Design of 1MW OTEC demonstration plant mounted on Octagonal Sevan type offshore platform

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Abstract

For sustainable development of small islands in the Pacific Ocean that are suffering from climate change, we plan to demonstrate technology of OTEC. To this end, 1MW OTEC demonstration plant is designed. The plant will be installed and demonstration experiment will be carried out on the shore of Tarawa, Kiribati. 1MW OTEC plant with simple Rankine cycle, using R32, and a offshore structure with riser and 4 points mooring system, on which OTEC plant will be mounted, are designed. Final results of the design received AIP (Approval in Principle) by BV (Bureau Veritas).

1. Introduction

Use of ocean thermal gradient energy was introduced in the 19th century. Yet, despite its abundance, the technology is currently at research and development stage. Ocean thermal energy conversion is a great source of renewable energy for small islands of equator waters for climate change response and sustainable development. We believe fruition of OTEC is a task of our generation. Technology is ready but lack of demonstration is delaying commercialization of OTEC. Therefore, we initiated OTEC demonstration plant installation and operation design.

2. 1MW OTEC plant design

OTEC demonstration plant, to be installed on shore of Tarawa, Kiribati, uses R32 as working fluid and its simple Rankine cycle uses deep seawater (1000m) at 5℃ and surface water at 29℃. The efficiency of seawater and working fluid pump, motor, turbine, and generator and transformer are assumed to be 80%, 90%, 87.5%, and 93.1%. Pinch point and pressure drop in the evaporator and condenser are appropriately considered. As a result, gross power is analyzed to be 1,016kW.

Turbine is designed for radial inflow, and rotor is composed of 14 slots with inner diameter of 33cm. A permanent magnet synchronous generator with 300RPM, 50Hz, and 6,300V is selected. For evaporator and condenser, semi-welded, titanium plate type heat exchangers are designed. A long-life pump is selected as working fluid pump.

3. 1MW OTEC structural design

Design wind speed of Tarawa, Kiribati, with 100 year recurrence period is analyzed to be 28.4m/sec. As design wave, significant wave height and period are analyzed to be 3.89m and 14sec, respectively. Flow velocity on the surface is estimated at 1.4m/sec, and at 0.15m/sec below 300m depth. For the submarine topography, data from multi-beam survey conducted by SPC (Pacific Community) is used.

At first, rectangular barge is designed based on its response characteristics to external force. The response characteristics of an Octagonal pontoon is examined with the addition of a damper. An octagonal Cevan-type offshore platform is selected (Length: 35m (damper) and 27m (mainframe), width: 27m(mainframe), depth: 14m). For the design, we conducted a floating body behavior characteristic analysis. Numerical analysis and model experiment in a marine engineering aquarium are conducted to the effects of tidal current and regular and irregular wave on the marine structure. Safety is confirmed in complex conditions considering mooring stiffness effect and additional instability when the riser is attached to the system.

Intake riser is made of high density poly ethylene (HDPE) pipe with 1.2m diameter. It's length is 1000m and stainless wire is added on the outer surface of the pipe in longitudinal direction to increase its tensile strength. Riser's stability is tested with modal analysis and fatigue analysis. Mooring system is designed as a 4-point system (chain – rope – chain – anchor) and analysed for its stability. The anchor is used as a mooring anchor, and anchor depth is determined to be between 1100~1700m. Mooring tension in both intact and damaged state is simulated with fatigue analysis.

Design of submerged power cable, and transportation and installation of the plant are completed and added to other designs completed as explained above. Entire document is submitted to Bureau Veritas (BV) for Approval in Principle (AIP) and issued in January, 2016.

4. 1MW OTEC Demonstration Plant Implementation and Operation Plan

Supported by Korean government (Ministry of Oceans and Fisheries), KRISO plans to manufacture 1MW OTEC demonstration plant and test its performance on the offshore of East Sea of Korea during the summer of 2019. After test operation trials, modification and supplement, the plant will be transported to and installed on the shore of Tarawa, Kiribati in late 2019 or early 2020, and its long-term operation and maintenance experiment will follow.

5. Conclusion

1MW OTEC demonstration plant, to be installed on the shore of Tarawa, is designed. Despite introduction of OTEC to the world in the 19th century, the equator region has not utilized its plentiful thermal gradient energy through OTEC due to lack of demonstration of technical readiness of OTEC. We hope that this 1MW OTEC design will be a stepping stone of the proof of OTEC in the equator region and commercialization of OTEC.

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