Experimental Performance Analysis and Evaluation of COP of Vapor Compression Refrigeration System on Different Mass Flow Rate of R134a as Refrigerant

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***Abstract*- The present project report is based on Vapor Compression refrigeration. Refrigeration is one of the most equipment used in home appliances utilizing vapor compression cycle in its process. The refrigerant is a heat carrying medium which during their cycle (i.e. compression, condensation, expansion and evaporation) in the refrigeration system absorbs heat from a low temperature system and discards the heat so absorbed to a higher temperature system. Properties of good refrigerants are low boiling point, high critical temperature, high latent heat of vaporization, low cost. Refrigerant is a substance used in a heat cycle usually for enhancing efficiency, by a reversible phase transition from a liquid to a gas. R134a is an inert gas used primarily as a "high-temperature" refrigerant for domestic refrigeration and automobile air conditioners. In this paper, the experiment used Domestic Refrigerator R-134a. The main objective of this experiment is to find out coefficient of performance of refrigerator and Actual COP, avg. COP etc. In this experiment we used Refrigerant R-134a to calculate the COP at particular time and measure temperature and pressure. The project setup run in 2 hrs. to evaporate refrigeration measure for COP of Domestic Refrigeration. The thermocouple and pressure gauge are used to measure temperature and pressure of all unit. Four thermocouple is used to measure temperature and Burdon tubed type pressure gauge is used to measure pressure at Inlet and outlet of the compressor. Therefore, this paper presentation experimental investigation of the performance of refrigeration cycle the COP is studied by using different mass flow rate value.**

Index Terms- R-134a, Refrigerator, thermocouple, COP, Refrigerator Test Rig. VCRs system, condenser, air cooled, evaporator, compressor, expansion device, Capillary tube.

I. LITERATURE REVIEW & INTRODUCTION

Refrigeration may be defined as lowering the temperature of an enclosed space by removing heat from that space and transferring it elsewhere. The most frequently used refrigeration cycle is the vapor compression refrigeration cycle. The refrigerator is employing the isentropic compression at lower pressure by Refrigeration Ideal vapor compression refrigeration cycle results, by eliminating impracticalities associated with reversed Carnot cycle such as vaporizing the refrigerant completely before compression, replacing turbine with throttling device (expansion valve or capillary tube). Generally, domestic and industrial refrigerator, air conditioning system, heat pump and water cooler designed based on vapor compression refrigeration cycle. The refrigeration systems work on vapor compression cycle comprising of evaporator, compressor, condenser, and expansion device. A capillary tube as an expansion device allows hermetically sealed compressor to start in an unloaded condition by allowing the pressures between the condenser and evaporator to equalize during the off cycle, thus, reduces the required starting torque of the compressor. The capillary tube as a throttling device is simple, reliable, and inexpensive. The capillary tube is used where the cooling load is almost constant and the cooling capacity is less than 3 TR. Capillary tube is a long narrow hollow copper tube with an internal diameter ranging from 0.5 to 2.0 mm.

II. LITERATURE REVIEW

In 1805, the American inventor Oliver Evans [1] described a closed vapor-compression refrigeration cycle for the production of ice by ether under vacuum. Heat would be removed from the environment by recycling vaporized refrigerant, where it would move through a compressor and condenser and would eventually revert to a liquid form in order to repeat the refrigeration process over again. Bergander [2] investigated new regenerative cycle for vapor compression refrigeration which described a novel approach to the Rankine vapor compression cycle for cooling and refrigeration. Results obtained were showed that pressure on the ejector increased by 15-16% and prototype achieved energy saving of 16%. Akintunde [3] obtained the validation of a design model for vapor compression refrigeration system developed by Akintunde [4]. This model was used to design a vapor compression refrigeration system. The analysis showed that the model results were comparable to the actual system from both quantitative and qualitative points of view. Under the same operational conditions, maximum absolute deviations of the variable parameters – mass flow rate, coefficient of performance and circulating water temperature were within the range of 16%. A. Selvaraju and A. Mani [5] investigate the experimental analysis of the performance of a vapor ejector refrigeration system. The Kairouani, M. Elakhdar, E. Nehdi and N. Bouaziz [6] presented an improved cooling cycle for a conventional multi-evaporators simple compression system utilizing ejector for vapor precompression is analyzed.

EXPERIMENTAL SETUP DESCRIPTION

The refrigeration tutor works on vapor compression cycle. The basic components of VCC are:

FIGURE 1: VCRT RIG EQUIPMENT

1-Thermocouples: Five thermocouples are used in our test rig. The readings of the thermocouples are taken by knob by rotating it. first thermocouple fit at outlet of the condenser. Second and third thermocouples are fitted in the condenser tank and evaporator tank respectively. And remaining thermocouples are fitted in inlet water tank, inlet to condenser and outlet to evaporator.

