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Study of absorption in refrigeration systems

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Abstract

In recent years, finding ways to improve absorption-system efficiency has been a great challenge for researchers. Works were mainly focused on inventing new or hybrid cycles for refrigeration systems. The aim of this paper is to study the absorption refrigeration. A number of absorption refrigeration systems are examined and discussed. The study shows that double-effect absorption systems using lithium bromide/water seem to be the only high performance system which is available commercially .It must be noted that, when the number of effects increase, COP of each effect will not be as high as that for a single-effect system.

Key words :Refrigeration, Absorption cycle, Lithium bromide

1. Introduction

Global warming (due to greenhouse gas accumulation in the lower atmosphere) partly-related processes threatening to upset the ecological support system of the Earth. A recent analysis of the potential public-health impact of climate change concluded that a few degrees increase of average global temperature would lead to: increased incidence of heat strokes and heat-related death in chronic diseases; geo-graphic shifts in tropical and infectious diseases; increased occurrence of death, injury and epidemics due to weather-related emergencies and flooding of coastal. In order to curb the global warming and ozone depletion, two important documents, The United Nations Framework Convention on Climate Change (FCCC) and Montreal Protocol, were signed by many countries. According to these two documents, CFC and HCFC fluids, which are widely used in vapour-compression refrigerators and heat pumps will be gradually phased out and the emission of greenhouse gas CO2 should be reduced to their 1990 levels. In some EU countries, this ban extends to HFC fluids. The ban on CFC, HCFC and HFC fluids has encouraged research into environmental friendly refrigerants such as water. Apart from reducing fossil-fuel consumption, improving the efficiency of the refrigerators and heat pumps and utilization of low-grade energy are the effective ways to reduce CO2 emissions. Forthe latter, heat powered refrigeration cycles can provide the answer. The vapour absorption cycle is considered to be the best in terms of energy performance today and it has potential to be improved among the several heat-powered cycles. Compared with the vapour-compression cycle, the absorption cycle has a reputation of low efficiency although this is a result of unfair comparison between them, but the environmental concern calls for high efficiency, no pollution refrigerators and heat pumps. The early development of an absorption cycle dates back to the 1700's. It was known that ice could be produced by an evaporation of

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pure water from a vessel contained within an evacuated container in the presence of sulfuric acid. In 1810, ice could be made from water in a vessel, which was connected to another vessel containing sulfuric acid. As the acid absorbed water vapor, causing a reduction of temperature, layers of ice were formed on the water surface. The major problems of this system were corrosion and leakage of air into the vacuum vessel. In 1859, Ferdinand Carre introduced a novel machine using water/ammonia as the working fluid. The lithium bromide-water absorption chiller is one of the favourite due to the following specific reasons: (a) it can be thermally driven by gas, solar energy, and geothermal energy as well as waste heat, which help to substantially reduce carbon dioxide emission; (b) its use of water as a refrigerant;(c) it is quiet, durable and cheap to maintain, being nearly void of high speed moving parts; (d) its vacuumed operation renders it amenable to scale up applications. The internal operation of a lithium bromide-water absorption chiller is intimately influenced by the pressures and concentrations of its working fluid. In recent years, finding ways to improve absorption-system efficiency has been a great challenge for researchers. Works were mainly focused on inventing new or hybrid cycles for refrigeration systems.

2. Absorption process

Many researchers have been conducted in order to understand and to improve an absorption process between the vapour refrigerant and the solution., literature on absorber designs are also provided [1–2].The most common type of absorber used for LiBr/water system is absorption of vapor refrigerant into a falling film of solution over cooled horizontal tubes [3– 10]. In this type of absorber, during the absorption process, heat is simultaneously removed from the liquid film. Hence, the absorption rate is increased. However, this design requires a high recirculation rate in order to achieve a good performance. Another notable approach devised by Rotex [11] is absorption of vapor refrigerant into liquid film on cooled rotating discs [12]. For a given surface area, absorption rate on rotating discs is much greater than that on a convention design. Thus, size of an absorber used based on this design is much smaller than a convention falling film design. Absorption process within a rotating drum was also studied [13] for water/NH3.

