

# International Journal of Innovative Research in Science, Engineering and Technology

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## Desert Cooler Operated on Vapour Absorption System Using by Two Stage Cooling using Three Fluid Systems

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**ABSTRACT:** An evaporative cooler produces effective cooling by combining a natural process-water evaporation with a simple reliable air moving system. Evaporative cooling is the most economical and effective means of refrigeration and air cooling since its inception particularly in the areas where the climatic conditions are hot and dry. In Rajasthan (India), during the summer Dry Bulb Temperature of air may reach up to 48°C while relative humidity stays below 50%. During present study efforts were made to make evaporative cooling system more versatile. In the process of study, a cooler cum refrigerator has been developed which can be utilised for purpose of air cooling. A viz. cooling the room and medicines without altering the purpose of the desert cooler.

**KEYWORDS:** VAS Effectiveness, Three Fluid System Coefficient of Performance (COP), Two Stage Cooling.

### I. INTRODUCTION

Many people in the world are currently experiencing dramatic shifts in life style as their economics make the transition from subsistence to an industrial and service base. The largest increase in the industry demand will take in the developing country where the proportion of the global energy consumption in the projected to surpass that in industrialized region in the global energy demand. In recent years many researchers have been carried out on refrigeration system driven by solar energy which achieves conservation of conventional energy and reduction of environmental pollution. Although many kinds of refrigeration systems have been developed and studied. It can be seen that very little work compared to the performance of refrigeration of air conditioning system under different power sources. This is the motivation for our work that will compare the performance of absorption refrigeration to the air conditioning.

In western part of India the humidity of air is quite low during the summer where the dry bulb temperature is high. This climate is most suitable for evaporative cooling. Fresh outside air is sucked through moist pad where it is cooled by evaporation of water and this cooled air is then circulated in the room or the building by a small fan or blower. Due to vaporisation of water, the temperature may decrease up-to wet bulb temperature of air that is around 22°C.

A simple scientific arrangement for cooling unlimited quantity of water with the little use of external power source such as electricity working on the principle of cooling by evaporation. The desert cooler is fabricated using mainly copper tubes. During the present study efforts have been made to utilize the cold water which is available in the cooler tank at wet bulb temperature. For indirect cooling of incoming air. The major advantage of this arrangement is maintenance cost is negligible. One of the ways of the increasing cooling effect or coefficient of performance is to apply vapour absorption system to the cooler. This improves effectiveness of cooling with less power consumption as compared to the air conditioner.

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Major objectives encompassing this work were that the earlier desert coolers give cooling effect up-to 28-30°C and the newly fabricated cooler gives cooling effect to a human comfort range of 20-25°C. Also to make the system reliable in any atmospheric condition. Moreover, to improve the cooling effect of the desert cooler VARS were run in the smaller system and cooling with dehumidification of air.

## II. LITERATURE REVIEW

In Paper “Performance of a Refrigeration Absorption Cycle Driven by Different Power Sources”, Sameh Alsaqoor, ET. Al. has studied performance assessment of absorption refrigeration cycle which has been carried out under variable power sources namely electric, conventional fuel and renewable energy sources. The ammonia-water absorption cycle was used in this work, the temperatures at each point in the cycle such as generator, absorber, evaporator and condenser have been measured and with using absorption devise system. The coefficient of performance and efficiency of the plant were measured and then compared the results showed that when the cycle driven by electricity, the coefficient of performance varied along the test time and the generator temperature changes with average efficiency and average coefficient of performance.

In Paper “Design and Development of energy Efficient Multi Utility Desert Cooler”, Poonia M. P., ET. Al. has presented Design of a multi-utilitydesert cooler. An evaporative cooler produces effective cooling by combining natural process –water evaporation with a simple, reliable air moving system evaporative cooling is the most economical and effective means of refrigeration and air cooling since its inception particularly in the areas where climatic conditions are hot and dry. Using such type of cooler to store medicines and food with a minimal operation and maintenance cost.

