University of Victoria | Graduate Studies

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

of

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BSc (University of Manitoba, 2015)

"Simulation Based Design and Performance Assessment of a Controlled Cascaded Pneumatic Wave Energy Converter"

Department of Mechanical Engineering

Thursday, August 17, 2017
10:00 A.M.
David Turpin Building
Room A144

Supervisory Committee:
Dr. Brad Buckham, Department of Mechanical Engineering, University of Victoria (Supervisor)
Dr. Henning Struchtrup, Department of Mechanical Engineering, UVic (Member)
Dr. Curran Crawford, Department of Mechanical Engineering, UVic (Member)

External Examiner:
Dr. Benjamin Maurer, Mechanical Engineering, University of Washington

Chair of Oral Examination:
Dr. Fayez Gebali, Department of Electrical and Computer Engineering, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

The AOE Accumulated Ocean Energy Inc. (AOE) wave energy converter (WEC) is a cascaded pneumatic system, in which air is successively compressed through three devices on the way to shore; this air is then used to drive an electricity generator. In order to better quantify the performance of this device, this thesis presents a dynamically coupled model architecture of the AOE WEC, which was developed using the finite element solver ProteusDS and MATLAB/Simulink. This model is subsequently applied for the development and implementation of control in the AOE WEC. At each control stage, comprehensive power matrix data is generated in order to assess power production as a function of control complexity.

The nature of the AOE WEC presented a series of novel challenges, centered on the significant residency time of air within the power take-off (PTO). As a result, control implementation was broken into two stages: passive and active control. The first stage, passive control, was realized as an optimization of eight critical PTO parameters with the objective of maximizing exergy output. After only 15 generations, the optimization procedure led to an increase of 330.35% over an initial, informed estimate of the optimal design, such that the annually-averaged power output was 29.37 kW. However, a disparity in power production between low and moderate energy sea-states was identified, which informed the development of an active control strategy for the increase of power production in low energy sea-states. To this aim, a recirculation-based control strategy was developed, in which three accumulator tanks were used to selectively pressurize and de-pressurize the piston at opportune times, thereby increasing the continuity of air throughput. Under the influence of active control, sea-states with significant wave heights between 0.75 m – 1.75 m, which encompass 55.93% of the hours on average throughout the year, saw a 16.3% increase in energy production.