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Cross comparison of two Analysis Tools for a Braceless Semi-Submersible Wind Turbine Versus Ocean Basin Test Results

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Abstract

In the frame of the IRPWind project (Integrated Research Programme on Wind Energy), a benchmark is going on for comparing the numerical tools versus results obtained from ocean basin tests. A braceless semi-submersible wind turbine platform is considered herein. Real-time hybrid model (ReaTHM) tests were done at 1:30 scale in MARINTEK’s Ocean Basin in 2015 (https://windbench.net/marintek). The goal was to estimate the performance of a novel hybrid technique which avoids the use of a physical turbine for reproducing the aerodynamic loads. Instead, these being representative of the Northern North Sea wind conditions, were in real time calculated by a BEM software and subsequently applied by a 5-degree-of-freedom actuators on the structure. The mooring system was typical of a three catenary mooring lines while the waves were produced by flapping mechanisms at basin’s borders. The above mentioned system produced experimental results that were taken as reference for calibrating numerical hydrodynamic and structural models [1, 2, 3].

Methods

Two distinct methods are cross-compared in this work (https://openfoamwiki.net/index.php/Contrib/waves2Foam). On the one hand, SIMA [Advanced Analyses of Marine Operations and Floating Systems] is the state of the art numerical tools of MARINTEK for coupled/integrated simulations of floating offshore structures considering aero-hydro-elastic formulations. It is about a nonlinear time-domain simulation tool which can capture all of the relevant hydrodynamic and aerodynamic loads, incorporate the control system actions and logic, and compute the structural response. On the other hand, HydroFoam is a combination of two open source tools forming a high fidelity analysis software for floating wind turbines. The first one is OpenFoam v.3.0.0 which predicts the hydrodynamic forces exerted on a moving floating through full CFD simulation, namely the Volume of Fluid method on moving meshes. This tool can be readily modified with the library waves2Foam (https://openfoamwiki.net/index.php/Contrib/waves2Foam) so that free surface water waves can be generated. In terms of the mooring system, OpenFoam supports only a simple spring-slider-dashpot model which is inadequate for simulating the concatenated, partially touching the floor chains used in the experiment. These can be simulated by making use of the open-source lumped-mass model line method. The open source code is the MoorDyn subroutine which is a stand-alone mooring simulator if fairlead motions are prescribed from a separate data file. This module is provided by the CAE tool FAST for horizontal wind turbines (https://www.npwtech.no).

Results

The results corresponds to significant wave height of 3.6 m and peak period of 10.2 s. Two sets of numerical modeling are presented, namely fully flexible tower-nacelle-rotor (Flex) and rigid modeling of tower-nacelle-rotor (Rigid). Both models agree very well for global motion responses and comparison of the numerical modeling in SIMA and test results are good, refer to [1, 2, 3].

Conclusions

In the present work a cross comparison between an engineering tool (SIMA) and a high level CFD software (HydroFoam) is attempted. While the former has reached a certain degree of maturity, the latter is a promising method for simulations under extreme weather conditions where the application of potential theory is very challenging. Nevertheless, the computational overhead induced by the CFD method decelerates the development of the code. The preliminary results provided by a fully unsteady simulation on calm water with constant excitation seems promising.

References


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