Title of Diploma Thesis

A Combined Offshore Wind and Wave Energy Exploitation System

Authors

Sofia Gkaraklova, Pavlos Chotzoglou

Academic Year

2018-2019

ABSTRACT

In the present diploma thesis a combined wind and wave energy exploitation system consisting of Wave Energy Converters (WECs) attached to a bottom-mounted Offshore Wind Turbine (OWT) is proposed and its performance is investigated. The floating WECs oscillate freely along their vertical axes, while the rest degrees of freedom are restricted. The wave energy is absorbed through a linear Power Take-Off (PTO) mechanism, actuated by the heave motion of each WEC. Two different WECs' geometries are examined; hemisphere-shaped and oblate spheroid-shaped WECs. The type of foundation of the OWT is the most widely applied, i.e. steel monopile.

After determining the most efficient, in terms of energy absorption, number of WECs, the following aspects are addressed: (a) the most efficient WECs' geometry, (b) the most efficient WECs' configuration for a given geometry and (c) the effect of the incident wave direction on the power absorption efficiently of the WECs. For the best WECs' geometry and configuration and the most favorable incident wave direction, the WECs are tuned in the best possible way to the sea conditions aiming at maximizing the absorbed energy. This is performed by controlling and varying the damping coefficient of the linear PTO mechanism (active PTO). The cumulative energy absorption of the WECs in this "optimal" configuration is assessed for 225 sea states by utilizing the Jonswap spectrum and it is found that at specific sea states the WECs can absorb more than 500 kWatt. Finally, the impact of the WECs on the bearing structure of the OWT is assessed, demonstrating, thus, the technical feasibility of the whole hybrid system.

In order to accomplish the above, AeroHydro's surface modeler, MultiSurf, is utilized to create the surface shapes of all bodies. The analysis of the hydrodynamic behaviour of the system requires the complete and simultaneous modelling of the diffraction and the radiation problem, taking into account the hydrodynamic interaction effects. This analysis is implemented in the frequency domain, in three dimensions, under the action of regular waves by utilizing of MIT's software, WAMIT (Wave Analysis Massachusetts Institute of Technology). For processing the WAMIT output data, codes are developed in MATLAB's multi-paradigm numerical computing environment using the programming language of MathWorks. Moreover, for controlling the damping coefficient value of the linear PTO mechanism and, thus, maximizing the WECs' energy absorption an interface is developed allowing the appropriate relevant coupling of WAMIT with MATLAB Finally, CSI's (Computers and Structures Inc.) program, SAP2000 is used for the structural analysis of the OWT-WECs' structural system.

Keywords: Combined offshore wind and wave exploitation, Offshore hybrid system, Oblate spheroids, PTO control, Active PTO, Structural and modal analysis.