Wavefield near WEC arrays

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Work stream 4: Arrays Wakes and Near Field Effects

Introduction

With the increase of the wave energy projects it is important to understand how the nearshore wave conditions are going to be modified by the deployment of a large number of wave energy converters (WEC). Some studies have been published which assess the impact of the WEC arrays on nearshore (1) (2) (3). In these studies, the wave-WEC interaction is described by a constant transmission factor (K_T), i.e. a wave energy balance is done with the incoming and transmitted waves. However it is known that the wave propagation is also function of frequency hence it is useful to investigate alternative methods for describing wave-WEC interactions. In the present study, an approach is presented based on potential flow and experimental measurements. The objective is to assess the frequency dependent wavefield changes (K_T) using both potential theory and experimental measurements.

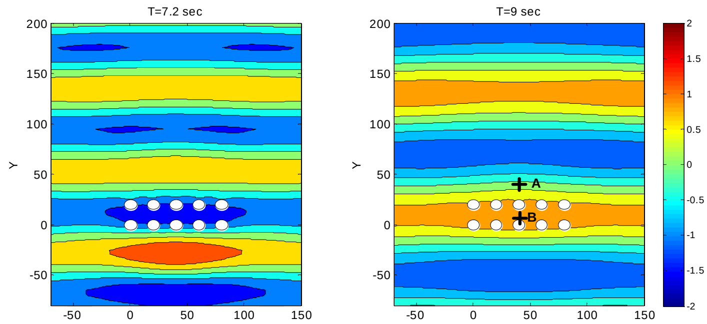

Fig. **1** – Free surface displacement near a 5x2 WEC array. Initial wave amplitude (A) 0.5 m , T=7.2 and 9 sec, propagating with Y axis. For T=7.2 sec WEC measured RAO and phase: 1rst row: 1.47 and -0.82 rad 2nd row: 1.29, 0.9. For T=9 sec WEC measured RAO and phase: 1rst row: 1.7 and -0.82 rad 2nd row: RAO 1.2, phase 0.6 rad.

Model description

A model with a 5x2 array of devices has been used in order to allow direct comparisons with experimental measurements. The devices considered have a semi-hemispherical wetted shape and 5 m radius, separated by 4 radii. Following linear theory, fluid is assumed incompressible and boundary conditions are applied at the body surface and mean water line such that the velocity potential, ϕ can be written as :

$$\phi = \sum_{n=1}^{N_{devices}} RAO_n \, \phi_{radiation_n} + A_{Scattered}\, \phi_{Scattered} + A_{Iincident}\, \phi_{Incident} \quad [1]$$

Where A is wave amplitude. The radiated wavefield of the problem can be assumed the sum of the 10 different radiating fields from the each device (i). The response amplitudes (RAO) applied to each device vary with incident wave frequency and were measured from 1:67th scale experiments conducted in Manchester University wide wave tank using the Manchester Bobber point absorber (further details of these tests given in (4)).

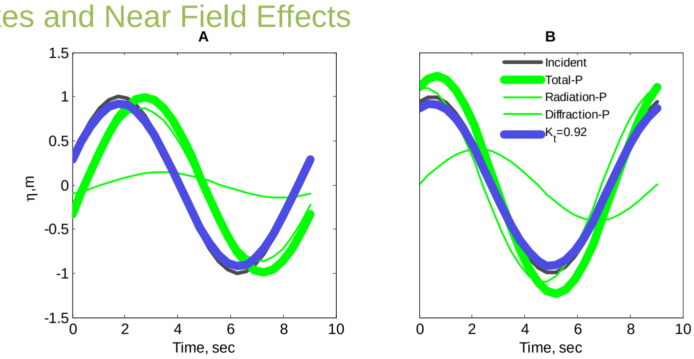

Fig. **2** – Total diffracted and radiated (with measured RAO) wave amplitudes from potential theory (green lines -P), Incident wave and wave in the wave of arrays using K_T= 0.92 (value from Experiments). Initial wave height 1m , T=9 sec, for point A (Fig. 1) downwave and B where the maximum wave amplitude in a cycle is obtained.

Results

Surface elevation contour plots for T=7.2 and 9 sec calculated using potential theory are presented in Figure **1**. Figure **2** represents the free-surface variation at two positions within the wavefield (see Fig.1): **A** - location 40 m downwave of array which could later be used for propagation models; **B** - where the maximum amplitude is reached. The blue line represents the free surface when a constant K_T is applied (92% calculated from experimental measurements of power extraction). The green lines are the results from potential theory (thin dashed - diffracted wave and solid –radiated wave). It can be seen that potential theory and constant K_T predict different wave amplitudes and phases for a point downwave of the array (Fig. 2-A). From Fig. 2-B the amplitude of the radiated wave is nearly 6 times larger that the scattered wave indicating that there is the possibility to separate both components in experimental measurement.

Summary

The two methods for wave-WEC interactions compared here differ on the final wave amplitude and phase results for downwave locations (Fig. 2-A). These differences are explained because the potential theory takes into account changes in wave phase as well as amplitude. The potential theory solution also point the different influence of diffraction and radiation (Fig. 2-B). A range of experimental measurements are now planned in order to evaluate the wave-field modification across an array of heaving devices.

References

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