Development of Simulator for the Oscillating Water Column Type Wave Power Generator
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ABSTRACT

Renewable energy is attracting attention as an alternative to current mainstream power generator sources. One source of renewable energy is wave energy. We devised a simulator for the OWC-type wave power generator and developed a reciprocating airflow generator is generated reciprocating airflow by using the reciprocating motion of a piston. Thus, an arbitrary reciprocating airflow was achieved. Furthermore, we examined the starting characteristics of the vertical axis turbine, thereby confirming its start up at an arbitrary wind speed.

KEY WORDS: Wave power generator; oscillating water column; reciprocating airflow; vertical axis turbine; starting characteristics.

INTRODUCTION

Renewable energy power generator systems are garnering attention as a means to combat climate change and provide stable energy sources. Wave energy is one of the renewable energy sources. In Japan, the density of wave energy increases as the wave moves offshore. For example, the average wave energy density of about 10 kW/m around Japan produces about 50 GW of energy (Maeda and Kinoshita, 1979). By contrast, an average wave energy density of 7 kW/m on the coast of Japan produces about 36 GW of energy (Takahashi and Adachi, 1989).

Wave power generator methods include the oscillating water column (OWC), motion convert, and overtopping methods (The New Energy and Industrial Technology Development Organization, 2010). The airflow in the OWC-type wave power generator reciprocates with the rise and fall of sea levels. Therefore, the OWC-type wave power generator used a turbine that rotates in one direction even in the presence of a reciprocating airflow. The Wells turbine, which is a horizontal-axis turbine, has been previously used in OWC-type wave power generators (The Queen’s University of Belfast, 2002; Torre-Enciso et al., 2009; Otaola et al., 2015; Inoue et al., 1988; Murakami et al., 2015; Lekube et al., 2017). The Queen’s University of Belfast (2002) examined various wave power generator elements of a 2.6-m diameter Wells turbine for OWC-type wave power generator. Torre-Enciso et al. (2009) developed an OWC-type wave power generator with 16 Wells turbines at Mutriku, Spain, and Otaola et al. (2015) examined its chamber model. The Wells turbine characteristics against irregular waves were investigated (Inoue, Kaneko, Setoguchi and Saruwatari, 1988). Thereafter, its starting and running characteristics were obtained through computer simulation and compared with experimental results. Murakami et al. (2015) examined an OWC wave power generator with an impulse turbine, and clarified that the turbine efficiency changes with the air-chamber-shaped. Lekube et al. (2017) focus on the implementation of a novel MPPT control approach for the OWC systems in order to optimize the power delivered to the grid. An OWC-type wave power generator using a horizontal axis turbine requires the installation of the generator in a duct. However, the generator may easily corrode due to exposure to a salt-containing air stream and the air stream influx to the turbine may be reduced. To address these issues, we proposed the use of a vertical axis turbine, which allows installation of the generator outside the duct, thereby preventing salt damage.

In this paper, we devised a simulator for OWC-type wave power generator and developed a reciprocating airflow generator is generated reciprocating airflow by the reciprocating piston motion. This piston motion was achieved by converting the rotational motion of the motor into linear motion of the ball screw via gears. Furthermore, we used a turbine with arc camber blades and examined the starting characteristics of this vertical axis turbine.

RECIPIROCATING AIRFLOW GENERATOR

Fig. 1 shows the square cross section of the piston and measurement section with sides of 1.25 m and 0.4 m, respectively, connected by a contraction flow section. The piston linearly reciprocates to exhalation and inhalation of the air in the piston section. The reciprocating linear motion of the piston is realized by converting the rotational motion of the motor to the linear motion of the ball screw via a gear. The ball screw is rotated forward and backward with a motor, thereby producing a linear motion. A screw hole is cut in the center of the piston. The reciprocating airflow moves through the contraction flow section and into the measurement section. Since the tip of the measurement section is open, the reciprocating airflow flowed in and out the section. The piston section and contraction flow section are constructed of a galvanized steel plate, whereas the measurement section is constructed from an acrylic plate.