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Energetic and Exergetic Analysis of some Models of Vapor Absorption Chillers Using Lithium Bromide and Water

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Abstract—*Although vapour absorption systems came into existence much earlier than vapour compression refrigeration systems but they were replaced by the later due to ease of their usage. However due to environmental concerns such as global warming and ozone hole problems, absorption chillers are regaining the lost ground. The motive of this study is to provide design engineers, appropriate information for developing sustainable machine. In this study a parametric analysis of three models is carried out (single effect model, double effect series flow and double effect parallel flow model). It is observed that COP of double effect is much higher as compared to single effect. Second law analysis was also carried out and efforts are made to reduce irreversibility in each component of the whole system, thereby reducing net exergy loss .*

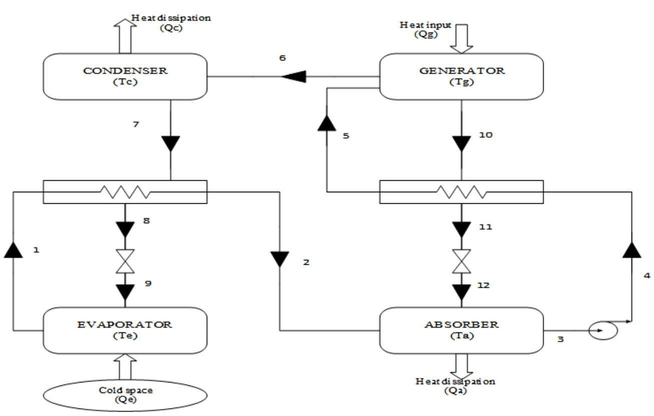
Keywords: *Energy, Exergy, vapor absorption, COP, Irreversibility.*

1. INTRODUCTION

In recent years, interest in vapour absorption refrigeration technology has become increasingly popular because this system uses such pair of refrigerants and absorbents which do not cause the ozone layer depletion and global warming. There are different pairs of working fluids such as H_2O-NH_3, $LiNO_3$-NH_3 and $LiBr$-H_2O etc. Moreover, absorption refrigeration system is heat operated due to which it can be driven either by low-grade heat such as solar energy, geothermal energy, waste heat from industries and so on. The eco-friendly aspect of vapour absorption refrigeration system overshadows their low coefficient of performance as compared to vapour compression refrigeration systems. Commercial chillers using $LiBr$-H_2O have been developed by many companies throughout the world. In India the leading manufacturers of the absorption systems are Voltas Limited at Mumbai and Thermax at Pune. Double effect and Triple effect cycles with different flow configurations of the solution like series, parallel and reverse flow have been proposed. The performance of the system improves in the parallel flow type as compared to the series flow. In the late 1950's, the first working module of a double effect LiBr-water absorption chiller was built, which yielded higher COP as compared to the simple absorption chiller. In 1960's, the natural gas industry was very effective in promoting this alternative to electric driven cooling. At that time, absorption chillers were very popular on the basis of lower operating costs.

2. MODELS CONSIDERED FOR ANALYSIS

The analysis was carried out for one Ton of refrigeration.



Model 1: Single Effect Vapour Absorption Refrigeration System

Mass balance: $\sum m_i - \sum m_o = 0$

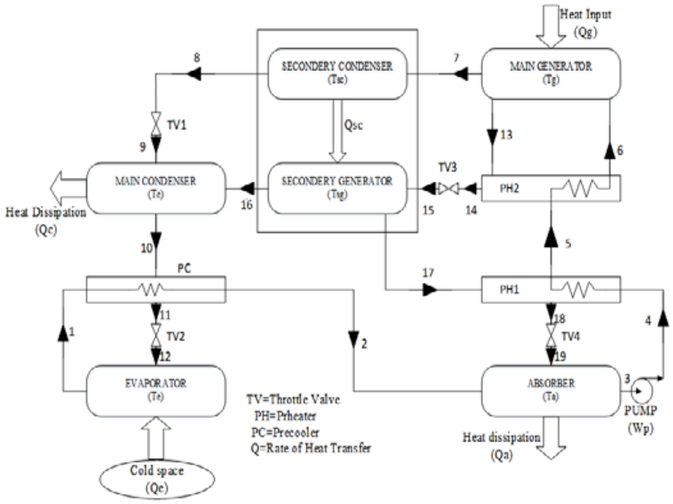
Concentration balance $\sum(\mathrm{mX})_\mathrm{i} - \sum(\mathrm{mX})_\mathrm{o} = 0$

