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To Study Various Performance Parameter of a Vapor Compression Refrigeration System with Two Evaporators using R-134(a)

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Abstract—*This experimental study is based on vapor compression refrigeration (VCR) system with two evaporators which are connected one after another in series. These evaporators are identical in every aspect. The cooling of the second evaporator takes place after the first. In this study we discussed variation of various parameters with time i.e. C.O.P., cooling capacity, heat rejection in condenser, suction and discharge pressure etc. There C.O.P. found in the range of 2.82-3.11; cooling capacity in the range of 149.22-152.88 KJ/kg, heat rejection in the range of 200-202.7 kJ/kg, suction and discharge pressure in the range of 1.11-1.21and 11.31-12.41 bar respectively. In this study, the value of C.O.P., Cooling capacity and heat rejection is minimum & work input and discharge pressure is maximum at peak hour condition i.e. about 1:00-2:00 PM. R-134(a) is used as a circulating refrigerant in this study.*

1. INTRODUCTION

Some processes are to be carried out at a temperature lower than that of surroundings, for maintaining this lower temperature some refrigeration system is required. These refrigeration systems may be thermoelectric refrigeration, reverse Brayton cycle, air refrigeration system, steam jet refrigeration system and vapor compression refrigeration system. But all these refrigeration system vapor compression refrigeration system is highly efficient. Jacob Perkins in 1834 made the first vapor compression refrigeration system. A vapor compression refrigeration system basically consists of four components i.e. Evaporator, compressor, condenser and an expansion device. In this refrigeration system, there are two pressure sides, one is called high-pressure side and other is lower pressure side. Lower pressure side is the side on which evaporator is fitted and compressor takes suction from this & High-pressure side on which condenser is fitted and compressor discharge to this pressure. In expansion device, refrigerant expands from condenser pressure to evaporator pressure.

Refrigeration and air-conditioning systems consume a large amount of electricity. For a developing nation, generation of electricity is a major problem because these have limited resources. So that certain modifications are made in the VCR cycle to increase the C.O.P. of the refrigeration system.

Qureshi and Zubair [1] studied the effect of various refrigerants in dedicated mechanical cooling VCR system and it is concluded that R-134 (a) gives the better result as compare to another refrigerant. Pottker and Hrnjak [2] studied that as the size of condenser increases, then there increase in C.O.P. of the system because of subcooling of refrigerant in the coils of the condenser. The maximum degree of subcooling is achieved for R-744 as compare to R-717 and R-410A. Li and Hrnjak [3] studied that as we separate the two-phase flow in condenser coil there decrease in temperature of 1.3 kelvin for the same mass flow rate of R-134(a) and cause an increase in efficiency of the system. Park et al. [4] studied that by employing suction line heat exchanger in VCR system categorized refrigerant into two groups, one for increase in C.O.P. (R-507A, R-134 (a), R-12, R-404A, R-290, R-407, R-600, R744, R-1234yf and R-410A) and another group for C.O.P. is same for (R-22, R-32 and R-717). Li and Su [5] studied a refrigeration system by using two evaporators with R-290 as a refrigerant and showed that mass flow rate of R-290 is a function of condenser pressure, high-temperature capillary length & subcooling of refrigerant and heat transfer coefficient is affected by condensing pressure and LMTD of evaporators. He. et al. [6] Studied experimentally a VCR system with multi evaporators in series and parallel configuration, and discuss various parameter of both of the configuration. Yataganbaba et al. [7] studied the exergy efficiency of a two evaporator VCR system mainly depends upon the temperature of first evaporator and condenser. This has the highest value for R-1234ze and R-134 (a).

2. EXPERIMENTAL SETUP

Figure 1 shows the experimental setup for this study. The basic components of this experimental setup are a compressor, condenser with fan motor, drier, adiabatic capillary tube and two evaporators. In this experimental setup, we used two pressure gauges at the inlet and outlet of the compressor to measure the suction and discharge pressure of the system. These are represented by the Symbol [P] in the schematic diagram. We also provide some temperature measuring instrument called thermocouple at the requisite position to measure the temperature of that position. These are represented by the symbol [T].

