A smart rotor configuration with linear quadratic control of adaptive trailing edge flaps for active load alleviation

The paper proposes a smart rotor configuration where adaptive trailing edge flaps (ATEFs) are employed for active alleviation of the aerodynamic loads on the blades of the NREL 5 MW reference turbine. The flaps extend for 20% of the blade length and are controlled by a linear quadratic (LQ) algorithm based on measurements of the blade root flapwise bending moment. The control algorithm includes frequency weighting to discourage flap activity at frequencies higher than 0.5 Hz. The linear model required by the LQ algorithm is obtained from subspace system identification; periodic disturbance signals described by simple functions of the blade azimuthal position are included in the identification to avoid biases from the periodic load variations observed on a rotating blade. The LQ controller uses the same periodic disturbance signals to handle anticipation of the loads periodic component. The effects of active flap control are assessed with aeroelastic simulations of the turbine in normal operation conditions, as prescribed by the International Electrotechnical Commission standard. The turbine lifetime fatigue damage equivalent loads provide a convenient summary of the results achieved with ATEF control: 10% reduction of the blade root flapwise bending moment is reported in the simplest control configuration, whereas reductions of approximately 14% are achieved by including periodic loads anticipation. The simulations also highlight impacts on the fatigue damage loads in other parts of the structure, in particular, an increase of the blade torsion moment and a reduction of the tower fore-aft loads. Copyright © 2014 John Wiley & Sons, Ltd.

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