Aero-elastic Wind Turbine Design with Active Flaps for AEP Maximization

In optimal wind turbine design, there is a compromise between maximizing the energy producing forces and minimizing the absolute peak loads carried by the structures. Active flaps are an attractive strategy because they give engineers greater freedom to vary the aerodynamic forces under any condition. Flaps can be used in a variety of different ways (i.e. reducing fatigue, peak loads etc.), however this article focuses on how quasi-static actuation as a function of mean wind speed can be used for Annual Energy Production (AEP) maximization. Numerical design optimization of the DTU 10MW Reference Wind Turbine (RWT), with the HAWTOpt2 framework, was used to both find the optimal flap control strategy and the optimal turbine designs. The research shows that active flaps can provide a 1% gain in AEP for aero-structurally optimized blades in both add-on (i.e. the flap is added after the blade is designed) and integrated (i.e. the blade design and flap angle is optimized together) solutions. The results show that flaps are complementary to passive load alleviation because they provide high-order alleviation, where passive strategies only provide linear alleviation with respect to average wind speed. However, the changing loading from the flaps further complicates the design of torsionally active blades, thus, integrated design methods are needed to design these systems.

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