3. Absorption cycles

3.1. Single-effect absorption system

A single-effect absorption refrigeration system is the simplest and most commonly used design. There are two design configurations depending on the working fluids used. Fig. 1 shows a single-effect system using non-volatility absorbent such as LiBr/water. High temperature heat supplied to the generator is used to evaporate refrigerant out from the solution (rejected out to the surroundings at the condenser) and is used to heat the solution from the absorber temperature (rejected out to the surroundings at the absorber). Thus, an irreversibility is caused as high temperature heat at the generator is wasted out at the absorber and the condenser. In order to reduce this irreversibility, a solution heat exchange is introduced as show in Fig. 1. The heat exchanger allows the solution from the absorber to be preheated before entering the generator by using the heat from the hot solution leaving the generator. Therefore, the COP is improved as the heat input at the generator is reduced. Moreover, the size of the absorber can be reduced as less heat is rejected. Experimental studies shows that COP can be increased up to 60% when a solution heat exchanger is used.

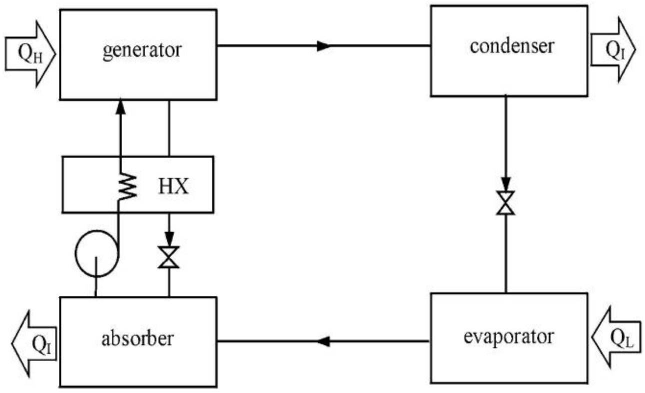

Fig. 1. A single-effect LiBr/water absorption refrigeration system

3.2. Multi-effect absorption refrigeration cycle

The main objective of a higher effect cycle is to increase system performance when high temperature heat source is available. By the term “multi-effect”, the cycle has to be configured in a way that heat rejected from a high-temperature stage is used as heat input in a low-temperature stage for generation of additional cooling effect in the low-temperature stage.

Double-effect absorption refrigeration cycle was introduced during 1956 and 1958. Fig. 2 shows a system using LiBr/water. High temperature heat from an external source supplies to the first-effect generator. The vapor refrigerant generated is condensed at high pressure in the second-effect generator. The heat rejected is used to produce addition refrigerant vapour from the solution coming from the first-effect generator. This system configuration is considered as a series-flow-double-effect absorption system.

A double-effect absorption system is considered as a combination of two single effect absorption systems whose COP value is COP single. For one unit of heat input from the external source, cooling effect produced from the refrigerant generated from the first-effect generator is 1×COP.

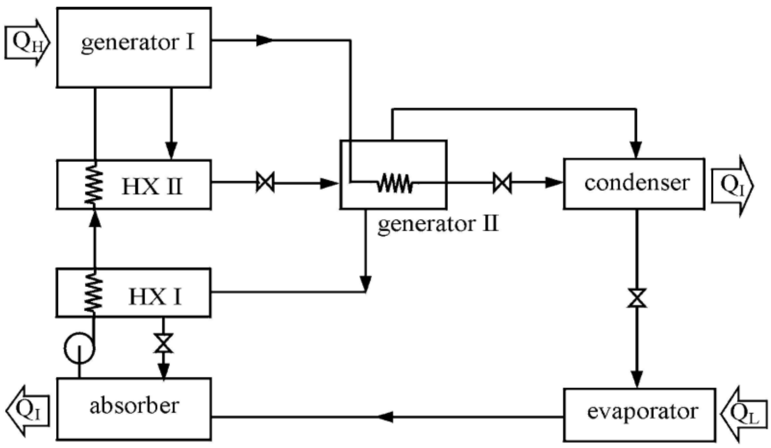

Fig. 2. A double-effect water/LiB cycle. and low pressure.

