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Global Performance of a KRISO Semisubmersible Multiunit Floating Offshore Wind Turbine: Numerical Simulation vs. Model Test

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The global performance of the KRISO square-type semisubmersible multiunit floating offshore wind turbine (MUFOWT) in irregular waves is numerically simulated by using a multiturbine floater-mooring coupled dynamic analysis program. The developed time-domain numerical-simulation tool is extended from the FAST–CHARM3D coupled dynamics program for a single turbine on a single floater. FAST has been developed by the National Renewable Energy Laboratory for years for the single unit. Recently, KRISO has designed and studied a square-type semisubmersible MUFOWT in which four 3 MW wind turbines are installed at each corner of a single floater. Additionally, 24 point-power-absorber-type linear-generator-based wave energy converters are set up, with six wave energy converters at each side of the platform. For verification, KRISO performed a series of model tests for this MUFOWT with 1:50 Froude scale. In this paper, the MUFOWT simulation program is used to reproduce KRISO's model test results. In the fully-coupled multiturbine/hull/mooring dynamic simulations, the complete second-order difference-frequency wave forces are also included. The analysis results are systematically compared with the model test results, which shows reasonable correlation between them.

INTRODUCTION

The importance of clean renewable energy to secure new energy sources and protect environments has been underscored. Wind energy is especially appealing since it is economically competitive, technologically proven, and infinitely renewable and does not make any waste or carbon emission. In particular, offshore wind energy is very attractive since its quality is much better than that on land or coastal regions. When water depth is greater than 50 m, floating wind turbines (WTs) are usually recommended. Although considered to be more difficult to design than fixed offshore wind turbines, floating wind turbines have many advantages compared to onshore or bottom-fixed offshore wind turbines. In general, they are less restricted by governmental regulation and residents' opposition, with higher-quality wind, and less sensitive to restrictions regarding space, size, noise, appearance, and foundation. In this regard, if the technology is completely developed, floating offshore wind turbines are expected to be more popular to generate a considerable amount of clean renewable energy at competitive prices compared to other energy sources (Henderson et al., 2002; Henderson et al., 2004; Musial et al., 2004; Tong, 1998; Wayman et al., 2006).

In addition, a multiple unit floating offshore wind turbine (MUFOWT) is suggested as a feasible and interesting concept. Advantages and disadvantages of the MUFOWT are discussed in Barltrop (1993), and simplified analytical tools for the preliminary analysis of the multiple-turbine floater are suggested by Henderson et al. (2004). The MUFOWT enables many wind turbines to be installed on one floater. Using a large floater may improve overall dynamics and stability. The MUFOWT may also save installation and mooring line costs, since the whole unit can be fabricated at quayside, wet towed, and simply connected to a shared mooring system. It can also be used for a multipurpose energy station including other ocean renewable energy sources to multiply its economic value. Its defects may include wake effect for downstream turbines and uncertainties due to lack of experience.

One of the challenging issues for the MUFOWT is the coupled dynamics analysis among the mooring system, floating platform, and multiple-wind-turbine unit. Therefore, for reliable design, it is necessary to develop an integrated tool to accurately analyze the fully coupled dynamics including control. Some efforts in this direction are in progress for several selected types of floating offshore wind turbines. As an extension of the fully coupled dynamic analysis tool for the single-floater wind turbine, a combination of FAST (e.g., Jonkman and Buhl, 2004) and CHARM3D

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