Realistic Simulation of an Oscillating Wave Surge Converter

Daniela Benites-Munoz[1], Luofeng Huang*, Enrico Anderlini, Giles Thomas
Department of Mechanical Engineering, University College London
[1]First author: ucemben@ucl.ac.uk; *corresponding author: ucemlhu@ucl.ac.uk

Background

To meet new energy targets, the placement of wave energy devices is a primary approach, as waves are completely free of emission and possess high energy density compared with other renewable sources. Oscillating Wave Surge Converter (OWSC) is one of the most popular device type, with a flap rotating around a fixed hinge, tally with the periodic feature of wave motions, as shown in Figure 1. Thus OWSC has proved to capture wave energy with promising convert efficiency and its design becomes of great research interest.

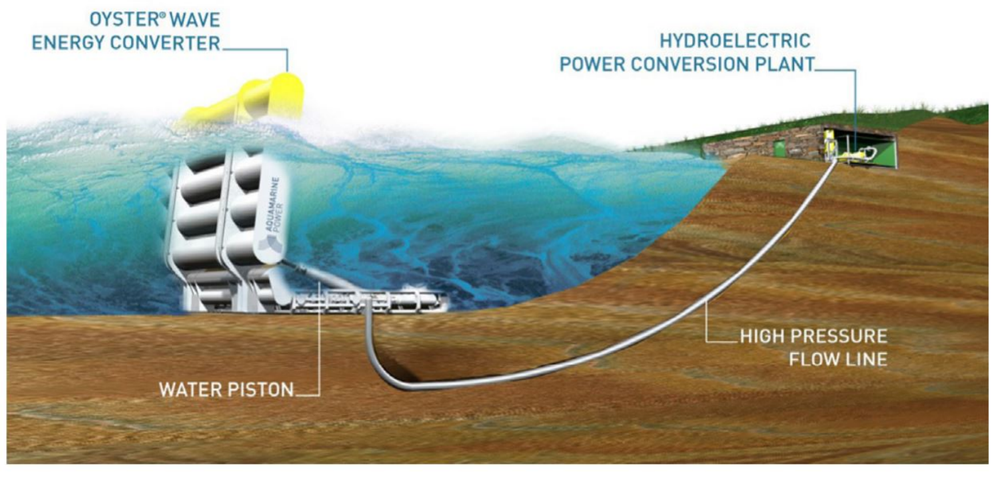

Fig 1: Illustration of an OWSC (Credit: Aquamarine Power).

Numerical Approach

In this work, OpenFOAM has been applied to simulate the operation of an OWSC, by which the aim is to study the optimal device dimensions against various wave conditions, as well as providing power and fatigue estimates for the device. As presented in Figure 2, the interaction process is replicated with high fidelity, in which regular waves are generated from the left hand side and propagate towards the right hand side, and the large displacement of the device is handled by the overset mesh method. By comparison with validation experiments, the simulation is found to accurately predict the rotation angle at all phases of an entire period.

