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Theoretical Calculation of Energy Savings From 100 kW Solar Based Triple Effect Vapor Absorption Machine used for Air Conditioning, National Institute of Solar Energy, Haryana, India

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Abstract:* The green house effect has been continuously increasing on the earth. This leads to increase the temperature of earth very rapidly than the normal pace. The green house effect is caused by the liberation of green house gases such as NO_x , SO_x, CO_2 etc. due to burning and combustion of the fuel. Another major reason of the green house effect is libration of the gases from the domestic appliances such as TVs, air conditioners, refrigerators etc. the gases librated from domestic appliances plays a major role in ozone layer depletion. The continuous increase in green house effect and ozone layer depletion has leaded us to think over the use of renewable energy sources. Triple effect Vapor Absorption Machine is an innovative approach for cooling. The system is efficient, environment friendly, does not lead to ozone layer depletion and is economic. In this paper the performance of the Triple effect system is evaluated experimentally in the month of May. The pair used in this cooling system is LiBr (refrigerant) and Water (Absorber). From the result the COP of the Triple Effect Vapor Absorption Machine in the month of May is 1.53.

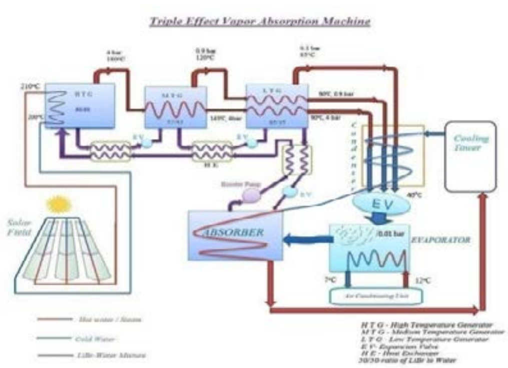
***Keywords:* Vapor Absorption Machine, LiBr, Coefficient of Performance.**

I. REVIEW OF LITERATURE

Since the beginning of the last century, average global temperature has risen by about 0.6K according to UN Intergovernmental Panel on Climate Change (IPCC). It is also wanted that the temperature may further increase by 1.4-4.5 K until 2100 . It has been observed over the year that with the increase in the temperature the energy requirement increases. Refrigeration and Air-Conditioning accounts for a significant portion of the energy consumption in many manufacturing industries (like chemicals, pharmaceuticals ,dairy, food etc.), agricultural & horticultural sectors (mainly cold stores) and commercial buildings (like hotels, hospitals, offices, airports, theatres, auditoria, multiplexes, data processing centres, telecom switching exchanges etc.)

II. INTRODUCTION

The Solar Air conditioning system at National Institute of Solar Energy is a "Triple effect Vapor Absorption System" which uses Lithium Bromide pair. The water in this solution is refrigerant and the Lithium Bromide is absorbent. It was funded with collaboration between Ministry of New and Renewable Energy, India and Thermax India Pvt. Ltd. The heat source to VAM is solar field. In this there are three generators the high temperature generator (HTG), Medium temperature generator (MTG), and Low temperature Generator (LTG). It follows the same operating principle as in double effect system. Only there is an addition of MTG. The heat rejected from the HTG is used in the following generators. The COP in triple effect system is around 1.7 and the input temperature is around 200^0C.



III. SYSTEM SPECIFICATION

Heat Source : Hot water from solar collectors

Collector type: 48 no. parabolic trough collectors.

Hot water temperature: 210^0C

Flow: 5-6m^3/hr

Cooling Capacity: 100 KW

Chilled Water Temperature: $12/7^{0C}$

Cooling water inlet temperature: 32^{0C}

Thermal storage: Hot-30 mins

: Cold-30 mins

COP of cooling System: 1.7

IV. EXPERIMENTAL SET UP

Solar powered LiBr-H2O absorption systems mainly consist of following components.

(A) Solar field.

(B) Tracking control panel.

(C) Vapor absorption machine.

(D) Cooling tower.

(E)Water treatment system

(F) Electric motor control panel.

(A) Solar field: Parabolic trough collectors are made by bending a sheet of reflective material into a parabolic shape. Parabolic trough collectors (PTC) can effectively produce heat at temperatures between 50°C and 400°C for solar thermal electricity generation or process heat applications. The receiver of a parabolic trough was linear. There were six rows of the parabolic trough in the solar field and each row having eight numbers of the collector modules. The parabolic modules are made up of the aluminum metal. And each module having a absorber area of 5.9m2. This leads to the total absorber area of 284 m2.

(B) Tracking control panel: This tracking control panel consists of
1) Pyranometer -to measure the sun radiations at every instance.
2) Two P.L.C- One for the rotation of first three rows and another for the next three i.e. fourth to sixth rows.

