UNIVERSITY OF EXETER

PhD Thesis

Improve the Understanding of Uncertainties in Numerical Analysis of Moored Floating Wave Energy Converters

Submitted by Andrew William Vickers to the University of Exeter as a Thesis for the degree of Doctor of Philosophy in Earth Resources in June 2012.

I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Signature..

July 30, 2013

Abstract

The wave energy industry, still in its infancy compared to similar activities offshore, must look to the oil and gas industry for guide lines on design criteria for survival, safety and operational optimisation for installations at sea. Numerical analysis tools for prediction of the response of floating moored structures have become an important part of the design task for the offshore industry offering a low cost and low risk option compared to scale tank testing. However, rather than having only a task of station keeping and survival, the moorings for a wave energy converters (WECs) would also be required to provide the ability of not adversely affecting the power capture task. The main aim of this work is to gain an understanding and reduce the uncertainties in the numerical modelling of WECs.

Experimental work designed and performed under the HydraLab III project of which the author was a member were used to evaluate the response characteristics of a 1:20 scale "generic WEC" device with a 3 point mooring system. The investigation was enhanced through further tests implemented by the author at Heriot-Watt wave tank using a single WEC device. The outcomes from these experiments were used to aid in the implementation of the aim identified above.

Two numerical model categories were set up to understand the uncertainties apparent to the mooring simulations. The first category included only the calculation of the mooring line response using experimental data to inform the motion of the floating body. The second category included the motion response of the floating body coupling the complex behaviour to the moored system. The mooring tension results for the first category shows an error between the numerical prediction and the experimental results up to 16 times that of the experimental value. This was mainly during slack conditions where the mooring line tension was lower than the pretension in the line at still water. During the higher tension events the average error was 26%. For the second category it was found that the numerical predictions of the WEC motion response in six degree of freedom (6DOF) were generally over predicted. The tension predictions for the coupled simulations identified an error of between 1.4 and 4.5%.

The work presented here contributed to the understanding of uncertainties in numerical simulations for WEC mooring designs. The disparity between the simulation and experimental results re-enforced the requirement for a better understanding of highly dynamic responding moored coupled systems. From this work it is clear that the numerical models used to approximate the response of moored WECs could provide a good first design step. Whilst this work contributed to the understanding of uncertainties and consequently reduced some of these, further work is recommended in chapter 6 to investigate the definition of some of the mechanical and hydrodynamic properties of the mooring line. It is also suggested that external functions should be included

that would allow to model the coupled effect of Power-Take-Off (PTO) system. It is intended to conduct future work deriving a fully dynamic mooring simulation including the effects of PTO.

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