In Paper “Solar thermal Based Power and Vapour Absorption Refrigeration System”, R. Shankar presented a system that combines the refrigeration cycle and power generation cycle using solar thermal as source. The current dual effect VAR system has two generators to meet the choice of only power /only cooling/ both power and cooling. The strong refrigerant solar (aqua ammonia) from the absorber is divided into two steams and one flows to the first generator and heat by the solar thermal heat, then turbine. This produces the maximum power to the maximum vapour aqua ammonia as inlet to the turbine and these changes with temperature and pressure and made the cooler effect at exit of turbine. The balance mass goes to the second generator for refrigeration and it is single effect refrigeration. Thus, the system cooling power have been integrated to get two benefits from single system.

## III. WORKING OF SYSTEM

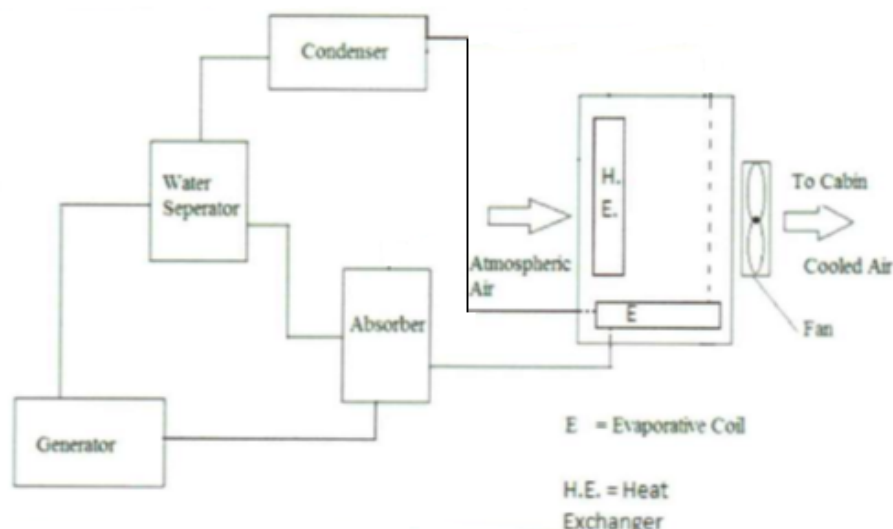


Fig 1: Working of System: The Figure above represents the working of the cycle.

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The Vapour Absorption System runs by three fluid absorption system. System comprises mainly Absorber consisting three fluids, Generator, Condenser, Evaporator and water separator as shown in Fig 1. Process start from absorber, it contains Chilled water, Ammonia and Hydrogen. In this system Ammonia is used as Refrigerant because it possess most desirable properties. The Strong Aqua-Ammonia solution is then passed to generator [4]. In Generator strong Aqua-Ammonia solution is heated by electric heating coil where it heats up the strong Aqua-Ammonia solution and then liquid ammonia is converted in vapour phase and it rises up and settles at upper part of generator. The water with vapour is separated out and remaining weak Aqua-Ammonia solution in form of water droplets drops into absorber because of gravity. The heated Ammonia present in vapour form then passes along with hydrogen into condenser. Here we are using fin type natural cooled condenser. In condenser hot vapour of ammonia gives its latent heat to surroundings and cools down and converts into chilled water. Again this chilled ammonia in liquid form is passed in-to evaporator. In evaporator hydrogen and ammonia solution is present and their relative masses are adjusted such that the partial pressure of hydrogen helps in achieving the evaporator pressure for rapid cooling. In this setup, the evaporator tube is immersed into the water storage in the desert cooler. Evaporator is providing required heat transfer surface area through which heat energy available in water storage is absorbed by vaporizing ammonia and exchanges its latent heat and thereby chilling the water available in storage. The Mixture of Hydrogen and Ammonia vapour that carrying the absorbed heat is now drawn back by gravity into absorber and the cycle starts again. [2][3]

## IV. ROLE OF THREE FLUID SYSTEM

Three Fluid System comprises Ammonia, Water and Hydrogen as base ingredients in absorber. As in this system Ammonia is used as Refrigerant because it possess most desirable properties. Though it is toxic in nature it's very safe in this system because of absence of any moving part. Ammonia is highly soluble in water as water has capacity to absorb ammonia vapour. Given an example that a 13°C of chilled water can dissolved 100 times of its own volume of Ammonia vapour hence ammonia is highly soluble in water easily.