Where m is the mass flow rate and X is mass concentration of LiBr in the solution

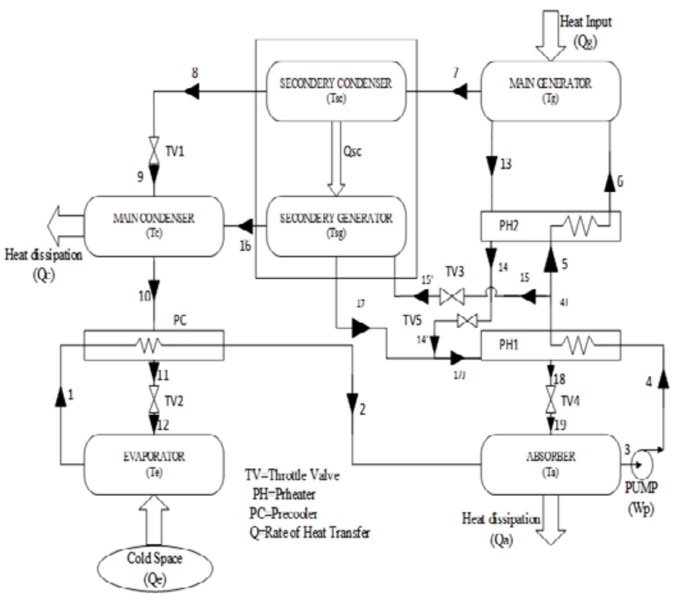
The Energy Equation is given by $\sum(\mathrm{mh})_\mathrm{i} - \sum(\mathrm{mh})_\mathrm{o} + Qi - Qo \pm \mathrm{W} = 0$

The Exergetic equation is given by:

$$\sum(\mathrm{me})_\mathrm{i} - \sum(\mathrm{me})_\mathrm{o} \pm \sum \mathrm{Q}\left(1 - \frac{\mathrm{T_0}}{\mathrm{T}}\right) \pm \mathrm{W} - \mathrm{ED} = 0$$



Model 2: Double Effect Series Flow Vapour Absorption Refrigeration System



Model 3: Double Effect Parallel Flow Vapour Absorption Refrigeration System

3. RESULTS

Following are the results obtained by solving the Non-Linear Equations using Programming in FORTRAN language. The non-linear equations are solved using iterative methods.

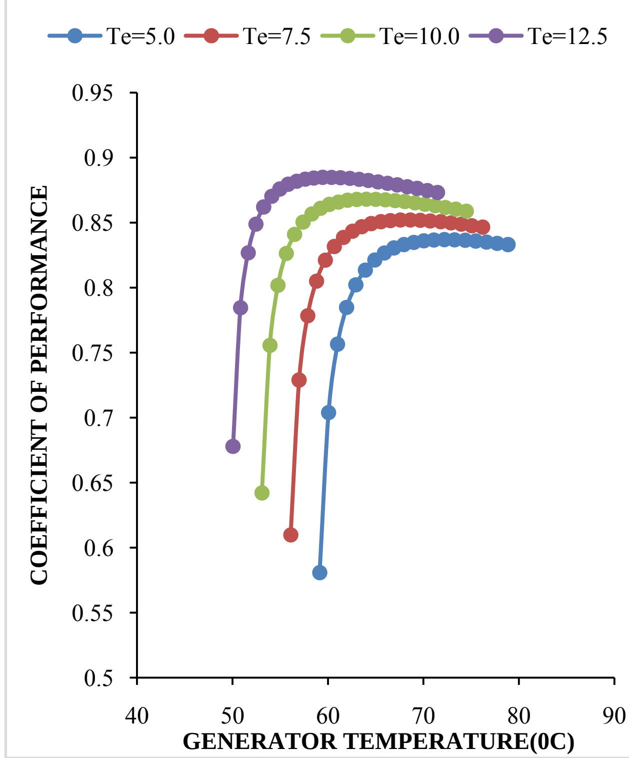


Fig. 1: Variations in COP of single effect cycle with generator temperature at Ta=Tc=30°C ,

