A Simulation Tool with an Optimal Controller for Offshore Floating Wind Turbines

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ABSTRACT

In the paper, a coupled aero-hydrodynamic simulation tool in MATLAB/Simulink is developed for simulating the response and performance of offshore floating wind turbines (OFWTs) under wind and waves in the time domain. For aerodynamics, an unsteady blade element momentum (BEM) model and the free vortex wake method (FVM) are chosen to calculate the loads of the wind turbine. For hydrodynamics, the code uses the linearized classic marine hydrodynamic model with Morison’s equation to compute the loads of the platform. In addition, a variable speed controller is designed on the basis of the linear parameter-varying (LPV) technique for the wind turbine to the platform. Considering the advantages and disadvantages of FAST and WInDS, a new coupled aero-hydrodynamic simulation tool in MATLAB/Simulink is developed in this paper research, for simulating the response and performance of OFWTs under wind and waves in the time domain. For aerodynamics, the code uses an unsteady BEM model or the FVM to calculate the aerodynamic loads of the wind turbine. For hydrodynamics, a linearized classic marine hydrodynamic model, based on the frequency-dependent parameters obtained from the code of WAMIT (Lee and Newman, 2006), is employed to calculate the hydrodynamic loads of the platform by solving the hydrostatic, diffraction and radiation problems with fluid-memory effect. Furthermore, Morison’s equation and the strip theory (Faltinsen, 1990) are applied to calculate the nonlinear viscous drag for improving the quality of the model.

In addition, some researchers are interested in controllers for OFWTs. Usually, the operational region of OFWTs may be divided into four parts by the cut-in, rated and cut-out wind velocities: Region 1 (below the cut-in wind velocity), Region 2 (between the cut-in and rated wind velocities), Region 3 (between the rated and cut-out wind velocities) and Region 4 (above the cut-out wind velocity). In this work, we focus on Region 2 in which the control objective is to extract maximum energy from the wind by controlling the rotor speed. Baseline controller (Wright and Fingersh, 2008; Jonkman et al., 2009) was firstly designed for onshore wind turbines and later used on OFWTs. It employs the generator speed as a variable and controls the generator torque by following the optimal generator-torque versus generator-speed curve.