Flow Prediction of Offshore Wind Turbine with Rotating Flexible Blades

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This study predicts the aerodynamic performance of a NREL 5MW offshore wind turbine via a two-way fluid-structure interaction (FSI) approach. The flow field around a wind turbine is computed by solving the Navier–Stokes equations incorporated with a k-ω turbulence model, where air is assumed as an incompressible viscous fluid, and three blades are all considered as flexible material. The governing equations are discretized using a finite volume method and solved in a segregated approach. The velocity and pressure is decoupled with a SIMPLE-type algorithm. In this study STAR-CCM+ is used to predict the flow around a rotating wind turbine, whereas Abaqus is employed to estimate the blade deformation during its rotation motion. In order to simplify the numerical complexity, a weak coupling approach is adopted in the studied FSI problem. A remeshing process is then adopted to obtain the required grid quality of the sliding grid system as well as the mesh around the deformed blades. The simulation performed under the rated wind velocity 11.4 m/s and rated rotor speed 12.1 rpm at full scale is employed as a comparison baseline. The simulation suggests that the blade near tip can deviate about 6.45% of the total blade length from its original position, and a power decrease by 9.56% is expected when compared with the power predicted for the wind turbine without any blade deformation. The noise characteristics of flexible-blade turbine are then compared with those of its rigid counterpart to identify the influence of blade deformation on the noise generation. The flexible-blade computation is believed more close to the real operation practice and can deliver more realistic information of flow field around wind turbine, which is important to evaluate the safety and reliability of the wind turbine system.