Journal of Material Science and Mechanical Engineering (JMSME)
Print ISSN: 2393-9095; Online ISSN: 2393-9109; Volume 2, Number 9; April-June, 2015 pp. 6-8

http://www.krishisanskriti.org/jmsme.html

Exergy Destruction Analysis of Double-effect LiBr-H_2O Absorption Refrigeration System

Rajesh Kumar*[1] and Ravindra Kannojiya[2]

[1,2]Department of Mechanical Engineering, Delhi Technological University
(Government of NCT of Delhi), Bawana Road, Delhi-110042, India
*E-mail: *dr.rajeshmits@gmail.com*

Abstract—*Exergy destruction analysis of double-effect LiBr-H_2O refrigeration system has been performed to observe the exergy utilization by the components of the cycle. The effect of most governing parameter such as generator temperature on exergy loss of evaporator, absorber, condenser, heat exchangers and throttle valves of the thermodynamic cycle has been studied.*

Keywords*: Exergy, renewable sources,ozone layer, destruction, quality.*

1. INTRODUCTION

The energy utilization potential and its conversion through double-effect lithium bromide-water absorption refrigeration system has been an area of research for distinct applications. Analysis of this system provides the information about the effect of variation of temperature of generator and on the overall performance. For efficient utilization of energy resources, absorption refrigeration cycle has been analyzed to determine the change in performance of the system by changing some parameters. Sarbuand Sebarchievici (2013) explained that the absorption refrigeration technology has a generator, a pump and an absorber that are together capable of compressing the refrigerant vapour. Evaporator draws the vapour refrigerant by absorption into the absorber. The thermal energy separates the refrigerant vapour from the rich-solution. The condenser condenses the refrigerant by rejecting the heat and then the cooled liquid refrigerant is expanded by the evaporator, and the cycle is completed.

Sirwan et al. (2013) explained that solar absorption cooling technology have the potential to replace the conventional refrigeration and air conditioning if more studies are carried on technical issues such as heat source temperature limitation and the high condensation temperature under critical conditions. Paurine et al. (2012) described the design and operation of a thermo-gravity pump which is also known as thermally activated pumping mechanism for circulating the refrigerant, water vapour, weak and strong LiBr-H_2O inside vapour absorption refrigeration system. Gebreslassie et al. (2010) calculated the COP, exergetic efficiencies and exergy destruction rates are determined and the effect of the heat source temperature. The COP increases significantly from double to triple effect cycles. The exergetic efficiency varies a little among the different configurations. In all cycles the effect of the heat source temperature on the exergy destruction rates is similar while the quantitative contributions depend on cycle type and flow configuration. It has also been shown that largest exergy destruction occurs in the absorbers and generators, especially at higher heat source temperatures.

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.

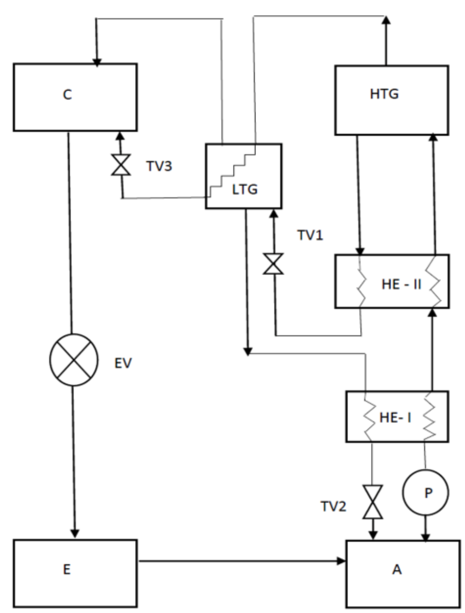

Fig. 1: Double-effect absorption cycle

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
AbsorberTemperature (K)	313
Heat exchanger effectiveness	0.82
Condenser temperature (K)	313
Evaporator temperature (K)	283
LTG temperature(K)	368
HTG temperature range (K)	433-453

3. THERMODYNAMIC ANALYSIS

The thermodynamic behavior of the absorption refrigeration system and its components have been studied. Part of the exergy supplied to an actual thermal system is destroyed due to irreversibility within the system. The exergy destruction is equal to the product of entropy generation within the system and the temperature of the reference environment. Misra et al. (2005) calculated from second law analysis the system performance based on the basis of exergy, which is the maximum theoretical useful work obtainable to bring the system to equilibrium with the environment. The total exergy of a system has two components: physical 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.

