Performance analysis VCRS by using Different Dimensions of Capillary

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Abstract- *Refrigeration is very important for the comfort of human. There are various types of refrigeration systems are present like VCRS System, VARS system etc. But VCRS system was most widely used in domestic and commercial applications for food preservation. The main objectives of this work is to Evaluate performance of the domestic VCRS system by using different dimension of capillary .The experimental study was conducted to investigate the cop of VCRS for different dimensions of capillary. The different dimensions of capillary include diameter (0.45mm, 0.50mm, 0.60mm) & length (0.6m, 0.8m, 0.9m) respectively. It was observed that the best suitable diameter and length of capillary tube for 0.5HP compressor was 0.5mm diameter and 0.9m length.*

Keywords- Refrigeration, VCRS system, Capillary tube, COP

I. INTRODUCTION

Refrigeration

Refrigeration may be defined as the process of achieving and maintaining a temperature below that of the surroundings, the aim being to cool some product or space to the required temperature. The history of refrigeration is very interesting since every aspect of it, the availability of refrigerants, the prime movers and the developments in compressors and the methods of refrigeration all are a part of it.

A simple vapour compression refrigeration system consists of mainly five components namely compressor, condenser, expansion device, evaporator and a filter/drier. A capillary tube is a small diameter tube which is used for the expansion of the flowing fluid. The pressure difference between the entry and exit ends of the capillary tube is always equal to the pressure difference between the condenser and the evaporator.

Background

The first mechanically produced cooling system was developed in England in 1834. The system later became known as vapor compression. After availability of electricity automatic refrigeration system was developed in 1897. Air conditioning and refrigeration systems play an important role in industry, commercial infrastructure and households. The industrial sector includes the food industry, textiles, chemicals, printing, transport and others. Infrastructure includes banks, restaurants, schools, hotels and recreational facilities.[2]

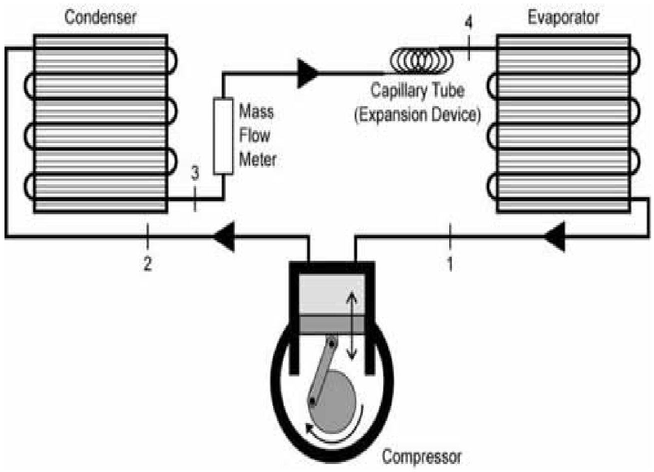

Figure 1. Vapor-Compression Refrigeration Cycle

II. LITRATURE REVIEW

Shaikh[3] performed experiment on VCRS system by using accumulator and two different types of capillary tubes. According to test results COP varies according to the diameter of the capillary tube. As the diameter changes from 3.6mm to 3.1 mm COP increases from 5.16 to 5.51.Also use of accumulator increases the life of compressor.

G. Maruthiprasad [4] used two different refrigerant and installed liquid line suction line heat exchanger in VCRS system. They concluded that refrigerant effect increases as length of heat exchanger increases.

A. Matani [5] used three different refrigerant and different diameter of capillary tubes to find COP of VCRS system. They observed that at pressure 70lb/in2 COP of refrigerant R-134a is maximum. Also smaller diameter of capillary tube shows maximum COP.

James M. Calm [6], has studied the emission and environmental impacts of R11, R123, R134a due to leakage from centrifugal chiller system. He also investigated the total impact in form of TEWI and change in system efficiency or performance due to charge loss. He also summarized the methods to reduce the refrigerant losses by the system like design modifications, improvement in preventive maintenance techniques, use of purge system for refrigerant vapour recovery, servicing and lubricant changing in system.

