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Technology application of district heating system with Co-generation based on absorption heat exchange

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ABSTRACT

Aiming to explore the energy saving potential of Co-generation and improve the feasibility of district heating, a new type of district heating system with Co-generation based on absorption heat exchange (Co-ah system) has been proposed. It can improve the heating capacity and the energy efficiency by recycling the waste heat from the exhausted steam, and enhance the delivery capacity of the heat network by increasing the temperature difference between the supply and the return water. This paper focuses on the first large-scale industrial application project built in Datong City, China. The delivery capacity of the heat network had increased by 40%, and the heating capacity of the Co-generation system had increased by 50% due to the Co-ah technology. Study of the process design and the operation scheme of the Co-ah system have been introduced in this paper. By experiment methods, the feasibility and reliability of the Co-ah technology have been verified. In addition, through the analyses of measured data in the practical operation condition, the optimum operation condition is determined.

1. Introduction

In recent years, the large-scale DH system (district heating system) has become the dominate way for building heating in Northern China. The heat networks in many cities are supplied by the CHP (combined heating and power) plants or the district boilers. By 2012, the DH systems with Co-generation had accounted for about 45% of total building heating, due to its significant advantages on energy-saving and CO_2 emission-reduction [1–3].

However, the DH system with Co-generation (Fig. 1) has been limited by the following issues:

1) The insufficient delivery capacity of the heat network: Generally, enlarged the diameter of the pipeline network needs a huge investment and a complex process of implementation [4,5].
2) Enormous waste heat discharged by the cooling tower has not been fully used, due to its low temperature (20–40 °C) [6].
3) Larger heat transfer temperature differences in two links cause enormous irreversible exergy (available energy) loss: In the plant, the extraction steam (0.3–1.0 MPa) is used to heat the primary heat network water (130 °C/70 °C). In the substation, the secondary heat network water is heated (70 °C/50 °C) by the primary heat network water [7].

Aiming at the above problems, our research group has brought forward the “Absorption Heat Exchange” and “A new type of district heating system with Co-generation based on absorption heat exchange (referred to as the Co-ah System)” [8,9].

2. The description of the Co-ah system

2.1. Absorption heat exchange

Using the available energy existed in the supply water of the primary heat network as driving force, the absorption heat exchange units (Fig. 2a) can greatly reduce the exergy loss in the water/water exchange link of the substation.

The absorption heat-exchanger is composed of a water/water heat exchanger **1** and an AHP (absorption heat pump) **2**. The supply water of the primary heat network (130 °C) releases heat to the generator **G** of AHP (heat flux Q_g), the high-temperature side of water/water heat-exchanger (heat flux Q_2), and the evaporator **E** of AHP (heat flux Q_e) in series, and finally returns to the primary heat network at a lower temperature (about 25 °C). The hot water of the

