Response and Power Absorption Assessment of the TALOS Wave Energy Converter in Time Domain

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In this paper, the response and the power absorption ability of the TALOS multi-mode WEC are preliminarily assessed for various environmental and operational conditions, by deploying two different computational tools and assuming linear mooring lines’ behavior. The device consists of an internal sphere attached to its floater with springs and dampers, while power is absorbed through the sphere’s motions relatively to the floater. A comparative study is, initially, conducted assuming rigid connection of the sphere with the floater. Next, by enabling the sphere to oscillate in heave, as well as in both heave and surge, the device’s performance for one and two operational modes is assessed. The two-mode PTO mechanism operation results in an increased power absorption of the device (max mean value of 238 kW) and in insignificant effects in motion responses.

INTRODUCTION

Wave energy corresponds to a vast, clean source of ocean renewable energy. Its strategic-driven exploitation, as reflected in the EU’s Offshore Energy Strategy with the 2030 deployment target of 1 GW for both wave and tidal energy (European Commission, 2020), can accelerate the decarbonization of Europe’s power supply, advance the realization of a diverse energy supply, and complement existing variable generation to balance grids (Colombet and Cagney, 2022). Accordingly, the wave energy sector during the last decades is rapidly growing and a variety of Wave Energy Converters (WECs) with different working principles have been investigated, developed, and tested (Rusu and Onea, 2018; Guo and Ringwood, 2021). Among the existing WECs types, Point Absorbers (PAs) correspond nowadays to one of the most advanced and research-focused wave technologies that usually harness wave power only through the heave or pitch oscillations of their floater (Guo et al., 2022). These WECs are characterized by design, manufacturing, deployment, and operation simplicity; however, their single-mode operational feature leads to reduced energy extraction ability under off-resonance conditions and narrow power capture bandwidth (Huang et al., 2019).

To tackle the latter drawbacks, multi-mode PAs, offering the advantage of energy extraction from more than one oscillation mode, could be developed and deployed. However, up to now, there exist quite limited studies dealing with those devices and demonstrating their increased power absorption ability compared to single-mode PAs. Specifically, Zhang et al. (2013), Zhang et al. (2015), and Tan et al. (2021) investigated numerically and/or experimentally 3-mode PAs, oscillating and operating in heave, surge, and pitch, with a Power-Take Off (PTO) mechanism modeled as a linear damping system of 3 Degrees of Freedom (DoFs). A 3-mode PA has also been examined numerically by Huang et al. (2019), with emphasis on the effect of different, nonlinear and linear, 3-DoFs PTO mechanisms on the performance of the device. Ye and Chen (2017) proposed a 6-DoFs PA with a 6-DoFs PTO mechanism and assessed numerically the performance of a simplified 3-mode PA that oscillates in heave, surge, and pitch and has an idealized 3-DoFs linear damping system for the PTO mechanism.

A novel multi-mode PA, the so-called TALOS (Technologically Advanced Learning Ocean System) WEC (Fig. 1), which is the focus of the present paper, corresponds to part of ongoing research and development activities on wave energy conversion at Lancaster University (Aggidis and Taylor, 2017). The device has a 6-DoFs rigid floater and a PTO mechanism enclosed inside the hull; hence, all mechanical components are not exposed to the harsh marine environment. Unlike the traditional PTO mechanisms, the TALOS internal PTO system consists of an inertial mass (sphere) attached to the floater with springs and dampers (e.g., hydraulic cylinders), while power is absorbed through the relative motions between the sphere and the floater. So, depending upon the arrangement of the multiple spring-damper system’s components, the TALOS device can extract power by exploiting the relative sphere-floater motions ideally in all six DoFs. The initial device (TALOS I, Fig. 1a) was developed and tested experimentally by Osborne et al. (2015), while a refined design of the WEC (TALOS II, Fig. 1b), focusing on hull geometry and

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