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Experimental Study of Improving the COP of VCRS system by using Single and Double Cellulose pad in Cooling Tower

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Abstract: *In subtropical region where the outside climate air is humid and hot. Here water cooled condenser system is more effective as compared to air cooled condenser system. As the standard VCRS (water cooled condenser) approach practical limits, experimental modification should be performed to increase the system efficiency and capacity. One possible mean to increase the COP of VCRS (water cooled condenser) is by using cooling tower. Cooling tower consist of single or double thickness cellulose pad within the system.*
Related studied focus on to improve the COP of VCRS system. Here the cooling tower performance is improved due to good water wet ability of cellulose pad that cause a uniform water circulation over the entire surface of pad and a perfect contact between water and cooling air.

A VCRS (water cooled condenser) has been built attached with a cooling tower consist of two different same thickness cellulose pad. In first case when single pad 2inch thickness is used in cooling tower at two different ambient temperatures 27°C and 30°C.The COP changes from 4.93 to 4.68 as ambient temperature increase. Similarly in second case when double pad of same 2inch thickness is used in cooling tower COP change from 5.15 to 4.98 as move from 27°C to 30°C.

Keywords: *Water cooled condenser, Cooling tower, vapour compression refrigeration system, evaporative cooling pad.*

I. INTRODUCTION

Increase in Environmental pollution and Depleting energy resources have changed the attention of all scientists and researchers toward alternative Air Conditioning System. Also power demand associated with refrigeration system increase the energy consumption all over across country has been noticeably in last few decade. The climatic changes occur and global warming in environment rises due to increase in demand of Refrigeration Air Conditioning appliances. Per capita power consumption, economy and population growth has shown an increasing demand of power from last few decades. According to survey conducted by RECS (Residential Energy Consumption Survey) in US during 2009, it shows a report that 62% of Residential homes have air conditioning system. It is very high in value as compared to year 1997 which is 48% and in 1978 it is 24%.During hot summer days there is increase in energy demand due to which electricity consumption is also increases. In this project we have concentrated our focus toward the improving the performance of VCRS(water cooled condenser) by using cooling tower consist of single and double same thickness of cellulose pad. Here cooling tower cool the warm water discharged from the condenser and feed the cooled water back to the condenser. They, thus reduce the demand of cooling water in system. At two different ambient temperatures 27°C and 30°C COP is more in double pad thickness 4.98 to 5.15 as compare to single cellulose pad thickness 4.93 to 4.68.

S.S. Hu, B.J. Huang et al. [1] 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. [2] 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. S.D.White et al. [3] in this work aims to develop a system which requires less floor area, increase the evaporation rate and to recover the fresh water from the water evaporated from the effluent. The system works on the principle of simultaneous heat and mass transfer that takes place between the soak liquor and air in the spray tower leading to evaporation of water in soak liquor. Studies are carried out to utilize the heat rejected from the condenser of the VCR system to increase the temperature of the soak liquor [4]. The hot soak liquor can be sprayed in the enclosed chamber to enhance the contact area between the soak liquor and air. Thus, both the process will contribute for increase in the evaporation rate compared to the conventional method. Moreover in present situation there is more scarcity for the availability of water. It will be useful if we recover fresh water from the above evaporation process. Efforts are made to recover the fresh water from the above evaporation process using the cooling load available in the evaporator of the VCR system. Two Korean patents try to reduce the amount of water by reducing the amount of evaporative losses. Kyung Seok Kang uses hollow fiber membrane filter modules to recapture cooling water vapour and Hoogeun Lee uses honeycomb, pleated or web-like fiber filters to absorb water vapor coming out of cooling towers. However, the amount of vapor that can be recovered from such systems is not indicated. The ultimate goal of the Water Efficiency Project is to find applicable mechanisms which improve overall water efficiency of cooling towers. K.A. Jahangeer et al**.** [5] concentrated on lowering of the condensing temperature will help to reduce compressor pressure lift, thereby reducing the power required by the compressor. Yang et al.[6] investigated about application of mist evaporative precooling to air cooled chillers. The experimental results showed that the dry bulb temperature of entering condenser air with water mist pre-cooling could drop by up to 9.40 C from the ambient air temperature. COP could be improved by up to 18.6%. This study showed that the water mist system coupled to air-cooled chillers is an energy efficient and environment friendly technique. G.G. Momin et al. [6] in this paper recover waste heat from condenser unit of a household refrigerator to improve the performance of the system. The heat recovery from the household refrigerator is by thermo siphon. From the experimentation it was found that after recovering heat from the condenser of the conventional refrigerator its performance get improved than conventional refrigerator [7].

