

Numerical Analysis on 2-D Optimal Profile of Floating Device with OWC-type Wave Energy Converter

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A floating-type wave power generating system has an Oscillating Water Column (OWC). The device captures the wave energy using the heaving, pitching and surging motion of the device and the heaving motion of the OWC. The investigations are motivated by the experiments and the numerical analyses undertaken to find a possibility different from an OWC-type floating device, e.g. the Mighty Whale of the Japan Marine Science and Technology Center. The 2-dimensional numerical expansion method for analyzing a floating body with an OWC-type wave energy conversion device is introduced where the eigenfunction method is described under the condition that the linear water wave theory is applicable. It is confirmed that these solutions give good agreement with several experimental results in our previous paper. The 2-D optimal profiles are eliminated according to conditions different from high efficiency, i.e. the minimum size per one power unit and so on. The investigations are established by many calculations, and the optimal load damping coefficient is solved. In this way we can obtain the optimal profiles considered for the construction cost.

NOMENCLATURE

a, a_i :	amplitude of incident wave
a_r :	amplitude of reflected wave
a_t :	amplitude of transmitted wave
A_W :	OWC's water plane area = BW
B :	breadth of air chamber
c_{ij} :	hydrostatic restoring force coefficient
D :	load damping coefficient of OWC ($D = pA_W/i\omega z_{OWC}$)
$f(k_0h)$:	$2 \cosh^2(k_0h)/(2k_0h + \sinh(2k_0h))$
g :	gravitational acceleration
h :	water depth
k_0 :	wave number of incident wave
p :	amplitude of pressure in air chamber
R :	opening ratio of orifice (or air chamber)
t :	time
W :	width of air chamber
W_i :	incident regular wave power
W_{OWC} :	output of OWC in regular water wave
δ_{ij} :	Kronecker's delta = $\begin{cases} 1 & (i = j) \\ 0 & (i \neq j) \end{cases}$
η_{OWC} :	efficiency of OWC for regular wave
λ :	wavelength
θ :	amplitude of pitching angle of floating body

ρ :	water density
ξ :	amplitude of surging of floating body
ω :	angular frequency
ζ :	amplitude of heaving displacement of floating body

Subscripts

c :	center of buoyancy
g :	center of gravity
1:	surging of floating body
2:	heaving of floating body
3:	pitching of floating body
4:	diffraction of floating body
5:	heaving of OWC

INTRODUCTION

A wave power generating system of the Oscillating Water Column (OWC) type is composed of a turbine generator and an air chamber in which the OWC converts wave energy into oscillating airflow (Raghuathan, 1995; Washio et al., 2000). A Wells-type turbine is used for the air turbine because it is suitable for operation in an oscillating airflow. The Wells turbine will always rotate in the same direction irrespective of the direction of the oscillating airflow. Further, because the Wells turbine has a simple configuration and structure, it is very commonly used for conversion of wave energy. The Wells turbine has a special characteristic for the OWC which has a linear pressure drop over the blade against the flow rate under the constant rotational speed, that is, the load damping coefficient of the OWC has linear characteristics (Suzuki et al., 2000).

The numerical methods for analyzing a wave energy conversion device of the OWC type are described under the condition that

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