Interactions between an Oscillating Wave Surge Converter and a Heaving Point Absorber

Dripta Sarkar\textsuperscript{1}, Emiliano Renzi\textsuperscript{1}, and Frederic Dias\textsuperscript{1}

\textsuperscript{1}UCD School of Mathematical Sciences, University College Dublin, Ireland

ABSTRACT

In this paper, we investigate the mutual hydrodynamic interactions between two different kinds of devices, namely the Oscillating Wave Surge Converter and the heaving point absorber. A three-dimensional mathematical model is developed based on linear potential flow theory where it is assumed that the effect of the evanescent modes of the disturbed potential due to one of the converters is negligible in the vicinity of the other, considering a reasonable distance of separation between the two devices. We then investigate the influence of location, oblique wave incidence and other parameters on the power absorption characteristics of the two bodies.

INTRODUCTION

It is well recognised now that to make wave energy commercially viable, a large number of wave energy converters (WECs) must be deployed at designated sites. Wave farm devices like Oyster (developed by Aquamarine Power) are already planned at the Isle of Lewis in Scotland. The hydrodynamics of a large number of Oscillating Wave Surge Converters (OWSC) has been studied recently by Sarkar et al. (2013), while Borgarino et al. (2012) examined the interaction between a large number of heaving point absorbers (HPA) using a numerical approach. However, the studies mentioned essentially comprise of devices of the same kind. In reality, circumstances might entail locating devices of more than one kind at nearby locations. It is also important to understand the effect of the mutual interactions in such cases. The dynamics of such systems has not been studied before, and in this paper we attempt to develop a mathematical model to address the problem. The complexity in modelling such systems is the contrasting geometry of the devices coupled with the different modes of motion they perform.

Wave interaction in an array of WECs has been studied by many starting with the seminal work of Budal (1977), followed by many others. In general it has been shown that the interactions in an array lead to regimes of constructive and destructive interference effects on the performance of the individual WECs and also on the array as a whole. The nature of such interactions depend strongly on the configuration of the array, the geometry of the systems and also on the incident wave frequency. Babarit (2010) had investigated the effect of the interactions between two WECs of the same kind for large distances of separation. In this study, we are going to focus on a similar sparse distribution of two WECs but of different kind. However, the motivation is not just to see the impact of the separating distances, but also to understand the essence of the interactions given their disparate attributes. A three-dimensional mathematical model is developed based on linear potential flow theory, which basically assumes the fluid to be inviscid and incompressible and the flow irrotational. The HPA is modelled as a truncated vertical cylinder, while thin rigid-plate approximation of Linton and McIver (2001) has been utilized for the OWSC. The isolated hydrodynamic characteristics of a truncated cylinder has been studied extensively in the literature. Garrett (1971) was the first to analyse the diffraction problem using the series expansion of eigenfunctions of the velocity potential, while Yeung (1981) extended the approach to obtain the solution to the radiation problem. There are also numerous studies which have investigated the interaction in an array of truncated cylinders. Most of them have employed the interaction theory of Kagemo and Yue (1986) which utilises the addition theorems of the Hankel and Bessel functions. The theory of Kagemo and Yue (1986) is in fact quite general and can be applied to arbitrary geometries provided their isolated diffraction solution is known.

Recent studies have analysed the hydrodynamics of both - isolated and arrays of the flap-type OWSC thoroughly. The method of the solution employs Green’s integral equation formulation and Green’s function yielding hypersingular integrals which are solved numerically via a collocation scheme, using the Chebychev polynomials of the second kind. The mathematical approach followed in the later is distinctively different from that adopted for truncated cylinders. In our model, we unify the above two methods and express the final solution as a combination of the isolated cases of the respective bodies. The net spatial potential is then re-