University of Victoria | Graduate Studies

Notice of the Final Oral Examination for the Degree of Doctor of Philosophy

of

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MASc (University of Victoria, 2009)
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"Self-Reacting Point Absorber Wave Energy Converters"

Department of Mechanical Engineering

Tuesday, June 16, 2015
10:00 A.M.
David Turpin Building
Room A144

Supervisory Committee:
Dr. Brad Buckham, Department of Mechanical Engineering, University of Victoria (Co-Supervisor)
Dr. Peter Wild, Department of Mechanical Engineering, UVic (Co-Supervisor)
Dr. Jody Klymak, School of Earth and Ocean Sciences, UVic (Outside Member)

External Examiner:
Dr. Matthew Folley, School of Planning, Architecture and Civil Engineering, Queen's University of Belfast

Chair of Oral Examination:
Dr. Karen MacKinnon, School of Nursing, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

A comprehensive set of experimental and numerical comparisons of the performance of two self-reacting point absorber wave energy converter (WEC) designs is undertaken in typical operating conditions. The designs are either currently, or have recently been, under development for commercialization. The experiments consist of a series of 1:25 scale model tests to quantify hydrodynamic parameters, motion dynamics, and power conversion. Each WEC is given a uniquely optimized power take off damping level. For hydrodynamic parameter identification, an optimization based method to simultaneously extract Morison drag and Coulomb friction coefficients from decay tests of under-damped, floating bodies is developed. The physical model features a re-configurable reacting body shape, a feedback controlled power take-off, a heave motion constraint system, and a mooring apparatus. A new theoretical upper bound on power conversion for two body WECs is established. The bound is an extension of Budal's upper bound for single body WECs.

The numerical analyses are done in three phases. In the first phase, the WECs are constrained to heave motion and subjected to monochromatic waves. Quantitative comparisons are made of the WEC designs in terms of heave motion dynamics and power conversion with reference to theoretical upper bounds. Design implications of a reactive power take-off control scheme and relative motion constraints on the wave energy converters are investigated using an experimentally validated, frequency domain, numerical dynamics model. In the second phase, the WECs are constrained to heave motion and subjected to panchromatic waves. A time domain numerical model, validated by the experimental results, is used to compare the WECs in terms of power matrices, capture width matrices, and mean annual energy production. Results indicate that the second WEC design can convert 30% more energy, on average, than the first design given the conditions at a representative location near the West coast of Vancouver Island, British Columbia, Canada. In the last phase, the WECs are held with three legged, horizontal, moorings and subjected to monochromatic waves. Numerical simulations using panelized body geometries for calculations of Froude-Krylov, Morison drag, and hydrostatic loads are developed in ProteusDS. The simulation results|mechanical power, mooring forces, and dynamic motions|are compared to model test results. The moored WEC designs exhibit power conversion consistent with heave motion constrained results in some wave conditions. However, large pitch and roll motions are observed at wave frequencies equal to twice the pitch natural frequency severely degrade the power conversion of each WEC. Using simulations, vertical stabilizing strakes, attached to the reacting bodies of the WECs are shown to increase the average power conversion up to 190% compared to the average power conversion of the WECs without strakes.