



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 5, May 2022

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.118

9940 572 462

6381 907 438

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Comparative Study on Performance of Solar and Electric Operated Vapour Absorption System Using Li-Br Solution

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ABSTRACT: Engineering is all about the application of knowledge and ideas for continuous development in society. Now –a-days, there is a strong need for a non polluting refrigerating and air conditioning system, therefore, needed to focus on a solar and electric powered vapour absorption refrigeration system. To make the surrounding or liquid substance lower than the atmospheric temperature due to usage of Li-Br – water as working fluid in vapour absorption system, that can run by the source of solar and electric energy. The main objective of this work was to compare the performance of solar and electric operated vapour absorption system using Li-Br solution. The vapour absorption system is operated by means of two power systems, solar and electric powered. In this results shows that the coefficient of performance of electric operated vapour absorption system is 2.316 and the coefficient of performance of solar operated vapour absorption system which equals to 2.181 which are nearly equal.

KEYWORDS: CFC, Li-Br solution, Wavy tube heat exchanger, Electric Vapour Absorption System.

I. INTRODUCTION

The vapour absorption system concentrates on eliminating the compressor work in order to reduce the mechanical work and reduce the usage of energy. The working fluids in an absorption system are refrigerant and absorbent. However, the cooling effect cannot be produced continuously because the steam generation, condensation, absorption, evaporation processes cannot be carried out simultaneously. This system is developed due to the demand on electricity and to reduce the usage of electric energy. Adopting the vapour absorption system can build a pollutant free environment and the phasing out of Chlorofluorocarbon (CFC) is completely crossed out.

Paper is organized as follows. Section II describes the literature surveys, the findings from the surveyed literatures and the stated problem statements. The materials and the methods are explained in Section III. Section IV shows the results of this work. At last, Section V states the conclusion.

II. LITERATURE SURVEY AND PROBLEM STATEMENT

G.E.Kondhalkar & V.N.Kapatkat (2012): Studied the performance analysis of spiral tube heat exchanger over the shell and tube type heat exchanger. They found that the cost saving using spiral tube heat exchanger is around 15 – 20 % as compared to shell and tube type heat exchanger and to establish that improvement in overall heat transfer coefficient as compared to shell and tube type heat exchanger from 400 to 650W/m²K [1]. Garousi Farshi et al (2011): The computational model to study and compare the effects of operating parameters on crystallization phenomena in three



classes of double effect lithium bromide–water absorption refrigeration systems (series, parallel and reverse parallel) with identical refrigeration capacities. They concluded that the range of operating conditions without crystallization risks in the parallel and the reverse parallel configurations is wider than those of the series flow system [2]. Qureshi and Zubair (2012): The Investigation is done on performance characteristics due to use of different refrigerant combinations in vapor compression cycles with dedicated mechanical sub-cooling. For basic designs, R-134a used in both cycles produced the best results in terms of COP, COP gain and relative compressor sizing. In retrofit cases, considering the high sensitivity of COP to the relative size of heat exchangers in the sub-cooler cycle and the low gain in COP obtained due to installation of a dedicated sub-cooling cycle when R-717 is the main cycle refrigerant, it seems that dedicated mechanical sub-cooling may be more suited to cycles using R-134a as the main cycle refrigerant rather than R-717. With R-134a as the main cycle refrigerant, no major difference was noted, by changing the sub-cooler cycle refrigerant, in the degradation of the performance parameters such as COP and cooling capacity, due to equal fouling of the heat exchangers[3]. P. Naphon (2007): Studied the heat exchanger consists of a shell and helically coiled tube unit with two different coil diameters. Cold and hot water are used as working fluids in shell side and tube side. The cold and hot water mass flow rates ranging between 0.10 and 0.22 kg/s, and between 0.02 and 0.12 kg/s. He conclude that Outlet cold water temperature increases with increasing hot water mass flow rate. An average heat transfer rate increases as hot and cold water mass flow rates increase [4]. Dr.M.S.Tandale & S.M.Joshi (2008): Studied the experimental results that show the deviation between calculated values of overall heat transfer coefficient from the experimental results and theoretical values obtained from the analytical model are within 12%. Also, the accuracy is found to be within $\pm 8\%$ in approximation. The pressure drop estimated is also compared with actual values observed during experimentation, which is found in acceptable range [5].

Understanding the Literature Survey and Addressing the Problem Statement

From the literature findings, the problem statements are stated that Li-Br is used of ammonia on order to increase the coefficient of performance. Solar vapour absorption cannot be used when the solar energy is unavailable, so an electric powered vapor absorption system is designed for the continuous work process whenever the insufficient of solar energy occurs .The performance of electric operated vapor absorption system is compared with the solar operated vapor absorption system.