3. SPECIFICATIONS OF COMPONENT

I. Compressor:

In this experimental study, we used hermetically sealed compressor of 140 watts of model NO. THK1351YJF manufactured by Tecumseh.

II. Condenser:

In this investigation, we used a condenser of copper piping with fins and provided with a fan motor of capacity 5 watts to reject waste heat from the system to the ambient.

III. Adiabatic capillary tube:

The cheapest and main component of this experimental study is the expansion device. This is used for fall in pressure and temperature from condenser conditions to the evaporators' conditions for production of refrigeration effect at constant enthalpy in ideal condition. In this investigation, we use a coiled capillary tube of diameter 0.7mm and length of 1.6 meters.

IV. Evaporators:

This is the region that we want to maintain at desired temperature conditions irrespective of environmental conditions. So this component is the most important component of any refrigeration system. In this study, we used two evaporators made of wooden of size 12''*10''*6'' and inside both of this same length copper pipe is fold of diameter 9mm and proper insulation is provided to prevent heat gain from surroundings.

V. Drier:

This is the necessary fitting provided between the condenser and adiabatic capillary tube for the proper functioning of any VCR system. The purpose of this to entrap the impurity and moisture may come from surroundings.

Figure 2 and figure 3 shows the schematic diagram of and corresponding pressure-enthalpy (P-h) diagram of this experimental study. The processes on P-h curve 1-2 (compression), 2-3 (heat rejection), and 3-4 (isenthalpic expansion) as usual. The point 4 & 5 represents the outlet of capillary tube/inlet of 1st evaporator and outlet of 1st evaporator/inlet of 2nd evaporator respectively, Where Points 5 & 1 represents outlet of 1st evaporator/inlet of 2nd evaporator and outlet of 2nd evaporator/inlet to the compressor.

Figure 1: Experimental Setup, At NIT Kurukshetra

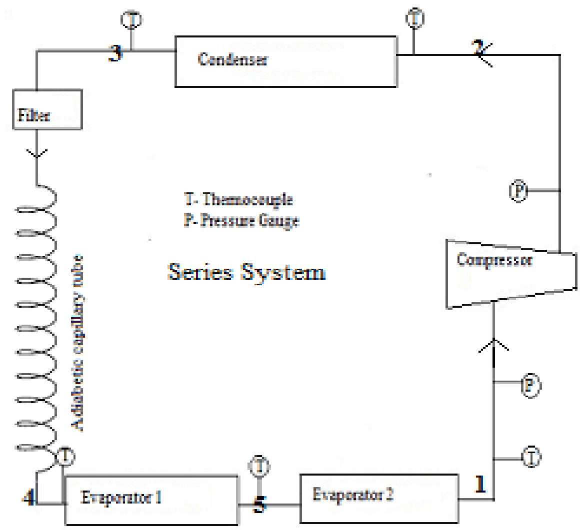

Figure 2: Schematic diagram experimental study

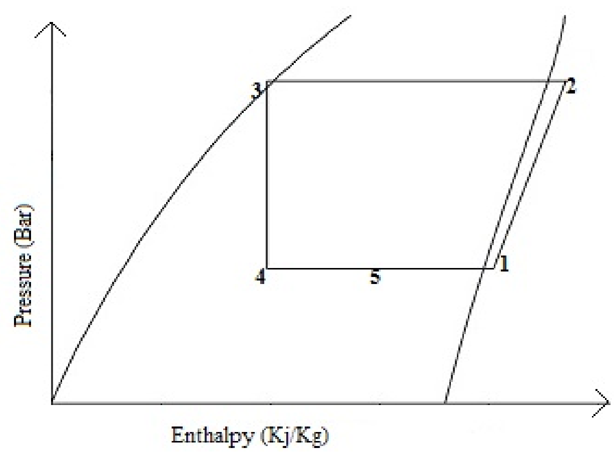

Figure 3: Pressure-Enthalpy diagram for series system

All the components are discussed above are connected by the copper pipe of diameter 9 mm and proper insulation is provided on requisite location and we assume that this is 100% effective. There is no heat gain from the surroundings.

