or the joint. Do the authors think it would be possible to implement such a constraint in the optimization?

Reference:

Rosemeier, M. and Saathoff, M.: Assessment of a rotor blade extension retrofit as a supplement to the lifetime extension of wind turbines, Wind Energ. Sci., 5, 897–909, https://doi.org/10.5194/wes-5-897-2020, 2020.