3.3. Absorption cycle with GAX

GAX stands for generator/absorber heat exchanger or sometimes is called DAHX which stands for desorber/absorber heat exchanger. Higher performance can be achieved with a single-effect absorption system. Referring to the parallel-flow-double effect absorption system mentioned earlier, the system consists of two single-effect cycles working in a parallel manner Fig. 3. The concept of GAX is to simplify this two stage-double-effect absorption cycle but still produce the same performance.

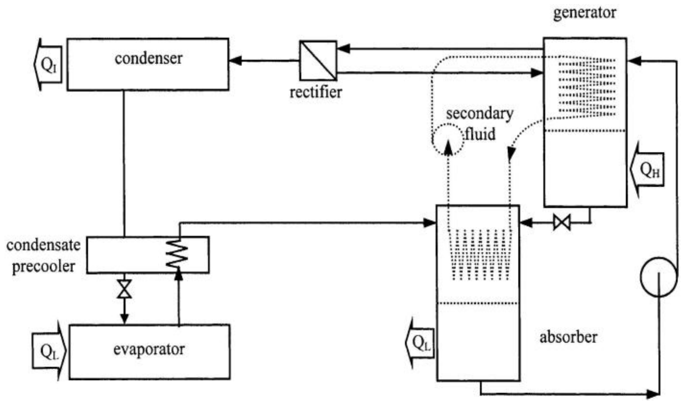

Fig. 3. A GAX cycle.

3.4. Sorption-resorption cycle

Altenkirch introduced the idea of a sorption-resorption cycle in 1913. The cycle employs two solution circuits instead of only one. The condenser and evaporator section of a conventional single-effect absorption system is replaced with a resorber and a desorber respectively as shown in Fig. 4. This provides more flexibility in the cycle design and operations. The solution loops concentrations can be varied allowing adjustment of the component temperatures and pressures to the application requirement.

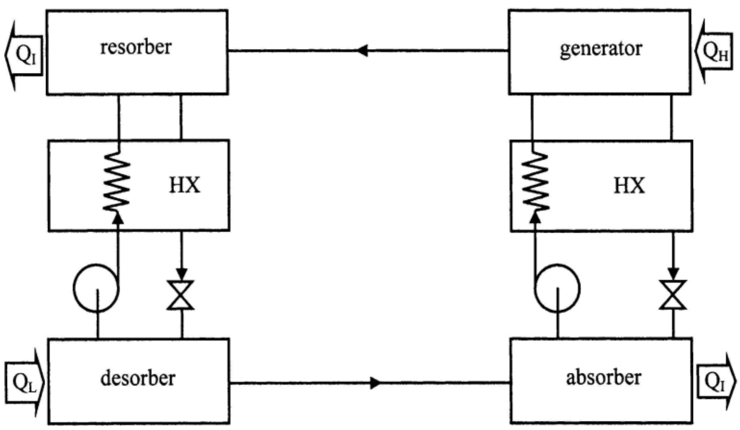

Fig. 4. A resorption cycle.

3.5. Combined vapour absorption-compression cycle

This system is usually known as an absorption-compression system. A schematic diagram of a typical absorption/compression cycle is shown in Fig. 5(a). It can be seen that, a condenser and an evaporator of a conventional vapor-compression system are replaced with a resorber (vapor absorber) and a desorber (vapor generator). For given surrounding temperature and refrigerating temperature, the pressure differential across the compressor is much lower than a conventional vapor-compression system. Thus, the COP is expected to be better than a conventional vapor-compression system. Altenkirch did the first investigation in 1950 and proposed a potential for energy-saving . The cycle can be configured as a heat pump cycle as shown in Fig. 5(b).

