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Thermodynamic Analysis of Double-effect LiBr-H_2O Absorption Refrigeration System

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Abstract—*Thermodynamic analysis of double-effect LiBr-H_2O refrigeration system being performed to observe the effect of temperature variation of various components on the coefficient of performance(COP), exergetic coefficient of performance(ECOP) and circulation ratio(f). The effect of most governing parameter such as generator temperature, evaporator temperature, absorber temperature and condenser temperature of the thermodynamic cycle have been studied.*

Keywords: *Energy, circulation ratio, double-effect,exergetic COP, ozone depletion, simulation.*

1. INTRODUCTION

The performance analysis and study of double-effect lithium bromide-water absorption system has been an area of research for distinct applications. Analysis of this system provides the detailed information about the effect of variation of pressure, temperature and concentration on the overall performance. For effective utilization of energy resources, absorption refrigeration cycle has been analysed to observe the change in performance of the system by varying some parameters. Arun et al. (2000) showed that suitable control systems can be incorporated when the necessary data are known to make the system operate at optimum conditions for maximum coefficient of performance (COP). In its operation, the strong solution of the absorbent-refrigerant is pumped from the absorber to the high pressure generator where it is heated at relatively higher temperature to separate the refrigerant vapour from the solution.

Huicochea et al. (2011) have performed the analysis of the trigeneration system at different ambient temperatures, generation temperatures and microturbine fuel mass flow rate. The results indicated that system shows an appreciable technology to use the energy from the microturbine exhaust gases for electric power, cooling and heating produced simultaneously. Jiang et al. (2002) have compared coefficient of performance and the cyclic characteristics between the three-pressure absorption–ejector hybrid refrigeration system (AEHRS) and small double-effect absorption refrigeration system. The thermo-economical models of the two systems in two cases of high-temperature heat resources: waste heat resources and natural gas fuel have been presented. Liu Y.L. and Wang R.Z. (2004) showed the Performance prediction of a solar/gas driving double effect LiBr–H_2O absorption system. In this system, the high-pressure generator is driven by conventional energy, natural gas, and solar energy together with water vapor generated in the high-pressure generator, which supplies energy to the low-pressure generator for a double effect absorption system. RabahGomri (2010) discussed that absorption heat transformer systems are good to use energy as heat source and delivering thermal energy to higher temperature than the temperature of the fluid. Study between single effect and double effect absorption heat transformer systems used for seawater desalination.

2. SYSTEM DESCRIPTION

Fig.1 shows the double-effect LiBr-H_2O absorption refrigeration cycle. It consists of an absorber (A) and generators having different pressure levels (HTG and LTG) which form the part of solution circuit. Condenser (C) and evaporator (E) are the parts of refrigeration circuit which produces cooling.

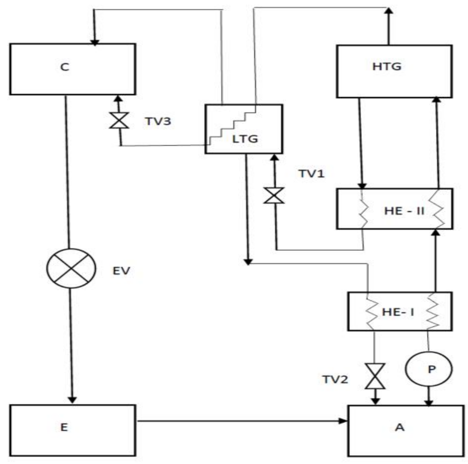

Fig. 1 Double-effect absorption cycle

Strong solution of refrigerant from heat exchangers (HE-I and HE-II) enters into the generator (HTG) and refrigerant water vapour being sent to the condenser. The remaining part of the solution subjected to LTG which further produces refrigerant vapour and the solution strong in LiBr reaches to the absorber. The absorber and evaporator are at low pressure levels while generators and condenser are at higher pressure level.