**Role of Hydrogen:** Hydrogen is used as driving fluid in this system. A rich solution is pumped by hydrogen as Hydrogen has property to maintain total uniform pressure throughout system. At the same time it permits the Ammonia-water to evaporate at low temperature in the evaporator. Thus, the condenser and evaporator pressure of refrigerant are maintained as per below,

1. In the condenser only ammonia is present and total pressure is the condensing pressure.
2. In evaporator hydrogen and ammonia solution is present and their relative masses are adjusted such that the partial pressure of hydrogen helps in achieving the evaporator pressure for rapid cooling.

By using hydrogen we have eliminated pump and valves and thus it's a completely mechanical system. As Compressor is absent in this system, only small amount of electric energy is used to heat the solution in generator making the system silent i.e. without any mechanical noise. [3]

## V. TWO STAGE COOLING

In this project we have implied 2 stage evaporative cooling to improve effectiveness of cooler by using direct and indirect cooling methods. For that, we have designed a heat exchanger from which a chilled water will be circulated. We have designed a cross flow heat exchanger using tubes. The tubes material is selected as copper because of its high thermal conductivity, along with their excellent corrosion resistance (particularly in fresh and saline cooling waters) and their ease of fabrication.

### Temperature reduction achievable using Two-stage Indirect/Direct Evaporative Cooling

1. First the achievable dry bulb and wet bulb temperatures with direct evaporative cooling were calculated:  
Temp drop (achievable) = (dry bulb - wet bulb) x (efficiency of indirect module)  
Achievable temp = dry bulb - temp drop achievable

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Results after stage -1, Direct cooling  
Starting DB /WB: 86°F / 66°F  
Ending DB / WB: 68°F / 66°F

- Using the above results, calculation of achievable dry bulb/wet bulb temperatures with indirect evaporative cooling were proceeded: Refer Fig 2.

Temp drop achievable = (dry bulb - wet bulb) x (efficiency of indirect module)  
Achievable temp = dry bulb - temp drop achievable

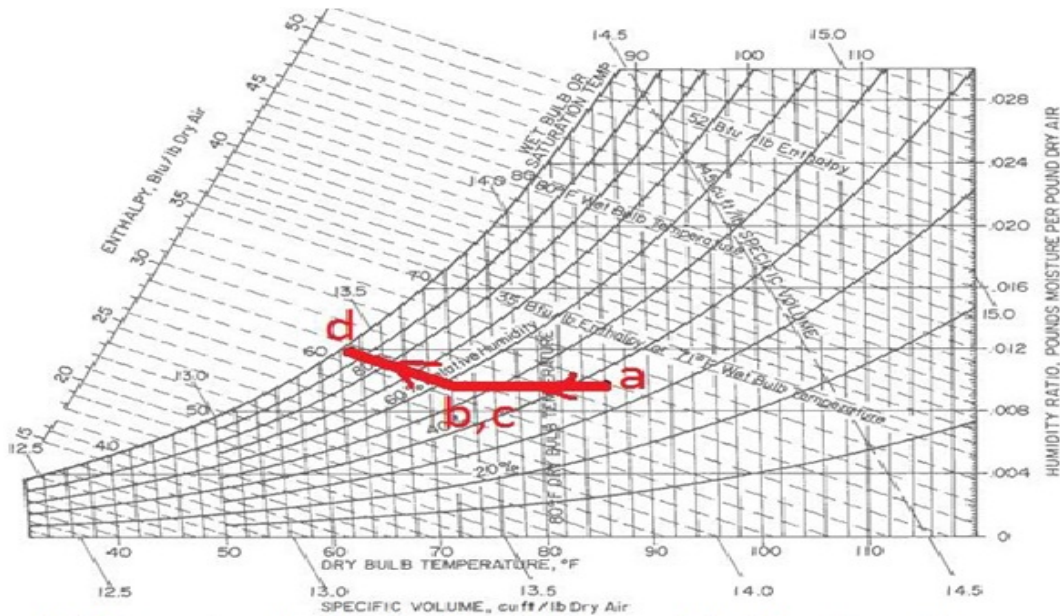


Fig 2: Enthalpy Chart: The chart represents the values taken into consideration for Calculations