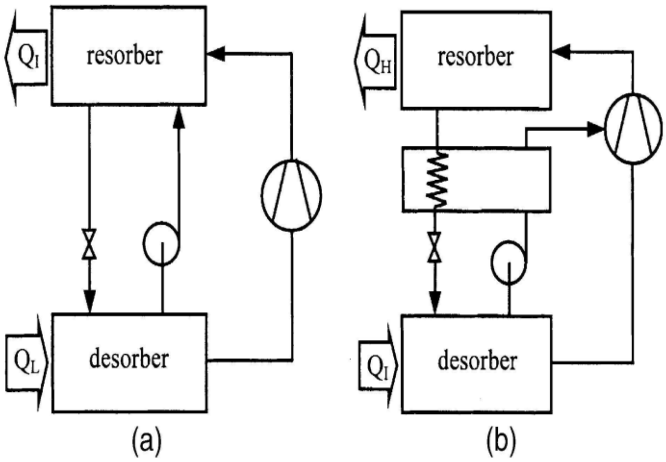

Fig. 5. Combined vapor absorption/compression heat pump.

Conclusion

Various types of absorption refrigeration systems have been developed. There are to improve absorber performance, and to invent new advance cycles. The study shows that double-effect absorption systems using lithium bromide/water seem to be the only high performance system which is available commercially It must be noted that, when the number of effects increase, COP of each effect will not be as high as that for a single-effect system. Moreover, the higher number of effect leads to more system complexity.

References

[1] Kang YT, Chen W, Christensen RN. A generalized component design model by combined heat and mass transfer analysis in NH3-H2O absorption heat pump systems. *ASHRAE Trans*. PH-97-3-2, 1997.
[2] Jeong S, Lee SK. Heat transfer performance of a coiled tube absorber with working fluid of ammonia/water. *ASHRAE Trans*. SF-98-21-4, 1998.
[3] Choudhury SK, Hisajima D, Ohuchi T, Nishiguchi A, Fukushima T, Sakaguchi S. Absorption of vapors into liquid films flowing over cooled horizontal tubes. *ASHRAE Trans* 1993; 99:81–9.
[4] Matsuda A, Choi KH, Hada K, Kawamura T. Effect of pressure and concentration on performance of a vertical falling-

film type of absorber and generator using lithium bromide aqueous solutions.*Int J Refrig* 1994;17(8):538–42.
[5] Cosenza F, Vliet GC. Absorption in falling water/LiBr films on horizontal tubes. *ASHRAE Trans* 1990; 96:693–701.
[6] Morioka I, Kiyota M. Absorption of water vapor into a wavy film of an aqueous solution of LiBr.*JSME Int J*, Series II 1991;34(2):183–8.
[7] Kim KJ, Berman NS, Chau DSC, Wood BD. Absorption of water vapour into falling films of aqueous lithium bromide. *Int J Refrig* 1995; 18(7):486–94.
[8] Benzeguir B, Setterwall F, Uddholm H. Use of wave model to evaluate falling film absorber efficiency. *Int J Refrig* 1991; 14:292–6.
[9] Fujita T. Falling liquid films in absorber machines. *Int J Refrig* 1993;16(4):282–94.
[10] Andberg JW, Vliet GC. A simplified model for absorption of vapors into liquid films flowing over cooled horizontal tubes. *ASHRAE Trans* 1987; 93:2454–66.
[11] Ramshaw C, Winnington TL. An intensified absorption heat pump. *Proc Inst Refrig* 1988; 85:26–33.
[12] Swallow FE, Smith IE. Vapour absorption into liquid films on rotating discs. *School of Mech.Eng.*, Cranfield Institute of Technology, England.
[13] Kang YT, Christensen RN. Transient analysis and design model of LiBr-H2O absorber with rotating drums. *ASHRAE Trans* 1995; 101:1163–74.