(C) Vapor absorption machine- Chiller was installed by the Thermax India pvt.ltd in the institute having a capacity of 100 kW i.e. 30 TR. This machine can operated on the temperature of 210℃ obtained from solar field depending upon the solar radiations. This is the main part of the whole system because the heat produced by the solar field is used here for converting it into the chilling effect. The generator design of the machine allowed the use of hot water in the temperature range of 140℃–210℃. Cold production was observed to begin when the temperature is above or equal to 140℃. The measured volumetric flow rate of hot water delivered by generator pump was ranging from 2 to 5.6m3/h. The cooling capacity of 100 kW can be produced with this chiller.

(D) COOLING TOWER: A cooling tower was used for rejecting the heat of absorption and condensation and supplied cooling water to the absorber and condenser in parallel at about 30℃ t0 35℃. Crystallization problem was not encountered by supplying a low cooling water temperature. The measured flow rate of cooling water delivered by the condenser pumps was varying depending upon the heat gain by evaporator and generator. The cooling tower used was of open forced-draft type

(E)WATER TREATMENT SYSTEM: The water treatment of chilled and hot/cooling water is important for the machine performance and long life. If the water quality is bad and shows a scaling tendency, scale adheres to the inside of the heat transfer tubes of the evaporator, absorber and condenser. The heat transfer between the chilled water and the refrigerant, and the hot/cooling water and the LiBr solution and the condensing refrigerant reduce. This causes an increase in the LiBr and condensed refrigerant temperature and increases the steam consumption. If the chilled or hot/cooling water becomes corrosive, it will corrode the inside of the evaporator, absorber and condenser tubes. Tube failure due to corrosion will occur. It is essential to fully treat the chilled and hot / cooling water to prevent corrosive tendency. To avoid this type of corrosion problem a set of the reverse osmosis was being planted with the cooling tower,

(F) CONTROL PANEL. The chiller control panel is based on PLC of Siemens S7-200series with CPU-226. It has onboard 24 digital inputs (Sink/source, IEC Type 1) and 16 digital outputs (Solid state MOSFET). The I/O modules can be expanded to a maximum of 7 modules, which adds 256 digital inputs or 32 analog inputs or 32 analog outputs. It has 2 no's of RS-485 ports for communication, one dedicated for communication with HMI and other can be used for third party communication via MODBUS RTU protocol.

V. PERFORMANCE EVALUATION OF VAM

These are the results of the performance evaluation of triple effect VAM

Day	Total Operating Time (in min)	Hot Water Flow (m^3/hr)	Cold water Flow (m^3/hr)	Total Heat Energy Supplied (kJ/hr)	Cold ouput (kJ/hr)	COP
1	71	1.54	59.89	172700	189530	1.55
2	13	1.74	59.94	111100	205640	1.37
3	26	1.5	59.21	186450	196230	1.69
4	173	1.66	59.98	129140	186450	1.56
5	167	1.71	59.36	205640	146430	1.72
6	226	1.67	59.50	106180	257500	1.59
7	111	1.62	59.63	131080	186960	1.47
8	212	1.68	59.64	124160	198900	1.63
9	226	1.64	59.35	114180	178520	1.62
10	128	1.68	59.29	143230	222110	1.59
11	146	1.72	58.21	128200	196960	1.54
12	65	1.92	59.74	163890	216280	1.40
13	127	1.80	58.77	151220	184360	1.24

Total operating time = 1691 minutes = 33 hours 11 mins
Total Heat Quantity Supplied = 1867220 kJ/hr
Total Cold Output = 2565870 kJ/hr
COP for the period of 13 days = 1.53
Thus, 1.53 is the COP for the period of 13 days.
The highest COP was noted on day 5 (15.3.15) = 1.72
The lowest COP was noted on day 13 (12.4.15) = 1.24

VI. ENERGY SAVINGS

The cold output given by the system is 2565870 kJ/hr
Thus the capacity of energy saved for a period of 13 days is 2565870 kJ/hr = 712.74 kW.
The system is operating for a period of April to July.
It is only operated on the Working days
So, let's assume the working hours for the 1 month = 50 hours
The working hours for 4 months = 200 hours
For 1 hour = 712.74 * 60 /1691 = 25.28 kW
Then the energy output for 200 hours = 200 * 25.28
= 5057.88 kWh
Thus, 5057.88 kWh Energy is saved per year because of the triple effect solar air Conditioning system.

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VII. CONCLUSION

Thus the overall Cop of the system for the period of 13 days is 1.53. The highest COP of the system is 1.72 and lowest COP of the system is 1.24. From the energy saving calculation the 5057.88 kWh energy can be saved by using triple Effect Vapor Absorption Machine in 4 months of summer. Thus it is obvious that there are huge chances of energy savings if this cooling system is used throughout the summer season.

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