Structural Analysis of the Primary Transduction System of a Floating Pendulum Wave Energy Converter

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ABSTRACT

The floating pendulum type wave energy converter device, a type of rotating body wave energy converter, directs wave energy into the water chamber of the floating body, converting the energy thereof into the alternating motion of the pendulum to generate electricity. The pendulum-type energy converter uses a pendulum plate in direct transduction, converting the potential and kinetic energy of waves into mechanical energy, with the advantage of high conversion efficiency. However, as the motion is directly exposed to wave load, there is a need to examine structural stability against various loads. In this study, structural analysis was performed on the primary transduction system under various conditions. Static/dynamic structural analysis was performed under wave load, and impact analysis was performed between the pendulum plate and water chamber. The commercial software Ansys was used for numerical analysis. Results of analysis showed the stress distribution on each part, based on which the safety of each part was evaluated.

KEY WORDS: Floating pendulum wave energy converter, primary transduction system, finite element analysis, structural analysis.

INTRODUCTION

Marine energy is an environmentally friendly new and renewable energy that is able to overcome problems such as the recent instability of oil prices due to the depletion of fossil fuels and the regulation of pollutant emissions, the demand for which, accordingly, is rapidly increasing. Wave energy is available over wide areas in Korea, a peninsula surrounded on 3 sides by ocean, therefore can be employed on a large scale.

The pendulum wave energy converter, a type of movable body energy converter that uses the potential and kinetic energy of waves, directs traveling waves into the water chamber of the floating body. A stationary wave is formed by the wave reflected by the wall surfaces in the water chamber. A pendulum is installed at the node of this stationary wave, converting wave energy into oscillating motion of the pendulum to generate power. The floating pendulum wave energy converter, as seen in Fig. 1, comprises 3 main parts, namely the floater, pendulum and damping plates. The floater is a space designed to receive incident waves to create resonance between the incident wave and the energy absorber. As for the pendulum, which is the primary transduction system, the top is connected to the floater, and, through rotational and oscillating motion in the same axial direction, converts kinetic and potential wave energy into mechanical energy. The damping plate is a plate-shaped structure connected to the rear of the floater. By reducing the motion of the entire body and increasing the relative motion of the pendulum, the damping plate increases generation efficiency (Park et al, 2012).

Fig. 1. Floating pendulum wave energy converter

The pendulum WEC employs a direct conversion method, using a pendulum, which is a moving body, to convert the potential and kinetic energy of waves into mechanical energy, therefore has high energy conversion efficiency. The high operation ratio of the device and the possibility of creating large complexes of such devices allow for high economy. However, the primary transduction system, which directly receives wave loads, is exposed to impact loads and repeated loads, therefore structural vulnerabilities must be addressed.

A wide variety of research relating to floating pendulum wave energy converter devices is being performed. Nam et al (2011) performed flow analysis based on a potential model for the wave-induced motion of a floating pendulum wave energy converter device. Park et al (2012) performed two-dimensional tank tests using a scaled-down model of a floating pendulum wave energy converter structure, and analyzed the wave motion characteristics of the pendulum and structure to evaluate...