The change in total exergy (E_2-E_1) of a closed system caused through transfers of energy by work and heat between the system and its surroundings is given by

$$E_2-E_1 = E_q + E_w - ED \quad (1)$$

Where exergy transfer due to heat transfer is given by

$$E_q = Q*(1 - T_O/T_1) \quad (2)$$

The exergy transfer E_w associated with the transfer of energy by work W is given by

$$E_w = W + P(V_2-V_1) \quad (3)$$

The exergy destruction can be calculated either from the entropy generation using an entropy balance or directly from an exergy balance.

All real energy conversion processes are irreversible due to some effects such as chemical reaction, heat transfer through a finite temperature difference, mixing of matter at different compositions, unrestrained expansion and friction. Exergy balances help in calculating the exergy destruction within system. Thus, the thermodynamic inefficiencies are identified. Only a part of the thermodynamic inefficiencies can be avoided by using best available technology. Improvement should be focused on avoidable inefficiencies. Dimensionless variables used for performance evaluations. An appropriately defined exergetic efficiency characterizes the performanceof a system from thermodynamic view.

A decision concerning the absorption system configuration is dependent on the temperature of the external energy sources of the cooled and heated medium.

4. RESULTS AND DISCUSSION

A thermodynamic analysis has been done to observe the effect of temperature variation of HTG temperature on various components of double-effect absorption system such as absorber, condenser, evaporator, generator, throttle valves and heat exchangers.

Fig. 2, 3, 4 and 5 shows the effect of HTG temperature variation on absorber, condenser, evaporator, generator, throttle valves and heat exchangers. The exergy destruction in absorber and evaporator remains same as the temperature increases and is larger than in case of condenser. In condenser the exergy destruction increases slightly.

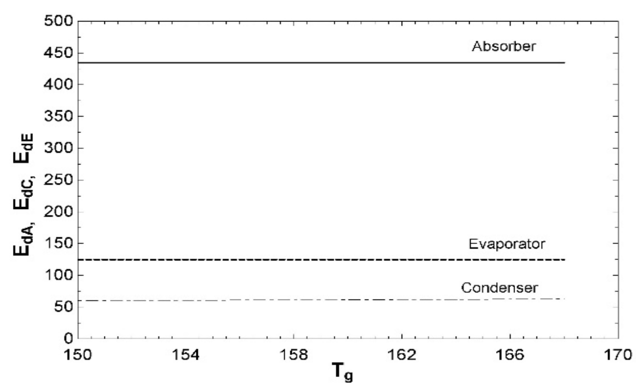

Fig. 2: Effect of generator temperature variation on exergy destruction of absorber, condenser and evaporator

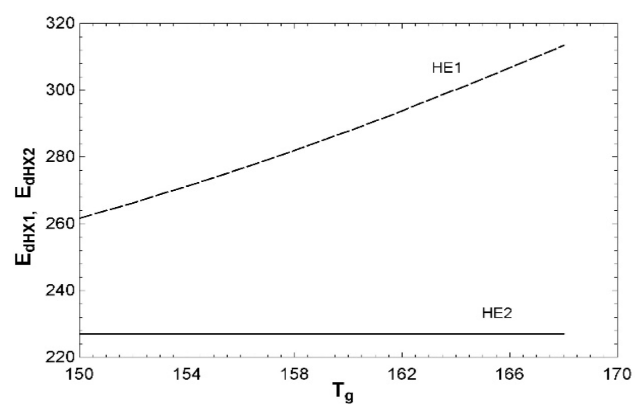

Fig. 3 Effect of generator temperature variation on exergy destruction of heat exchangers