III. MATERIALS AND METHODS

Specifications of vapour absorption system

- 1) 5 litre generator, rectangular stainless steel tank with Copper wavy tube for hot water.
- 2) 5 litre absorber & evaporator, rectangular stainless steel tank with Copper wavy tube for cold water.
- 3) 5 litre condenser, rectangular structural steel tank.
- 4) 5 litre water reservoir, rectangular structural steel tank.
- 5) Connection copper tube 1 metre.
- 6) 1.5 litre Lithium Bromide solution.
- 7) Heater 0.5kw with power supply
- 8) Thermal sensors for temperature measurements.
- 9) 3 - 24V DC, 1.2 AMP RO pumps.
- 10) Digital Temperature Scanner.
- 11) 24V AC to DC adaptor.

FORMULA USED

$$\text{Co-efficient Of Performance} = \frac{\text{Heat absorbed in Evaporator}}{\text{Heat supplied in Generator} + \text{Work done by pump}}$$

Work done by Pump is very low, so the pump work is neglected.

$$\text{Co-efficient Of Performance} = \frac{\text{Heat absorbed in Evaporator}}{\text{Heat supplied in Generator}}$$

$$\text{Heat absorbed in Evaporator, } Q_e = m_w \times (T_7 - T_1) \text{ W}$$

$$\text{Heat supplied in Generator, } Q_g = m_L \times (T_1 - T_2) \text{ W}$$

12) Mass flow rate, $m = \frac{\text{Voulme in litres} \times 1000}{\text{Time in seconds}} \text{ kg / s}$

III.A.1 SOLAR VAPOUR ABSORPTION SYSTEM

The photoelectric cell is used to receive energy from sunlight called solar energy and energy stored in dc battery. The solar collected energy is provide to a heater that is used to generate the water vapour from the lithium bromide solution, in the generator, the strong solution of Li-Br is produced due to the high temperature and pressure . Then, the water vapours passes to the condenser, to cool down water vapour and it get converted into liquid. The high pressure water at liquid stage is passed through the condenser to and to the evaporator, the high pressure liquid is evaporated at low pressure, thus the system provide the cooling to the space to be cooled. Subsequently, the water vapours from the evaporator to the absorber. Simultaneously, the strong Li-Br solution is carried out from generator to absorber. In the absorber, the strong lithium bromide solution absorbed the water vapour leaving the evaporator to form a weak solution. Then, the weak solution of Li-Br is fed into the generator .The process is continued in cyclic manner. The temperature of the absorber has a higher influence on the efficiency of the system than the condensing temperature where the heat is dissipated to the environment.

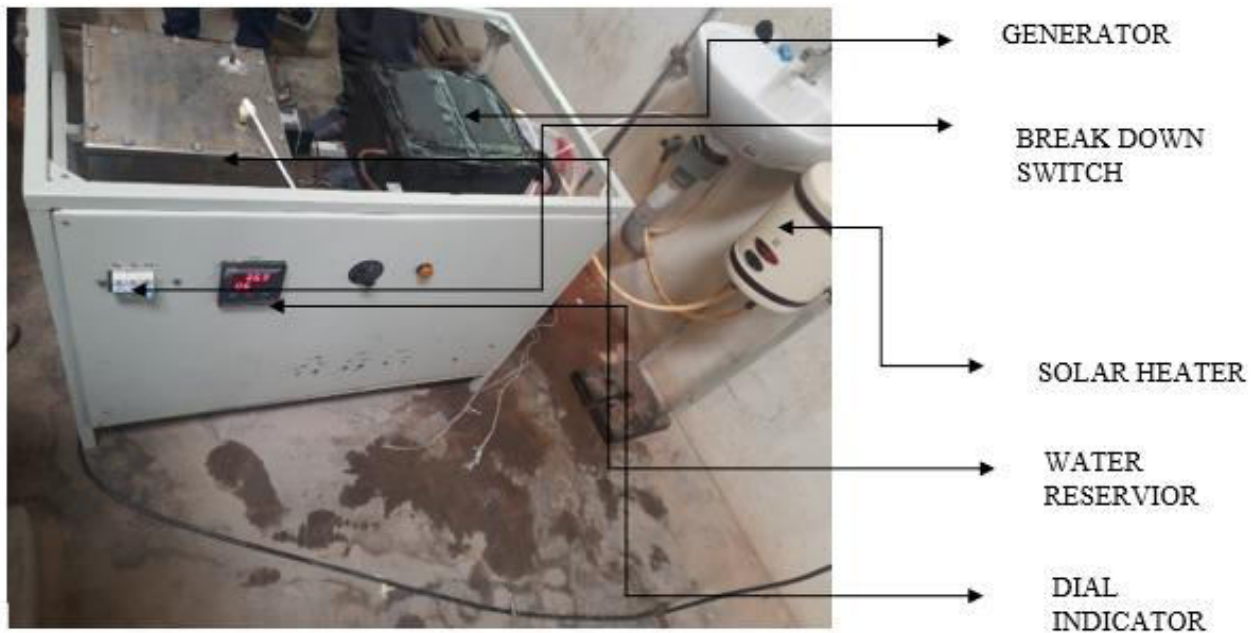


Figure 1. Photographic view of Solar vapour absorption system

The figure 1 shows the experimental setup of the solar operated vapour absorption system along with its components.

