Parameter Sensitivities Affecting the Flutter Speed of a MW-Sized Blade

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With the current trend toward larger and larger horizontal axis wind turbines, classical flutter is becoming a more critical issue. Recent studies have indicated that for a single blade turning in still air the flutter speed for a modern 35 meter blade occurs at approximately twice its operating speed (2 per rev), whereas for smaller blades (5-9 meters), both modern and early designs, the flutter speeds are in the range of 3.5-6 per rev. Scaling studies demonstrate that the per rev flutter speed should not change with scale. Thus design requirements that change with increasing blade size are producing the concurrent reduction in per rev flutter speeds. In comparison with an early small blade design (5 meter blade), flutter computations indicate that the non-rotating modes which combine to create the flutter mode change as the blade becomes larger (i.e. for the larger blade the 2nd flapwise mode, as opposed to the 1st flapwise mode for the smaller blade, combines with the 1st torsional mode to produce the flutter mode). For the more modern smaller blade design (9 meter blade), results show that the non-rotating modes that couple are similar to those of the larger blade. For the wings of fixed-wing aircraft, it is common knowledge that judicious selection of certain design parameters can increase the airspeed associated with the onset of flutter. Two parameters, the chordwise location of the center of mass and the ratio of the flapwise natural frequency to the torsional natural frequency, are especially significant. In this paper studies are performed to determine the sensitivity of the per rev flutter speed to these parameters for a 35 meter wind turbine blade. Additional studies are performed to determine which structural characteristics of the blade are most significant in explaining the previously mentioned per rev flutter speed differences. As a point of interest, flutter results are also reported for two recently designed 9 meter twist/coupled blades.

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