A Novel, Robust, Near-shore, Wave Energy Converter for Remote Communities

Early Career Researcher Research Fund – Rachel Nicholls-Lee

Summary

This project tested the feasibility, both experimentally and numerically, of a novel concept for a robust wave energy converter (WEC) operating in the near-shore region. The converter uses a series of non-return valves, constrained by a tapered pipe, where the incoming wave builds up pressure in each compartment and finally drives a turbine onshore with the pressurised water. The device is ideal for remote communities to gain energy security and reduce dependence on imports. The device facilitates local engagement, and it is intended that local people are trained to perform most maintenance tasks using low cost, readily available, parts. This work assessed the feasibility of the WEC through physical testing, the results of which were compared to initial numerical models. The device captured energy; however, was of low efficiency, and concerns regarding marine fouling and difficulties involving sourcing of parts resulted in the concept being deemed unfeasible.

Methodology

The experimental trials took the form of a series of tubes of reducing diameter, with non-return valves between each, located in the University of Exeter's flume tank. Pressure sensors were installed in two compartments, to monitor the build-up in the tubes. Waves were generated using a purpose-built wedge and absorbed using a purpose-built beach, Figure 1.

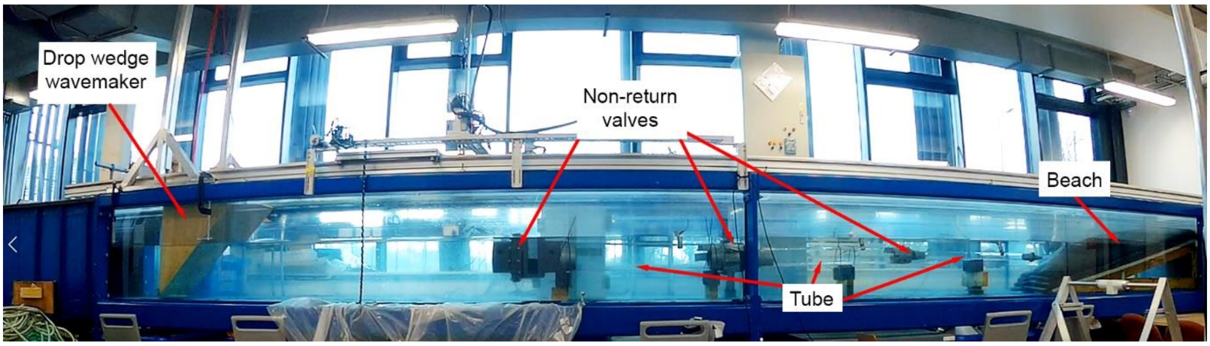

Figure 1: Experimental set up in the University of Exeter flume tank

The beach worked well, with the tank calming in less than two minutes between waves. The wavemaker generated consistent breaking waves of 10cm in height, similar in style to those found in the near shore region. Figure 2 shows the WEC as modelled in ANSYS CFX, replicating the experimental setup, with the contours showing the pressure build up under a wave.

