Direct calculation of wind turbine tip loss - DTU Orbit (09/11/2017)

Direct calculation of wind turbine tip loss

The usual method to account for a finite number of blades in blade element calculations of wind turbine performance is through a tip loss factor. Most analyses use the tip loss approximation due to Prandtl which is easily and cheaply calculated but is known to be inaccurate at low tip speed ratio. We develop three methods for the direct calculation of the tip loss. The first is the computationally expensive calculation of the velocities induced by the helicoidal wake which requires the evaluation of infinite sums of products of Bessel functions. The second uses the asymptotic evaluation of those sums by Kawada. The third uses the approximation due to Okulov which avoids the sums altogether. These methods are compared to the tip loss determined independently and exactly for an ideal three-bladed rotor at tip speed ratios between zero and 15. Kawada's asymptotic approximation and Okulov's equations are preferable to the Prandtl factor at all tip speed ratios, with the Okulov equations being generally more accurate. In particular the tip loss factor exceeds unity near the axis of rotation by a large amount at all tip speed ratios, which Prandtl's factor cannot reproduce. Neither the Kawada nor the Okulov equations impose a large computational burden on a blade element program.

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