Experimental Study of Multi-heat Sourced Ocean Thermal Energy Conversion System

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ABSTRACT

We investigated an integrated multi-source OTEC system that extracts heat from warm sources in high latitude areas and uses deep seawater as the heat sink. By means of numerical analysis, simulation, and experiments, we evaluated the practicability of the system. The experimentally determined turbine generation and cycle efficiencies were about 75.1% and 2.16%, respectively. For a constant heat flow rate, the generation efficiency increased by an average of 6.51% when the heat source flow rate was decreased owing to excess evaporation. And the generation efficiency increased by an average of 16.51% temperature at a constant inflow rate. Furthermore, using weather information at specific times, we also studied the continuous operation of the system when stored incineration energy was used to supplement solar and wind energies. Despite the low conversion efficiency, the integrated multi-source OTEC system was found to be useful for continuous, stable, and renewable energy generation.

KEY WORDS: Multi-heat source, Ocean thermal energy conversion, Organic Rakine cycle, Heat sink,

INTRODUCTION

Electric power of 1.1 trillion kW was sourced from ocean thermal energy conversion (OTEC) in 2000, which amounted to about one hundred times the total global energy demand that year. The equatorial area between latitudes 20° south and north and the subtropical offshore contain substantial amounts of potential ocean thermal energy. At the higher latitudes, however, OTEC can only be applied during summer because the temperature difference between the water surface and depth is insufficient at other times of the year. Many parts of the world are also presently witnessing the increasing development of geothermal energy and the use of the organic rankine cycle (ORC) in diverse power plants. The plants mostly use cooling towers as the heat sink and their outputs are therefore liable to heavy fluctuation with seasonal temperature changes. If deep seawater with its year-round temperature could be used as the heat sink, more efficient and stable electricity generation could be achieved. Surface water as the heat source and deep seawater as the heat sink is not only feasible at low latitudes for low temperature differences, but waste heat can also be integrated at higher latitudes to achieve higher temperature differences. In our study, we investigated an integrated multi-source OTEC system that extracts heat from warm sources in high latitude areas and uses deep seawater as the heat sink. By means of numerical analysis, simulation, and experiments, we evaluated the practicability of the system.

Characteristics of Ocean Thermal Energy

Deep ocean waters in the Arctic and Antarctic maintain constant temperatures of less than 2°C, which are the same as those of the water surface. At mid latitudes, however, the temperatures can be much lower at 200 m below sea level, and yet lower at deeper than 2000 m at low latitudes. Below the thermocline at low latitudes, depending on the depth, the temperature is often between 2°C and 8°C and generally below 10°C, which affords a suitable heat sink. In the Republic of Korea, which is at the mid latitudes, the surface water temperature reaches about 26°C during summer, but declines to about 8°C in winter. Ocean water around the country at depths greater than 200 m is maintained at a temperature below 2°C throughout the year. In the East Sea in summer, the temperature difference between the surface and a depth of 200 m is between 20°C and 24°C.