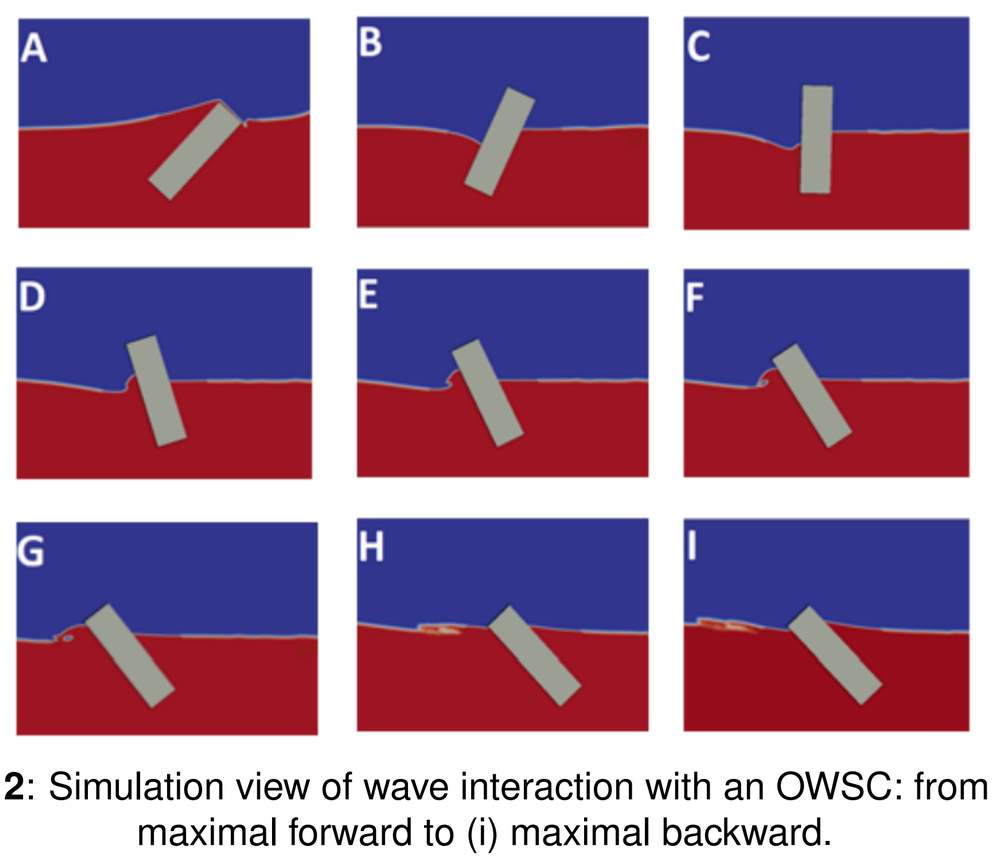

Fig 2: Simulation view of wave interaction with an OWSC: from (a) maximal forward to (i) maximal backward.

Whilst the rotation amplitude and frequency of an OWSC varies with specific wave conditions, the actual usable power is instead governed by the Power Taken Off (PTO) connected on the device, which is not linear with the motion amplitude or frequency. In such a context, this work has implemented a PTO model with the OpenFOAM model to be able to estimate the actual power of a device in a given wave condition. This signifies that the current work is not only replicating the fluid field and structural movement, but also providing a tool that can evaluate the energy efficiency thus supporting the optimisation of OWSC in a realistic way.

Discussion and future work

Compared with experimental methods, the present approach has the following advantages:

- Convenient to assess the performance of a device in various wave conditions; easy to edit device dimension to investigate the most suitable geometry.
- Able to map out pressure distribution on the whole device during a wave period, thus to find out critical areas and suggest local strengthening.
- Able to obtain the surrounding flow field, as shown in Figure 3 - OWSCs are normally arranged in arrays, the wave flow associated with one OWSC can affect the efficiency of its neighbour devices.

Intended future work is (a) to conduct extensive simulations to build up the response surface of a device in variable wave conditions (b) place multiple devices in a simulation to investigate the interaction between near OWSCs and then suggest arrangement strategies.

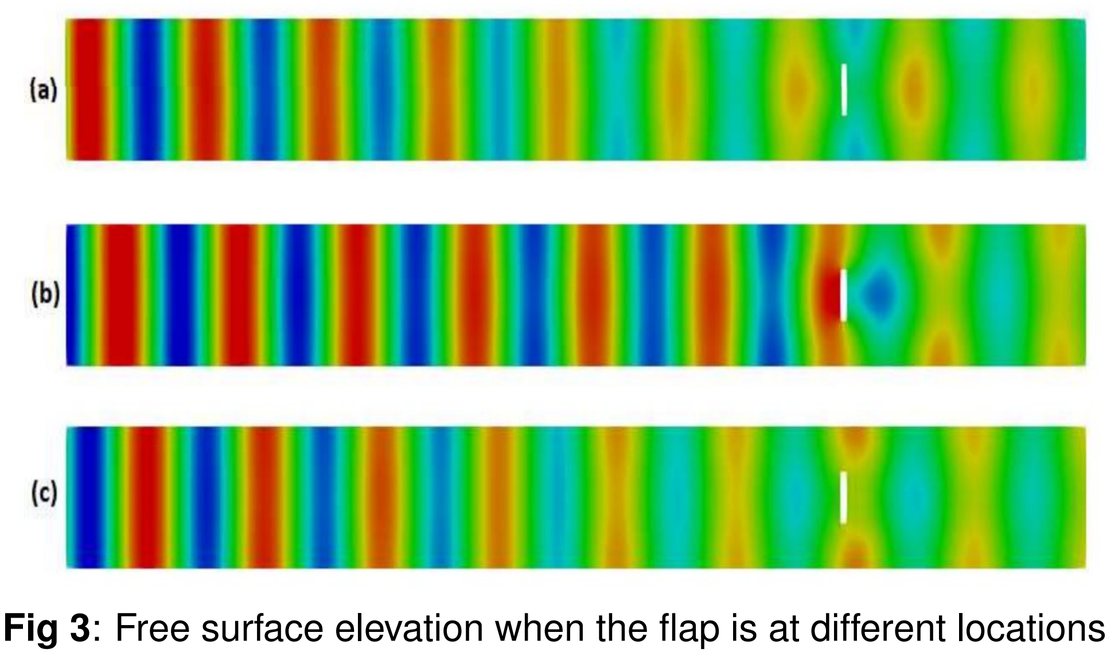

Fig 3: Free surface elevation when the flap is at different locations: (a) maximal forward; (b) upright; (c) maximal backward.

References:
Benites Munoz, D., Huang, L. and Thomas, G., 2019, July. The interaction of cnoidal waves with oscillating wave surge energy converters. The 14th OpenFOAM Workshop.
Benites Munoz, D., Huang, L., Anderlini, E., Marín-López, J. and Thomas, G., 2020, October. Simulation of the wave evolution and power capture of an oscillating wave surge converter. The 30th International Ocean and Polar Engineering Conference (ISOPE).