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New waste heat district heating system with combined heat and power based on absorption heat exchange cycle in China

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ABSTRACT

A new waste heat district heating system with combined heat and power based on absorption heat exchange cycle (DHAC) was developed to increase the heating capacity of combined heat and power (CHP) through waste heat recovery, and enhance heat transmission capacity of the existing primary side district heating network through decreasing return water temperature by new type absorption heat exchanger (AHE). The DHAC system and a conventional district heating system based on CHP (CDH) were analyzed in terms of both thermodynamics and economics. Compared to CDH, the DHAC increased heating capacity by 31% and increased heat transmission capacity of the existing primary side district heating network by 75%. The results showed that the exergetic efficiency of DHAC was 10.41% higher and the product exergy monetary cost was 36.6 ¥/GJ less than a CHD. DHAC is an effective way to increase thermal utilization factor of CHP, and to reduce district heating cost.

1. Introduction

Space heating is responsible for about 70% of the energy consumption of buildings in the north of China. District heating systems based on combined heat and power (CHP) account for approximately 30% of the space heating area in the north of China [1]. With district heating areas experiencing 17% annual growth, the district heating load demand has increased sharply, especially in downtown areas [2]. However, the development of new heat sources for district heating is restricted because of urban environmental protection policies in China. With the rapid development of cities, many problems related to district heating system have been faced. The main problems are summarized as follows:

(1) Heat sources for district heating are in short supply for the metropolis in the north of China.
(2) Heat transmission capacity of the existing primary side district heating network cannot meet the heating load demand for district heating using conventional district heating technologies.
(3) For conventional district heating system based on CHP with condensing/extraction steam turbine, a great deal of heat in the circulating cooling water is wasted, and the thermal utilization factor is relatively lower.

According to data collected in China, there is a great deal of waste heat discharged directly into the environment. However, the waste heat can be recovered by heat pumps. Xuehu Ma [3] researched on application of absorption heat transformer to recover waste heat from a synthetic rubber plant. L. Lopez [4] analyzed the waste heat in the industry of the Basque country from energy and exergy viewpoint. Public opinion on waste process heat for district heating in United Kingdom is investigated [5]. The investigated results showed end-users concerns are addressed throng trust-building and price inducement. S. Jeong [6] indicated that heating capacity of AHP becomes higher with increase of heat transfer area for recovering low grade waste heat. But the higher flow rate leads to higher heating capacity and lower COP.

The utilization of waste heat in power plants has been studied for many years. J. Karkheck and J. Powell [7] showed that the thermal pollution of power plants would be decreased through the waste heat utilization. R.W. Timmerman [8] also indicated the waste heat of power plants is an economically viable heating source. M. Huber and F. Bukau [9] proposed a model of district heating that involved supplying the circulating cooling water from power plants directly to consumers. R.A. Cunniff [10] carried out a low-temperature district heating demonstration project for a public school by utilizing the waste heat from a power plant. J.J. Bonilla [11] indicated that heat exchangers and heat pumps are the technologies with the greatest potential for application. J. Ji [12] analyzed the feasibility of waste heat recovery using a compression heat pump in a power plant. S. Smolen and M. Budnik-Rodz

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