4. EXPERIMENTAL RESULTS AND DISCUSSIONS

We had to take the reading of the experimental setup for the seven different days of the 1st week of month February 2018, at NIT Kurukshetra from 9:30 AM to 3:30 PM. The reading is taken after every 30 minutes. For plotting various graphs we take the average of different seven days reading.

Figure 4 shows the variation of heat rejection in the condenser with time. This represents the total heat rejected by both evaporators. The heat is rejected by the refrigerant in the air-cooled condenser is a function of time. The average value of heat rejection in the condenser is given by 201.13 KJ/Kg. This is nearly constant between 11:00 AM to 1:00 PM. The value of heat rejection is minimum at peak hour condition. This figure shows the total heat capacity of both evaporators at that particular time. The maximum value of cooling capacity is 152.88 KJ/kg at ambient temperature about 14-16°C. The cooling capacity also varies as ambient temperature varies from morning to evening is shown in the figure 5. The average value of total cooling capacity is about 150.82 KJ/Kg.

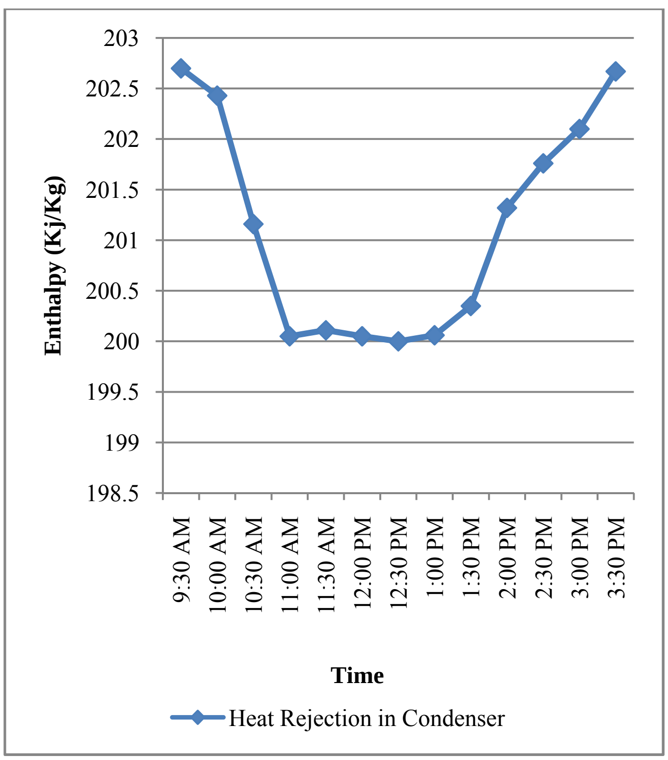

Figure 4: Heat rejection in condenser

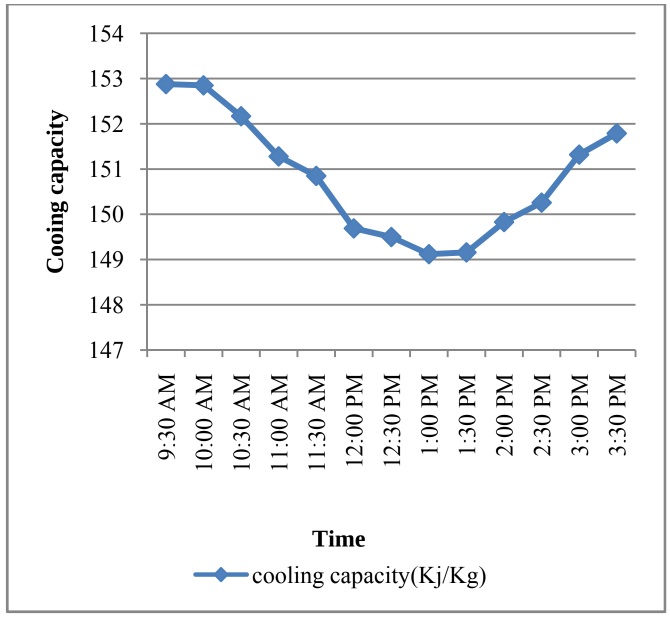

Figure 5: Variation of total cooling capacity of system with time

Figure 6 shows the inside temperature of both evaporators and their variation with time. The inside temperature of the first evaporator (means 1st after capillary tube) lower than the 2nd one. This temperature variation showed that evaporator 1st space cools at the higher rate and in less time. So items placed in 2nd cools after first. This also verified by us by putting 300 ML of water in both evaporators. Figure 7 shows the C.O.P. variation of the system with time. The C.O.P. varies in the similar fashion as the cooling capacity and heat rejection in condenser varies with time. The average value of C.O.P. is about 2.93.

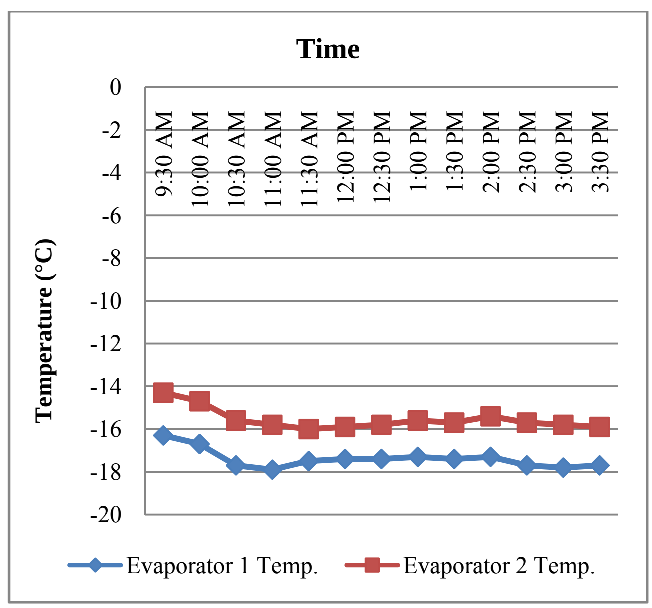

Figure 6: Variation of evaporators inside temperature with time

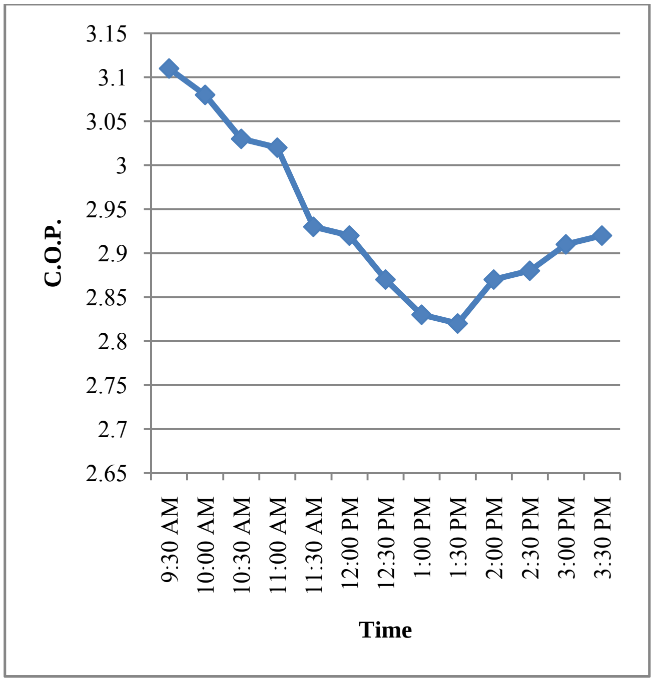

Figure 7 Variation of C.O.P. of system with time.