2-Condenser: The condenser condensate refrigerant where it loses heat energy to atmospheric air and the temp of refrigerant is decreased. The low temperature refrigerant is transferred to expansion valve. Vapor refrigerant gets condensed by rejecting latent heat and changes to liquid state then passes to expansion valve. Follows constant pressure process. Wet refrigerant abstracts latent heat from surroundings/room to be cooled and produces required refrigeration. The refrigerant converts to vapor and passes to compressor to continue the cycle.

3-Evaporator: The refrigerant absorb heat energy from hot water which is heated by using heater.so because of absorption of heat energy the temp of water is decreased and temp of refrigerant is increased. The high temp refrigerant is entered in compressor and same cycle is repeated. Then evaporation process is absorbing the heat from a refrigerated space and refrigerant against convent liquid to vapor and process completed and recycle. Condenser is rejecting the heat to atmosphere from a Refrigeration process. as shown in the figure the tub and tube type condenser and evaporator are used in the kit and the evaporator having insulator on it. These tanks contain the two mechanical agitators as shown in figure, for the continuous mixture the water, the agitator can be controlled by switch. These tanks have two valves at the lower side of tanks for the water outlet. A copper tube is used for the flow of the refrigerant in spiral form in the tub.

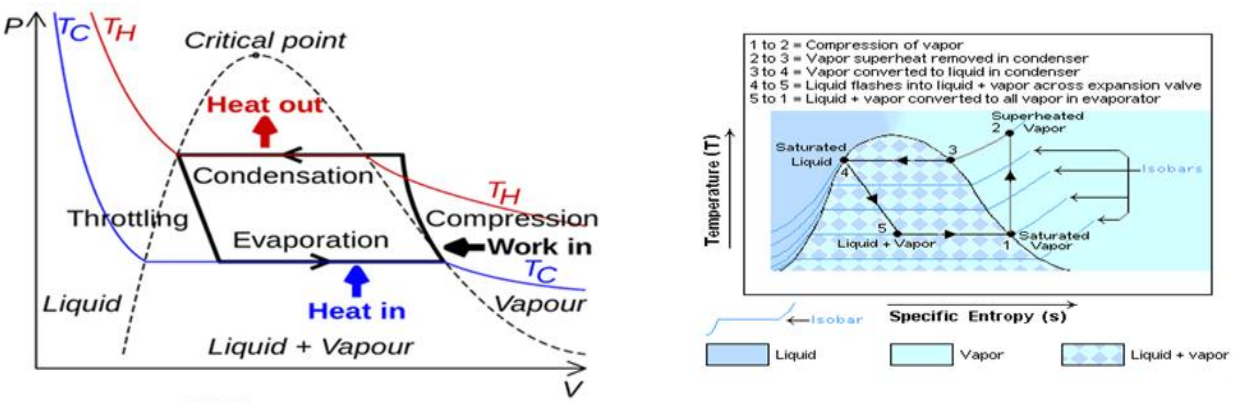
4-Display devices: Our refrigeration test-rig contains LED type display device. All the readings are shown through these display devices.

5-Rotameter and water tank: Rotameter is fitted in between water tank and the condenser and evaporator tank and it contains a motor that is used to raise the pressure of the water and it contains a switch by which the flow of water can be controlled.

6-Expansion valve, compressor and drier: The high temp refrigerant comes into compressor where it is compressed to high pressure and it is transferred to condenser. Low pressure and low temperature vapor refrigerant from evaporator gets compressed to high pressure and high temperature vapor refrigerant then passes to condenser. Follows isentropic process Liquid refrigerant pressure, temperature got reduced to low and converts to wet state condition due to throttling then passes to evaporator. Follows isenthalpic process. Then, expansion valve is throttle to control refrigerant flow to condenser to evaporator or in closed space. Expansion valve is called capillary tube. Compressor is a mechanical device used to compress the Refrigeration from leveling the evaporator at low pressure temp region and discharge to high pressure. The drier is used to absorb the moisture content and it is placed between the inlet to evaporator and outlet to the condenser. A copper capillary tube type expansion device is being used for the expansion of the refrigerant and it is placed between drier and evaporator.

7-Pressure gauges: The two pressure gauges are used, one at high pressure side and other one is placed at the lower pressure side to measure the condenser pressure and evaporator pressure respectively. Means one is suction pressure gauge and other one is discharge pressure gauge, suction pressure gauge having pressure range from 0 to 150 psi and discharge pressure gauge having pressure range from 0 to 300 psi.

