University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Master of Applied Science

of

BRYCE BOCKING

BEng (University of Victoria, 2014)

"Numerical and Experimental Modelling of an Oscillating Wave Surge Converter Model in Partially Standing Wave Fields"

Department of Mechanical Engineering

Friday, November 3, 2017
12:30 P.M.
Clearihue Building
Room B007

Supervisory Committee:
Dr. Brad Buckham, Department of Mechanical Engineering, University of Victoria (Co-Supervisor)
Dr. Peter Oshkai, Department of Mechanical Engineering, UVic (Co-Supervisor)

External Examiner:
Dr. Robert Cavagnaro, Applied Physics Laboratory, University of Washington

Chair of Oral Examination:
Dr. Kristin Semmens, Department of History, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

In the field of ocean wave energy converters (WECs), active areas of research are on a priori or in situ methods for power production estimates and on control system design. Linear potential flow theory modelling techniques often underpin these studies; however, such models rely upon small wave and body motion amplitude assumptions and therefore cannot be applied to all wave conditions. Nonlinear extensions can be applied to the fluid loads upon the structure to extend the range of wave conditions for which these models can provide accurate predictions. However, careful consideration of the thresholds of wave height and periods to which these models can be applied is still required. Experimental modelling in wave tank facilities can be used for this purpose by comparing experimental observations to numerical predictions using the experimental wave field as an input.

This study establishes a recommended time domain numerical modeling approach for power production assessments of oscillating wave surge converters (OWSCs), a class of WEC designed to operate in shallow and intermediate water depths. Three candidate models were developed based on nonlinear numerical modelling techniques in literature, each with varying levels of complexity. Numerical predictions provided by each model were found to be very similar for small wave amplitudes, but divergence between the models was observed as wave height increased.

Experimental data collected with a scale model OWSC for a variety of wave conditions was used to evaluate the accuracy of the candidate models. These experiments were conducted in a small-scale wave flume at the University of Victoria. A challenge with this experimental work was managing wave reflections from the boundaries of the tank, which were significant and impacted the dynamics of the scale model OWSC. To resolve this challenge, a modified reflection algorithm based upon the Mansard and Funke method was created to identify the incident and reflected wave amplitudes while the OWSC model is in the tank. Both incident and reflected wave amplitudes are then input to the candidate models to compare numerical predictions with experimental observations.

The candidate models agreed reasonably well with the experimental data, and demonstrated the utility of the modified wave reflection algorithm for future experiments. However, the maximum wave height generated in the wave tank was found to be limited by the stroke length of the wavemaker. As a result, no significant divergence of the candidate model

predictions from the experimental data could be observed for the limited range of wave conditions, and therefore a recommended model could not be selected based solely on the experimental/numerical model comparisons.

Preliminary assessments of the annual power production (APP) for the OWSC were obtained for a potential deployment site on the west coast of Vancouver Island. Optimal power take-off (PTO) settings for the candidate models were identified using a least-squares optimization to maximize power production for a given set of wave conditions. The power production of the OWSC at full scale was then simulated for each bin of a wave histogram representing one year of sea states at the deployment site. Of the three candidate models, APP estimates were only obtained for Model 1, which has the lowest computational requirements, and Model 3, which implements the most accurate algorithm for computing the fluid loads upon the OWSC device. Model 2 was not considered as it provides neither advantages of Models 1 and 3.

The APP estimates from Models 1 and 3 were 337 and 361 MWh per year. For future power production assessments, Model 3 is recommended due to its more accurate model of the fluid loads upon the OWSC. However, if the high computational requirements of Model 3 are problematic, then Model 1 can be used to obtain a slightly conservative estimate of APP with a much lower computational effort.