Improved fixed point iterative method for blade element momentum computations

The blade element momentum (BEM) theory is widely used in aerodynamic performance calculations and optimization applications for wind turbines. The fixed point iterative method is the most commonly utilized technique to solve the BEM equations. However, this method sometimes does not converge to the physical solution, especially for the locations near the blade tip and root where the failure rate of the iterative method is high. The stability and accuracy of aerodynamic calculations and optimizations are greatly reduced due to this problem. The intrinsic mechanisms leading to convergence problems are addressed through both theoretical analysis and numerical tests. A term from the BEM equations equals to zero at a critical inflow angle is the source of the convergence problems. When the initial inflow angle is set larger than the critical inflow angle and the relaxation methodology is adopted, the convergence ability of the iterative method will be greatly enhanced. Numerical tests have been performed under different combinations of local tip speed ratio, local solidity, local twist and airfoil aerodynamic data. Results show that the simple iterative methods have a good convergence ability which will improve the aerodynamic or structural design of wind turbines.