

An Experimental Study of Closely Spaced Point Absorber Arrays

Tim Stallard, Peter K. Stansby and Alan J. Williamson

School of Mechanical, Aerospace and Civil Engineering, University of Manchester.
Manchester, UK.

ABSTRACT

Experimental measurements of the response of a group of closely spaced heaving devices are reported. Details of the experimental technique are presented and the effect of both array size and configuration on the power output and response of individual floats is reported and compared to an isolated float. Power output measurements relate to a non-linear drivetrain representative of the Manchester Bobber wave energy device in which each float and counterweight is supported from a pulley which drives a flywheel and generator. Net power amplification relative to an equal number of isolated floats is observed at several wave frequencies, generally when the wave period is greater than natural period. Response measurements are also presented with negligible mechanical friction (i.e. free-response) to provide dataset for easy comparison of response to general numerical simulation. As theory suggests, the measurements indicate that response and net power capture is amplified at particular ratios of device spacing to wavelength.

KEY WORDS: Wave Energy; Array; Experiment; Friction

NOTATION:

a float radius
 d water depth (= 0.46 m)
 η regular wave amplitude
 k wave number satisfying linear dispersion equation: $\omega^2 = gk \tanh kd$
 q_m interaction factor
 s centre to centre float spacing (suffix denotes axes)
 ω angular wave frequency (rad/s)
 x axis parallel to direction of wave propagation
 y axis parallel to wave front

INTRODUCTION

Many wave energy devices generate electricity by restraining the motion of a rigid body subject to wave excitation. One emerging class of wave energy device consists of a number of generating units installed in close proximity and supported from a common structure. The Manchester Bobber, the WaveStar the Fred Olsen FO³ (Buldra

and Trident Energy are examples of this type of device. Indicative dimensions of these systems are a float radius $a = 5$ m at spacing $s = 4a$ (i.e. separation of the order of one diameter). In wave periods between 6 and 12 s, these dimensions correspond to normalized radius in the range $0.55 > ka > 0.15$ and normalized spacing in the range $2.25 > ks > 0.55$. At the close separations considered the response of each device is influenced by the diffracted and radiated wave fields due to the other devices. Much theoretical work has been published concerning both the loading of arrays of fixed cylinders and the interaction of arrays of point absorbers. Wave device interactions have generally been studied under the assumptions of linear wave forcing and radiation from body motion only. These studies have shown significant amplification of response amplitude and power extraction at certain spacing. However, the theoretical findings have received limited experimental comparison and generally relate to relatively large device spacing. The purpose of this paper is to provide an overview of a series of experimental measurements of several closely spaced arrays of heaving floats. The data reported provide the basis for further numerical comparison.

In the remainder of this section, a brief review of the literature is presented with particular emphasis on experimental studies. Subsequently, the mechanical system is described. Configurations of three arrays and corresponding power and response measurements are presented. The implications of these measurements for device design are briefly discussed.

Arrays of Fixed Structures

Much theoretical work has been published concerning the hydrodynamic interactions within periodic arrays of fixed structures. Linear analysis has shown that significant amplification of excitation force may occur within an array of regularly spaced, fixed cylinders. This is associated with near-trapping of waves and can lead to a nine-fold increase of excitation force even in relatively small arrays of 25 bodies (Maniar & Newman, 1997). Such force magnifications occur in both infinite and finite arrays with maxima close to integer multiples of ks/π but amplifications are also observed at other frequencies. Newman (2001) and McIver (2002) have reviewed the phenomena of near-trapping and, more broadly, array interactions and their relevance