

The Contrast of the Absorption Refrigeration Cycle of the Water-Lithium Bromide-Lithium Nitrate and the Water-Lithium Bromide

Yingbai Xie, Xuedong Zhang, Zhun Yu, Xutao Zhang

Institute of energy and power engineering, North China Electric Power University, Baoding, China

Abstract: The water-lithium bromide-lithium nitrate absorption refrigeration cycle is compared with the traditional water-lithium bromide system. The effect of temperature, which is generating temperature or condensing temperature or evaporating temperature, on system performance is analyzed. Moreover the double-effect absorption refrigeration system is also investigated. The results show that the COP of the water-lithium bromide-lithium nitrate absorption refrigeration system has been enhanced. And the other thermodynamics parameters are also improved. Especially for the double-effect absorption system, the COP has been increased by 30%, and then the f has been reduced by 12%. Thus, the water-lithium bromide-lithium nitrate absorption system has better performance than the system of water-lithium bromide.

Keywords: water-lithium Bromide-lithium nitrate, water-lithium Bromide, absorption refrigeration cycle, system performance

NOMENCLATURE

COP	Coefficient of performance
t_c	condensing temperature[°C]
t_e	evaporating temperature[°C]
t_{g1}	high pressure generating temperature[°C]
Q_e	thermal load of evaporator[kW]
Q_a	thermal load of absorber[kW]
Q_g	thermal load of generator[kW]
Q_c	thermal load of condenser[kW]
Q_t	thermal load of solution heat exchanger [kW]
Greek symbol	
$\Delta\xi$	blow-off range[%]
f	solution circulating ratio
Subscripts	
a	absorber
c	condenser
e	evaporator
g	generator

1. INTRODUCTION

As called for energy saving and environmental protection, water-lithium bromide cycle has been successfully applied in air-conditioning and refrigeration processes. During its operation, the refrigerant-absorbent pair should not form a solid phase over the range of composition and temperature to which it might be subjected, and the absorption

fluids can corrode materials used in constructing equipment. Some researchers solve these problems by adding new components^[1-8].

New components can improve absorption refrigeration cycle in two way, either to decrease crystallizing point, improving absorption capability, enhancing COP, or to prevent corrosion. Research has shown, the work medium of water-lithium bromide-lithium nitrate has well thermodynamic performance, preventing corrosion capability, and has cheaper price. The new solution is suitable for absorption refrigeration system, especially for double-effect absorption refrigeration system. The new work medium also has well development in the three-effect and four-effect absorption refrigeration cycle system.

The paper objective analyzes performance effect of water-lithium bromide-lithium nitrate for the traditional water-lithium bromide absorption refrigeration system. If the new work medium was generalized in practical unit, it would give new energy on our national water-lithium bromide absorption refrigeration industry.

2. SINGLE-EFFECT ABSORPTION CYCLE

2.1 minimum generating temperatures

The water-lithium bromide-lithium nitrate absorption system has a minimum generating temperature in the definite evaporating temperature and condensing temperature. By all appearances, water-lithium bromide absorption system also has a minimum generating temperature. The system can be working when the generating temperature exceeds minimum generating temperature. Because the minimum generating temperature basically determines the condensing temperature, evaporating temperature and evaporating pressure, so minimum generating

temperature of two work medium cycles approach in the same condition.

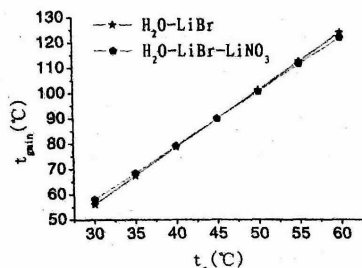


Figure 1: minimum generating temperature

Figure 1 shows comparison of minimum generating temperature (t_{min}) of different condensing temperature, t_c , in 5°C of evaporating temperature, t_e .

In the same way, the water-lithium bromide-lithium nitrate absorption system has a optimal generating temperature and corresponding maximal thermodynamic coefficient. Elevation of generating temperature can increase blow-off range and reduce circulating ratio, but thermodynamic coefficient does also not enhance with generating temperature increase. The generating temperature increase can enhance concentration of concentrated solution and absorption effect; at the same time, concentrated solution temperature of entry absorber enhances and affects absorbing effect. In the two aspect function, generating temperature has a optimal point and thermodynamic coefficient attains maximum; when generating temperature exceeds the optimal point, thermodynamic coefficient falls with generating temperature increase.

