EXPERIMENTAL INVESTIGATION OF COMPARISON OF NORMAL COOLING TOWER AND EVAPORATIVE COOLING TOWER IN VCRS SYSTEM

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ABSTRACT

Beginning from a early time period of refrigeration and air conditioning system. Improving COP is one of the important parameter and major aspect in the field of RAC system. Air cooled condenser give satisfactory performance and less costly than water cooled condenser. The COP is mainly affected in air cooled condenser by the temperature of ambient air, which is used as a cooling medium in condenser. In order to solve this problem we can use water cooled condenser. But water cooled condenser increase the overall cost of VCRS system. By attaching the cooling tower to water cooled condenser the performance of overall system increase. The main motive of this experimental study is to concentrated toward the improving the COP of VCRS system by using evaporative cooling tower as compared normal cooling tower.

A VCRS with water cooled condenser has been built .Initially it's attached with simple cooling tower and further it is attached to evaporative cooling tower. We have taken evaporative cooling concepts from evaporative cooled condenser. We have taken two different ambient temperatures 25°C and 30°C and calculate the COP. In starting case when simple cooling tower is used at 25°C and 30°C the COP change from 4.5 to 4.48.Similarly in next case when we take evaporative cooling tower at 25°C and 30°C,the COP rises and change as compared to normal cooling tower which changed from 4.72 to 4.61.

***Keywords**: Refrigeration And Air Conditioning, Water Cooled Condenser, Cooling Tower, Vapour Compression Refrigeration System, Evaporative Cooling Pad*

I .INTRODUCTION

Refrigeration is the process of removing heat from that place where it is not required. In order to maintain quality and flavor of food, heat is removed from air. There is innumerable application in industry in which heat is taken out from the particular place or material to achieve a desired effect. In 1834 the first mechanical producing cooling system was developed later it become vapour compressor. Refrigeration or air conditioning is a kind of heat pump whose function is to remove heat from a lower temperature source to high temperature sink. Evaporative cooling tower concept was developed by evaporative condenser. In our experimental setup we have focus over the cooling tower. Initially we use normal cooling tower at two different ambient temperature 25°C and 30°C.In normal cooling tower hot water from water cooled condenser is pumped at the top of the tower, from the bottom of cooling tower circulated air drawn into the tower by using draught fan. Similarly in second case evaporative cooling tower is used. In evaporative cooling tower we use evaporative pad in front of draught fan at a same time another pump is used to circulate normal water over a cellulose pad .When air is draw through fan ,first it enter in cellulose pad taken some moisture from it and then it enter into cooling tower.

Experimental performance at ambient temperature 25°C and 30°C respectively.COP of system decrease from 4.5 to 4.48 as we move from 25°C to30°C .Similarly again it decrease from 4.72 to 4.61 respectively as move from 25°C to30°C

Fouda and Melikyan et al. [1] A simplified mathematical model was used to discuss the heat and mass transfer between the air and water in a direct evaporative cooler. A comparison between the model results and the experimental results was presented. The results indicate that during a steady state condition, the cooling efficiency is decreased by increasing the inlet frontal air velocity, and increased by increasing the pad thickness. This is because the contact surface between water and air is increased.

Kulkarni and Rajput et al. [2] theoretically analyzed the performance of indirect-direct two stage cooler with cellulose and aspen media in direct stage. They selected the most frequently occurring inlet condition of 39.9 0C DBT and 32.8 % RH for the analysis. The saturation efficiency ranged from 121.5 to 106.7 % for two stages cooler.

Jain et al. [3] developed and tested a two stage evaporative cooler with wooden shave as packing material. The effectiveness ranged from 1.1 to 1.2 and could achieve favorable temperature and relative humidity for storage of tomatoes for 14 days.

S.S. Hu, B.J. Huang et al. [4] conducted an experimental investigation on a split air conditioner having water cooled condenser. They developed a simple water-cooled air conditioner utilizing a cooling tower with cellulose pad filling material to cool the water for condensing operation. The experimental investigation verified that the water-cooled condenser and cooling tower results in decreasing the power consumption of the compressor.

Sreejith K et al. [5] Heat can be recovered by using the water-cooled condenser and the system can work as a waste heat recovery unit. The recovered heat from the condenser can be used for bathing, cleaning, laundry, dish washing etc. The modified system can be used both as a refrigerator and also as a water heater. Therefore by retrofitting a water cooled condenser it produce hot water and even reduce the utility bill of a small family. In this system the water-cooled condenser is designed as a tube in tube heat exchanger of overall length of 1m. It consists of an inlet for the cooling water and an exit for collecting the hot water. The hot water can be used instantly or it can be stored in a thermal storage tank for later use.