II. EXPERIMENTAL SETUP

The experimental setup (Figure 1) consists of a single stage vapour compression system with the basic components i.e. evaporator, compressor, expansion device and condenser. A tank of ten liters is built and condenser is put in that tank and tank is filled with water as shown in the figures. A water circulation system including a small pump (15Watt) is put in the tank and the outlet of pump is connected to the cooling tower because the function of the pump is to transfer the hot water from the condenser tank in to the cooling tower where it is cooled a bucket. Water circulation rate is constant for all tests. Hot ambient water is passes over the evaporative media pad of the cooling tower and gets cooled and cooled water is collected in the tank which is located in the below of the cooling tower in the cooling tower tank second pump is installed, function of this pump is to transfer the cooled water from the cooling tower tank in to the condenser tank, it become a closed cycle in which hot water and cold water circulate. In cooling tower evaporative pad of thickness 2 inch is used.

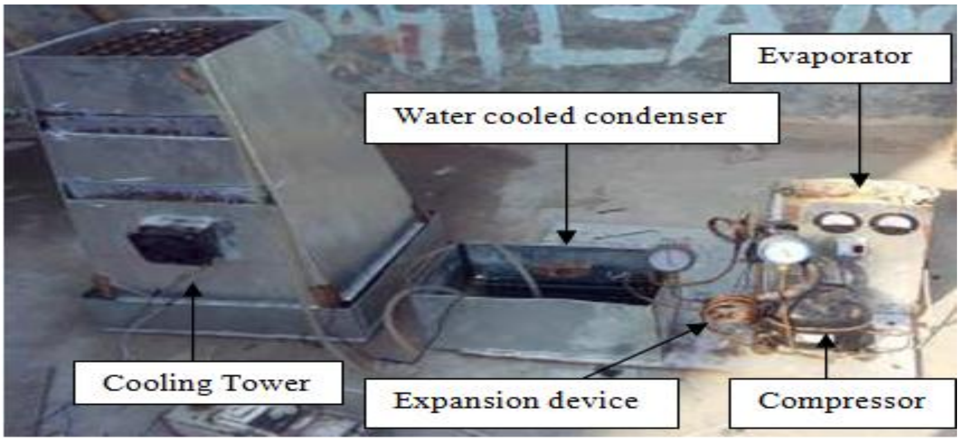


Fig.1. VCRS system attached with cooling tower

A cellulose pad of 2 inch thickness is installed in the cooling tower. The main function of cellulose pad is to provide the evaporative action by transferring the latent heat of water coming from water dip condenser.

Ammeter and voltmeter is used to measure the electrical current and voltage of input power respectively. The bourdon pressure gauges are used to measure the inlet and outlet pressure of compressor. Temperatures of refrigerant and circulation air at different points are recorded with RTD PT100 type thermocouples. Before temperature measurement, the surfaces of the tubes are polished for removing any dust or rust and then the thermocouples are laid down on the surface. Insulation tapes are wrapped around the copper tubes to make good contact and also prevent any convection effect of ambient air on the temperature readings.

Table 1: Result obtained by using single and double cellulose pad

Parameters	Unit and Symbol	Single Cellulose Pad		Double Cellulose Pad	
		At 27°C	At 30°C	At 27 °C	At 30 °C
Suction Pressure	Psi	5	5	5	5
Discharge Pressure	Psi	148	148	160	160
Condenser Inlet Temperature	Degree Celsius(°C)	35.2	37.4	35.7	37.9
Condenser Outlet Temperature	Degree Celsius(°C)	28.1	30.3	26.4	28.6
Compressor Inlet Temperature	Degree Celsius(°C)	19.2	21.2	13.1	15.1
Compressor Outlet Temperature	Degree Celsius(°C)	35.3	37.3	32.1	34.1
Evaporator Inlet Temperature	Degree Celsius(°C)	21.2	20.5	20.5	19.8
Evaporator Outlet Temperature	Degree Celsius(°C)	-18.1	-17.4	-19.8	-19.1
Current	Ampere(A)	1.5	1.25	0.7	0.72
Voltage	Volt(V)	200	200	210	210

III. CALCULATION AND RESULT

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 and we are getting different parameter by varying the cellulose pad. Such parameters are compressor work, COP of the system is calculating from the required following equation.

