SIMULATION AND PERFORMANCE EVALUATION OF MULTI-DOF POINT ABSORBERS AND OWC DEVICES OPERATING IN VARIABLE BATHYMETRY REGIONS BY BEM AND COUPLED-MODE SYSTEMS

Belibassakis Kostas,
School of Naval Architecture & Marine Engineering, National Technical University of Athens
Zografos 15710, Athens, Greece, e-mail: kbel@fluid.mech.ntua.gr

Bonovas Markos,
School of Naval Architecture & Marine Engineering, National Technical University of Athens
Zografos 15710, Athens, Greece, e-mail: markosbonovas@hotmail.com

Magkouris Alexandros,
School of Naval Architecture & Marine Engineering, National Technical University of Athens
Zografos 15710, Athens, Greece, e-mail: alexmagouris@gmail.com

Rusu Eugen,
Department of Mechanical Engineering, “Dunarea de Jos” University of Galati, 111 Domneasca St., 80008 Galati, Romania, e-mail: erusu@ugal.ro

Wave energy converters are constantly being deployed in nearshore and coastal areas characterized by increased potential, and a recent review concerning point absorber wave energy harvesters is presented in Ref.[1]. The performance of the devices installed in the nearshore and coastal environment, where the bottom terrain may present significant variations, can be evaluated by formulating and solving interaction problems of free surface gravity waves, floating bodies, and the seafloor; see, e.g., Mei [2]. A thorough presentation of the interaction between waves and oscillating energy systems can be found in Falnes [3].

Models describing coupling methodologies for numerical modelling of near and far-field effects of wave energy converter arrays are presented in various works; see, e.g, Ref.[4–7].In the present work a hybrid boundary element method is used, in conjunction with a coupled mode model and perfectly matched layer model, for obtaining the solution of the propagation/diffraction/radiation problems of floating bodies in variable bathymetry regions. The implemented methodology is free of mild-slope assumptions and restrictions. The present work ia based on extends previous results concerning heaving floaters over a region of general bottom topography in the case of generally shaped wave energy converters (WECs) operating in multiple degrees of freedom. Numerical results concerning the details of the wave field and the power output are presented, and the effects of WEC shape on the optimization of power extraction are discussed. It is demonstrated that consideration of heave in combination with pitch oscillation modes leads to a possible increase of the WEC performance.

Furthermore, a novel Boundary Element Method (BEM) is developed and applied to the investigation of the performance of Oscillating Water Column (OWC) systems, taking into account the interaction of the incident wave field with the bottom topography [8]. The modelling includes the effect of additional upwave walls and barriers used to modify the resonance characteristics of the device and improve its performance as the U-OWC configuration [9,10]. Numerical results illustrating the effects of depth variation in conjunction with other parameters—such as chamber dimensions as well as the parameters associated with the turbine and power take-off system—on the device performance are presented and discussed. Finally, a case study is presented regarding the potential installation of an OWC in a selected port site in the Black Sea, characterized by a good wave energy potential, on the coast of Romania, and more details can be found in Ref.[8].

Keywords: marine renewable energy, performance evaluation, coupled-mode systems, BEM

Acknowledgment: This work was carried out in the framework of the research project DREAM (Dynamics of the REsources and technological Advance in harvesting Marine renewable energy), supported by the Romanian Executive Agency for Higher Education, Research, Development and Innovation Funding – UEFISCDI, grant number PN-III-P4-ID-PCE-2020-0008.

References

1. Al Shami, E.; Zhang, R.; Wang, X. Point Absorber Wave Energy Harvesters: A Review of Recent Developments. Energies 2019, 12, 47. [CrossRef]

2. Mei, C.C. The Applied Dynamics of Ocean Surface Waves; World Scientific: Singapore, 1989

3. Falnes, J. Ocean Waves and Oscillating Systems: Linear Interactions including Wave Energy Extraction; Cambridge University Press: Cambridge, UK, 2004.

4. Falcão, A.F.O. The shoreline OWC wave power plant at the Azores. In Proceedings of the 4th European Wave Energy Conference, Aalborg, Denmark, 4–6 December 2000.

5. Boake, C.; Whittaker, T.; Folley, M.; Hamish, E. Overview and Initial Operational Experience of the LIMPET Wave Energy Plant. In Proceedings of the 12th International Offshore and Polar Engineering Conference, Kitakyushu, Japan, 26–31 May 2002.

6. Belibassakis, K.; Bonovas, M.; Rusu, E. A Novel Method for Estimating Wave Energy Converter Performance in Variable Bathymetry Regions and Applications. Energies 2018, 11, 2092.

7. Bonovas, M.; Belibassakis, K.; Rusu, E. Multi-DOF WEC Performance in Variable Bathymetry Regions Using a Hybrid 3D BEM and Optimization. Energies 2019, 12, 2108. [CrossRef]

8. Belibassakis K.A, Magkouris A., Rusu E., 2020, A BEM for the hydrodynamic analysis of Oscillating Water Column systems in variable bathymetry, *Energies* 2020, *13*(13), 3403.

9. Boccotti, P. On a new wave energy absorber. Ocean. Eng. 2003, 30, 1191–1200.

10. Malara, G.; Arena, F. U—Oscillating Water Column in random waves: Modelling and Performances. In Proceedings of the 32nd International Conference on Ocean, Offshore and Arctic Engineering, Nantes, France, 9–14 June 2013.