Float-counterweight Type Wave Power Generation System: Experiments in Open Sea

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ABSTRACT

The wave power generation system which consists of wire(s), float(s), counterweight(s), driving pulley and ratchet mechanism is set at Shiranui Bay in the Yatsushiro Sea towards the completion of a smart grid on February 2011. The smart grid is being constructed in Minamata City, Kumamoto Prefecture, Japan. Besides wave power generation, the grid is composed of photovoltaic power generation (PV), fuel cell (FC) and lead-acid battery. The consideration of the float-counterweight type of wave energy converter for this project is based on several merits of this device. Firstly, the device can take advantage of the existing onshore or offshore structures reducing the installation cost significantly. Secondly, since all the mechanical and electrical components except the float and the counterweight are set well above the water level, supervision and maintenance are convenient. Finally, it is free from major structural problems common to most movable body types due to the use of the flexible wire as the medium of energy transfer. In this paper, several examinations for setting the device are introduced. Firstly, the energy gain, the maximum wire tension on the float side, and the maximum torque that the driving pulley receives from the generator in anticlockwise direction are evaluated from the mechanical dynamics model for stable operation of the device. Furthermore, the device is set on a Curtain-Wall-Type Breakwater in which the substructure of the breakwater is propped up by plural columns. Due to the surge motion of the float during low tide, it is possible that the float scrapes the columns. As a measure for protection of the breakwater shock absorber is placed around the float and net around the columns. After satisfactory completion of the setup, the device is brought into operation. This paper presents the sea trial results of the electrical power output.

KEY WORDS: Float-counterweight type, smart grid, curtain-wall-type breakwater, natural period, sea trial.

INTRODUCTION

The development of alternative energy technologies has become imperative in the context of today’s global environment which faces the problem of a massive increase in energy demand coupled with the rising global warming. At present, the development of alternative energies such photovoltaic power generation (PV), wind power and miniature hydraulic power etc. are being earnestly taken up in the developed countries. However, the electric power output generated by the renewable energy is influenced by the weather conditions, i.e., it is so unstable. If the amount of the supply is increasing as the electricity is in little demand, it is a problem that the mass-produced electricity is transmitted and loaded in the power line. In order to propagate alternative energy technologies, it is necessary to stabilize the system interconnection, e.g., adjusting the balance between supply and demand.

The present concrete plan is that the system controls the flow of the electricity from both the supply and demand by using the battery, and optimizes the transmission network. This is what is called the Smart Grid (1). The system is considered quite likely to stabilize the system interconnection so that the demonstration tests for stable supply of electricity are being started in various parts of Japan.

The authors have been testing the stable supply of electricity by the PV, FC, the float-type wave power generation device and lead-acid battery on the premises of a fish farm of Marushima Fishery Port in Minamata city, Kumamoto Prefecture by the subsidy from Ministry of Internal Affairs and Communications.

The general wave power generation system has two inconsistent problems both cost and durability. However, it is said that the float-type wave power generation device developed by Yamaguchi University is able to overcome the above problems at the high level. The use of wire, made with a flexible material frees the system from serious structural problems common to most movable body types systems. Since all mechanical and electrical components except the float and the counterweight are set well above the water level, their supervision and maintenance is convenient. In order to realize the above demonstration tests, the wave power generation system is constructed in the smart grid.

The authors have been developing the float-type wave power generation device (2), which consists of pulley(s), wire(s), float(s), counterweight(s) and ratchet mechanism. The principal is that the heaving motions of the partially submerged float cause the driving pulley and the shaft to rotate as shown in Fig.1. The rotary converter rotates the shaft in a single direction independent of the direction of the float motion, i.e. up or down. The gearbox increases output shaft speed so that the size of the generator can be reduced depending upon the gear ratio.

In this paper, the results of the past wave investigation around the area of sea set up the wave power generation device are shown. Next, it is examined the estimation of the occurred electrical power output and the