Preview predictive control layer design based upon known wind turbine blade-pitch controllers

The use of upstream wind measurements has motivated the development of blade-pitch preview controllers for improving rotor speed tracking and structural load reduction beyond that achievable via conventional feedback control. Such preview controllers, typically based upon model predictive control (MPC) for its constraint handling properties, alter the closed-loop dynamics of the existing blade-pitch feedback control system. This can result in a deterioration of the robustness properties and performance of the existing feedback control system. Furthermore, performance gains from utilising the upcoming real-time measurements cannot be easily distinguished from the feedback control, making it difficult to formulate a clear business case for the use of preview control. Therefore, the aim of this work is to formulate a modular MPC layer on top of a given output-feedback blade-pitch controller, with a view to retaining the closed-loop robustness and frequency-domain performance of the latter. The separate nature of the proposed controller structure enables clear and transparent quantification of the benefits gained by using preview control, beyond that of the underlying feedback controller. This is illustrated by results obtained from high-fidelity closed-loop turbine simulations, showing the proposed control scheme incorporating knowledge of the oncoming wind and constraints achieved significant 43% and 30% reductions in the rotor speed and flap-wise blade moment standard deviations, respectively. Additionally, the chance of constraint violations on the rotor speed decreased remarkably from 2.15% to 0.01%, compared to the nominal controller. Copyright (c) 2017 John Wiley & Sons, Ltd.