Effect of Inlet Geometry Modification of Wave Energy Conversion System

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ABSTRACT

The ocean holds a tremendous amount of untapped energy which is a non-polluting and renewable source. Due to development of stand-alone renewable energy systems, it is a trend to install the Oscillating Water Column (OWC) with rechargeable batteries on the buoy. It is important to improve the energy conversion efficiency to keep a certain range of battery voltage in order to extend the battery’s replacement cycle. Two types of inlet geometry (the trumpet type and the cylindrical type) are designed and compared their performances through scale model experiment in a 2-D wave tank as well as through the full scale experiment in the sea. The results confirm that the trumpet-shaped inlet of OWC generates more electric power than the cylindrical-shaped inlet.

KEY WORDS: OWC; buoy; inlet; geometry; modification; trumpet; efficiency.

INTRODUCTION

The recent signing of the Kyoto Treaty has sparked a renewed emphasis on research into clean alternative energy worldwide. The ocean holds a tremendous amount of untapped energy which is a non-polluting and renewable source. Ocean energy comes in a variety of forms such as marine currents, tidal currents and waves. Especially, wave energy provides 15-20 times more available energy per square metre than either wind or solar. Vining (2005) proposed that wave energy is more predictable than wind or solar energy. Therefore many wave energy converters have recently been developed and enhanced, e.g., the Oscillating Water Column (OWC). The OWC is one of the most operates much like a wind turbine via the principle of wave induced air pressurization. There are numerous factors that affect the design of the OWC such as wave height, length and period plus chamber dimensions, total mean water depth, by-pass valve control, etc. In this paper, the inlet shape of the OWC, especially for a buoy, is taken into consideration to improve its energy conversion efficiency. The buoy plays a vital role for the safety of maritime traffic as aids to navigation. A battery, which used to be frequently replaced by a man, supplied electric power to the lamp, communication devices, control devices, etc. on the buoy. However, due to development of stand-alone renewable energy systems, e.g., photovoltaic (PV), wind turbine and wave energy converter, etc., it is a recent trend to install these energy systems with rechargeable batteries on it. Over discharge of batteries by the weather conditions and the low energy conversion efficiency shorten their replacement cycle. As a result, it is important to improve the energy conversion efficiency to keep a certain range of battery voltage. In order to improve the energy conversion efficiency of the OWC, two types of inlet geometry, i.e., the trumpet type and the cylindrical type are designed in this study. In order to compare their performance, scale model experiment was conducted in a 2-D wave tank. Furthermore, the full scale experiment on the buoy in the sea was also carried out to collect output power data.

INLET GEOMETRY OF THE OWC

Internal Wave Height and Seawater Inflow

To simplify the theoretical analysis, several things are assumed as follows.

- Air is incompressible.
- Wave forces are far greater than the air force.
- Pressure at the exhaust of the OWC is atmospheric. (Zero gauge pressure)
- External wave is linear (Sinusoidal).
- Viscous effects are ignored.
- Seawater flow is irrotational.
- Heaving motion of the buoy is ignored (Stationary buoy).
- Depth of water is greater than half of the wavelength (Deep water).
- Internal wave height of trumpet type depends on the seawater inflow, which is proportional to the opening surface area at the bottom of the OWC.

It was noted (McCormick, 1974) that the floating generation equipment in buoy consists of a circular floating body which contains a vertical water column that has free communication with the sea. Thus, the water surface in the center of the OWC rises and falls with the same period as that of the external wave. Inlet geometry of the OWC is shown in Fig. 1.