The process of Simple VCRS is as follows:



P-V Diagram T-S Diagram

FIGURE 2: Typical Single Layout Vapor Compression Refrigeration

Mathematical Calculation

Observation Table No. 1:

Sr. No.	Description	Symbol	Readings terms
1	Condensing Pressure	Pc	Discharge pressure
2	Evaporator Pressure	Pe	Suction pressure
3	Condensing inlet	T2	Discharge

	Temp		temperature
4	Condensing outlet Temp	T3	Condenser temperature
5	Evaporator inlet Temp	T4	Expansion temperature
6	Evaporator Outlet Temp	T1	Suction temperature
7	Water temp in tank	T5	Water temperature
8	Compressor energy -Time for 10 Flashes	Second	Meter reading

Observation Table No. 2:

Capillary Length inches	T1 ℃	T2 ℃	T3 ℃	T4 ℃	Mass flow rate Kg/sec	Wcomp	C.O.P.
36	35.8	42.6	36.3	29.8	0.15	0.20	0.88
40	35.8	46.1	36.8	28.3	0.30	0.22	0.72
44	35.8	49.1	37.0	27.8	0.36	0.24	0.60
50	35.8	53.3	37.0	26.2	0.42	0.25	0.54
55	35.8	55.1	37.0	24.9	0.45	0.26	0.56

Calculations:

1.Compressor Work = $\frac{No.of\ turn\ counted}{Time\ taken\ to\ completed\ no.} \times \frac{3600}{600}$

Sr. No.	Capillary length Inch.	Mass flow rate	No. of counted turn	Time taken to complete turns	Wcomp
1	36	0.15	10	300 sec	0.20
2	40	0.30	10	270 sec	0.22
3	44	0.36	10	250 sec	0.24
4	50	0.42	10	240 sec	0.25
5	55	0.45	10	230 sec	0.26

2.Actual COP = $\frac{Refrigeration\ effect}{Work\ Done}$

For 36inch capillary tube length

COP = $\frac{T1-T4}{T2-T1} = \frac{35.8-29.8}{42.6-35.8}$ = 0.88 or 88%

Similarly,

For 40inch capillary tube length, COP = 0.72 or 72%

For 44inch capillary tube length, COP = 0.60 or 60%

For 50inch capillary tube length, COP = 0.54 or 54%

For 55inch capillary tube length, COP = 0.50 or 50%

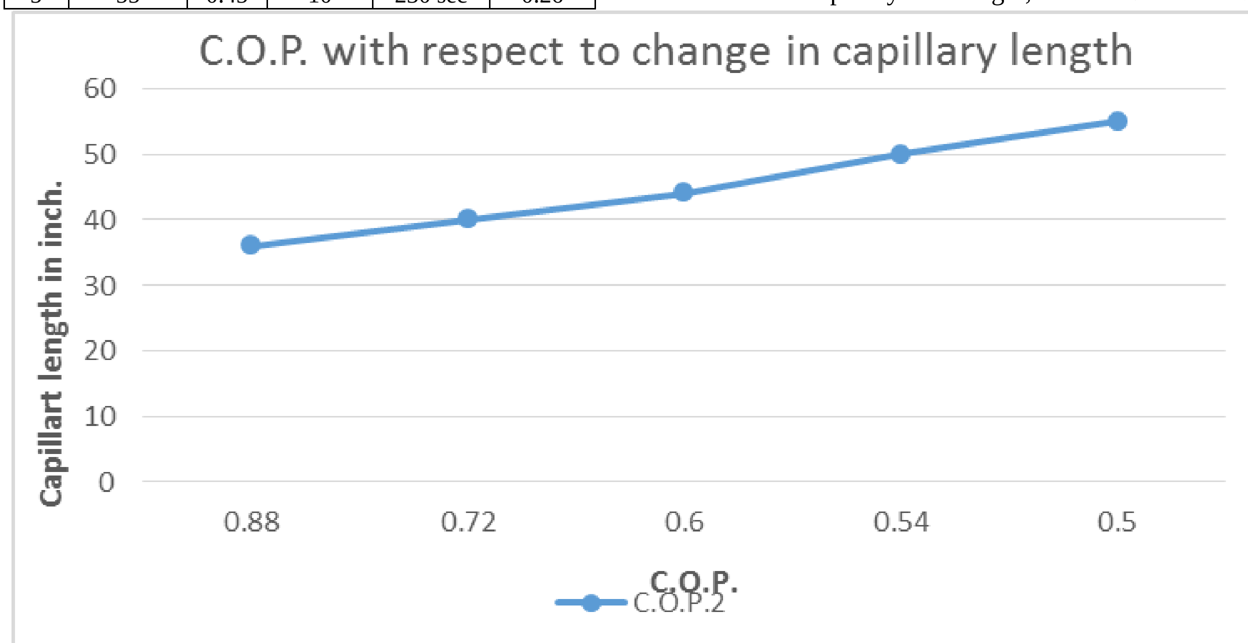


FIGURE 3: Chart of Relationship or C.O.P. & Capillary Length

III. CONCLUSION

The performance of VCR system successfully validated with the help of our mathematical model and the effect of various parameters like mass flow rate of refrigerant, condenser temperature, evaporator temperature, input temperatures in condenser and evaporator etc. on the COP and vapor compression refrigeration system. After drawing the curves between the capillary tube length and C.O.P. The result come like:

1. As mass flow rate of water increases the COP of VCR system decreases.
2. As compressor work increases the COP of the VCR system decreases.
3. As the input temperature increases the COP of the VCR system decreases.
4. As capillary tube length is increase the COP of the VCR system decreases.

REFERENCE

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