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Designing Short-Term Wave Traces to Assess Wave Power Devices

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It is generally accepted that an estimate of mean power capture for a wave energy converter (WEC) in a given sea state can only be obtained over many hundreds (or thousands) of wave cycles. The difficulty stems from the fact that WECs typically exhibit significant nonlinearities in their responses. A reduction in the number of wave cycles needed to obtain accurate results would allow the use of numerical tools for design optimization tasks that are currently too computationally demanding. In this paper, experimental time traces are analyzed to provide reasonable estimates of relative variations in device performance using short-duration sea states. We examine the suitability of various metrics of surface elevation time traces by comparing corresponding WEC data of interest. The results show that carefully selected wave traces can be used to reliably assess variations in power output due to changes in hydrodynamic design or wave climate. It is also demonstrated how confidence levels increase with running time, so in the future simulations could be run until sufficient accuracy is achieved to choose the best design.

INTRODUCTION

One of the most common methods used in the development of wave energy converters (WECs) is physical experimentation undertaken in a wave tank, which can be both time consuming and expensive.

Oscillating wave surge converters (OWSCs) are designed to be deployed in the near shore region in water depths of approximately 12–15 m and utilize the amplified surge motion of water surface waves in this region to pitch back and forward about a hinge mounted on the seabed. The basic concept is shown in Fig. 1.

One design feature of OWSCs is the shape of the side edges (as shown in Fig. 2). The thickness of the edges of the flap affects energy loss, as a result of viscous effects, and thus power capture (Cameron et al., 2010).

The utilization of computational fluid dynamics (CFD) simulations has become general practice in many areas of marine engineering. Correctly used, CFD tools achieve results with the same accuracy as physical testing (Schmitt and Elsäßer, 2015; Palm et al., 2016; Kim et al., 2015; Chen et al., 2017). However, in an industrial setting, and in contrast to experimental testing, CFD tools are still not capable of obtaining results for long-duration wave traces at a comparable cost (Schmitt et al., 2012). To receive valid and statistically significant data, calibrated seas often have running times longer than 256 s at the 40th scale. It is evident that simulations of that length would be infeasible in CFD in an industrial context.

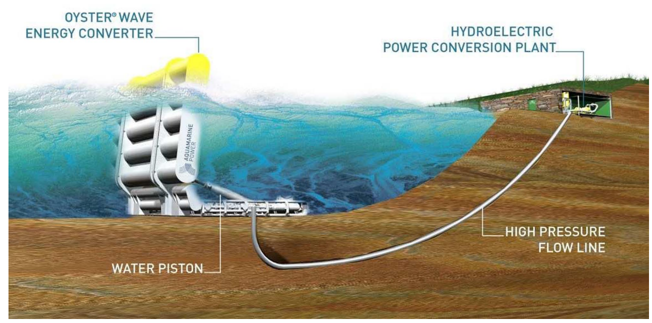

Fig. 1 Conceptual sketch of Oyster 1

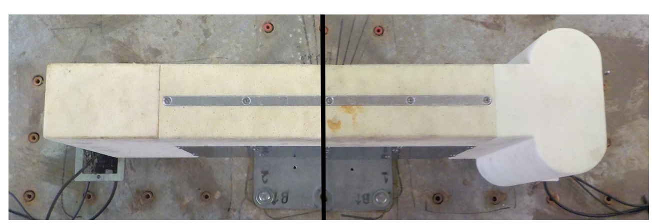

Fig. 2 40th scale model of common box-shaped flap shown without (left) and with (right) end-effectors

Ransley et al. (2017) used CFD tools to investigate the extreme loads on a WEC. They concluded that, even for relatively short-term events like wave impacts, the specific wave group combinations responsible for the most severe structural loads are unclear and can only be found by testing a range of conditions.

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KEY WORDS: Sea state, wave trace, experimental tank testing, wave parameters, nonlinear effects, statistics.