Further, when generating temperature overtops, it causes extortionate concentration of concentrated solution and is likely to crystallization. The water-lithium bromide absorption system theoretically existing optimal generating temperature and thermodynamic coefficient attains maximum. In practical function, it often can not obtain the optimal generating temperature by crystallization limit, because solution concentration correspondingly overtops and generates crystallization. Optimal generating temperature of water-lithium bromide absorption system is determined by crystallization condition. When generating temperature does not arrive at the point, thermodynamic coefficient enhances with generating temperature increase.

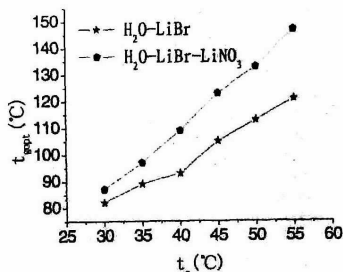


Figure 2: optimal generating temperature

So optimal generating temperature and maximal thermodynamic coefficient were chosen according to 60% (generating temperature below 100°C) or 62% (generating temperature above 100°C) of upper limit of solution concentration.

The results of comparison of water-lithium bromide absorption system and water-lithium bromide-lithium nitrate absorption system show Figure 2 and Figure 3.

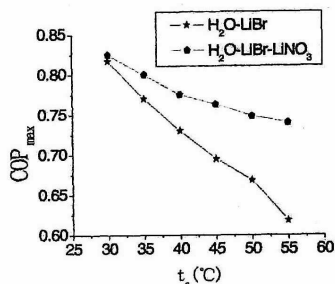


Figure 3: maximum system COP

By all appearances, water-lithium bromide-lithium nitrate absorption system has more optimal generating temperature and thermodynamic coefficient. The more optimal generating temperature system has, the bigger difference. So generating temperature scope of water-lithium bromide-lithium nitrate absorption system increases and is propitious to adopt high temperature heat source.

2.2 Other parameters

Coefficient of performance COP, blow-off range $\Delta\xi$, circulating ratio f and thermal load of solution heat exchanger q_1 are important economic indicators of thermodynamic performance of refrigeration system.

Figure 4 shows the parametrical contrast of refrigeration cycle of two working fluids. Figure 4 shows slow rise of COP of refrigeration cycle of two work medium, about linear rise of $\Delta\xi$ and hyperbolic decline of f and q_1 with rise of evaporating temperature t_e . We can reach diverse extent improvement of each thermo-dynamic parameter of water-lithium bromide-lithium nitrate absorption system from figures.

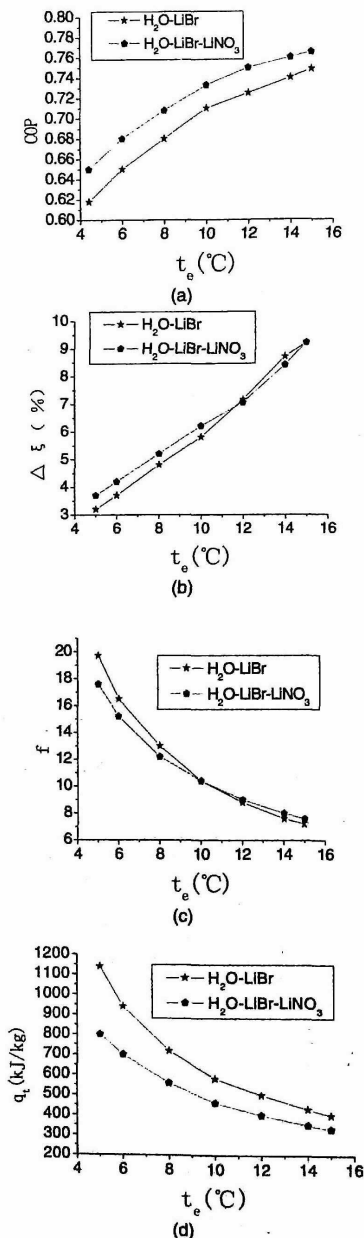


Figure 4: Comparison of COP, $\Delta \xi$, f and q_t
($t_c=40^{\circ}\text{C}$, $t_g=100^{\circ}\text{C}$)

3. DOUBLE-EFFECT ABSORPTION CYCLE

3.1 Thermodynamic calculation

It takes example for thermodynamic calculation of 581KW capability of water-lithium bromide cooling and hot water unit. Cycle was assumed series flow of weak solution primarily entering high pressure generator. Thermodynamic calculations of water-lithium bromide-lithium nitrate absorption system and water-lithium bromide absorption system progress when evaporating temperature t_e and condensing temperature t_c are 5°C and 40°C respectively, and solution heated by fume in high pressure generator outlet temperature t_{g1} is 152°C .