Table 1: Main parameters considered for the analysis

Environment Temperature (K)	298
Environment pressure (MPa)	0.10135
Absorber Temperature (K)	313
Heat exchanger effectiveness	0.82
Condenser temperature (K)	313
Evaporator temperature (K)	283
LTG temperature(K)	368
HTG temperature(K)	433

3. THERMODYNAMIC ANALYSIS

The thermodynamic behavior of the absorption refrigeration system and its components have been studied.

The coefficient of performance of the cycle is given as:

$$COP = Q_e/(Q_g+W_p) \quad (1)$$

The exergetic coefficient of performance is given as:

$$ECOP = Q_e\{1-(To/T_e)\}/[Q_g\{1-(T_o/T_g)+W_p] \quad (2)$$

The circulation ratio of EARS is given as:

$$f = m_a/m_e \quad (3)$$

Misra et al. (2005) showed that second law analysis calculates the system performance based on exergy, which is defined as the maximum theoretical, useful work obtainable in bringing the system to equilibrium with the environment. The total exergy of a system consists of two components: physical exergy and chemical exergy. In this analysis the temperatures in high temperature heat source, medium temperature heat sink and low temperature heat source are assumed to be constant while the fluid temperature varies in non-isothermal components due to different inlet/outlet solution concentrations.

The thermodynamic study of the absorption cycle is a necessity to observe the utilization of energy potential. The waste of energy potential leads to exergy crisis. The losses at throttling and expansion valves play a major role in the analysis. The utilization of energy observed with the study of exergy destruction. The second law of thermodynamics helps in calculating the performance of system based on exergy, which always decreases owing to irreversibility because of exergy destruction.

The refrigerant states leaving the condenser and evaporator are assumed to be saturated. Refrigerant vapour leaving the generator is considered to be superheated. Non-equilibrium states at the inlet to generator and absorber, and states at outlet to the solution pump and solution heat exchanger are taken to be at their actual conditions.

Solution leaving the absorber and the generator are assumed to be saturated in equilibrium conditions at their respective temperatures and concentrations. On the basis of this configuration, in this system it can be seen that energy potential can easily be determined with the help of thermodynamic equations.

4. RESULTS AND DISCUSSION

A thermodynamic analysis has been done to observe the effect of temperature variation of various components of double-effect absorption system.

