Dynamics of the Float-Counterweight Type Wave Power Generation System

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ABSTRACT

The dynamics of a wave power generation system which consists of wire(s), float(s), counterweight(s) and ratchet mechanism is examined in this paper. The model is composed of the several equations: the equation for the generator, the equation for the float and counterweight motion, the equation for the driving pulley motion. The hydrodynamic excitation force is calculated numerically along with the added mass force and damping force, which are then combined with the equation for float motion given by the rigid body dynamics to obtain the float displacement and other physical quantities. Wave tank test results are found to agree closely with the numerical results, thereby validating the proposed numerical model. Key physical quantities, electrical power output and maximum wire tension, are examined for different wave conditions.

KEY WORDS: Cable; float-counterweight; heave; radiation forces.

INTRODUCTION

Waves are one of the most abundant renewable energy resources which have a higher energy density and more stability than solar or wind energy. Despite this, utilization of wave power on a commercial scale still seems far fetched. Although many innovative technologies that work well in ideal wave conditions exist, none has have proved efficient from economical and reliability point of views in real sea environment. However, the renewed interest in alternative energy globally, has revitalized this field. In Japan, on the other hand, after the disappointing performance of Mighty Whale (Osawa 2002), wave-power has largely been ignored in the new-energy policy of the government.

In this paper, a movable body type wave energy converter is proposed which mainly consists of a float, a counterweight, a cable, a driving pulley, a shaft, a ratchet, a gearbox and an electric generator (see. Fig. 1). The heaving motion of the float caused by the waves rotates the driving pulley and the connected shaft. The ratchet mechanism is used to allow only the clockwise torque, generated during the lowering of the float, to be transmitted to the generator. Finally, the shaft speed is increased before driving the electric generator.

The proposed system has two major advantages. Firstly, it is free from major structural problems common to most of the movable body types due to the use of the flexible cable. 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.

In this paper, first, the dynamics model of the wave-energy conversion process proposed by Hadano (2006) is improved by introducing the frequency dependent added mass and wave damping together with the wave excitation force. These new quantities are evaluated using the 3D-source-distribution method (Garrison 1978). Results from the numerical calculation of the refined model are then compared with experimental results for validation.