Wind Turbine Impacts on Its Semi-Submersible Floating Supporting System for Phase II of OC4

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ABSTRACT

The motion response of floating supporting system for offshore wind turbine is critical in designing and confirming the safety and efficiency of wind turbine. This paper aims to study the wind turbine impacts on its semi-submersible floating system for Phase II of OC4, which is a project to compare dynamic computer codes and models used to design offshore wind turbines and support structures by International Energy Agency. Firstly, the validation of wave generation and absorbing has been performed to guarantee the accuracy of wave. Then, the grid convergence is used to eliminate the influence of grid on the results of simulation results. At last, motion of the semi-submersible floating system in specific wave has been compared between without wind turbine and with equivalent wind turbine. The equivalent forces and moments of the NREL 5-MW in different wind speeds (V=5m/s, 7m/s and 11.4m/s) have been exerted in the rotation center of the semi-submersible floating system. The results show the influences of the wind turbine on the supporting system in wave that give the guidance to the design of floating supporting system of offshore floating wind turbine.

KEY WORDS: offshore wind turbine; semi-submersible floating system; OC4; numerical simulation; naoe-FOAM-SJTU solver.

INTRODUCTION

With the rapid economic development, the demand for energy is growing. However, the traditional energy, such as fossil fuel, has been overexploited with arising many environmental and climate problems. Nowadays, more and more attention is paid to the new energy to settle the increasingly urgent energy crisis. There are many kinds of new energy, such as the solar, tidal and wind energy. The wind energy has been research focus as its clean, renewable and recycle features. It is widely recognized that the wind energy is the most promising energy among all the new renewable energies. There also have some wind farms in the world. America and many European countries such as the Denmark and the Netherlands governments had poured a large sum of resources to study the development and utilization of the wind energy. Comparing with the onshore wind energy, the offshore energy has more advantages such as high wind speed, stable wind, week wind shear and little visual and noise pollution (Zhao, 2013). In 1990, with the first offshore wind farm constructed in Sweden, the offshore wind energy

begins a fast development. Up to the end of 2012,the installed capacity of the offshore wind power has reached 5 million kilowatts in Europe and it is planned to reach 40 million kilowatts in 2020 and 150 million kilowatts in 2030 (Zhao, 2013).

The reliability of the supporting platform is a critical factor in the safety design of the offshore wind turbine. At sea, the wind turbine may encounter a variety of wind and waves. The dynamic response of the supporting system in different circumstances deserved extensive studies to make sure its security and availability. The support structures for offshore wind turbines can be divided into fixed and floating foundations. Research about the floating foundations has begun since 1990s (Tang et al., 2011). Zhang et al. (2012) analyzed some key dynamic problems and risk factors of the floating structure for working load caused by turbine running and sea environment loads of floating structure. Roddier et al. (2010) investigated the WindFloat, a floating foundation for offshore wind turbines. There are three common floating foundation of the offshore wind turbine: the tension leg platform, spar foundation and the semi-submersible platform (Sclavounos, 2008). Gao et al. (2013) based on the boundary element method and combined with multi-body dynamics analyzing the motion response and wave force mechanism to the tension leg platform of floating offshore wind turbine. Utsunomiya, et al. (2009) carried out an experiment validation for motion of a 2MW SPAR type floating offshore wind turbine. Coulling et al. (2013) validate a model constructed in the National Renewable Energy Laboratory (NREL) floating wind turbine simulator FAST with 1/50th-scale model test data for a semi-submersible floating wind turbine system.

According to the report by International Energy Agency, Phase II of the Offshore Code Comparison Collaboration Continuation (OC4) project will involve modeling of a semi-submersible floating offshore wind turbine. OC4 is a continuation of the OC3 (Offshore Code Comparison Collaboration) project, which examined three different fixed-bottom and one floating offshore wind system. Nowadays many researches about the floating offshore wind turbine have been carried out about the OC4 project to validate their numerical simulation tools by comparing results of simulated response between various tools. Goupee et al., (2012) tested three different floating wind turbine configurations in a wave basin under combined wind/wave loading. The wind turbine for OC4 Phase II will be the National Renewable Energy Laboratory (NREL) offshore 5-MW baseline wind turbine (Jonkman, et al., 2009), which has abundant experiment data and simulation results. This wind