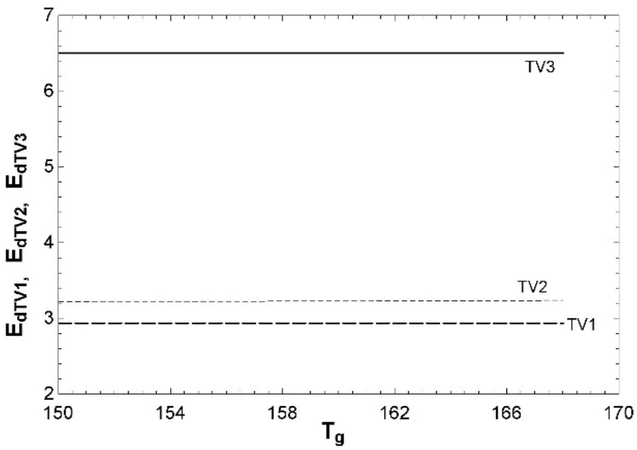

Fig. 4: Effect of generator temperature variation on exergy destruction of throttle valves

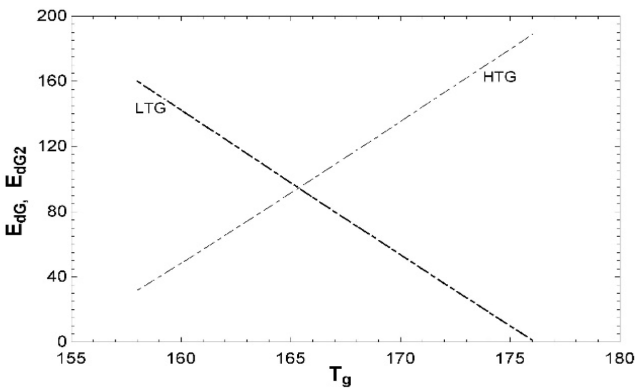

Fig. 5: Effect of generator temperature variation on exergy destruction of generators

It varies non-linearly in case of heat exchanger (HE1) and remains same for HE2. In case throttle valves the exergy destruction remains same (TV1 and TV3) while in TV2 it increases slightly with the increase in HTG temperature. The variation in both the generators for exergy destruction is different. For LTG it decreases while in HTG it increases.

For large and small scale applications the above study can be seen as a useful tool to consider the energy and exergy potential and other parameters. From this discussion we can find the essential and governing parameters of the cycle.

5. CONCLUSION

This study deals with the LiBr-H_2Oabsorption refrigeration system for cooling and air-conditioning with exergy loss and potential. The effect of generator 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 generator temperature varies in absorber and evaporator the exergy destruction remains same while it increases a little for condenser.
- As the generator temperature varies in heat exchangers (HE1 and HE2), the exergy destruction varies non-linearly and remains same respectively.
- As the generator temperature varies in throttle valves the exergy destruction in TV1 and TV3 remains same while in TV2 it increases a little.
- As the generator temperature varies in the generator the exergy destruction in HTG increases while in LTG it decreases.

REFERENCES

[1] SarbuIoan, SebarchieviciCalin, "Review of solar refrigeration and cooling systems", Energy and Buildings, 67, 2013,pp. 286–297.

[2] SirwanRanj, Alghoul M.A., Sopian K., Ali Yusoff, AbdulateefJasim, "Evaluation of adding flash tank to solar combined ejector–absorption refrigeration system", Solar Energy, 91, 2013, pp. 283–296.

[3] Paurine A., Maidment G.G., Eames I.W., Missenden J.F., "Development of a thermo-gravity pumping mechanism for circulating the working fluids in a novel LiBreH2O vapour absorption refrigeration (VAR) system", Applied Thermal Engineering, 47, 2012,pp. 25-33.

[4] GebreslassieBerhane H., Medrano Marc, Boer Dieter, "Exergy analysis of multi-effect water–LiBrabsorption systems from half to triple effect", Renewable Energy, 35, 2010, pp.1773–1782.

[5] Misra R.D., Sahoo P.K., Gupta A.," Thermoeconomic evaluation and optimization of a double-effect H_2O/LiBrvapour-absorption refrigeration system", International Journal of Refrigeration, 28, 2005,pp.331–343.