INORE North American Symposium, 31 Oct. - 3 Nov. 2014, Halifax, Canada

UNIVERSITÉ LAVAL

LMFN
www.lmfn.ulaval.ca

Impact of realistic flow conditions on the performance of hydrokinetic turbines

INTERNATIONAL NETWORK ON INORE OFFSHORE RENEWABLE ENERGY

C. Perron, T. Kinsey, G. Dumas
Department of Mechanical Engineering, Laval University, Québec (Qc), Canada
Contact: Christian.Perron.2@ulaval.ca

1. Context

Numerical simulations of hydrokinetic turbines are typically performed in idealized operating conditions, i.e., without vertical shear or flow misalignment. The real conditions present at an actual extraction site are undeniably much more complex and some impacts on the turbine performance are to be expected.

The purpose of this research is thus to assess and to compare the effect of realistic flow conditions on the performance of different concepts of hydrokinetic energy converter. Using unsteady 3D URANS simulations, valuable information will thereby be provided to engineers and energy producers as to the pros and cons of various turbine design.

2. Turbine concepts

HAO turbine (Oscillating foils)

The HAO turbine ("Hydrolienne à Aile Oscillante") is an innovative concept of turbine based on oscillating foils, that was developed at the Laboratoire de Mécanique des Fluides Numériques (LMFN) of Laval University. It uses a combined pitch and heave motion to extract hydrokinetic energy from the incoming flow.

Pitching motion :

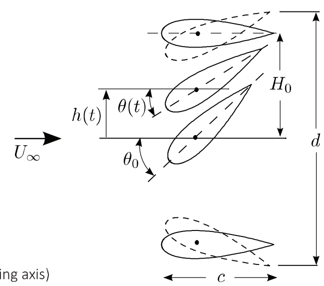
$\theta(t) = \theta_0 \sin(\omega t)$

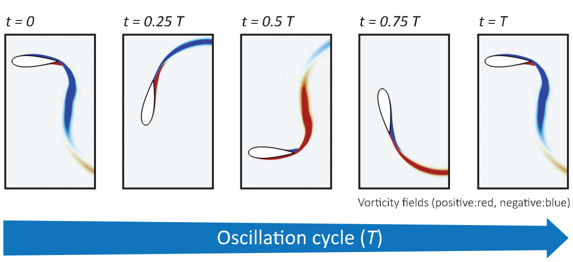
Heaving motion :

$h(t) = H_0 \cos(\omega t)$

Power production :

$P =$ (heaving velocity) $\times$ (vertical force)
$+$ (pitching velocity) $\times$ (moment at pitching axis)

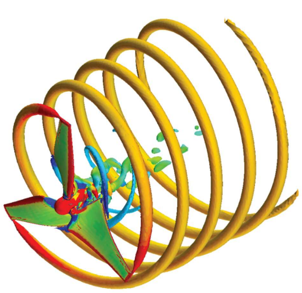


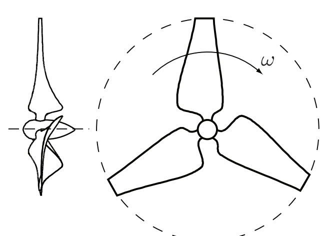


Vorticity fields (positive:red, negative:blue)

Horizontal axis turbine

Inspired from the field of wind energy, the horizontal axis turbine extracts hydrokinetic energy using a rotor axially aligned with the flow. The geometry used in this study was provided by University of Victoria.


Contours of λ_2 colored by azimuthal vorticity



Power production :

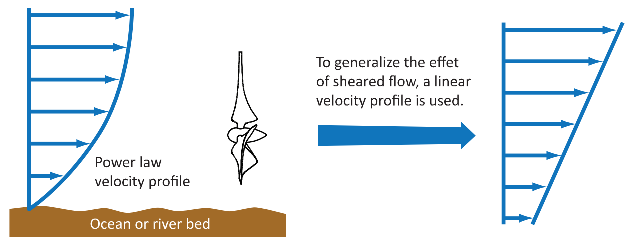
$P =$ (torque) $\times$ (angular velocity)

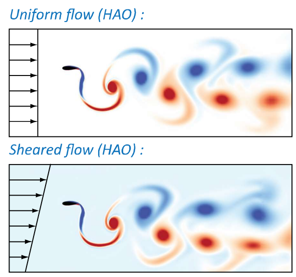
3. Flow imperfections

This study consider the following flow imperfections. Their impact on turbine performance is currently being quantified.

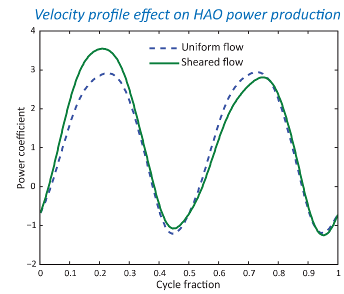
Sheared flow

The presence of the ocean or river bed produces a non-uniform velocity profile. This velocity gradient affects power production and creates asymmetrical loading, especially for bottom mounted turbines.



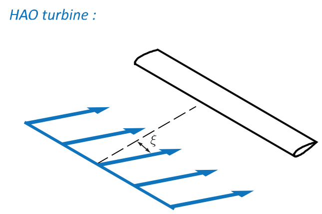


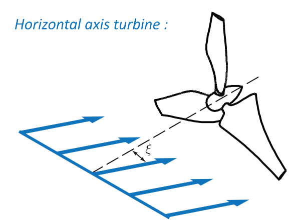
Vorticity fields (positive:red, negative:blue)

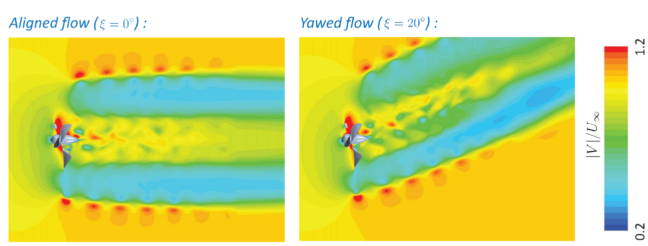


Misaligned flow

An alignment mechanism is often omitted in the design of a marine current turbine to favor simplicity and to lower cost. However, operation in yawed inflow may produce lateral loads and reduce power output.







Velocity magnitude contours at mid-height for a horizontal axis turbine

4. Acknowledgement

Financial support from the Natural Sciences and Engineering Research Council of Canada (NSERC) and les Fonds de recherche du Québec - Nature et technologies (FRQNT), is gratefully acknowledged. Computations were made on the supercomputers Colosse from Laval University, managed by Calcul Québec and Compute Canada.

Project website : *http://www.hydrolienne.fsg.ulaval.ca/en*