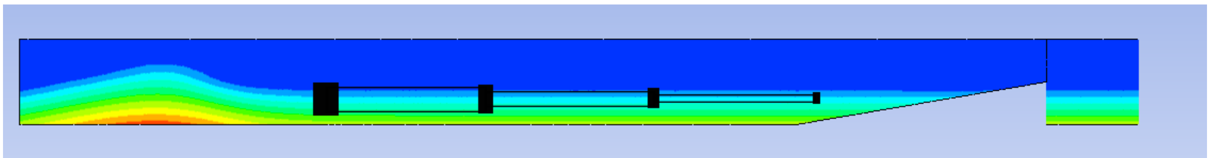

Figure 2: The experimental set up replicated in ANSYS CFX

A comparison of typical simulated results and experimental results is shown in Figure 3. The graph shows the pressure measured inside one of the compartments as a wave passes for the experimental test, and at the same location in the numerical model. It also shows the pressure measured outside the WEC in the numerical model. Due to limited budget and equipment it was not possible to measure the open water pressure during the physical tests. While, at first glance, it seems that the numerical model underpredicted the pressure, it should be noted that the pressure sensors had an accuracy level of 0.5kPa (this was due to a supplier issue, where the incorrect sensors were provided but too late to be changed for the testing schedule). The error bars are shown on the experimental testing plot in red. Considering the potential for error, the results compare well, with a similar increase in pressure as the wave enters the tube. There is larger pressure drop seen in the physical tests once the wave has passed when compared to the numerical model. This is due to the numerical perfection of the CFD simulation, whereas in reality there was some pressure leakage around the pressure sensors and the non-return valves. It can be noted, however, that some pressure was retained, showing that the WEC concept does indeed capture energy that could be used to pump water/generate electricity.

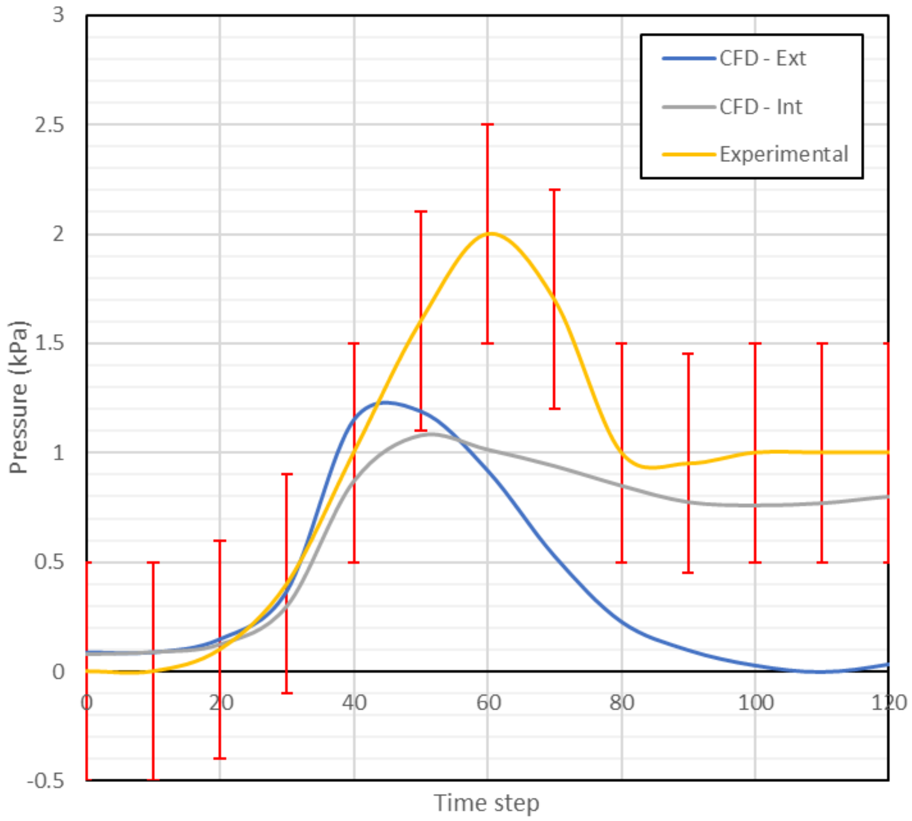

Figure 3: Comparison of typical results between the numerical model and experimental tests. Error bars for the pressures sensors in the experimental tests are shown in red.

Conclusions

It was found that the novel WEC concept did capture energy as a wave passed through the device, indicating the potential for use as a method of renewable energy generation. Problems were encountered in trying to source tuneable non-return valves and tapered pipe as off-the-shelf parts. Neither are available, and for the tests basic off-the-shelf equipment was used, but this resulted in a pressure drop over time as components were not ideally suited for the application. This negates the aim for ease of maintenance and could drive the cost of the device up, as it will need bespoke parts to operate. Another concern was around build-up of marine fouling – consultation with experts indicated that there is currently no method to prevent this occurring inside the device and that it would be likely to prevent the non-return valves from sealing properly, thereby reducing the efficiency of the device. While the experimental tests were successful and results compared relatively well to the numerical model, it was concluded that the device would not be feasible for real world applications.