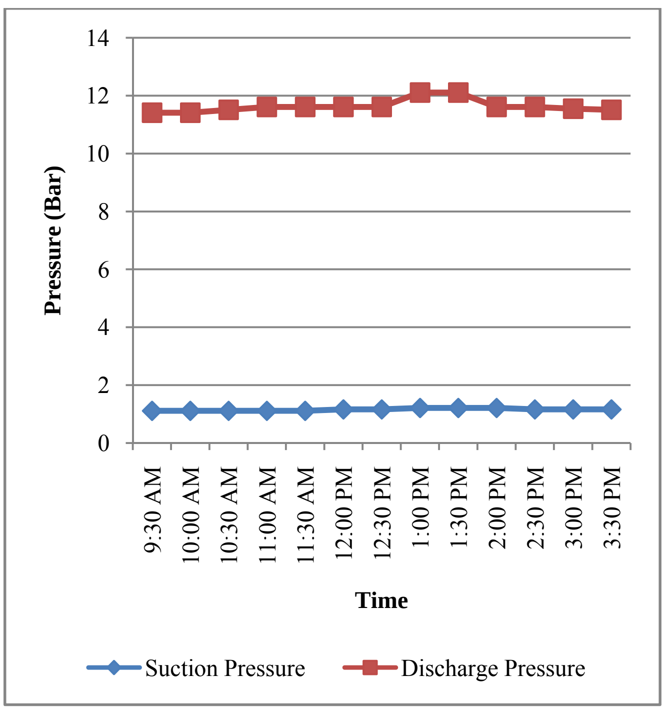

Figure 8 Variation of suction & discharge pressure with time.

For measurement of suction & discharge pressure, we assumed that there is no pressure loss in the system. The variation of both with time showed in figure 8. The suction pressure is nearly constant but discharge pressure strongly depends upon the ambient temperature and varies continuously with time. The discharge pressure is at its highest peak at about 1:30- 2:30 PM and the value of 12.41 bar.

5. CONCLUSIONS

In this paper, we had studied the various performance parameter of VCR system with two evaporators which are connected in series. The variation of these performance parameters with time is plotted. The value of each plot varies continuously with time. From the plot heat rejection in the condenser, we concluded that as the ambient temperature increases (9:30 AM to 1:30 PM) there decrease in heat rejection this is because of the decrease in the temperature difference between condenser temperature (refrigerant) and ambient. But cooling capacity also decreases because of increase in difference of evaporators temperature (refrigerant) and ambient. From combined effect all performance parameter we concluded that system C.O.P. is minimum at 1:00 PM - 2:00 PM and the evaporator 1 had always at the lower temperature than evaporator (figure 6). From this, we also concluded that if there two unequal loads, then putting the higher load in 1st evaporator gives higher C.O.P. than putting the higher load in the 2nd evaporator.

REFERENCES

[1] Qureshi Ahmed B., Zubair Syed M., “The effect of refrigerant combinations on performance of a vapor compression refrigeration system with dedicated mechanical sub-cooling”, International Journal of Refrigeration, 35, 6 October 2011, pp. 47-57.

[2] Pottker G., Hrnjak P., “Effect of the condenser subcooling on the performance of vapor compression systems”, International Journal of Refrigeration, 50, 10 November 2014, pp. 156-164.

[3] Li j., Hrnjak P., “Separation in condensers as a way to improve efficiency”, International Journal of Refrigeration, 18, 21 March 2017, pp. 1-9.

[4] Park C., Lee H., Hwang Y., Radermacher R., “Recent advances in vapor compression cycle technologies”, International Journal of Refrigeration, 60, 20 August 2015, pp. 118-125.

[5] Li Chao-J., Su Chin-C., "Characteristics of a series-connected two-evaporator refrigerating system", Applied Thermal Engineering, 25, 25 September 2004, pp. 519-532.

[6] He, J., Wu, Y., Chen X., Lu Y., Ma C., Du, C., Liu G., Ma R., " Experimental study of a miniature vapor compression refrigeration system with two heat sink evaporators connected in series or in parallel", International Journal of Refrigeration, 49, 16 October 2014, pp.28-35.

[7] Yataganbaba A., Kilicarslan A., Kurtbaş i. "Exergy analysis of r1234yf and R1234ze as R134a replacements in a two evaporator vapour compression refrigeration system", International Journal of Refrigeration", 20 August 2015, 60, pp. 26-37.