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Performance Comparison between an Absorption-compression Hybrid Refrigeration System and a Double-effect Absorption Refrigeration Sys-tem

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Abstract

Conventional absorption refrigeration systems (ARSs), which are mainly driven by heat, have a competitive primary energy efficiency (*PEE*) compared with chillers driven by electricity. In the typical ARS, a large quantity of high-temperature heat is supplied into the generator, while a substantial amount of low-temperature heat is rejected to the environment from the condenser, it's a huge waste. In order to decrease the input heat for generator and enhance the performance of conventional ARS, a kind of absorption-compression hybrid refrigeration system recovering condensation heat for generation (RCHG-ARS) was ever proposed. In the present study, the models of both RCHG-ARS and double-effect absorption refrigeration system (DEARS) are established, and the effects of different parameters on them are simulated and compared with each other. As a conclusion, the *PEE* of RCHG-ARS can be 29.0% higher than that of DEARS, and RCHG-ARS has a wider working conditions than DEARS due to the existence of the compressor.

Keywords: Absorption chiller; Absorption-compression cycle; Condensing heat recovery; Ammonia-water; Simulation.

1. Introduction

Air-conditioning consumes a large quantity of energy in China [1]. And due to the merits of energy saving and environmental protection, absorption refrigeration systems (ARSs) are widely used both in commercial and industrial projects. However, in conventional ARS, much low-temperature heat is exhausted to the environment

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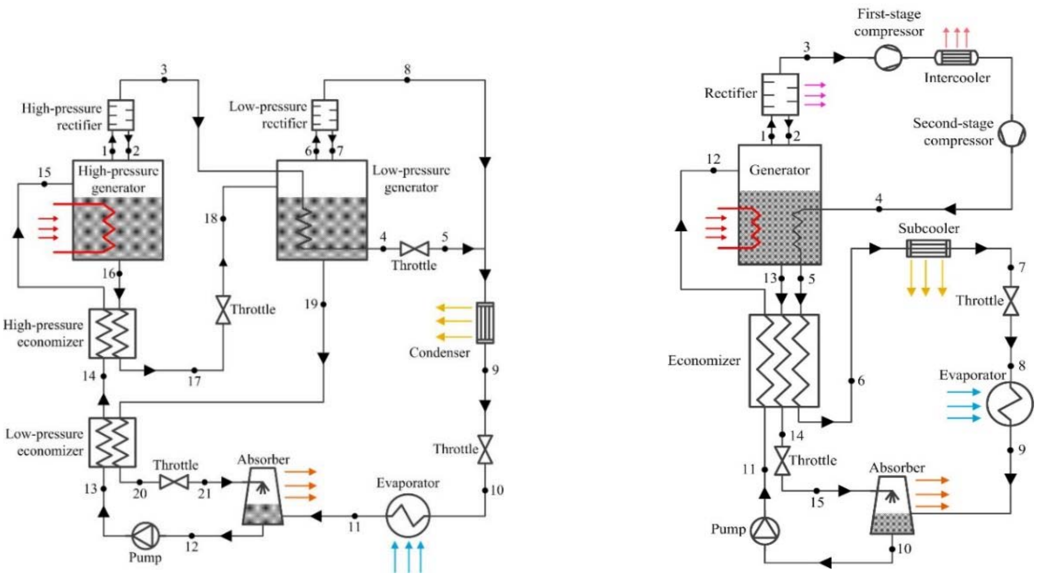
through the condenser, while the generator requires a large quantity of high-temperature heat at the same time. Thus, recovering the condensation heat is an important method to enhance the performance of the absorption refrigerator.

Multi-effect system is such one kind common method, including double-effect ARS (DEARS) shown in Fig. 1(a). In this system, part of the condensation heat originally rejected from the system is recovered for the generation of refrigerant in low-temperature cycles, be-cause the refrigerant vapor from the high-temperature generator condenses in the lower-temperature generator. Therefore, the generation heat inputted from outside is reduced, which leads to a higher *COP* than single-effect ARS [2]. Kaushik and Arora [3] studied single-effect and DEARSs by simulation, and their results showed that the *COP* of the double-effect system was nearly 60-70% higher than that of the single-effect sys-tem. Kim et al. [4] simulated a single-effect ARS, a double-effect ARS and a triple-effect ARS, finding that the *COP*s of them can be 0.75, 1.24 and 1.54, respectively. However, the lowest driving temperatures of DEARS and triple-effect system separately are as high as 140 ºC and 150 ºC [5]. What's more, part of the condensation heat in DEARS is still exhausted to the environment directly.

To fully recover condensation heat, an absorption-compression hybrid refrigeration system recovering condensation heat for generation (RCHG-ARS) was studied and compared with single-effect ARS [6]. Just as Fig. 1(b) shows, the refrigerant vapor from the generator was compressed by the compressor, and then it condensed and released heat in the generator, providing heat for the generation of refrigerant together with/without assistance of a driving heat source from outside. So all condensation heat was recovered for the generation process by improving the grade of condensation heat through the compressor. Its principle is similar with that of DEARS. Therefore, the objective of this work is to compare these two systems.



(a) DEARS (b) RCHG-ARS

Fig. 1. Principles of DEARS and RCHG-ARS.

Nomenclature

h	specific enthalpy, kJ/kg
m	mass flow rate, kg/s
Q	heat exchange rate, kW
x	mass concentration of NH3, %
W	compressor power consumption, kW
η_e	energy transformation efficiency from natural gas to electricity