INTERNSHIP FOR ENGINEERING SCHOOL OR MASTER DEGREE

2024

Modeling a horizontal axis tidal turbine with an actuator line model – Large Eddy Simulation and Lattice Boltzmann Method

Laboratory:

Laboratoire Universitaire des Sciences Appliquées de Cherbourg (LUSAC)

Team: Flows and Environment

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CONTEXT:

The growing scarcity of fossil fuels and the climate crisis are encouraging the development of low-carbon energies. Among these, tidal turbines are an innovative and promising solution. Just as wind turbines extract kinetic energy from the wind, tidal turbines extract kinetic energy from tidal currents. Most prototypes currently under development require strong currents that are only present in certain specific areas, such as the Raz Blanchard off the Cotentin peninsula. Flows in these areas are highly turbulent, with turbulence rates of up to 20% locally [1].

In order to predict the behavior of future tidal turbines, experimental and numerical test campaigns have been carried out in recent years. The LUSAC laboratory has taken part in these campaigns through a number of PhDs and projects, and has gained expertise in CFD modeling of tidal turbines using the Lattice Boltzmann Method (LBM) coupled with Large Eddy Simulation (LES). The choice of this approach is based on the unsteady nature of tidal flows [2].

There are two main types of tidal turbines: vertical-axis turbines and horizontal-axis turbines. To date, simulations of horizontal axis tidal turbines carried out at LUSAC with the LBM-LES have used blade-resolved approaches [3]. These approaches require significant computational resources and are limited to the modeling of reduced scale turbines. A model based on the Actuator Line Method (ALM) [4] has been developed for vertical axis turbines in order to reduce simulations cost. This internship aims to develop and validate our ALM-LBM-LES model for horizontal axis turbines.

CONTENT:

You will work on the simulation of horizontal axis tidal turbines using an Actuator Line Method coupled with the Lattice Boltzmann Method. Calculations will be performed using the LBM library coded in C++ PALABOS [5].

First, you will run simulations to compare results obtained with an ALM model with experimental and/or numerical reference data. The ALM model for horizontal-axis turbines will already be implemented in the code, but it may be improved. A literature review on the ALM is expected.

In a second phase, the study will focus on cases with ambient turbulence and/or interactions between turbines.

Data visualization and post-processing of results will be carried out mainly using Paraview.

KEYWORDS:
MRE, tidal turbines, actuator line, large eddy simulation, lattice Boltzmann method, C++ programming.

PROFILE:
The candidate should follow a Master degree or Engineering School in hydrodynamic, aerodynamics or fluid mechanics. Good writing skills are expected. A taste for numerical simulation and programming is necessary and expected.

DATES AND DURATION:
Starting in March/April 2024 for a duration of 6 months.

SALARY:
4.05 €/hour (≈ 566 €/month).

LOCATION:
Cherbourg, Normandie, France.

REFERENCES:
[1] A. E. Hay, J. McMillan, R. Cheel and D. Schillinger, "Turbulence and drag in a high Reynolds number tidal passage targetted for in-stream tidal power," 2013 OCEANS - San Diego, 2013, pp. 1-10.

[2] Philippe Mercier and Sylvain Guillou, "The impact of the seabed morphology on turbulence generation in a strong tidal stream", Physics of Fluids 33, 055125 (2021).

[3] Grondeau, Mikaël, Sylvain S. Guillou, Jean Charles Poirier, Philippe Mercier, Emmnuel Poizot, and Yann Méar. 2022. "Studying the Wake of a Tidal Turbine with an IBM-LBM Approach Using Realistic Inflow Conditions" Energies 15, no. 6: 2092.

[4] Grondeau, Mikaël, Sylvain Guillou, Philippe Mercier, and Emmanuel Poizot. 2019. "Wake of a Ducted Vertical Axis Tidal Turbine in Turbulent Flows, LBM Actuator-Line Approach" Energies 12, no. 22: 4273.

[5] Jonas Latt, Orestis Malaspinas, Dimitrios Kontaxakis, Andrea Parmigiani, Daniel Lagrava, Federico Brogi, Mohamed Ben Belgacem, Yann Thorimbert, Sébastien Leclaire, Sha Li, Francesco Marson, Jonathan Lemus, Christos Kotsalos, Raphaël Conradin, Christophe Coreixas, Rémy Petkantchin, Franck Raynaud, Joël Beny, Bastien Chopard. “Palabos: Parallel Lattice Boltzmann Solver”, Computers & Mathematics with Applications, Volume 81, 2021, Pages 334-350.