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Energy efficiency enhancement potential of the heat pump unit in a seawater source heat pump district heating system

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Abstract

Seawater source heat pump district heating system is a renewable energy utilization system as it can utilize the sensible heat energy contained in the seawater. The energy efficiency of the system is always the main concern for the system researchers. So a field measurement with an emphasis on the energy efficiency of an actual seawater source heat pump district heating system was conducted, and the energy efficiency enhancement potential of the heat pump unit was analyzed and evaluated. The measurement showed that the heat pump units consumed the largest part of energy consumption of the whole system, and the coefficient of heating performance (COP) of the seawater source heat pump units was quite low especially during the coldest measurement period which was only 2.43. In the light of the concept of Thermodynamic Perfectibility, the energy efficiency enhancement potential of the heat pump unit was carefully analyzed and calculated. And the results showed that there is about an average of 24.2% energy efficiency enhancement potential of the heat pump units in this project.

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Keywords: Air conditioning device; Radiation heat exchange; Cooling performance; Experiment

1. Introduction

Seawater source heat pump district heating system is a renewable energy utilization system as it can utilize the sensible heat energy contained in the seawater. North European countries like Norway and Sweden take a lead in the engineering application of the seawater source heat pump heating and cooling system^[1,2]. Now more research and applications of the system have been developed in the United States, Canada, China and Japan^[3-8]. And the energy efficiency of the seawater source heat pump district heating system is always the main concern for the system

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researchers. Here, a field measurement with an emphasis on the energy efficiency of an actual seawater source heat pump district heating system was conducted, and the energy efficiency enhancement potential of the heat pump unit was analyzed and evaluated.

2. Field measurement and energy efficiency evaluation of a seawater source heat pump district heating system

The seawater source heat pump district heating system is located on an island of Dalian, China with a total building area of 130,000m². The diagram scheme of this system is shown in fig. 1. The field measurement time was from January 24 to January 27th of 2013. This was nearly the coldest period of Dalian. The lowest outdoor air temperature measured was -11°C and the average outdoor air temperature was -7.0°C. A heat user with the floor radiant heating system was randomly selected and its indoor air temperature during measurement period was recorded. The average indoor air temperature was 17.4°C which meets the requirement of China national standard. The energy efficiencies of the seawater source heat pump unit and the whole system were calculated. As all the heat pump units were in the same capacity and operated stably, one of the heat pump units was selected as the representative unit and its operational data was collected. The actual COP profile of the heat pump unit during its measurement period is shown in fig. 2. The results showed that the COP values of the heat pump unit fluctuated around 2.43 within the range of 7% (i.e. COP=2.43±0.18).

The terminal device was placed approximately in the center of the artificial climate chamber of Dalian University of Technology. The chamber has a floor area of 42.75 m² (7.50 m×5.70 m) with the height of 3.60 m.

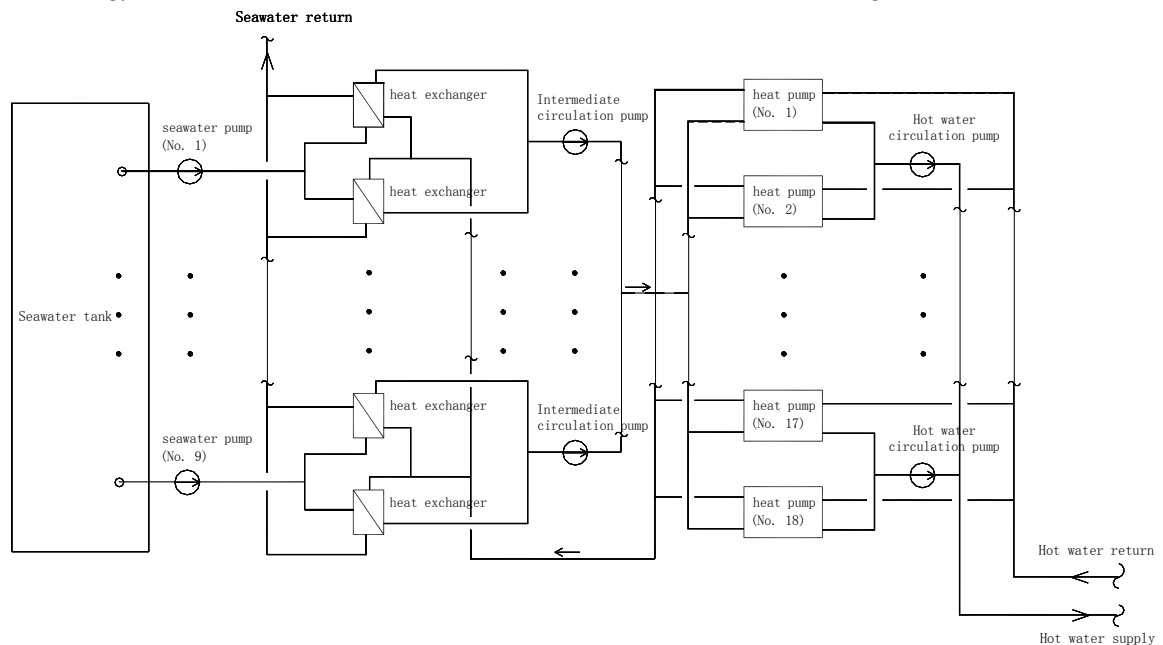


Fig. 1. Schematic diagram of the seawater source heat pump district heating system

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