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

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

Keywords*: Exergy utilization, non-conventional sources, thermal power, quality of energy.*

1. INTRODUCTION

The complete conversion of low grade energy to high grade energy is limited by the second law. The single-effect lithium bromide-water absorption refrigeration system has been an area for distinct small scale applications. Analysis of this system provides the information about the effects of variation of temperature of generator and on overall performance. For effective utilization of resources, absorption refrigeration cycle has been analyzed to observe the change in performance of the system by providing variation in some parameters. Gogoi and Talukdar (2014) said that exergy analysis based on second law of thermodynamics is a tool for evaluating inefficiency of thermodynamic processes and first law based analysis solely is not enough to calculate some features of energy resource utilizations it provides only the quantitative measurement not considering completely the qualitative aspects. Second law deals with energy quality and calculate irreversible losses occur in thermodynamic processes. Cai et al. (2014) showed that absorption refrigerators can directly utilize low grade energy i.e. heat input, is quite larger than the vapor compression system which utilizes energy in the form of high grade i.e. work. They also observed that neither heat nor work are equivalent form of energy, so they have conducted analysis based on the second law of thermodynamics for performance evaluation. Avanessian and Ameri (2014) have analyzed various water-cooled LiBr–H_2O absorption systems under different operating conditions and compared them, the effect of the chemical exergy of the LiBr–H_2O solution on the second law also has been probed. It showed that the EUF increases with increase in generator and evaporator temperatures and decreases with the increase in the temperature and relative humidity of environmental air. The total exergy efficiency increases with increase in generator or ambient air temperature and decreases with increase in the evaporator temperature. Gong and Boulana (2014) have conducted exergy analysis of a water-lithium bromide absorption refrigeration cycle. For the proposed analysis avoidable and unavoidable part of irreversibility has been found. They also investigated the irreversibility origin from inefficiencies within and outside of components. It was seen that the desorber and absorber conbribute to exergy destruction. The exergy destruction in these parts was found to be dominant and unavoidable.

2. SYSTEM DESCRIPTION

Fig.1 shows the single-effect LiBr-H_2O absorption refrigeration cycle. It consists of an absorber (A) and generator (G) which form the part of solution circuit. Condenser (C) and evaporator (E) are the parts of refrigeration circuit which produces cooling. Strong solution of refrigerant from heat exchanger (HE) enters into the generator and refrigerant water vapour sent to the condenser. The remaining part of 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.

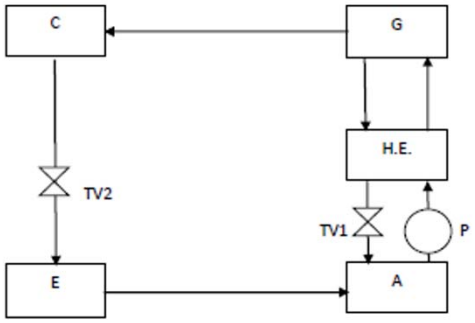

Fig. 1: Single-effect absorption cycle

Table 1: Main parameters considered for the analysis

Environment Temperature (K)	298
Environment pressure (MPa)	0.10135
Absorber Temperature (K)	311
Heat exchanger effectiveness	0.60
Condenser temperature (K)	311
Evaporator temperature (K)	283
Generator temperature(K)	363

3. THERMODYNAMIC ANALYSIS

The thermodynamic behavior of the absorption refrigeration system and its components has 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.

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 *Ew* associated with the transfer of energy by work *W* is given by

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

Exergy destruction analysis of single-effect absorption system is vital for the practical applications.

4. RESULTS AND DISCUSSION

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

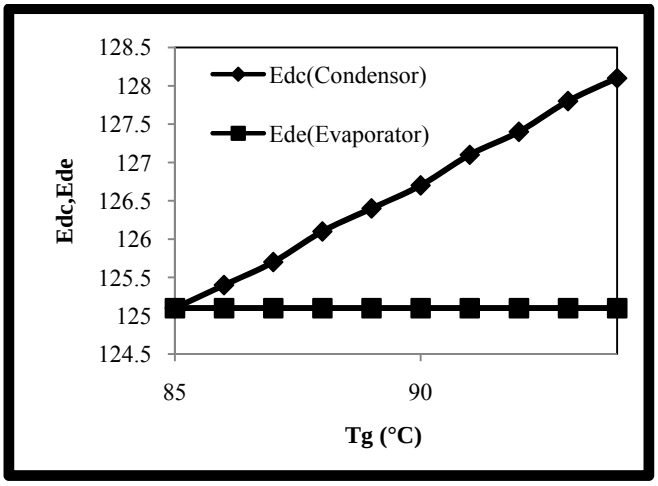

Fig. 2: Effect of generator temperature variation on exergy destruction of condenser and evaporator

