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Numerical and experimental test of a cylindrical wave energy system with horizontal rotation

Min-Su Park[a]*, Youn-Ju Jeong[a], Jeong-Soo Kim[a], Yoon-Koog Hwang[a]

[a]*Structural Engineering Research Institute, Korea institute of Civil Engineering and Building Technology, 283 Goyang-daero Illsnseo-gu, Goyang-si 10223, South Korea*

Abstract

In the present study a cylindrical wave energy system with horizontal rotation is newly suggested. The suggested cylindrical wave energy system is composed of the horizontal cylinder and the swing plate. The horizontal cylinder is floated at the free surface, and rotated by the water particle velocity and the current flow. The swing plate is submerged at the bottom of horizontal cylinder and has the pendulum motion according to incident wave motion. To evaluate the characteristic of cylindrical wave energy system the numerical test is carried out using ANSYS Fluent V15 for various parameters. Moreover, the numerical results are compared with experimental results.

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Keywords: Cylindrical wave energy system; horizontal rotation; horizontal cylinder; swing plate; ANSYS fluent

1. Introduction

Nowadays, the main source of energy in the world is fossil fuel. But the amount of fossil fuel is limited, and the use of it causes environmental pollution and global warming. Thus, the studies of renewable energy such as wave energy, wind energy, solar energy and geothermal energy are being carried out actively all over the world. Particularly, the wave energy has gained attention from many countries to find alternative and reliable energy sources since the potential of wave energy has been recognized for long and mostly associated with a nondestructive

* Corresponding author. Tel.: +82-31-910-0289; fax: +82-31-910-0121.
E-mail address: mspark@kict.re.kr

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renewable energy. Unlike large wind turbines, there is a wide variety of wave energy technologies, resulting from the different ways in which energy can be absorbed from the waves, and also depending on the water depth and on the location (shoreline, near-shore and offshore). Recent reviews identified about one hundred projects at various stages of development (Falcao, 2010). Several methods have been proposed to classify wave energy systems, according to location, to working principle and to size. The classification such as the oscillation water column (Sakata (Ohneda et al., 1991), Pico (Falcao, 2000), LIMPET (Heath et al., 2000)), the oscillating bodies (AquaBuoy (Weinstein et al., 2004), Pelamis (Pizer et al., 2005), AWS (Gardner, 2005)) and the overtopping (TAPCHAN (Evans and Falcao, 1986), SSG (Margheritini et al., 2007), Wave Dragon (Kofoed et al., 2006)) is based mostly on working principle.

In the present study, a cylindrical wave energy system with horizontal rotation is newly suggested. The suggested cylindrical wave energy system is composed of the horizontal cylinder and the swing plate as shown in Fig 1. The horizontal cylinder is floated at the free surface, and rotated by the water particle velocity and the current flow. The electric generator is located in the horizontal cylinder. Thus, the generator is not affected by sea waters. The swing plate is submerged at the bottom of horizontal cylinder and has the pendulum motion according to incident wave motion. In real ocean environments, the propagation direction of wave may change from day to day. Therefore, the yaw system is adopted in this design. To evaluate the characteristic of cylindrical wave energy system the numerical test is carried out using ANSYS Fluent V15 for the horizontal cylinder and the swing plate, separately. In case of horizontal cylinder the various parameters such as the number of bucket, the length of bucket, the diameter of cylinder and the height of draft are considered. The rotation speed of horizontal cylinder is strongly dependent on the diameter of the cylinder and the height of draft. For the swing plate, the thickness of swing plate is considered. It is found that the period of swing plate is closely related to the period of incident wave. Moreover, the numerical results are compared with the experimental results.

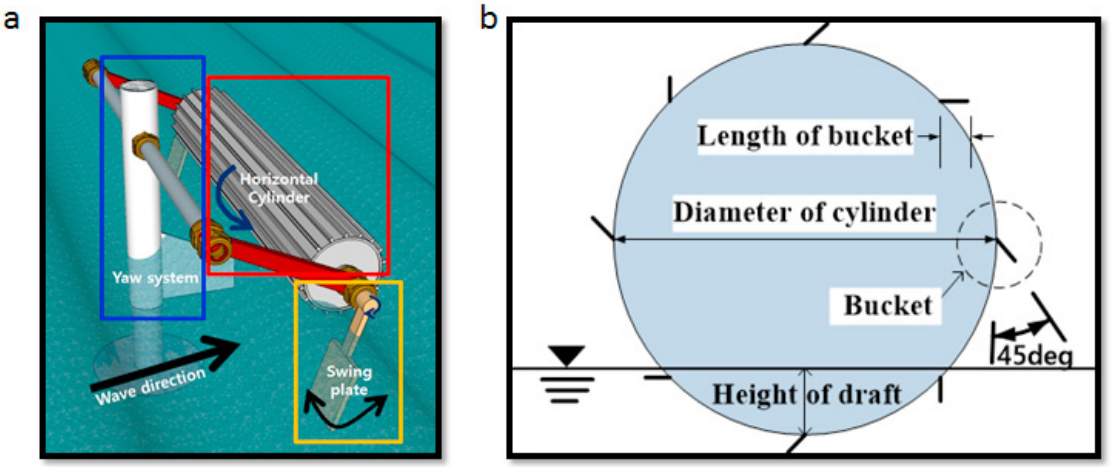

Fig. 1. (a) Cylindrical wave energy system; (b) Geometrical definition of the horizontal cylinder.

2. Numerical test

ANSYS Fluent V15 is used to evaluate the characteristic of cylindrical wave energy system. ANSYS Fluent is the most powerful computational fluid dynamics (CFD) software, and includes well validated physical modeling capabilities to deliver fast, accurate results across the widest range of CFD and multi-physics applications. The numerical test of horizontal cylinder is carried out for various parameters as shown in Table 1. The thickness of swing plate is only considered in the numerical test since the 2 dimension numerical analysis is performed. The numerical conditions for the swing plate are presented in Table 2. Fig. 2 shows the model and mesh of numerical test. The distance between wave maker and structure is 2 L (L: incident wave length), and the distance between structure and damping zone is 3 L to reduce the reflected wave from damping zone. The standard k-ε model is