

Modeling Tower Effects of Floating Offshore Wind Turbine Based on Unsteady Actuator Line Model

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Abstract

The floating offshore wind turbine (FOWT), consisting of wind turbine, floating support platform and mooring system, is quite a complex floating structure system. Accurate prediction of FOWT's coupled aerodynamic responses is of great challenge. The tower effects are usually not taken into consideration in the simulations of wind turbine aerodynamics using an actuator line model. However, it has been suggested by other researchers that including the tower effects is important in better predicting the near wake and unsteady power output. To study the influence of tower effects on coupled aero-hydrodynamic responses of FOWTs, the tower is modeled within an unsteady actuator line model in fully coupled simulations of FOWTs under variable wind and wave conditions.

In the present study, the unsteady actuator line model (UALM) is embedded into in-house CFD solver naoe-FOAM-SJTU to establish a fully coupled CFD analysis tool named FOWT-UALM-SJTU for simulations of FOWTs. The blades and the tower of the wind turbine are represented by actuator lines, and the body forces applied to the flow field are calculated according to two-dimensional airfoil data. Coupled aero-hydrodynamic simulations of OC3 Hywindspar FOWT model under shear wind and regular wave conditions are conducted. The unsteady aerodynamics of wind turbines and tower effects are predicted by the UALM, and the hydrodynamic responses of floating platforms and mooring tensions can be obtained by naoe-FOAM-SJTU.

From the simulations, unsteady aerodynamic characteristics including the rotor power, thrust, and detailed wake flow information are available. To better understand tower effects, the numerical results considering the tower effects are compared with previous results that the tower effects are ignored. Furthermore, both the wake flow and the aerodynamic loads are analyzed to study the influence of tower effects on coupled dynamic responses of the FOWTs. It can be found that the use of a tower model with unsteady actuator line model can improve near wake prediction accuracy. And considering the tower effects helps in more precisely predicting transient aerodynamic loads of the FOWTs.

Keywords: Floating offshore wind turbines; Tower effects; Unsteady actuator line model; FOWT-UALM-SJTU solver