Experimental Analysis of a Wave Energy Converter Device

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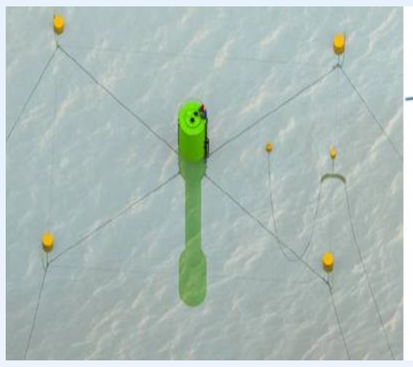
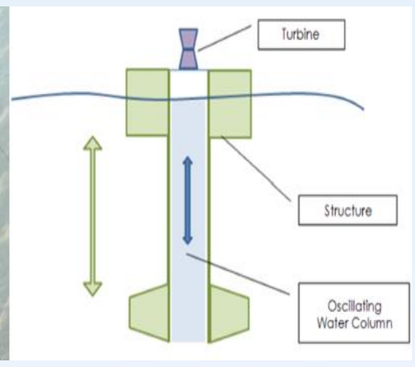
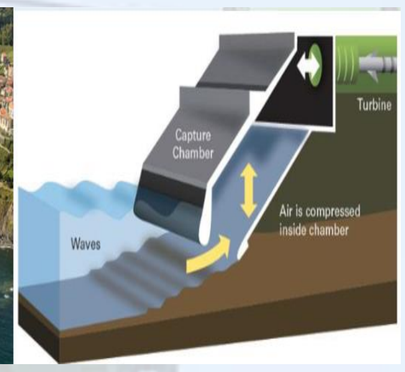
OBJECTIVE





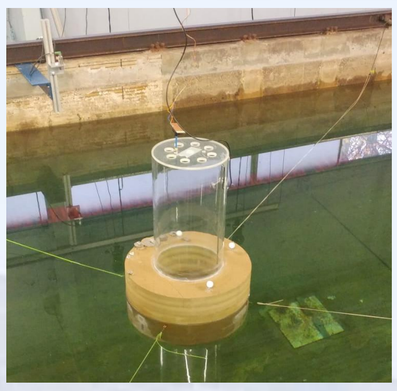
MARMOK-A-5 Floating OWC

Investigate the behaviour of a floating type oscillating water column (OWC) device varying its wave energy capture capability. It was also one of the goals of this experiment to compare results with an equivalent experiment performed previously with a fixed type OWC.



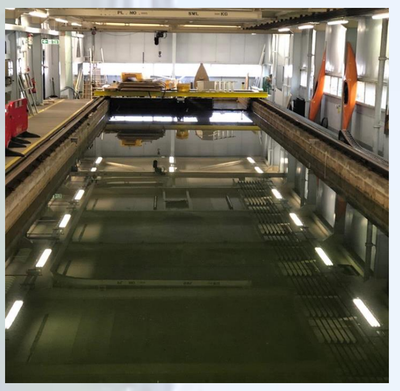
Mutriku Wave Plant Fixed OWC

PROCEDURE



Experimental Model

Experiment Setup → Frequency of Oscillation → Energy Capture



Wave Tank

A model in a 1:50 scale was tested in a wave tank at the Kelvin Hydrodynamics Laboratory in Glasgow. Wave probes, pressure transducers and Qualysis motion caption system were used to take measurements during the experiment. The model is composed of floater, a vertical tube representing the air chamber and an orifice plate on top to represent the energy capture system. Furthermore, mooring lines were also attached to prevent wave drifting.

Power capture from the waves is accomplished by wave energy converters through a Power-Take-Off (PTO) system. The PTO extracts energy from the oscillating motion of the device by applying damping to the system. In the case of the experiment, the orifices in the plate apply damping to the vertical air displacement of the oscillating motion. By blocking some orifices, we can vary the damping quantity in the system.

Simulations were conducted with constant wave amplitude in various regular waves frequencies, PTO damping was set constant with four blocked orifices. Motions and power were recorded to identify the peak frequency when both parameters are maximum.

In a second stage, the amount of damping on the system was varied by changing the quantity of blocked orifices. This was done in order to analyse the correlation between power generation (RMS Power), oscillating water column inside the chamber (OWC motion) and the floater motion (Heave motion). This stage was performed in constant wave amplitude at the peak frequency identified in the first stage of the experiment.

