Numerical and experimental study on a scaled TALOS wave energy converter
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ABSTRACT
A Variety of different concepts of multi-axis wave conversion devices, most of which belongs to the so-called point absorber wave energy converters, have been proposed over the years aiming to harvest more wave energy and improve the efficiency. This paper considers a multi-axis concept device named TALOS that has been initially proposed and developed by Lancaster University. TALOS is a point absorber wave energy converter, with a fully-enclosed hull containing all the internal reaction mechanisms. The internal power take-off system consists of an inertial mass with secondary transmission mechanism, which can be hydraulic cylinders or other types of components, connecting the mass to the solid outer hull. In this paper, a full-scale device (based on a sea trial prototype width of 3 m, expected to be deployed in the East China Sea) is studied numerically and a 1/4th scale model is tank tested at Zhejiang University. A new form of power take-off (PTO) design is introduced, which is that the inertial mass is connected to rotary DC generators by screw drive mechanisms. A numerical model is firstly built with the help of open-source software WEC-Sim and is used to estimate the system’s dynamics. Subsequently, further tank tests are carried out to obtain experimental results. Also, based on the current research progress, some design that can be improved in the future are summarized and introduced.

KEY WORDS: TALOS wave energy converter; Tank testing; Numerical modeling.

INTRODUCTION
As a clean and renewable resource, wave energy has the significant potential to make a contribution to meet the world’s energy demand. In the past few decades, various concepts of wave energy converters have been proposed and developed with the goal of approaching the economically competitive level compared to other resources. One of the most popular devices is the oscillating-body type, which is classified according to working principle. Under ideal conditions, an oscillating-body type wave energy converter can convert all available energy of ocean waves into electricity through linear or rotational oscillation. Recent reviews on current research progress and stages of such devices can be found in (Falcao, 2010). Famous examples include Wavebob (Weber et al., 2009), PowerBuoy (PowerBuoy, 2013) and Archimedes wave swing (AWS) (Cruz and Sarmento, 2007).

Most oscillating-body wave energy converters in the world are single motion mode devices with single PTO axis, which means that they only extract energy from one direction of motion and thus one PTO axis would be sufficient. As is known to all, the energy in ocean waves is composed of kinetic and potential energy in multiple directions. An oscillating-body wave energy converter has six modes of motion from which energy can be captured. Learned from the ship kinematics, the six modes of motion are usually defined as heave, surge, sway, pitch, roll and yaw (Falnes, 2003). A device working in multiple modes of motion should be able to generate more electricity more than single-axis devices. At the same time, more PTO axes would be needed to achieve the more complex motion and energy conversion of the oscillating body system (Richardson, 2019).

Recently, much research has focused on the multi degree of freedom (DOF) wave energy converters. A simple way to increase the number of DOF of the wave energy conversion system is to increase the number of the oscillating bodies. The earliest multiple DOF device can be traced back to the Raft proposed by Christopher Cockerell. It is composed of rafts and pontoons connected by hinges and hydraulic system to converter wave energy to electricity through pitching and rolling oscillating. Probably the most famous multi-DOF device is the Pelamis, developed by (Henderson, 2006). Hydraulic system is also used in Pelamis to generate electricity through hydraulic cylinders actuated by relative motions between adjacent pontoons linked by hinged joints. WaveNET, a hive-like wave energy converter with many floating bodies connected with each other, is developed by Albatern Ltd in Scotland (Albatern Wave Energy, 2017). Brunel University proposed a device similar to Pelamis in which the hydraulics is also used to generate electrical power. Tank tests with a scaled model is conducted at Lancaster university in 2016 (Ward, 2013).

The above devices are almost multi-body systems, and the way to increase the number of PTO axes for single-body systems is the usage of multi-axis PTO system. However, few literatures and projects looking into multi-DOF single body wave energy converters with multi-axis PTO system were found. Lancaster university has played an