Table 1 Thermodynamic calculation results

Items	Water-lithium bromide-lithium nitrate system	Water-lithium bromide system
Q_e	581.5000kW	581.5000kW
Q_a	736.9105kW	777.1054kW
Q_{g1}	404.5623kW	535.1488kW
Q_{g2}	365.9818kW	284.1279kW
Q_c	267.5295kW	352.6537kW
Q_{l1}	259.0274kW	361.6677kW
Q_{l2}	109.3976kW	150.6587kW
ξ_d	59.1170(%)	56.93.9(%)
ξ_m	62(%)	60(%)
ξ_r	65.1170(%)	61.9309(%)
$\Delta \xi$	6(%)	5(%)
f	10.8528	12.3862
COP	1.4374	1.0866

Because water-lithium bromide was limited by crystallization condition at high temperature, concentration of concentrated solution can not overtop. Concentration upper limit is 62% in thermodynamic calculation. However, concentration upper limit of water-lithium bromide-lithium nitrate may consudedly exceed 62%. Table 1 shows thermodynamic calculation results.

Table 1 show that the thermodynamic performance of double-effect absorption refrigeration cycle distinctly enhanced. Thermodynamic coefficient COP was increased by 32%, and circulating ratio f was reduced by 12%, and then thermal load Q_t of solution heat exchanger was reduced by 28%.

3.2 cycle performance in variable work condition

Figure 5 shows variable curve of coefficient of performance COP with high pressure generating temperature t_{g1} of double-effect absorption refrigeration cycle of the two work medium. Figure 6 shows variable curve of thermal load Q_t of solution heat exchanger with high pressure generating temperature t_{g1} of double-effect absorption refrigeration cycle of the two working fluid.

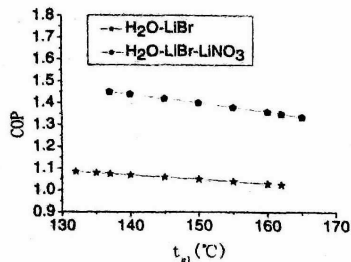


Figure 5: Relation between COP and t_{s1}

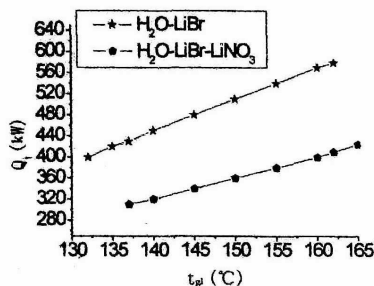


Figure 6: Relation between Q_L and t_{sp}

Thus, when working fluid adopts water-lithium bromide-lithium nitrate, COP was about enhanced by 30%~32%, and then thermal load of solution heat exchanger was about reduced by 28%~30%. Thermodynamic coefficient increase consumedly improves refrigerating cycle, and reduced thermal load of solution heat exchanger results in reduced area of heat exchanger.

4. CONCLUSION

From above contrast of calculation results and performance curve, we can reach conclusion below:

(1) In the same work condition, coefficient of performance COP of single-effect or double-effect water-lithium bromide-lithium nitrate refrigeration system distinctly enhances. According to performance curve, COP of single-effect water-lithium bromide-lithium nitrate refrigeration system about enhanced by 2%~9%; and COP of direct-combustion double-effect water-lithium bromide-lithium nitrate refrigeration system about enhanced by 30%~32%.

(2) Thermal load q_L of solution heat exchanger for single-effect or direct-combustion double-effect water-lithium bromide-lithium nitrate refrigeration system distinctly reduced, and thermal load influences heat

transfer area. Solution circulating ratio f and blow-off range $\Delta\xi$ improve, and work scope was enlarged. Figure 2 and Figure 3 shows, for single-effect refrigeration system, optimal generating temperature was about enhanced by 7~24 °C, and maximal thermodynamic coefficient was about enhanced by 1%~18%. For double-effect cycle, owing to corrosion and crystallization limit, work temperature scope of water-lithium bromide work medium is blow 170 °C, and work temperature scope of new work medium is suitable for 200~400 °C.

Thus, the water-lithium bromide-lithium nitrate system has better performance than traditional water-lithium bromide system. The new solution is suitable for single, double-effect refrigeration system, especially for direct-combustion double-effect unit.

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