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Spectrum Analysis of OTEC System Outputs Using Ammonia/water Mixture as Working Fluid by Continuous Operation

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ABSTRACT

Though the power generation system using ammonia/water mixture (AWM) as working fluid has been put into practical use in the waste-heat power generation systems at high heat source temperatures, power generation using ocean thermal energy conversion (OTEC) system at low heat source temperatures is not verified thoroughly. Therefore, this paper reports on two weeks continuous operation of an OTEC experimental device. The influence of cold source temperature is clarified on the turbine inlet and outlet temperatures and pressures in this paper.

KEY WORDS: Ammonia/water mixture; Continuous operation; OTEC; Periodogram method.

INTRODUCTION

In the current century, energy and environmental problems are becoming critical, and the need for the development of renewable energy has become urgent. The Ocean Thermal Energy Conversion (OTEC) power plant is a system for generating electric power using the temperature difference between the shallow and the deep water of the ocean. It is an environment-friendly source of energy. Unlike most of the renewable energy resources which are weather dependents, OTEC system provides a stable source of electricity along the year because the shallow and the deep water temperatures are constant. In addition, the seawater used for electricity generation can be further used in many fields, such as desalination of seawater, agriculture, and Lithium recovery. As the temperature difference between the heat source and the heat sink of the ocean is much smaller than that in the conventional and in the nuclear power systems, the cycle efficiency of the OTEC systems is much lower and a huge amount of warm and cold water should be drawn from the ocean in order to drive the cycle; subsequently, the pumping power is huge. To realize the OTEC system, various studies have been conducted for long time; one of the fields of these studies is on the use of non-azeotropic mixtures as working fluids in order to make use of the increase of the system's exergy. One of the advantages of the ammonia/water mixture is the big difference between its boiling point and its dew point. As the use of ammonia/water mixture as working fluids was in its initial stage, there has been great concern regarding the stability of the cycle because the difference between of the boiling point and the dew point of ammonia/water mixture is larger than that of CFCs. The stability of the power cycle using at high heat source temperatures has been confirmed in several places (Sumitomo Metal Industries, Ltd., Fuji oil company, Ltd.). Moreover, in OTEC study Ikegami et al. (2010) succeeded in continuous operation for two weeks and confirmed the stability of OTEC system using ammonia/water mixture as working fluid. However, the spectrum characteristic of the system outputs using ammonia/water mixture has not been clarified yet. As it is a great importance for the practical design of the system, this paper reports on the spectrum characteristic of the OTEC system outputs.

Experimental Equipments and Method

Ocean Thermal Energy Conversion Using Ammonia/water mixture The photograph of OTEC using AWM as working fluid is shown in Fig. 1. The working fluid is channeled to the evaporator through regenerator using a circulation pump where it turns to vapor of the exchanging heat with the warm water. After separation into saturated vapor and saturated liquid in the separator, the vapor expands in the high-pressure turbine while the liquid phase is returned to the regenerator. The vapor passed the turbine, which is party condensed is then separated into saturated vapor and saturated liquid. The saturated vapor-phase is then channeled to a second turbine (low-pressure) while the saturated liquid phase is directed to the heater. The vapor leaving the second turbine which is also partly condensed is channeled to the absorber where the ammonia-rich working fluid is absorbed by water-rich working fluid coming from the regenerator. The two-phase working fluid leaving the absorber is then channeled to the condenser where it is condensed by the cold seawater. The non-condensed part of the working fluid is directed to an after-condenser to be condensed there and returned to the working fluid storage tank. After that the working fluid is sent again to the regenerator by the circulation pump.

Experimental Method The main experimental conditions are shown in Table 1. In this experiment, the two weeks of steady operation has been performed and the arithmetic mean values have been analyzed. The physical property of Ammonia/water mixture was evaluated using the M-PROPATH (Ibrahim and Kelein) (PROPATH group, 2008).