Results after stage -2, Indirect cooling  
Starting DB /WB: 72°F / 61.4°F  
Ending DB / WB: 62.5°F / 61.4°F

For achieving above result as shown in Fig 2, we must require a Heat Exchanger which will provide us indirect cooling for cooler after Direct cooling. Calculations for the temperature drop of water after passing through Vapour Absorption System are explained below.

### Calculation of Heat Exchanger for indirect cooling:

To calculate the Heat exchanger area required,

$$N = \frac{A}{\pi d o C}$$

Where,

A= Cross section area required for heat transfer

N=No of Turns

$$Q = UAE (\Delta T_{lm})$$

U = Overall Heat Transfer Coefficient

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E=Logarithmic Mean Temperature Difference Correction Factor  
 $\Delta T_m$  =Temperature Mean

## VI. CALCULATIONS FOR COP AND EFFECTIVENESS OF SYSTEM

- To find out average effectiveness of system

$$\text{Average Effectiveness} = \frac{T_1 - T_2}{T_1 - T_v} \dots [2]$$

Where,

T<sub>1</sub> = Temperature of Surrounding

T<sub>2</sub> = Temperature of air after cooler

T<sub>v</sub> = Wet Bulb temperature

- To find out COP of System

$$\text{COP} = \frac{\text{Heat removed (Qc)}}{\text{Energy consumed (E)}} \dots [2]$$

Where,

$$Q_c = VCR \times \rho_{air} \times C_{p,air} \times (T_{amb} - T_{cr})$$

Where,

VCR = Volume of the room (m<sup>3</sup>)

$\rho_{air}$  = Density of Air (Kg/m<sup>3</sup>)

C<sub>p,air</sub> = Specific Heat of air (KJ/Kg°C)

T<sub>amb</sub> = Ambient Temperature (°C)

T<sub>cr</sub> = Cold room Temperature (°C)

## VII. TESTING AND RESULTS

### 7.1 Desert Cooler without VAS after Two Stage Cooling.

The Table 7.1 indicates the results of the tests conducted on the system without using the VAS. The test was carried out for a time period of 60 mins. In which the outlet temperature and relative Humidity were measured by Relative Humidity/Temperature Meters. With these results effectiveness of the system was calculated respectively.[2]

Time (Min)	Temperature outlet (°C)	Temperature Surrounding (°C)	Relative Humidity (%)	Effectiveness (%)
10	31.8	35	22	18.7
20	31.5	35	25	20.34
30	30.6	35	28	25.73
40	30.2	35	30	28.82
50	28.6	35	32	38.98
60	26.8	35	35	44.91

Table 7.1: Tests without using the Vapour Absorption System

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The graph shown in Fig 3 Times vs. Temperature without VAS supported to desert cooler. It shows that over period of time we can attain minimum temperature about 26.8°C. And the average effective of using is 29.47%

