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ScienceDirect

Energy Procedia 105 (2017) 283 – 288

Energy Procedia

The 8th International Conference on Applied Energy – ICAE2016

A Model and Experiment Study of an Improved Pendulor Wave Energy Converter

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Abstract

This paper proposes one improved design of pendulor wave energy converter (PWEC), which integrates a pendulor, two side-walls and a slope to concentrate wave power. The slope guides the incident wave upward, and the wave drives the pendulor to rotate upward. Different from previous pendulors, one end of present pendulor is hinged near the free water surface, and the other end swings upward and downward. The mechanical flapping energy is converted to hydraulic energy by the connected hydraulic pump, and then it is converted to electrical energy. The proposed design is verified by theoretical and model-experimental study. The energy conversion efficiency is estimated by a simple weight-lifting method. Experimental results show that the first level conversion efficiency is averaged at 35% under the condition of wave height 0.18m, wave period 1.11s and pendulor length 0.6m. In short, this system has various advantages including simple, compact, modularized, light-weight and low-cost structure, which can be generally installed on ocean shore, near-shore piles and offshore platform, especially for China sea conditions.

Peer-review under responsibility of the scientific committee of the 8th International Conference on Applied Energy.

Keywords: Wave energy converter; Pendulor; Estimated model; Water tank test; Integrated Design;

1. Introduction

As one of the significant renewable energy, ocean wave energy holds a large part of the potential renewable energies. For China, the wave energy is rich, and the investigated potential is around 12.84 million kW at 20 miles offshore [1]. The wave energy of China is not well-distributed. The energy density of the sea in the South is larger than that in the North; that in the offshore areas is larger than that in the

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Peer-review under responsibility of the scientific committee of the 8th International Conference on Applied Energy.
doi:10.1016/j.egypro.2017.03.315

near-shore areas; that around the far islands is larger than that around the near-shore islands; that in autumn and winter is larger than that in spring and summer. Particularly, the wave energy of Southern Sea is much more promising. The annual power level of the areas from Luzon Strait to the coasts of the Indo-China Peninsula varies between 10 and 16 kW/m, with the highest values occurring in the area of Luzon Strait. Thus, developing effective and economic devices to utilize the potential tremendous wave energy in China is quite promising.

Compared to other sustainable energy utilization, there are various design types of wave energy conversion or converter (WEC), which can be generally divided into a few types including oscillating water column, overtopping apparatus, point absorber and surging equipment, etc. [2-4]. To be competitive, the conceptual WEC design has to be effective, efficient, environment-friendly and economical. One type of these designs is surging pendulum device, which contain a pendulum flap to swing back and forth to harvest the wave energy near-shore or at the sea bottom.

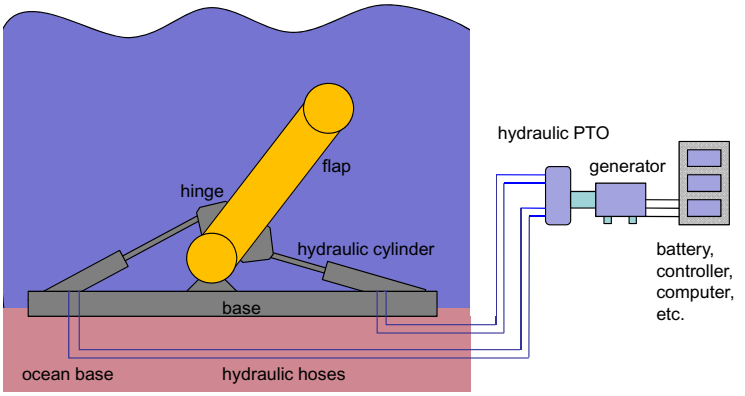

Fig. 1. A concept design of an 'Inverted Pendulum' wave energy converter (WEC) in the bottom wave areas of China

In China, especially since 2010, the efforts in research and development (R&D) in WEC have gained the support of national plans and funding, which is optimistic on the development in the wave energy fields. The R&D works on the surging type of WEC start a few more only from recent years. As demonstrated in Figure 1, Zhang et al. [5,6] report studies on a dual action hydraulic power take-off (PTO) system for a WEC device with inverse pendulum. To find out the complex interaction between PTO characteristics and WEC hydraulic performance, these papers describe time domain simulation and corresponding preliminary experiment verification, by which the design feasibility, reliability and advantages are discovered. Recently, Wan and co-workers proposed an innovative pendulum WEC with track, caisson and wave collectors used onshore and near-shore, since China has long coastlines and numerous islands that need nearby renewable energies [7,8]. This designed device can collect more waves and energies.

Since the general wave energy density in China is smaller than that in Europe [9,10], especially in north China sea areas, lowering the utilization cost and expanding application ocean areas are necessary for China to utilize wave energy. Consequently, this paper proposes one improved kind of pendulor wave energy converter (PWEC) to lower the above mentioned cost, combining the principle of pendulum, overtopping and wave moment concentration. The floating pendulor swings above the water surface around the fixed horizontal axis. Under the pendulor, there is a slope, along which incident waves climb up and drive the floating pendulor to rotate upward. There are walls on both sides of the pendulor. The