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3D Numerical Investigation on Reservoir System for an Overtopping Wave Energy Convertor

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ABSTRACT

Overtopping Wave Energy Convertor (OWEC) is an offshore wave energy convertor, which comprises the circular ramp and reservoir. It collects the overtopped waves and converting water pressure head into electric power through the hydro-turbines installed in the vertical duct, which is fixed in the sea bed. The performance of OWEC can be represented by the operating water heads of the device, which depends on the amount of the wave water overtopping into the reservoir. In the present paper, the reservoir with the duct connecting to the sea water are studied in the 3D numerical wave tank, which has been developed based on the computational fluid dynamics software Fluent 6.3. Both the overtopping motion and the discharges of the reservoir are investigated together, and several shape parameters and incident wave conditions are varied to demonstrate their effects on the performance of OWEC.

KEY WORDS: Wave energy; overtopping; reservoir; numerical wave tank; operating performance.

INTRODUCTION

The generation of electric power utilizing clean and renewable ocean resources is one of the most important alternative energy technologies for overcoming shortages in energy resources caused by excessive use of fossil fuels. Among various ocean resources, wave energy is the most abundantly available and applicable in most coastal and offshore areas. Due to the advantages of simple converting technique and producing cost over other types of ocean energy, the wave energy conversion system is feasible to be established for the commercial power production.

Plenty of wave energy absorption devices have been invented, and several of them have been utilized in the electricity generation. Recently, the Oscillating Water Column (OWC) type has been widely employed in the application for the wave energy conversion. The disadvantage of this device is the low wave energy converting efficiency.

Overtopping Wave Energy Convertor (OWEC) has the sloping walls and reservoirs to lift waves to the levels above the average surrounding ocean. The released reservoir water is used to drive hydro-turbines or other converting devices. OWEC has several distinct advantages over other types of wave energy converting devices. It produces a relatively small fluctuation in the derived electricity because it converts wave energy to potential energy in the calm water of the reservoir. Furthermore, OWEC is more feasible economically since it can be combined with other coastal facilities such as break waters.

TAPCHAN is a prototype onshore OWEC plant which was installed on a remote Norwegian island in 1985 described by Falnes et al. (1991) and has been functioning ever since. The name is an abbreviation of "tapered channel", which describes the basic idea behind the device. TAPCHAN consists of a reservoir built into a cliff a fewer meters above the sea level. A tapered channel, which is wide at the mouth and open to the sea, becomes narrower as it penetrates the reservoir. Incoming waves increase in height as they move up the channel, eventually overflowing the lip of the channel and pouring into the reservoir.

Kofoed et al. (2006) proposed a floating wave energy convertor of the overtopping type, Wave Dragon. It consists of two patented wave reflectors focusing the wave towards the ramp, linked to the wave reservoir. The wave reflectors have the verified effects of increasing the significant wave height substantially and thereby increasing the energy capture. Waves focused by the reflectors overtop the ramp and fill the reservoir, which is situated at a higher level than the surrounding sea. A study of overtopping flow series on the Wave Dragon prototype was performed by Tedd and Kofoed (2009). A low crested device is designed to maximize flow in a real sea. Their study aimed to fill the gap in the literature on time series of flow overtopping low crested structures. By comparing to a simulated flow the characteristics of the overtopping flow are discussed and the simulation algorithm is tested. The SSG (Sea Slot-cone Generator) is also a wave energy converter of the overtopping type, which was investigated by Margheritini et. al (2009). The structure consists of a number of reservoirs including one on the top of each other above the mean water level in which the water of incoming waves is stored temporary. In each reservoir, expressively designed low head hydro-turbines are converting the potential energy