CFD Simulation of Semi-Submersible Floating Offshore Wind Turbine under Regular Waves

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ABSTRACT

Floating offshore wind industry is developing rapidly under joint efforts of academics and industry. The International Energy Agency Wind Technology Collaboration Program (IEA Wind TCP) initiated the Offshore Code Comparison Collaboration, Continued, with Correlation (OC5) project to validate offshore wind modeling tools by comparison of simulated response to physical test data. The DeepCwind semisubmersible as one concept of floating wind turbine, was adopted by OC5 as the main model to study for Phase II of OC5. Measured data from 1/50th-scale model test performed at the Maritime Research Institute Netherlands (MARIN) offshore wave basin are used for validation of simulated results. This work adopts a computational fluid dynamics (CFD) code – REliable&Fast Rans Equations (solver for) Ships (and) Constructions Offshore (ReFRESCO) for numerical simulations. Behavior of semi-submersible under surge decay and pitch decay motion was studied using ReFRESCO, this work extends the application of ReFRESCO to simulate responses of semi-submersible under two regular waves conditions in consistence with experiment. Response Amplitude Operators (RAOs) are then derived from the computational results of the heave, surge and pitch motions for the validation study. A representative pair of grid size and time increment is chosen and simulated thoroughly with 8 wave periods. Results from the simulation are then validated with the model test data in RAOs. Free surface interaction with the floater and flow characteristics as velocity magnitude and vorticity field in the near field of the floater are illustrated.

KEY WORDS: FOWT, CFD, free surface, regular waves, RAO

INTRODUCTION

Offshore wind energy harvesting has grown into an enormous industry and drawn attentions from several parties. Floating Offshore Wind Turbines (FOWTs) as an innovative concept within the industry is also developing rapidly. Thus, simulation tools to accurately analyze the motion of FOWTs under changing sea conditions are desired. There exists a large amount of simulation tools with the capability to simulate the aerodynamics of the turbine and the hydrodynamics of the floater including mooring effect. The International Energy Agency Wind Technology Collaboration Program (IEA Wind TCP) initiated the Offshore Code Comparison, Collaboration, Continued, with Correlation (OC5) Project to validate these tools. Computational results of several methods for a semi-submersible floating wind turbine were gathered, validated with model test data and compared to each other (Robertson et al., 2017). Most of methods compared in this work were based on potential flow theory which lead to a conclusion that potential-flow based methods needed improvement in accuracy when simulating the oscillatory motions of the floater around the natural frequencies. The lack of consideration of viscous effects was suspected to be the main reason causing the discrepancies.

CFD codes which utilize numerical methods to solve Reynolds-averaged Navier-Stokes (RANS) equations are able to take into account viscosity and transport of turbulent momentum. Moreover, RANS based solvers can also provide detailed flow characteristics around the floater. There were several researches applied CFD codes in simulations of FOWTs. Beyer et al. (2013) and Quallen et al. (2016) evaluated the Hywind spar floater which was a rather simple cylindrical shape using Ansys CFX and in-house CFD codes. The semi-submersible design DeepCwind, adopted by OC4 and OC5, is a more complex geometry.