Design and calibration of a semi-active control logic to mitigate structural vibrations in wind turbines

The design of a semi-active (SA) control system addressed to mitigate wind induced structural demand to high wind turbine towers is discussed herein. Actually, the remarkable growth in height of wind turbines in the last decades, for a higher production of electricity, makes this issue pressing than ever. The main objective is limiting bending moment demand by relaxing the base restraint, without increasing the top displacement, so reducing the incidence of harmful "p-delta" effects. A variable restraint at the base, able to modify in real time its mechanical properties according to the instantaneous response of the tower, is proposed. It is made of a smooth hinge with additional elastic stiffness and variable damping respectively given by springs and SA magnetorheological (MR) dampers installed in parallel. The idea has been physically realized at the Denmark Technical University where a 1/20 scale model of a real, one hundred meters tall wind turbine has been assumed as case study for shaking table tests. A special control algorithm has been purposely designed to drive MR dampers. Starting from the results of preliminary laboratory tests, a finite element model of such structure has been calibrated so as to develop several numerical simulations addressed to calibrate the controller, i.e., to achieve as much as possible different, even conflicting, structural goals. The results are definitely encouraging, since the best configuration of the controller leded to about 80% of reduction of base stress, as well as to about 30% of reduction of top displacement in respect to the fixed base case.

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