CHAPTER

6

FLOATING OSCILLATING WATER COLUMN WAVE ENERGY CONVERTER

Muhamad Aiman Jalani, Mohd Rashdan Saad,
Norazila Othman and Mohd Rosdzimin Abdul Rahman

6.1 INTRODUCTION

The scarcity of fossil energy reserves and the need for stricter environmental regulations have prompted the emergence of wave energy converter (WEC) devices aimed at harnessing abundant wave energy resources (Rezanejad et al., 2019). The WEC can be classified into three main categories: Oscillating water columns (OWC), wave-activated bodies and overtopping bodies (Yusof et al., 2019). Amongst all, the reliable and developed wave energy converters are oscillating water column (OWC) Sheng & Lewis, 2017). It is because of the practicality and less cost for the development on a big scale. An OWC can be built as a floating hollow structure at the offshore surface as shown in Figure 6.1. A floating type of the OWC called a Backward Bent Duct Buoy (BBDB) that was proposed by Masuda et al. (1987). The BBDB boasts a straightforward floating design, lower costs, and superior conversion efficiency when contrasted with alternative WECs (Wu et al., 2018). Comprising a water column, buoy, and L-shaped duct, the BBDB stands as a testament to its simplicity and effectiveness (Doyle & Aggidis, 2019). The BBDB transforms wave energy into electricity by converting mechanical energy into pneumatic energy. Its design features a partially submerged L-shaped chamber, open at one end with an orifice at the top. As waves alter the water level within the water column, the fluctuation in water height induces changes in air pressure, leading to bidirectional airflow through the orifice (El Barakaz & El Marjani, 2016). Leveraging the heave motion, the BBDB effectively captures wave energy for utilisation (Sheng, 2019).

Drawing upon the notable advantages offered by the BBDB, rigorous set of studies have been done to investigate the hydrodynamic and pneumatic characteristics of the BBDB. For the incident wave direction, Toyota et al. (2010) studied the effect of the incident waves direction toward the BBDB and found that backward direction produces high efficiency. In a numerical investigation by Sheng (2019), it was found that the BBDB exhibits significantly superior performance compared to its forward counterpart. The effect of hull shape on BBDB was studied by Wu et al. (2018) conducted experiments at regular wave state in a two-dimensional wave tank and irregular wave state in a three-dimensional wave basin. Their findings revealed that under regular wave conditions, primary conversion efficiency rises to 1.21, whereas in irregular waves, it achieved up to 0.89. Toyota et al. (2008) investigated five different body hull of BBDB with a dimension of 0.85m x 0.6m x 0.563m in a wave basin using a regular wave and found that the modified BBDB duct has the best performance with 0.35 primary conversion efficiency compared to without extension duct. Imai et al. (2011) further examined the BBDB by extended duct at both a two-dimensional wave tank and a three-dimensional wave basin. Their findings indicated that in the absence of the extended duct, the primary conversion efficiency gets higher, reaching 0.7 in the two-dimensional wave tank and 1.1 in the three-dimensional wave basin. Pathak et al. (1999) used four different models with different additional duct at regular and irregular wave states. Results show that the efficiency in regular and irregular cases is 1.72 and 0.52, respectively. In their study, Baanu et al. (2014) explored the impact of an extended duct on BBDB performance. They determined that the extended duct did not improve the efficiency of the BBDB. This was attributed to the extended duct diminishing the pitch of the BBDB. An effect of the shape of the BBDB was study by Wu et al. (2017). They modified the BBDB by transitioning from a square to a triangular shape, aiming to reduce fluid velocity perpendicular to the BBDB walls and thereby increase energy harvesting. Experiments were carried out in both regular and irregular wave state within both the two-dimensional wave tank and the three-dimensional wave basin. Results for regular state indicate an efficiency of 1.19 and 1.47 for the two-dimensional and the three-dimensional wave tank, respectively. In irregular wave state, the efficiency measured at 0.87.

The previous study underscores the positive influence of altering the BBDB shape on primary conversion efficiency. Consequently, the current investigation aims to assess how variations in the geometry of bottom wall of the BBDB affect pneumatic characteristics within the water column and efficiency under different wave height within the three-dimensional wave basin.

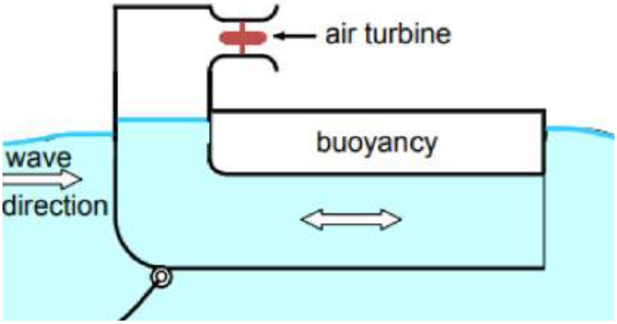

Figure 6.1 Schematic diagram of a floating OWC (Source: Falcao & Henriques, 2016)

6.2 OSCILLATING WATER COLUMN

A floating OWC model was optimised and designed from the directory of previous research. Wave parameters like average wave height and period were different for all locations they depend on climate and experiment input. It is anticipated that bottom corner shape will