Analytical and experimental modelling of a floating/submerged elastic disk

Dr Siming Zheng, Dr Simone Michele

School of Engineering, Computing and Mathematics, University of Plymouth

The SUPERGEN ORE HUB ECR funding has helped us develop two analytical models to evaluate the hydrodynamics and wave power absorption of a floating flexible circular wave energy converters. These two analytical models related work has been published in two journal papers:

[1] **Michele, S., Zheng, S.**, Greaves, D., 2022. Wave energy extraction from a floating flexible circular plate. *Ocean Engineering*, 245, 110275. [open access] https://doi.org/10.1016/j.oceaneng.2021.110275

[2] **Zheng, S., Michele, S.**, Liang, H., Meylan, M.H., Greaves, D., 2022. Wave power extraction from a floating elastic disk-shaped wave energy converter. *Journal of Fluid Mechanics*. doi: 10.1017/jfm.2022.701 [accepted for publication]

The abstracts of these two journal papers are listed below.

Abstract (Michele et al., 2022)

We present a theoretical model to investigate the hydrodynamics of a floating flexible circular wave energy converter (WEC). Decomposition in rigid and bending elastic modes of the plate allows us to investigate power extraction efficiency in monochromatic incident waves. We show that plate elasticity increases the number of eigenfrequencies, which has a positive beneficial effect on power output. We also show how plate radius and power take-off (PTO) distribution affect the response of the system and the consequent absorbed energy. This work highlights the need to extend theoretical studies and experimental investigations on flexible devices, currently seen as the future of WEC technology.

Abstract (Zheng et al., 2022)

In this paper, a concept of a floating elastic wave energy converter consisting of a disk-shaped elastic plate is proposed. The floating plate is moored to the seabed through a series of power take-off (PTO) units. A theoretical model based on the linear potential flow theory and eigenfunction matching method is developed to study the hydroelastic characteristics and evaluate wave power absorption of the device. The PTO system is simulated as a discrete PTO, and moreover, it is also modelled as a continuum PTO to represent the case when the PTO system is composed of a large number of PTO units. The continuum PTO approximation is tested against the discrete PTO simulation for accuracy. Two methods are proposed to predict the wave power absorption of the device. After running convergence analysis and model validation, the present model is employed to do a multiparameter impact analysis. The device adopting a continuum PTO system is found to capture wave power efficiently in an extensive range of wave frequencies. For the continuum PTO system, it is theoretically possible to adopt optimised PTO damper and stiffness/mass to guarantee the absorption of 100% of the energy flux available in one circular component of the plane incident wave.

The SUPERGEN ORE HUB ECR funding has also enabled us to carry out a series of physical tests of a floating elastic disk in the Ocean Basin, COAST Laboratory at the University of Plymouth. Apart from the deflection of the floating elastic disk, an unexpected phenomenon “crossing waves” was observed for some special wave conditions. We are still working on the analysis of the physical data, and we are planning to develop a theoretical model to explain the above phenomena.