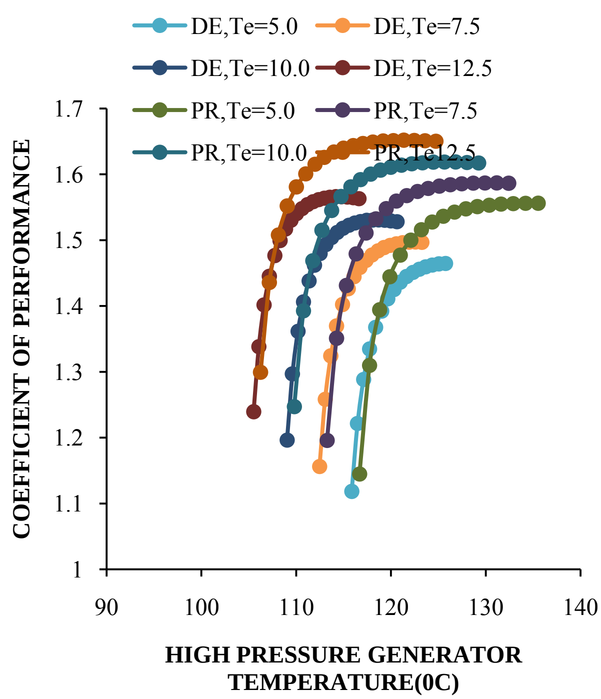


Fig. 2: Variations in COP of double effect(series & parallel flow) cycles with high pressure generatortemperature at secondary condenser temperature 80 0C

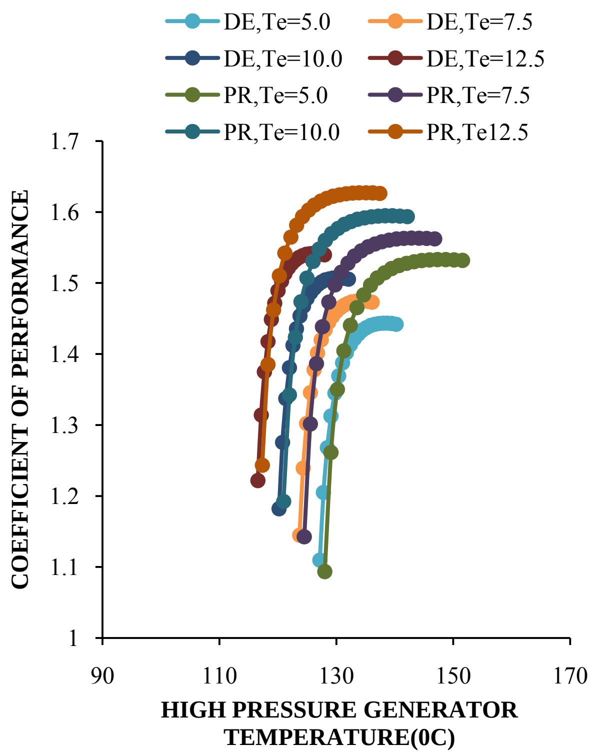


Fig. 3: Fig. 3 Variations in COP of double effect (series & parallel flow) cycles with high pressure generator temperature at secondary condenser temperature 900C.

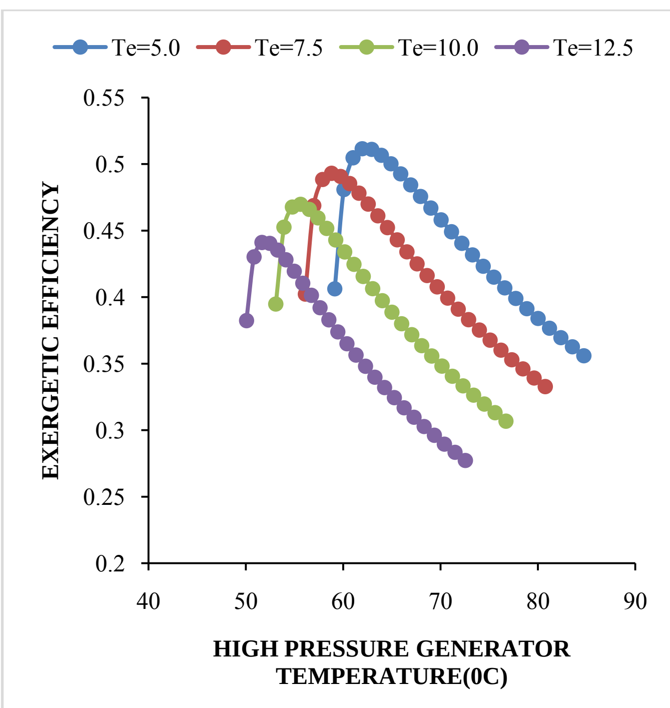


Fig. 4: Variations in exergetic efficiency of single effect cycle with generator temperature at Ta=Tc=30oC.