RESULTS AND DISCUSSION

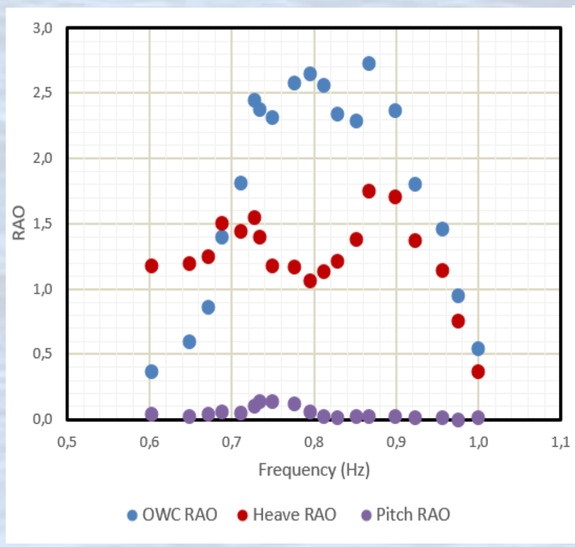


Figure A: Motion vs Wave Frequency

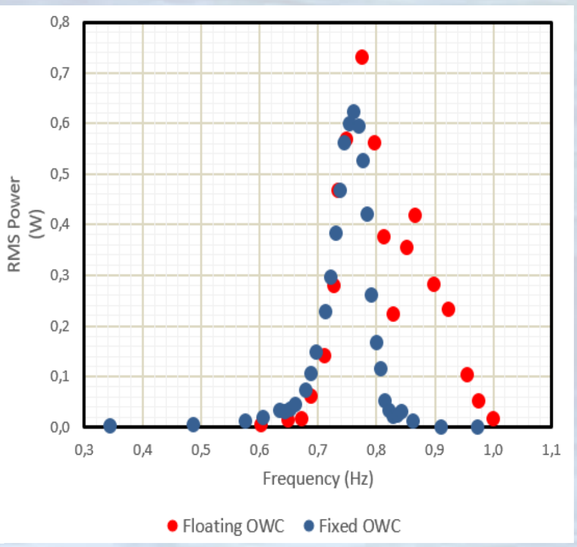


Figure B: Power vs Wave Frequency

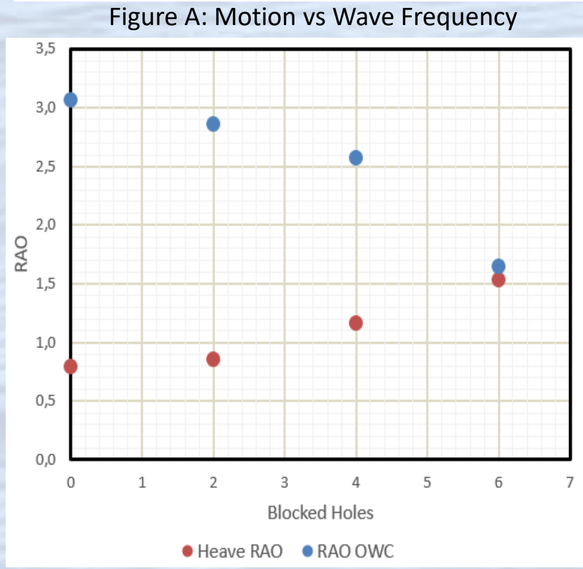


Figure C: Motion vs Damping

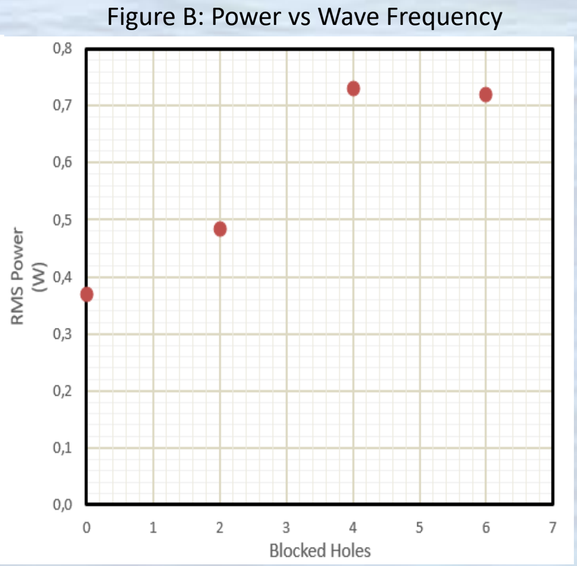


Figure D: Power vs Damping

The motions measured are compared in terms of Response Amplitude Operator (RAO), this is a parameter used in ocean studies to show the relative motion of a body in relation to the incoming wave.

Analyzing Figure A, it can be concluded that Pitch motion is negligible as compared with OWC and Heave motion. Furthermore, it can be noticed that both in Heave and Pitch motions, two peak frequencies are observed at 0.73 Hz and 0.87 Hz. This phenomenon is due to the coupling between OWC and Heave motion. In Figure B it is observed that RMS Power also has two peak frequencies located similarly to the motion peak frequencies. This benefits the floating OWC device because yields a wider bandwidth frequency which gives higher power output in sea-state operation than fixed OWC. The fixed OWC, as shown in Figure B, only has one peak frequency.

In the second stage, the experiment simulates variation of the damping load from PTO. In Figure C, the RAO of Heave and OWC motions tend to be the same with increasing PTO damping. This implies that the water inside the chamber and the floating structure will move together as a single body if the PTO damping is high. Concluding the findings of the experiment, it can be seen that the optimum PTO damping that maximizes power capture at the peak frequency is found with four blocked orifices. In this optimum situation, a full scale device could theoretically produce up to 645 kW.

ACKNOWLEDGEMENT

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REFERENCES

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- Dai, S. (2016) *Assessing the performance of an Oscillating Water Column type wave energy device*. PhD thesis. University of Strathclyde.
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