Numerical Simulations on Performance of Hydropower Turbine in a Duct for the System Utilizing Tidal Jet Generator

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ABSTRACT

The marine hydropower system proposed in this study uses a seawater exchange type breakwater, which has empty space like a basin to store ocean water in it, as a tidal jet generator. Due to the water level difference between the inner and outer sides of the breakwater, strong and uni-directional jets are generated and the energy from the jets are gained by putting turbines in the ducts of the breakwater.

In this study, the proposed system is introduced at first. Then, the results of numerical simulations to predict the efficiency of newly designed hydropower turbine for the system are presented. The performances of the turbine were estimated under the open water and duct conditions. It was confirmed the estimated power could be generated by using the developed turbine.

KEY WORDS: Renewable energy, seawater exchange breakwater, tidal jet generator (TJD), hydropower, horizontal axis turbine (HAT), computational fluid dynamics (CFD).

INTRODUCTION

To prevent the harmful effect of global warming, development of renewable energy source has come into the spotlight. As known widely, renewable energy is called also as clean energy since it does not emit CO₂. Renewable energies include wind energy, solar energy, ocean energy, geothermal energy and so forth. In these days, the countries located near shore like South Korea and some European countries have been developing renewable energy systems utilizing ocean energy.

The ocean energies can be categorized by their sources such as tidal rise & fall, tidal/ocean current, salinity gradient, thermal gradient and so on. However, in some cases, great expense for construction is needed to utilize the ocean energy. For example, over the 4 billion dollars were spent for the construction of the Sihwa tidal power station.

In the vicinity of tidal inlets, such as estuary, river/bay mouths, and port entrances, tide-induced currents play a significant role in various coastal/environmental processes. Furthermore, in the presence of a narrow entrance, currents can produce strong and uni-directional jet flows in the neighborhood of such a sudden constriction. The jet is known as a tidal jet when it is solely caused by the tidal forcing (Park et al., 2006).

In order to utilize the effect of tidal jet and control coastal environment in a stagnated area, where resolved nutrients and/or littoral effluent materials are concentrated, a tidal jet generator (TJD) was proposed (Furukawa et al., 1994). The TJG is an enclosed rectangular reservoir, which has a vertical opening and large enclosed volume inside. During both phases of tide, strong and uni-directional jets are generated due to the water level difference between the inner and outer sides of reservoir. The residual time of a pollutant may be decreased by this flow. It means that the TJG can be used as a flushing system for water purification.

Although the major aim of a seawater exchange breakwater (Fig. 1) is to improve the seawater quality in the harbor, we propose a new hydropower system using this type breakwater as TJD.

Fig. 1 Schematic drawing of seawater exchange breakwater (Akeda et al., 1998).