Aerodynamic performance of wind turbine under different yaw angles - DTU Orbit (08/11/2017)

Aerodynamic performance of wind turbine under different yaw angles

A typical dynamic characteristic of horizontal axis wind turbine shows up under yaw condition. Prediction accuracy is low for momentum-blade element theory and related engineering prediction model. In order to improve the prediction accuracy of dynamic load characteristics, the whole wind turbine models, based on the experiment about MEXICO (model experiments in controlled conditions) rotor in 2006, are established by three-dimensional software called Pro/E. under different yaw conditions, i.e. yaw angle of 0, 15, 30 and 45 degree. ICEM CFD (integrated computer engineering and manufacturing code for computational fluid dynamics) is applied to grid division. The rotating domain containing rotor part is meshed into hexahedral grids, and the static domain containing part of wheel hub, tower and outflow field is meshed into tetrahedral grids. When the grid size of the first layer of blade surface is set as 5×10-6 m to ensure the first dimensionless size near the wall Y+<0.5 on the wall, the 2 numbers of grids are determined by the error of axial load on the airfoil in the 60% section of blades, which respectively are 6 572 451 and 2 961 385. The aerodynamic performance of models under rated condition is simulated by ANSYS CFX with the turbulence model of SST (shear stress transport), high resolution is chosen as advection scheme, and transient rotor stator as the domain interface method. The results are converted into data, processed and analyzed by MATLAB. Finally the following conclusions are drawn. The distributions of pressure coefficients along the airfoil chord in different blade sections calculated by CFD method are in good agreement with the experimental measurements, and the error on the suction surface of airfoil is mainly caused by stall separation occurring on the pressure surface of airfoil. With the increasing of yaw angle, the pressure coefficients of the suction side are increasing and the location of minimum pressure coefficient moves to airfoil trailing edge slightly. For the pressure side, the pressure coefficients increase at first and then decrease, and the location of maximum pressure coefficient moves to airfoil leading edge slightly. The axial load coefficients and tangential load coefficients of blades first decrease and then increase and then decrease again with the increase of the azimuthal angle. With the increase of the yaw angle, the axial and tangential load coefficients are both reduced. When the yaw angle is within 30°, the relative error of axial load coefficients is in the range of ±5% and the relative error of tangential load coefficients is in the range of ±15%. CFD method is higher than BEM (blade element momentum) method in forecasting accuracy of dynamic load calculation. Under yaw condition, the hysteresis characteristic of airfoil lift and drag in blade root is more remarkable than blade tip, while the variation range of the angle of attack in blade root is much less than that in blade tip. This characteristic must be considered when BEM method is used to predict wind turbine performance. For axial inflow condition, CFD method can well predict the average speed, but restricted by turbulence model and the wake model, CFD calculation did not show the velocity characteristics of rotating vortex shedding from wind turbine impeller under yaw condition. The study provides a data support to build up the forecast model on the engineering and provides the basis for wind turbine design under yaw condition.

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