II.EXPERIMENTAL SETUP

Our experimental setup contain different part of VCRS system i.e. expansion device, compressor, evaporator and water cooled condenser. A large tank is built and we placed condenser into it. From this tank a cooling tower is to be connected. With the help of pump hot water from condenser is circulated at the top of cooling tower. At a same time draught fan at the lower side of tower circulated air into the cooling tower. The compressor of volume (cc) 4.5 are used to increase the pressure and temperature of refrigerant (R134a).Here the capillary tube is used, made up of a copper tube of very small diameter 0.36mm.Capillary tube used as expansion device. The evaporator is used to reduce the pressure, dissipating heat and making liquid refrigerant to much cooler. Evaporator used in this experiment setup is tube and fin type. Flowing of water continuously circulate over the cellulose pad while performing the experiment. Different measuring devices are used in this experiment setup such as Digital Thermometer TPM-10, which gives the temperature at various points within the system. Pressure gauge is also used; first pressure gauge measures the suction pressure before the compressor and second pressure gauge measure the discharge pressure after the compressor. Similarly ammeter and voltmeter are used to measure the current and voltage to input to the system.

Fig. 1: VCRS System Attached With Normal Cooling Tower.

The above figure represent normal cooling tower which attached to simple vapour compression system. Hot water is circulated over cooling tower with the help of pump at a same time air is circulated from the lower position side of cooling tower with the help of fan. Due to gravity action water fallen down in the downward direction and when it comes in contact of circulated air it goes to cool down. At the bottom of cooling tower cooled water is present and again it circulated in condenser as cooling medium.

Figure 2: Cellulose Pad Kept In Front of Fan **Figure 3: Aerodynamic Fan**

From the figure 2 and figure 3 it represents the cellulose pad kept in front of draught fan and at a same time water is circulated over the cellulose pad with the help of another pump. Initially air enters into cellulose pad taken some moisture from it and then it enters into the cooling tower. When we use cellulose pad overall performance of VCRS system increase.

III. EXPERIMENT RESULT AND DISCUSSION

Table 1: Result obtained at two different ambient temperature 25°C and 30°C

Parameter	Symbol	Unit	Normal cooling tower		Evaporative cooling tower	
			Ambient air temperature 25°C	Ambient air temperature 30°C	Ambient air temperature 25°C	Ambient air temperature 30°C
Evaporator Absolute pressure	P_{eva}	bar	0.55	0.35	0.45	0.40
Condenser Absolute pressure	P_{con}	bar	10.34	11.14	11.44	11.32
Evaporator exit temperature	T_1	°C	-17.4	-16.9	-19.1	-20.5

Compressor exit temperature	T_2	°C	41.3	42.4	44.5	45
Condenser exit temperature	T_3	°C	28.8	31.4	33.5	32.4
Total electric curent	I	Ampere	0.72	0.77	0.67	0.72
Total electric voltage	V	Volts	210	210	210	210

In order to check the performance of vapour compression system which have normal cooling tower and evaporative cooling tower, experimental test are performed in two consequent stages. In first stage, normal cooling tower is attached we calculate COP at 25°C and 30°C.Similarly in second stage we use evaporative cooling and calculate following different property at 25°C and 30°C. The properties of refrigerant (R134a) and air remained constant (after 20min) throughout the process in order to maintain the steady state condition and data are recorded.

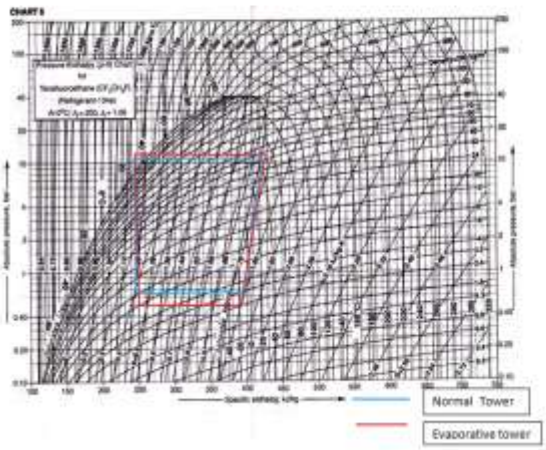


Fig. 4: Pressure-Enthalpy diagram for normal tower and Evaporative cooling tower at an ambient temperature 25°C.

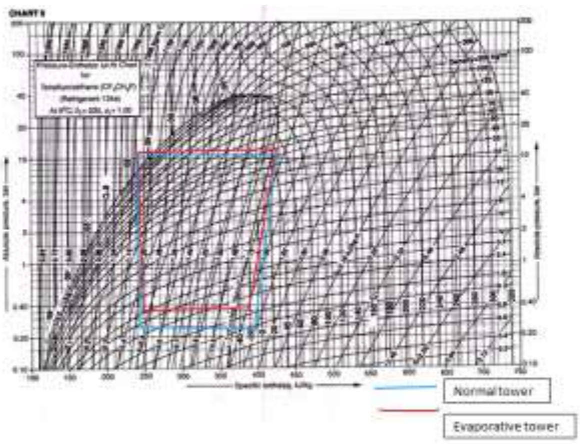


Fig. 5: Pressure-Enthalpy diagram for normal tower and evaporative cooling tower at an ambient temperature 30°C.

