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 (Catholic University of Chile, 2012)

"Experimental Studies of a Small Scale Horizontal Axis Tidal Turbine"

Department of Mechanical Engineering

Monday, October 31, 2016
10:30 A.M.
Engineering Office Wing
Room 108

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

External Examiner:
Dr. Sue Molloy, Department of Mechanical Engineering, Dalhousie University

Chair of Oral Examination:
Dr. Martin Farnham, Department of Economics, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

Abstract

The research on this thesis focuses on the investigation of tidal turbines using a small scale horizontal axis tidal turbine and a 2D hydrofoil testing rig, combining experiments with simulations to provide comprehensive results and to better understand some of the variables that affect their performance. The experimental campaigns were carried out at the University of Victoria fluids research lab and the Sustainable Systems Design Lab (SSDL). The experimental testing rigs were re-designed by the author and are now fully automated, including a friendly graphical user interface for easy implementation. Particle image velocimetry (PIV) technique was used as the quantitative ow visualization method to obtain the time-averaged ow fields.

This thesis presents three investigations. The first study aims to quantify the impacts of channel blockage, free surface effects and foundations on hydrokinetic turbine performance, using porous discs and an axial ow rotor. The results were used to cross-validate computational uid dynamics (CFD) simulations. It was found that as wall blockage increases, thrust and power are incremented with and without the inclusion of free surface deformation. Discrepancies between simulations and experimental results on free surface effects compared to a slip wall were obtained, hence further research is recommended and the author gives some advice on how to proceed in this investigation.

The second study determines the performance of four hydrofoil candidates using the 2D hydrofoil rig and PIV measurements. The experiments were carried out in the recirculating flume tank over the range of low Reynolds number expected for the small scale rotor rig, in order to provide more accurate results to improve rotor blade design. In addition, numerical simulations using XFOIL, a viscid-inviscid coupled method, were introduced to the study. These results were analysed against experiments to find the most suitable parameters for reliable performance prediction. The final results suggested that adding a numerical trip at a certain chordwise distance produced more reliable results.

Finally, an experimental study on turbine rotor performance and tip vortex behavior was performed using again the rotor rig and PIV. Blade design and rotor performance are assessed, showing good agreement with Blade Element Momentum (BEM) simulations, particularly at predicting the tip speed ratio corresponding to the maximum power coefficient point. Regarding the wake structure, tip vortex locations (shed from the blade tips) were captured using PIV in the near wake region, showing evidence of wake expansion. The velocity and vorticity fields are also provided to contribute to the development and validation of CFD and potential ow codes.