Design of a wind turbine swept blade through extensive load analysis

The main focus of this work is to offer an extensive investigation regarding the use of backward swept blades for passive load alleviation on wind turbines. Sweeping blades backward produces a structural coupling between flapwise bending towards the tower and torsion towards feathering. This coupling mitigates loads on the wind turbine structure due to a decrease in the angle of attack. The load alleviation can be achieved by changing the blade geometry according to three parameters: starting point for the change of shape along the blade span, blade tip sweep, and blade forward sweep. A parametric study is carried out on a 10 MW wind turbine with the purpose of outlining the relation between load variations and three geometric parameters used to introduce passive control on wind turbine blades. The objective is to estimate and analyze extreme and fatigue loads, formulating suggestions for the design of a wind turbine that employs backward swept blades. From the investigation, it is concluded that mildly and purely backward swept shapes are the best option because they allow the wind turbine to achieve load alleviations without a large increase of the blade root torsional extreme and lifetime equivalent fatigue moment. The efficacy of the design procedure provided with this work is proved through its application on a 5 MW wind turbine design.