A. Compressor Work $W_c = V * I = m_{ref} * (h_2 - h_1)$

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,
h1 = enthalpy of refrigerant at inlet of compressor in kj/kg (1)
h2 = enthalpy of refrigerant at exit of compressor in kj/kg (2)
h3 = enthalpy of refrigerant at exit of the condenser kj/kg (3)
h4 = enthalpy of refrigerant at entry of evaporator in kj/kg (4)

Table 2.Result of the experiment at ambient air temperature 27°C

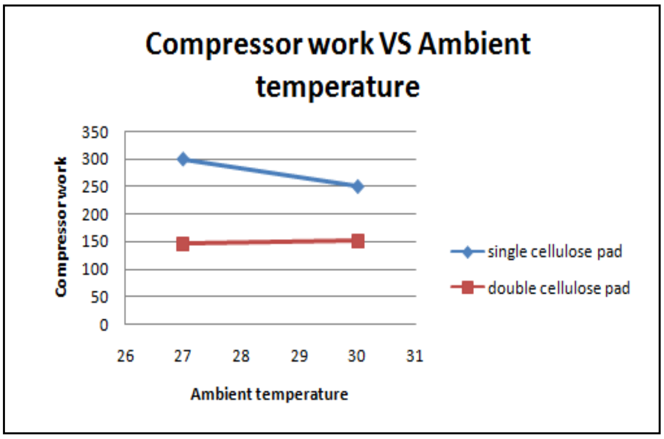
Performance result of Air Conditioner (T_{amb}-27°C)			
Parameter	**Unit**	**Single Thickness Pad**	**Double Thickness Pad**
Compressor work W_c	Watt	300	147
COP	------------	4.93	5.15

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

Performance result of Air Conditioner (T_{amb}-30°C)			
Parameter	**Unit**	**Single Thickness Pad**	**Double Thickness Pad**
Compressor work W_c	Watt	250	151.2
COP	------------	4.68	4.98

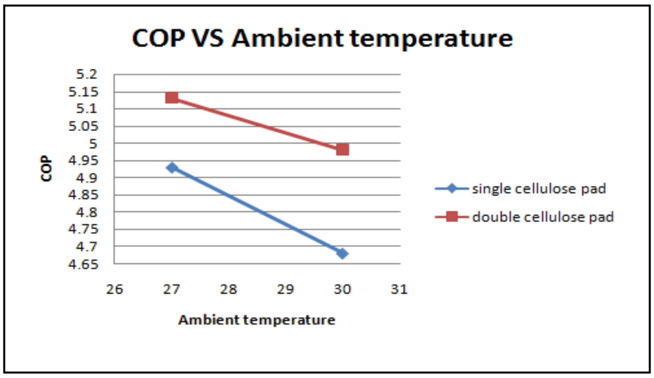
The compressor work done is obtained by the input power given to the experimental setup. The voltage and current of the input power is obtained by using the voltmeter and ammeter that attached to the setup. Table 2 and 3 given the result from the observation table at an ambient temperature 27°C and 30°C.

Graph 1. Compressor work variation with ambient temperature



Effect of ambient temperature on compressor work (Graph 1) shows that variation of compressor work with ambient temperature at two different thicknesses of cellulose pad. The compressor work at single cellulose pad is more than that of double cellulose pad at ambient temperature 27°C.Similarly in second case compressor work is more in single of cellulose pad as compare to double pad for ambient temperature 30°C.

Graph 2. COP variation with ambient temperature



Effect of ambient temperature on COP (Graph 2) show that the variation of COP with ambient temperature. The COP at double pad more than that of single pad at ambient temperature27°C.Similarly COP is more in case of double thickness pad as compare to the single pad at same ambient temperature 30°C. Also from the graph COP is more at an ambient temperature 27°C to that of 30°C.

IV. Conclusion

A VCRS With cooling tower is experimentally investigated. Experimentally result shows that there is considerable change in compressor work when we vary the thickness of cellulose pad at same ambient temperature. But when we compare compressor pressure work at two different ambient temperatures 27°C and 30°C for a same thickness of two cellulose pad i.e. single and double pad, compressor work is more in case of single pad.

Also experimental result shows that there is increase in COP, when we increase the single cellulose pad to double at same ambient temperature. But when we compare COP at two different temperatures 27°C and 30°C, COP is more at 27°C for both cellulose pad single and double. There is increase in the COP 0.22 from Single pad to double pad at same ambient temperature 27°C and at the ambient temperature 30°C there is increase in COP 0.3 from single to double .It is also seen that COP decrease 0.25 from ambient temperature 30°C to 27°C when we using single thickness pad. Similarly, COP decrease 0.17 from ambient temperature 30°C to 27°C by using double thickness cellulose pad. Thus increase in double of the cellulose pad increase the COP of the system at same ambient temperature.

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