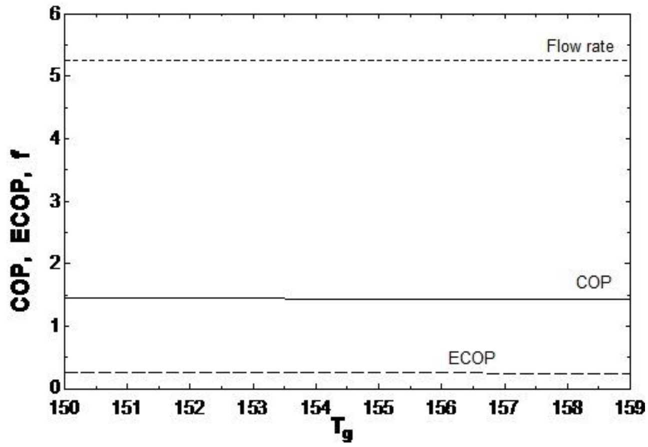

Fig. 2: Effect of generator temperature variation

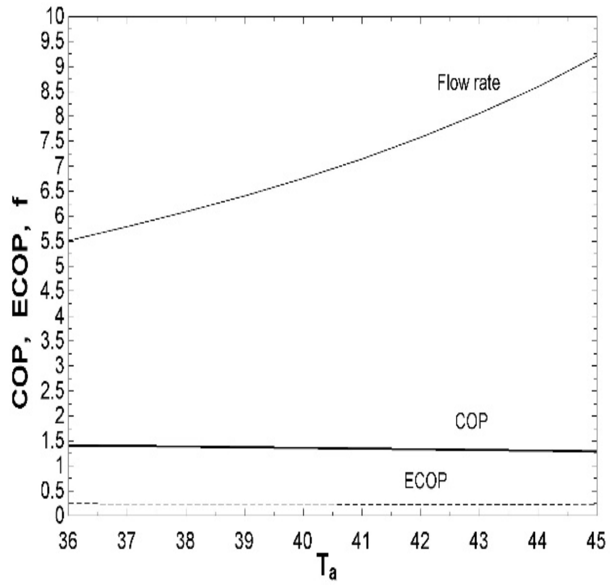

Fig. 3: Effect of absorber temperature variation

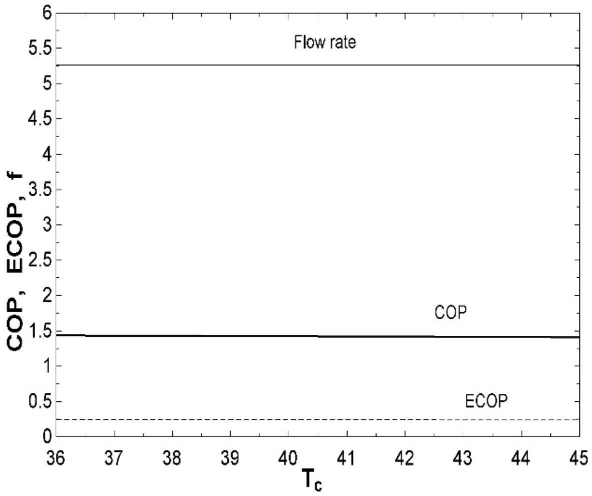

Fig. 4: Effect of condenser temperature variation

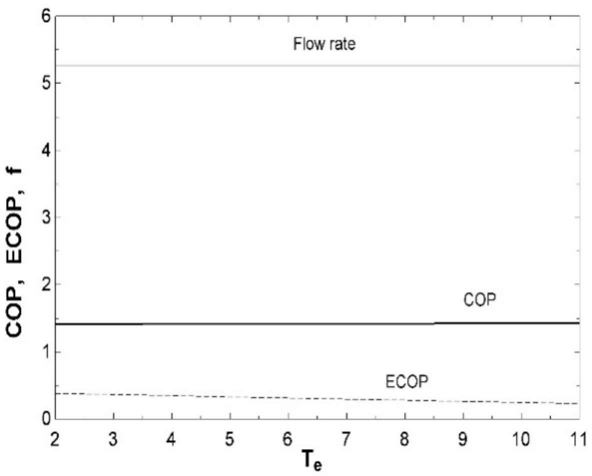

Fig. 5 : Effect of evaporator temperature variation

Fig. 2, 3, 4 and 5 shows the effect on circulation ratio with variation in generator, absorber, condenser and evaporator. The circulation ratio (f) remains same as the temperature increases in case of condenser, evaporator and generator. It varies non-linearly in case of absorber. The COP, however, increase in case of evaporator temperature but it decreases in other components like absorber, condenser and generator. The ECOP decreases with increase in the temperature of all four components. The results of this analysis also indicate that for the designing of the absorption refrigeration system has to be on the basis of thermal analysis. In the applications of residential and industrial, installation of the system is of great importance. The components of absorption refrigeration cycle like absorber, condenser, evaporator and generator play a significant role in the real world applications.

For small sacle applications the above study can be seen as a useful tool to consider the cooling load and other parameters. From this discussion we can easily find the essential and governing parameters of the cycle.

5. CONCLUSION

This study deals with the LiBr-H_2O operated absorption refrigeration system for cooling and air-conditioning with future possible working with ecofriendly refrigerants as working fluid. The effect of temperature variation has been observed on the performance with first law and second law of the proposed cycle.

From the above discussion, it can be concluded that

- As the temperature varies in absorber, the circulation ratio increases while COP nad ECOP decrease.
- As the temperature varies in evaporator, the circulation ratio and ECOP decrease while COP increases.
- As the temperature varies in condenser, the circulation ratio, COP and ECOP decease.
- As the temperature varies in the generator, the circulation ratio, COP nad ECOP decrease.

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