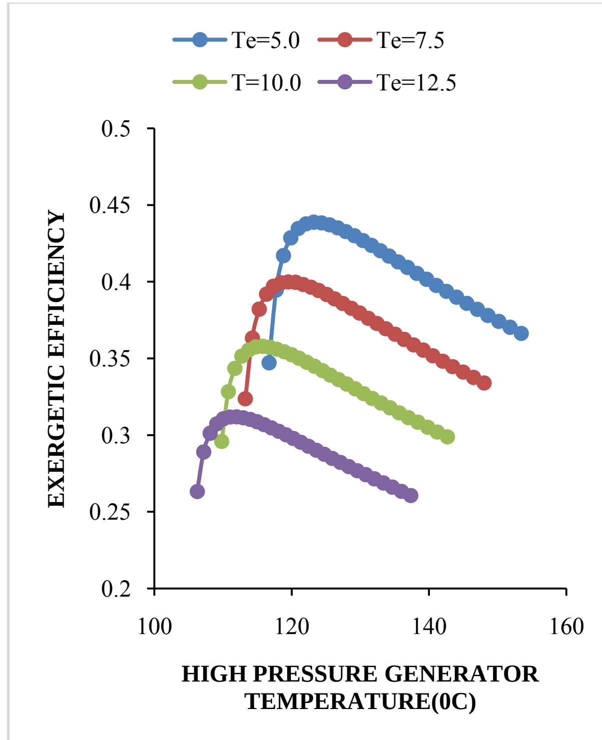


Fig. 5: Variations in exergetic efficiency of double effect parallel flow cycles with high pressure generator temperature at secondary condenser temperature 80 0C.,

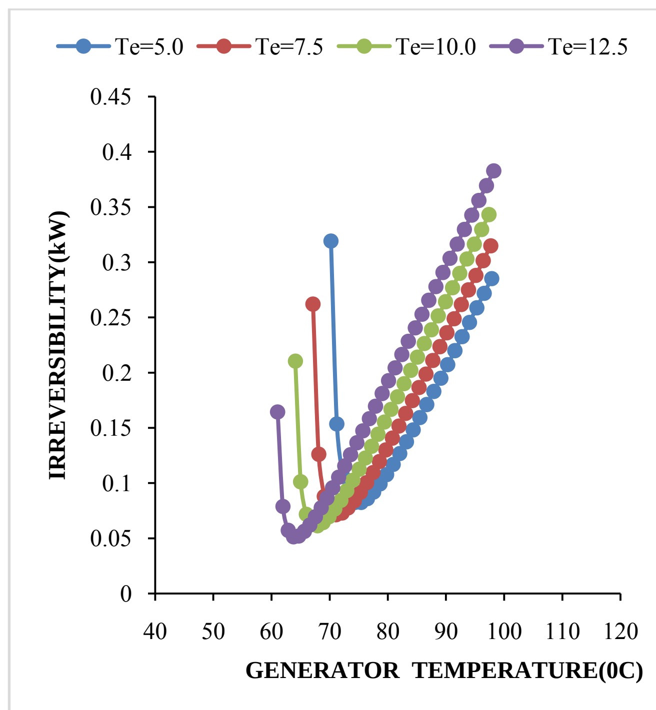


Fig. 6: Variations in exergetic efficiency of double effect parallel flow cycles with high pressure generator temperature at secondary condenser temperature 80 0C.

4. CONCLUSIONS

i. The coefficient of performance of single effect, double effect series flow and double effect parallel flow LiBr-H2O vapour absorption cycle increases with an increasing in generator temperature to which heat is supplied up to a certain limit and then decreases.
ii. Lowering of the evaporator temperature and raising of the condenser temperature leads to decrease in the coefficient of performance for all thethree cycle.
iii. COP of double effect parallel flow cycle is greater among all the three cycle and single effect cycle having least.
iv. Exergetic efficiency of single effect, double effect series flow and double effect parallel flow LiBr-H2O vapour absorption cycle initially increases with an increasing in generator temperature to which heat is supplied up to a certain limit and decreases thereafter.
v. Exergetic efficiency decreases with increase in evaporator temperature while COP increases for all the three cycle.
vi. Exergetic efficiency decrease with increase in the condenser temperature.
vii. Exergy destruction i.e. irreversibilityincrease with decrease in evaporator temperature.

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