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A Refined Model for Float Type Energy Conversion Device

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ABSTRACT

A refined dynamics model for the float-counterweight wave energy conversion system is presented here taking into account the previously unconsidered effects of the added mass and drag force on the behavior of float motion and energy gain. Computational results of the work rate, where the float was always in a partially submerged state were found to be in good agreement with the results obtained from wave tank tests. Comparative analysis of the results from the new and previous model has led to a better understanding of the effects of added mass and drag force on the system. Resonant frequency and the power output during resonance have been calculated for certain prototype designs.

KEY WORDS: Resonant heaving motion; driving pulley; wire tensile force; float; counterweight.

INTRODUCTION

The importance of wave energy conversion need not be exaggerated especially in the context of today's global environment which faces the problem of a massive increase in energy demand coupled with a rise in global warming. Various mechanisms for extracting wave energy have been developed but have not been fully utilized due to structural strength and economical problems. The OWC system seems to be considered a major one because it does not have serious problems of structural strength (Evans et. al. 1982, Malmo et. al. 1985, Folley et. al 2004, Suzuki et. al. 2006). However its practical use has not been attained due to economical reasons.

The authors have proposed a movable body type in which the heaving motion of the partially submerged float causes 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. The vertical motion of the float and therefore the energy gain is maximum during resonance, which will be discussed later. Therefore, the system can be designed so that its natural frequency of oscillation matches that of the dominant wave frequency which will enable us to reduce the component sizes for a given energy output. The use of wire, made with a flexible material frees the system from serious structural problems common to most movable body type 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. As a remaining problem, since the float on the water surface will trace an elliptical orbit in the wave field, a horizontal force will act on the float and therefore on the system. To obviate this problem and enhance the vertical motion of the float, the device can be located in slit type caissons as shown in Fig. 2.

Drag and added mass forces impede the motion of the float mass in water. Hadano (1998) proposed a dynamics model for the system where these forces had not been considered. This paper aims to propose a refined model considering all these forces, with an objective of understanding the dynamics of the system in the real environment. Computational results of the time series of various physical quantities have been presented using the new model highlighting the effects of the drag and added mass force. Next, the resonance phenomenon and its utilization in enhancing the energy extraction have been discussed.

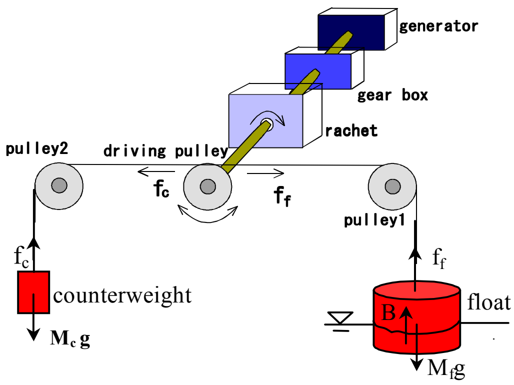

Fig. 1 Schematic diagram of the energy conversion system

THE MECHANICAL DYNAMICS MODEL

As shown in Fig.1, the device consists mainly of a float, counterweight, cable, driving pulley, ratchet, gearbox and generator. The mechanism of energy transfer is basically the conversion of the heaving of the float