III.A.2 ELECTRIC VAPOUR ABSORPTION SYSTEM

An electric heater of 0.5kw with power supply is placed in the generator which is used to separate the water vapour from the lithium bromide solution, , in the generator, the strong solution of Li-Br is produced due to the high temperature and pressure . Then, the water vapours passes to the condenser, to cool down water vapour and it get converted into liquid. The high pressure water at liquid stage is passed through the condenser to and to the evaporator, the high pressure liquid is evaporated at low pressure, thus the system provide the cooling to the space to be cooled. Subsequently, the water vapours from the evaporator to the absorber. Simultaneously, the strong Li-Br solution is carried out from generator to absorber. In the absorber, the strong lithium bromide solution absorbed the water vapour leaving the evaporator to form a weak solution. Then, the weak solution of Li-Br is fed into the generator .The process is continued in cyclic manner. The temperature of the absorber has a higher influence on the efficiency of the system than the condensing temperature where the heat is dissipated to the environment.



Figure 2. Photographic view of Electric vapour absorption system

The figure 2 shows the experimental setup of the electric operated vapour absorption system along with its components.

IV. RESULTS AND DISCUSSION

Comparison of C.O.P of Solar and Electric operated Vapour Absorption system

TIME(in min)	T _{S1}	T _{S2}	T _{S3}	T _{S4}	T _{S5}	T _{S6}	T _{S7}	T _{S8}	C.O.P
20	31.3	55.4	31.0	30.0	60.0	50.3	47.3	31.6	0.375
40	30.4	63.6	32.7	30.0	65.0	59.4	52.9	33.0	0.818
60	28.4	71.0	33.6	30.0	70.0	67.6	60.1	33.2	1.057
80	26.3	78.6	34.8	30.0	80.0	70.1	69.3	34.0	1.280
100	25.2	81.1	36.0	30.0	85.0	76.4	70.6	33.9	1.473
120	23.1	82.9	36.9	30.0	85.0	79.3	73.7	34.8	1.726
140	21.9	88.7	36.3	30.0	90.0	83.6	80.2	35.2	2.181

The table shows the temperature distributions and the co-efficient of performance with respect to time.



TIME (in min)	T _{E1}	T _{E2}	T _{E3}	T _{E4}	C.O.P
20	30.7	50.2	47.2	33.4	0.557
40	29.1	62.3	57.7	34.6	0.925
60	27.6	70.7	69.8	35.0	1.297
80	24.0	76.6	73.4	35.1	1.673
100	23.8	84.3	77.4	35.2	1.903
120	21.5	90.1	80.3	35.2	2.163
140	20.3	96.4	84.4	35.3	2.316

The table shows the temperature distributions and the co-efficient of performance with respect to time.

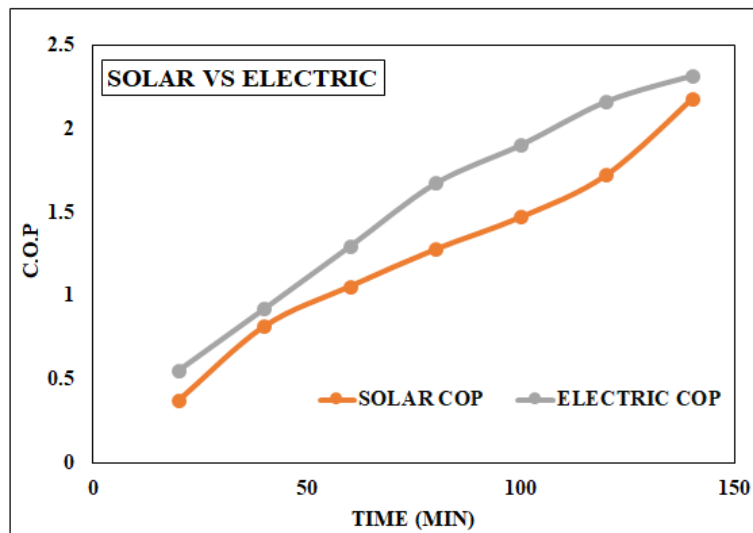


Figure 3. Solar C.O.P VS Electric C.O.P

The figure 3 shows the relationship between the co-efficient of performance of the solar operated vapour absorption system and the co-efficient of performance of the electric operated vapour absorption system.



V. CONCLUSION

The performance of the solar and electric operated vapour absorption system has been observed and the results are calculated. From these experimental results shows that

- i). The coefficient of performance of electric operated vapour absorption system is 2.316.
- ii). The coefficient of performance of solar operated vapour absorption system which equals to 2.181.

Comparatively the coefficient of performance of the solar and electrical energy operated vapour absorption system are nearly equal. Due to the demand on electrical energy, the solar energy is much better while considering the fuel availability, the fuel efficiency and to develop non polluting environment for the future. The scope of the future work is to increase the Li-Br feed to the system, the coefficient of performance of the system can be improved. The cost of the Li-Br solution is lesser than the cost of the conventional fuels. Adopting the vapour absorption system using Li-Br solution can built a pollutant free environment and usage of green energy reduces the dependence on conventional fuels in the future.

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