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Analysis of compression–absorption cascade refrigeration cycles

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ABSTRACT

In this study, LiBr–H_2O pair was used for the first time for absorption section of compression–absorption cascade refrigeration cycles. These cycles were analyzed theoretically and compared with using different refrigerants in the compression and absorption sections. While LiBr–H_2O and NH_3–H_2O are used as fluid pair in cascade absorption section, R134a, R-410A and NH_3 fluids were used in the vapour compression section of cascade cycle. It was presented that electrical energy consumption in the cascade refrigeration cycle is 48–51% lower than classical vapour compression refrigeration cycles that use R134a, R-410A and NH_3 as working fluids under the same operating conditions, that are an evaporator temperature of 263 K and a condenser temperature of 313 K. Separately the results show that by using LiBr–H_2O pair for absorption section the thermal energy consumption of cascade refrigeration cycle could be reduced by 35% and also general coefficient of performance ($COP_{cyclegen}$) could be improved by 33% compared to the NH_3–H_2O pair.

1. Introduction

The use of compression–absorption refrigeration cycles provides electrical energy saving compared to vapour compression cycles. The structure of the system is more complex but they use the advantages of both the absorption and vapour compression refrigeration cycles. These systems provide the usage of electricity and heat energy together at the same time for refrigeration. Furthermore, non-conventional sources of energy such as solar, geothermal, and waste heat could be supplied as heat energy for these cycles.

There are a lot of studies on the compression–absorption refrigeration cycles in the literature. When considering these studies they could be categorized as two groups and called as combined and cascade refrigeration cycles. In the combined cycle both of absorption and vapour compression sections have the same compression rate and this rate is equal the total compression rate of the combined cycle. But in the cascade cycle that vapour compression and absorption cycle are connected in serial form.

Kairouani et al. [1] studied the performance of compression–absorption refrigeration (cascade) cycles and NH_3–H_2O fluid pair was used at the absorption section of the refrigeration cycle and three different working fluids (R717, R22, R134a) were used at the vapour compression section. Kairouani et al. concluded that the coefficient of performance of the cycle is 37–54% higher than the vapour compression cycle using R717, R22 and R134a refrigerants for the same operating conditions.

A comparison has been done between classic vapour compression system using ammonia and the compression–absorption (combined) refrigeration system using NH_3–NaSCN at the same operating conditions according to economy and performance [2]. It was found that the capital and running costs of the compressors in the NH_3 + NaSCN were highly reduced as compared to the cycle using only pure ammonia.

Thermodynamic analysis was made of the compression–absorption (combined) refrigeration cycle by using fluid pair as R22 and DMETEG (Dimethyl Ether of Tetraethylene Glycol) for simultaneous heating and cooling application for the milk processing [3]. It was found that the compression–absorption system yielded much better overall performance especially when the temperature lifts are high as compared to the a single stage vapour compression system.

Ahlby et al. [4] performed a comparison study between the vapour compression cycle and the compression–absorption (combined) refrigeration cycle by using absorption section with NH_3–H_2O fluid pair and the vapour compression systems using R12. Ahlby et al. concluded that the coefficient of performance for the former always results in a higher coefficient and the capacity of the NH_3–H_2O system is also considerably higher.

Ayala et al. [5] found that the vapour compression–absorption (combined) refrigeration cycle using NH_3–NaSCN fluid pair has greater performance than the vapour compression or absorption

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