WindSTAR
Wind-Energy Science, Technology, and Research
Industry/University Cooperative Research Center

Advanced Control System for Evaluation of On-Blade Load Mitigation Technologies

Principal Investigator:
Mario Rotea (University of Texas at Dallas)

Co-Principal Investigator:
Yaoyu Li (University of Texas at Dallas)

Student Researcher:
Chang Liu (University of Texas at Dallas)

IAB Mentors:
Steve Nolet (TPI Composites)
Nicholas Althoff (GE Renewable Energy)
Neal Fine (Aquanis)

Rotor load mitigation technologies have the potential to allow new larger rotors with the same load envelope of smaller rotors, or extend the operational life of components in existing assets. In project D2-17, the team developed a simulation tool to aid in the analysis and design of on-blade active load control systems. The tool allows for control algorithms to command virtual on-blade actuators that modify the local sectional lift and drag coefficients over a partial-span of each blade. Then the impact of closed loop flow control on reduction in fatigue or extreme loads caused by turbulence, wind shear or gusts can be evaluated. While the work was originally motivated by plasma actuator devices, this computer tool is applicable to other on-blade devices for flow control, such as micro tabs and trailing edge flaps. In project D1-18, we proposed to develop advanced multivariable control algorithms, where all sectional actuator elements are allowed to vary independently (but coordinated). This controller is universally applicable to any actuation technology used to command changes in sectional lift.

Figure 1 shows a conceptual diagram of sectional lift control using plasma actuation. Figure 2 shows preliminary load reduction results for the DTU 10-MW Reference Wind Turbine. The load reduction is obtained using a feedback controller to command sectional lift in response to measured changes in the three blade-root flapwise bending moments.

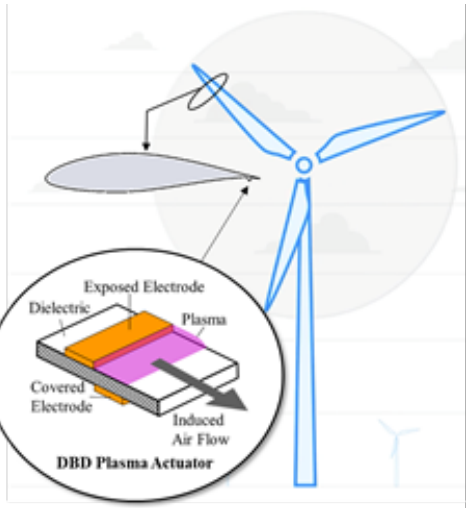

Figure 1: Conceptual diagram of a flow control device (DBD plasma actuator) to modulate the lift force along the blade span. Blade and rotor loads may be reduced by controlling the lift at various sections of the blade span. Diagram by Courtesy of Aquanis, Inc.

DTU 10-MW Reference Wind Turbine

Parameter	Value
Rated power	10 MW
Rotor Diameter	178.3 m
Hub Height	119.0 m
Cut-in, Rated, Cut-out Wind speed	4 m/s, 11.4 m/s, 25 m/s
Cut-in, Rated Rotor Speed	6 RPM, 9.6 RPM
Turbine Control	Variable speed, Collective pitch

Damage Equivalent Load Reduction (flapwise bending)

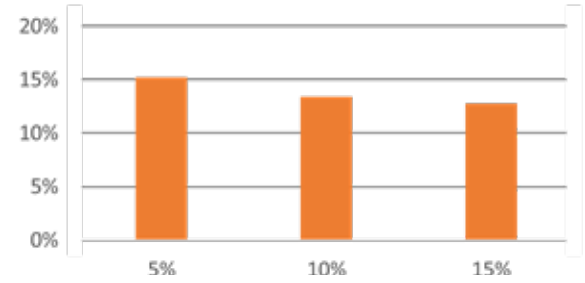

Figure 2: (Left) Parameters of the 10 MW Reference Turbine model developed at the Wind Energy Department in the Technical University of Denmark[i]. (Right) Percentage reduction in damage equivalent loads resulting from sectional lift control in the outer span of the blades. The wind conditions are 18 m/s hub-height wind with 0.2 shear exponent and three values of turbulence intensity.

[i]Bak, C., Zahle, F., Bitsche, R., Kim, T., Yde, A., Henriksen, L.C., Hansen, M.H., Blasques, J.P.A.A., Gaunaa, M. and Natarajan, A. (2013). The DTU 10-MW reference wind turbine. In Danish Wind Power Research 2013.