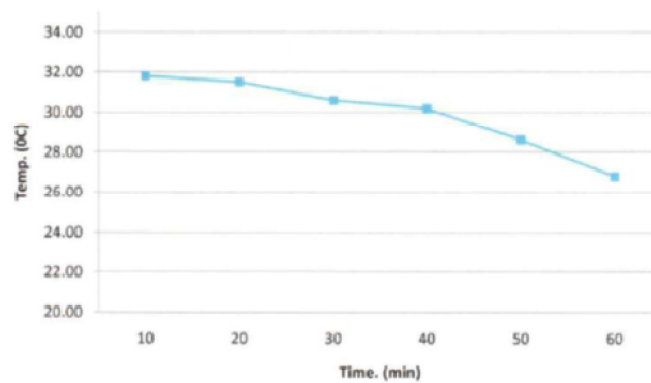


Fig 3 Times vs. Temperature

## 7.2 Desert Cooler with VAS after Two Stage Cooling.

The Table 7.2 indicates the results of the tests conducted on the system with using the VAS and Two Stage Cooling. The test was carried out for a time period of 60 mins. In which the outlet temperature and relative Humidity were measured by Relative Humidity/Temperature Meters. Effectiveness of the system was calculated respectively.[2]

Time (Min)	Temperature outlet (°C)	Temperature Surrounding (°C)	Relative Humidity (%)	Effectiveness (%)
10	25	35	40	53.19
20	24.4	35	42	56.08
30	23.9	35	44	58.42
40	24.2	35	43	57.36
50	23.5	35	48	61.9
60	22.3	35	52	67.18

Table 2: Vapour Absorption System along with 2 stage cooling

The graphs shown in Figure 4. Times Vs. Temperature with VAS supported to desert cooler along with two stage cooling. It shows that over period of time we can attain minimum temperature about 22.3°C. And the average effective of using is 59.02%

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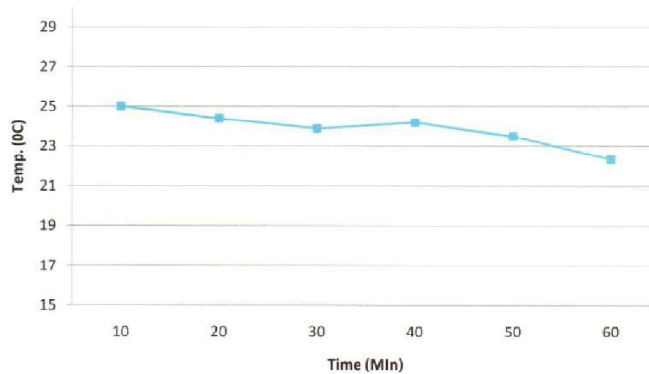


Fig 4: Times vs. Temperature

### 7.3 Comparison between the both Systems

Referring to Fig 5, it shows the comparison between both systems with using VAS and two stage cooling and without using VAS and two stage cooling. We came to know that over period of time cycle a system which using VAS and two stage cooling attains minimum temperature about 22.3°C.

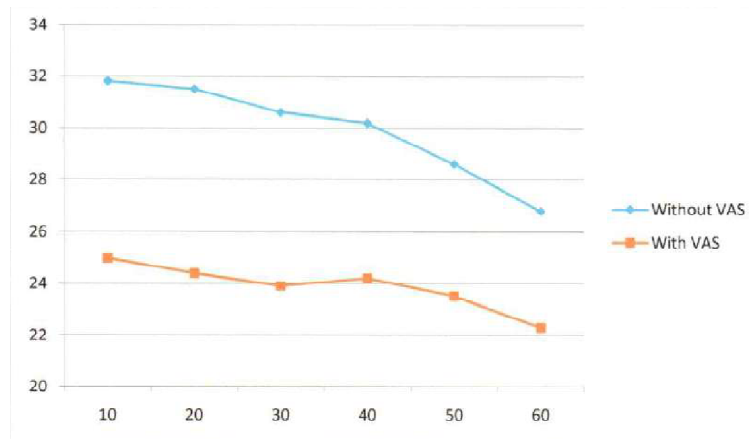


Fig.5: Combined Temperature vs. Time

## VIII. CONCLUSION

With the help of calculation it's clear that two stage cooling (Direct/Indirect) Evaporative cooling is more effective than only direct or indirect cooling. Both dry bulb temperature and wet bulb temperature get reduced in this process. Heat Exchanger required for indirect cooling is of area = 0.10162 m<sup>2</sup>. Therefore number of tubes required are =10. Vapour absorption system with using 2 stage cooling having Effectiveness 59.02% and COP of system is 3.55

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