IV. CALCULATION AND RESULTS

While performing the experiment, the result obtained. Based on this result thermodynamic properties of refrigerant R134a are obtained at the different point of the system. In order to calculate the enthalpy, using the P-h chart of the refrigerant R134a.Such parameter are compressor work, COP of the system are calculate from the required following equation.

A. Compressor Work Wc = V * I = m_{ref}* (h_2 –h_1)

B. Mass flow rate of refrigerant $m_{ref} = \frac{Wc}{(h2 - h1)}$

C. Cooling effect produced Qr=m_{ref}* (h_1 –h_4)

D. COP $= \frac{Qr}{Wc}$

Where,

h_1 = enthalpy of refrigerant at inlet of compressor in kj/kg (1)

h_2 = enthalpy of refrigerant at exit of compressor in kj/kg (2)

h_3 = enthalpy of refrigerant at exit of the condenser kj/kg (3)

h_4 = enthalpy of refrigerant at entry of evaporator in kj/kg (4)

The compressor work done is obtained by the input power given to the experimental setup. The voltage and current of the input power is obtained by using the voltmeter and ammeter that attached to the setup.

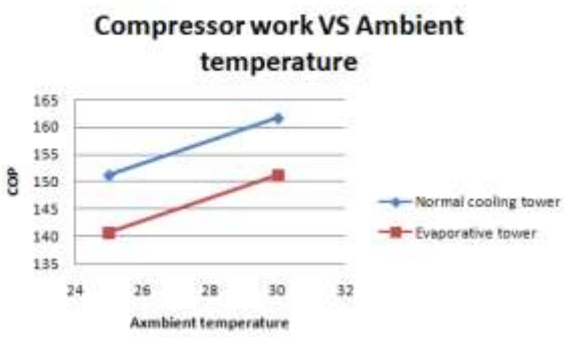
Table 2 and 3 given the result from the observation table at an ambient temperature 25°C and 30°C.

Performance result of Air Conditioner (T_{amb}-25°C)			
Parameter	**Unit**	Normal cooling tower	Evaporative cooling tower
Compressor work W_c	Watt	151.2	140.7
COP	------------	4.5	4.72

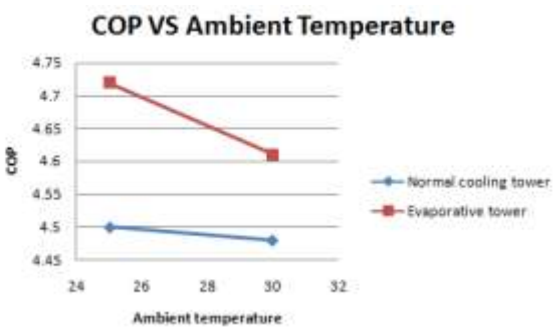
Table 2: Result of the experiment at ambient air temperature 25°C

Performance result of Air Conditioner (T_{amb}-30°C)			
Parameter	**Unit**	Normal cooling tower	Evaporative cooling tower
Compressor work W_c	Watt	161.7	151.2
COP	------------	4.48	4.61

Table 3: Result of the experiment at ambient air temperature 30°C



Graph 1: Compressor work variation ambient temperature



Graph 2: COP variation with ambient with temperature

V. CONCLUSION

This evaporative cooling tower design is very simple and we can easily applied to normal VCRS system. This can be done by employing cellulose pad in front of draught fan within cooling tower and circulate water over the cellulose pad. Due to which when incoming air pass through cellulose pad take some moisture content and then it enter into cooling tower at the same time hot water from condenser is pumped to cooling tower , which is cooled down by this circulated air. VCRS system requires certain economical modification with no extra skill require. So we can easily installed evaporative cooling tower in VCRS system.

We present a novel design of evaporative cooling tower concept in which cellulose pad is to be installed in front of draught fan. From(graph1) which shows that as increase in ambient temperature compressor work increase. But compressor work of evaporative cooling tower is less as compared to normal cooling tower. Similarly from (graph 2) COP of system decrease as the ambient temperature goes on increase. But COP of system with evaporative cooling tower is more as compared to normal cooling tower. The test result shows that evaporative cooling tower has high COP for both ambient temperature 25°C and 30°C. 4.8% change in COP as we move from normal cooling tower to evaporative cooling tower at ambient temperature 25°C.Similarly 2.9% change in COP when temperature changes from 25°C to 30°C.The test result explain that it have high cooling capacity as compared to normal cooling tower.

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BIOGRAPHICAL NOTES

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