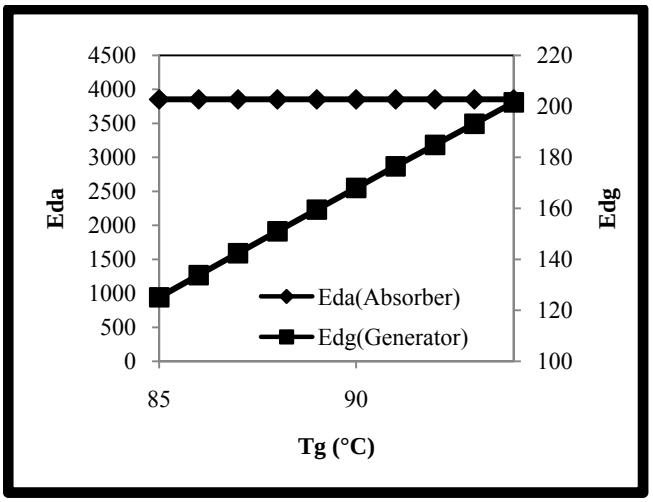

Fig. 3: Effect of generator temperature variation on exergy destruction of absorber and generator

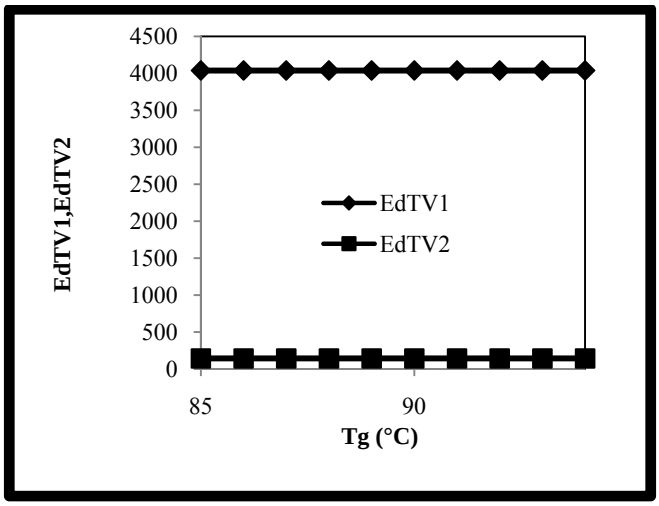

Fig. 4: Effect of generator temperature variation on exergy destruction of throttle valves

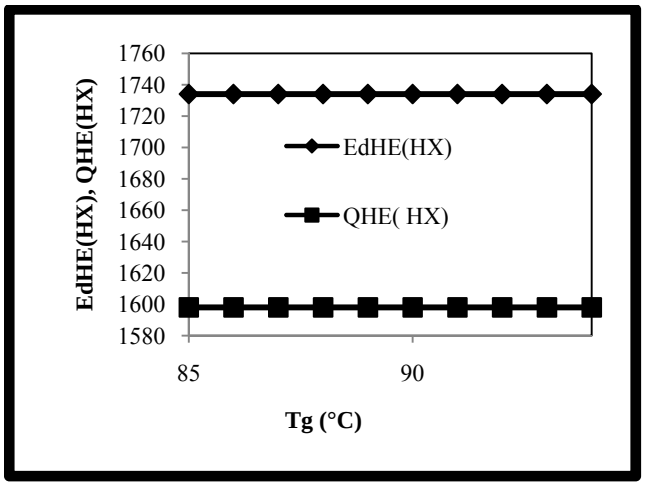

Fig. 5 Effect of generator temperature variation on exergy destruction of heat exchangers

Fig. 2, 3, 4 and 5 shows the effect of generator temperature variation on exergy destruction in generator, absorber, condenser, evaporator, throttle valves and heat exchangers. The exergy destruction in condenser increases while in evaporator remains the same with increase in generator temperature. In case of absorber exergy destruction remains same as the temperature increases while in case of generator it increases. It remains constant for both the throttle valves. The exergy destruction in case of heat exchangers shows that it remains the same with variation in generator temperature.

In the various applications this study is a useful one to consider the cooling and air-conditioning.

5. CONCLUSION

This study helps with the LiBr-H_2Oabsorption refrigeration system for cooling and air-conditioning. The effect of generator temperature variation has been observed on the performance.

From this discussion, it is concluded that

- As the generator temperature varies, the exergy destruction in absorber remains constant while it increases for generator.
- As the generator temperature varies, the exergy destruction in evaporator remains same while in condenser it increases.
- As the generator temperature varies, the exergy destruction in throttle valves remains constant for both the valves.
- As the generator temperature varies, the exergy destruction in the heat exchanger remains the same with heat change in the solution heat exchanger.

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