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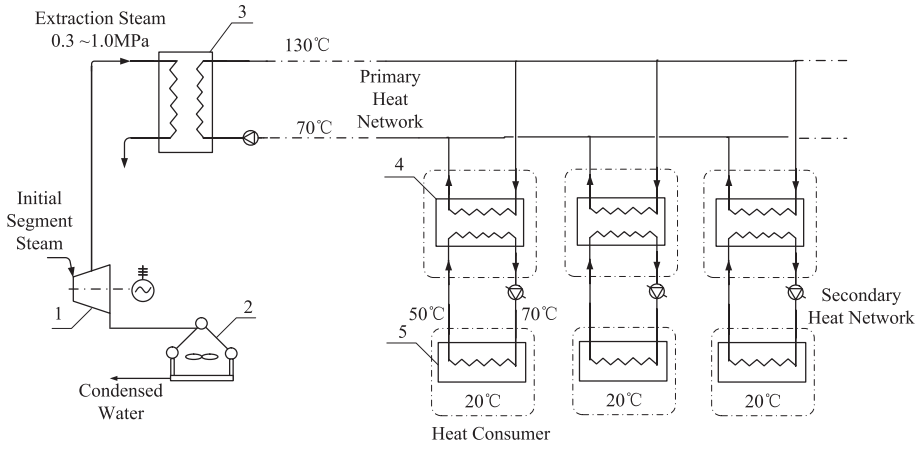
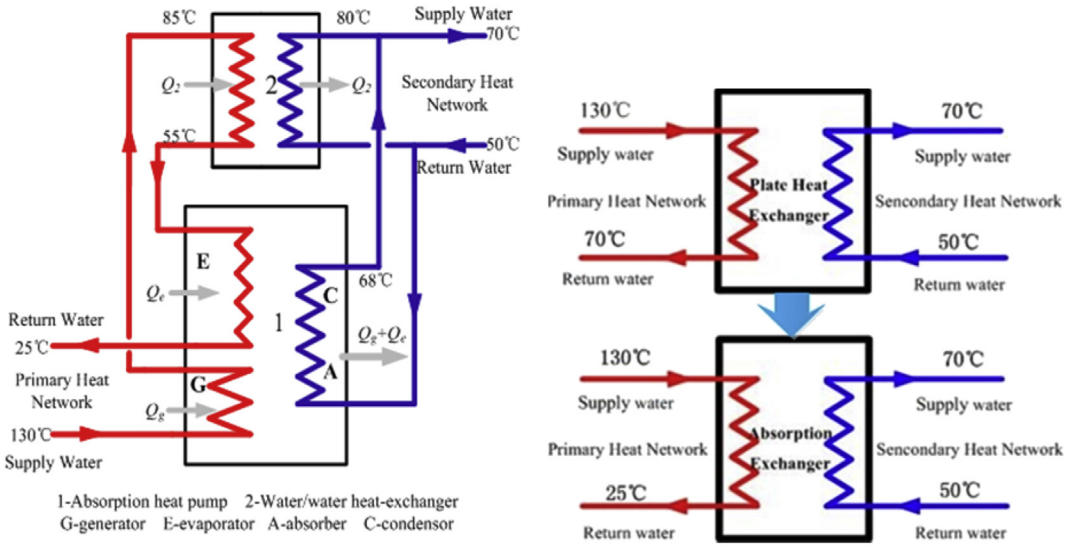


1-Co-generation unit 2-Air cooled condenser 3-Steam/water exchanger
4-Water /water exchanger 5-Terminal equipment

Fig. 1. Process chart of DH system supplied by Co-generation.



(a) Process Chart (b) Comparison of Characteristics

Fig. 2. Absorption heat-exchanger.

secondary heat network (50 °C) will be heated respectively by the absorber **A** and condenser **C** of AHP (total heat flux $Q_g + Q_e$), and the low-temperature side of water/water heat-exchanger (heat flux Q_2), and then be transported to the consumers finally. With the absorption heat-exchanger technique, the return water temperature of the primary heat network can be dropped to about 25 °C by the supply water of temperature 130 °C, while the secondary heat network temperature remains unchanged (Fig. 2b).

Therefore, the application of absorption heat-exchanger can bring the following two benefits for the DH system:

1) As the design temperature of the primary heat network is changed to 130 °C/25 °C, the delivery capacity of the heat network can be improved by 75%. As a consequence, both the diameter investment of network pipe and the power consumption of circulating water pump can be reduced significantly.
2) Due to the lower temperature of the return water, it is easier to be heated by the exhausted waste heat through the exchanger or AHP. This way creates a favorable condition for recovering waste heat.

2.2. The Co-ah system

Using the available energy existed in the extraction steam as driving force, the application of absorption heat pump (AHP) can greatly reduce the exergy loss in the steam/water exchange link of the plant (Fig. 3).

The return water of the primary heat network is gradually heated by the exhausted steam/water exchanger, AHP, and the extraction steam/water exchanger. In this way, a whole Co-ah system is built (Fig. 3).

The Co-ah system uses the extraction and the exhausted steam as heat sources. The exhausted waste heat can supply above 30% of