Optimized Active Aerodynamic Blade Control for Load Alleviation on Large Wind Turbines

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Abstract

Wind turbines are large complex dynamically flexible structures that must operate under very turbulent and unpredictable environmental conditions where the efficiency and reliability are highly dependent upon a well designed control strategy. At maximum energy capture capacity (operating region III) several popular control strategies are being investigated to help alleviate loads to prevent damage to the machinery. These include; individual pitch control, collective pitch control, and trailing-edge devices that change the effective camber of the airfoil. In this study the authors investigate the optimal deployment of one type of trailing-edge device, the micro-tabs, in conjunction with collective and individual pitch control to provide effective load alleviation for the NREL Controls Advanced Research Turbine (CART) in Colorado. The performance index maintains maximum power output while minimizing root bending moment during "actual simulated" turbulent wind conditions. The goal is to determine the micro-tab deployment profiles that keep blade root bending moments as close as possible to steady-state wind conditions during operation in a turbulent regime. A MATLAB optimization algorithm is applied as a "wrapper" around a FAST/Simulink wind turbine analysis model. The time-domain simulation results for reduced tip deflections and root bending moments are animated to visualize reduced loads with respect to micro-tab deployment profiles. The results demonstrate up to a potential 70% theoretical upper-bound reduction in root bending moments, for the cases investigated. This may allow the designer to; increase effective rotor size, extend potential life expectancy and reliability, and ultimately reduce the cost-of-energy of future large wind turbine machines.

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