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

of

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MASc (University of Alberta, 1994)

“Influence of the Sweep Angle on the Leading Edge Vortex and its Relation to the Power Extraction Performance of a Fully-Passive Oscillating-Plate Hydrokinetic Turbine Prototype”

Department of Mechanical Engineering

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Remote Defence

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

External Examiner:
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Dr. Robert Miles, Department of English, UVic

Dr. Stephen Evans, Acting Dean, Faculty of Graduate Studies
Abstract

Oscillating-foil hydrokinetic turbine has gained interest over the years to extract energy from renewable sources. The influence of the sweep angle on the performance of a fully-passive oscillating-plate hydrokinetic turbine prototype was investigated experimentally in the present work. The sweep angle was introduced to promote spanwise flow along the span of the plate in order to manipulate the leading edge vortex (LEV) and hydrodynamically optimize the hydrokinetic turbine. In the present work, flat plates of two configurations were considered: a plate with a 6° sweep angle and an unswept plate (control), which were undergoing fully passive pitch and heave motions in uniform inflow at the Reynolds numbers ranging from 15 000 to 30 000. The resulting kinematic parameters and the energy extraction performance were evaluated for both plates. Planar (2D) particle image velocimetry (PIV) was used to obtain patterns of the phase-averaged out-of-plane vorticity during the oscillation cycle. The circulation in the wake was then related to the induced-forces on the plate by calculating the moments of vorticity of the LEV with respect to the pitching axis of the plate. Tomographic (3D) PIV was implemented in evaluating the influence of the spanwise flow on the dynamics of the vortex structure in three-dimensional space. The rate of deformation of the vortex length was quantified by calculating the deformation terms embedded in the vorticity equations, then linked to the stability of the vortex. The results show evidence of delay of the shedding of LEV and increased vortex stability, in the case of the swept plate. The manipulation of the LEV by the spanwise flow was related to the induced kinematics exhibited by the prolonged heave forces experienced by the swept plate, which led to the higher power extraction performance at high inflow velocities. In the presence of spanwise flow, positive vortex stretching along the vortex line increased the stabilization of the vortex core and prevented the onset of helical vortex breakdown, observed in the case of the unswept plate. The use of the sweep profile on the plate has led to the improvement of energy extraction performance of the fully-passive hydrokinetic turbine.