University of Victoria | Graduate Studies

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

of

**DYLAN IVERSON**

BEng (University of Victoria, 2015)

**"Experimental Investigation of Oscillating-Foil Technologies"**

Department of Mechanical Engineering

Friday, September 14, 2018
12:30 P.M.
Clearihue Building
Room B017

Supervisory Committee:
Dr. Peter Oshkai, Department of Mechanical Engineering, University of Victoria (Co-Supervisor)
Dr. Guy Dumas, Department of Mechanical Engineering, Laval University (Co-Supervisor)

External Examiner:
Dr. Boualem Khouider, Department of Mathematics and Statistics, UVic

Chair of Oral Examination:
Dr. Adam Krawitz, Department of Psychology, UVic

Dr. David Capson, Dean, Faculty of Graduate Studies

## Abstract

This thesis contains an experimental campaign on the practical implementation of oscillating-foil technologies. It explores two possible engineering applications of oscillating-wings: thrust-generation, and energy-extraction. The history of, benefits of, and difficulties involved in the use of oscillating-foils is discussed throughout. Many existing technologies used for thrust generation and hydrokinetic energy extraction are based on rotating blades or foils, which have evolved over decades of use. In recent years, designs that use oscillating-foils, with motions analogous to the flapping of a fish's tail or a bird's wing, have shown increased hydrodynamic performance compared to the traditional rotary technologies. However, these systems are complex, both in terms of the governing unsteady fluid dynamics, and the methods by which kinematics are prescribed. Simply put, system complexity and cost need to be reduced before these devices see wide-spread use. For this reason, the work contained within this thesis explores possible methods of reducing the complexity of oscillating-foil systems in an effort to contribute to their development. For thrust-generation applications, this entailed using flexible foils to create passive pitching kinematics. This was parametrically studied by testing foils of different structural properties under a range of kinematics. The results suggested that properly tuning the flexibility of the foil could enhance both the thrust generation, and the efficiency of the propulsive system. With respect to energy-harvesting applications, the reliability of a novel fully passive turbine was assessed. The prototype tested had no active control strategy, and the degrees-of-freedom were not mechanically linked, greatly simplifying the design. The prototype was subjected to real-world conditions, including high turbulence levels and the wake of an upstream turbine, and displayed robust performance in most conditions. In both applications, the hydrodynamic performance of the oscillating-wings was directly measured, and particle image velocimetry was used to observe the flow topology in the wakes and boundary layers of the foils. The vortex and stall dynamics were highlighted as key flow features, and are studied in detail.