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Study of blocking effects in the operation of marine tidal turbines - Multi-Rotor Systems

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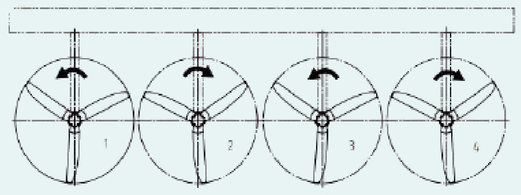
Context and objectives

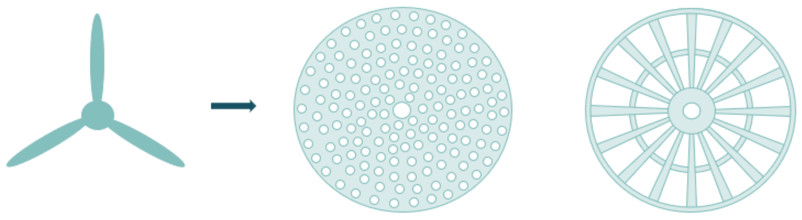
The LUSAC laboratory conducts research on tidal turbines, and this work focuses on multi-rotors systems composed of several tidal turbines placed next to each other in close proximity. This proximity will lead to potentially beneficial local blocking effects in energy production. Several multi-rotors systems are emerging and are currently being tested (Schottel Hydro, Orbital marine power, Tocardo). This project aims to design an instrumented model of a multi-rotors system composed of porous discs, in order to measure the forces exerted on the system as well as the velocity fields. Measurements for a single disc will be presented here.



Multi-Rotors schematic view (by Starzmann et al [1])

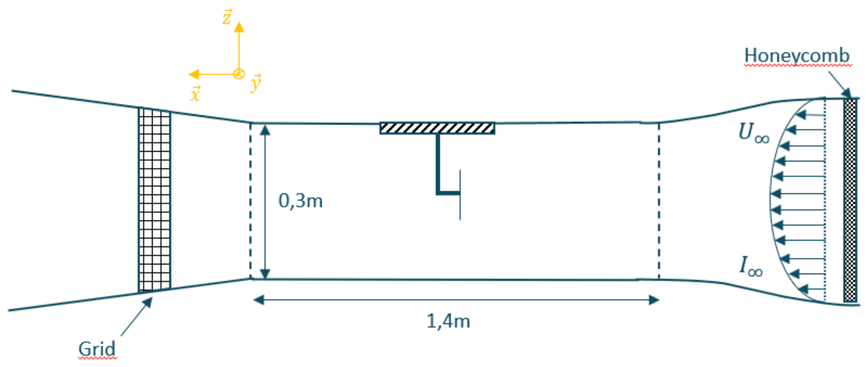
Turbine modeling

- The porous disc is an effective way to represent a rotating turbine.
- Porosities of 40%, 50% and 60% will be used.
- Several porosity distributions can be used. In this study, two forms were selected.

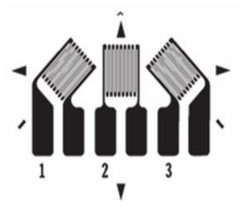


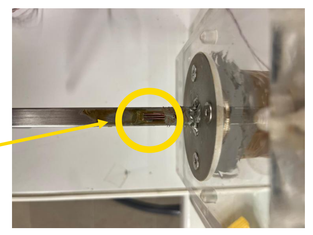
Measurement methods

- The LUSAC hydrodynamic tunnel is used.

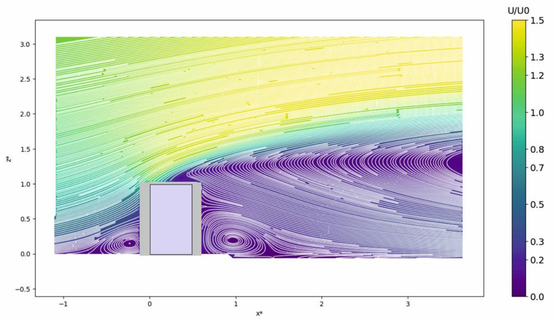


- The forces acting on the multi-rotors system will be quantified using strain gauges. These gauges will measure deformations caused by the flow. Drag force can be calculated with these deformations :

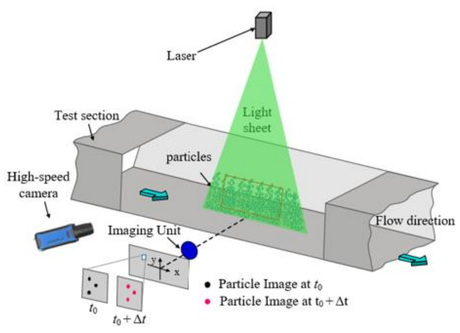




- A Particle Image Velocimetry (PIV) method is used to measure the velocity fields of the flow around the multi-rotor system.



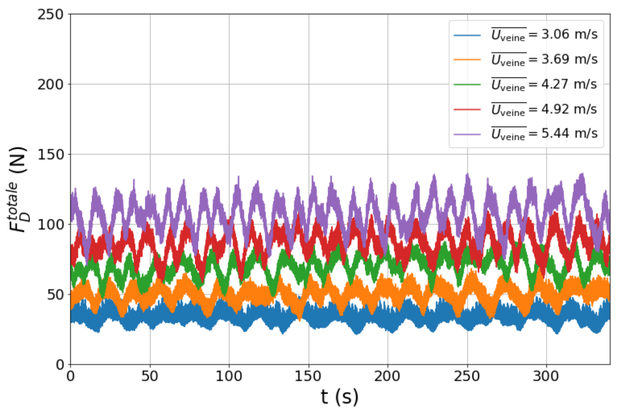
Flow generated downstream of a bottom obstacle (PIV)



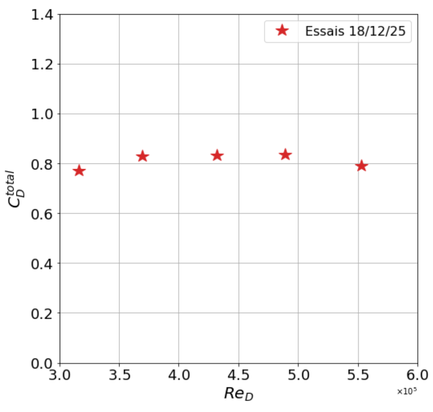
Schematic representation of PIV (by Raffel et al [3])

First results

- The first results focus on the measurements of the drag force and drag coefficient of a single porous disc.



(a) : instantaneous signal of drag force for different velocities



(b) : drag coefficient is relatively constant regardless the Reynolds number

Perspectives

The forces variations between the single-rotor and multi-rotor systems will be quantified. The wake generated by the two systems will also be compared. Finally, an obstacle will be placed upstream of the systems in order to quantify the impact of bathymetry.

References :

[1] : Starzmann, R., Goebel, I., and Jeffcoate, P. (2018). Field performance testing of a floating tidal energy platform - part 1 : Power performance. Asian Wave and Tidal EnergyConference.

[2] : McNaughton, J., Cao, B., Nambiar, A., Davey, T., Vogel, C., and Willden, R. (2022).Constructive interference effects for tidal turbine arrays. Journal of Fluid Mechanics.

[3] :Raffel, M., Willert, C., Wereley, S., and Kompenhans, J. (2018). Particle Image Velocimetry : A Pratical Guide. Springer.

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