S.G. Kim [7] study the mass flow rate for coiled capillary and straight capillary and develop the dimensionless correlations. The mass flow rates for coiled capillary tubes are quite reduced when compared with those for straight capillary tubes especially for the cases where the coiled diameter is reduced.

K. Neelakanta [8] investigate that change in performance of one component affect the performance of other component and in turn overall performance of system. performance of system is also depend on the refrigerent that we are use in cycle. In this work it is found that the best suitable length for capillary is 1.3m which gives better performance.

Shashank pathak [9] The experimental study was done on capillary tube of 31 gauge, 36 gauge, 40 gauge. with three different configuration i.e. helical coil, straight coil, serpentine coil. Decrease the capillary tube diameter increase the mass flow rate of system.

III. EXPERIMENTAL SETUP

Figure 2. Experimental setup

The objective of the study is to compare the coefficient of performance of vapor compression refrigeration system, change in working parameter by change in dimension of capillary. The experimental setup work on VCRS system i.e compressor, condenser, expansion device, evaporator. metal bracket is made to mount this component and for safety purpose. The capillary tube is provided with 3 different dimensions at a time and the on-off valve is provide for each capillary. For diameter of capillary 0.45 there are three different length are provided , so we have to take reading of first capillary other two capillary are off .Likewise other capillary are operated by providing this arrangement. The different capillary that we are use in this experiment are as show in table.

Table 1. Different capillary used in experiment

S.r. no.	Capillary Diameter (mm)	Capillary length (m)
1	0.45	0.6
		0.8
		0.9
2	0.50	0.6
		0.8
		0.9
3	0.60	0.6
		0.8
		0.9

voltmeter and ammeter to the suction and discharge line .we are use digital temperature sensor which are connected to the condenser and evaporator inlet and outlet. Component specification was given below

Table 2.

Part no	Component	Description
V	voltmeter	0-230V
A	ammeter	0-5 A
P_d	Discharge pressure gauge	0-500 PSI
P_s	Suction pressure gauge	0-250 PSI
T_x	Temperature sensor	Digital
1	Evaporator tank	Plastic bucket
2	Condenser	Air cooled
3	Compressor	0.5 HP (hermetic seal)
4	Capillary tube	9 different dimension

Refrigerant filling process

1. First we conduct leakage test. In this test we fill the air and check all fittings and joints by soap water.
2. Start vacuum process for 1 hour.

3. Now connect charging line with R134a cylinder and refill refrigerant up to 50- 60 PSI

Experimental procedure

1. After filling refrigerant on the valve of capillary diameter 0.45mm and length 0.6m
2. Run the system till steady state. After steady state note all readings.
3. Now on the valve of second capillary wait till steady state and note down the readings.
4. Repeat the procedure next different diameters and lengths of capillary tubes.

observation table

Table 3. Observations for capillary dia.0.45m

Parameters	L-0.6m	L-0.8m	L-0.9m
Discharge pressure (PSI)	160	155	180
Suction pressure (PSI)	38	25	42
Condenser inlet temp(°C)	68	68	68
Condenser outlet temp(°C)	60	58	59
Evaporator inlet temp(°C)	12	8	10
Evaporator outlet temp(°C)	16	12	14
Ambient temp(°C)	30	30	30

Table 4. Observation for capillary dia. 0.5m

Parameters	L-0.6m	L-0.8m	L-0.9m
Discharge pressure(PSI)	160	165	170
Suction pressure(PSI)	35	38	40
Condenser inlet temp(°C)	69	70	71
Condenser outlet temp(°C)	60	62	61
Evaporator inlet temp(°C)	13	8.2	13.2
Evaporator outlet temp(°C)	17	16.3	17.3
Ambient temp(°C)	30	30	30

Table 5. Observations for capillary dia. 0.6m

Parameters	L-0.6m	L-0.8m	L-0.9m
Discharge pressure(PSI)	159	160	165
Suction pressure(PSI)	28	25	32
Condenser inlet temp(°C)	67	68	69
Condenser outlet temp(°C)	59	61	62
Evaporator inlet temp(°C)	10	8.9	12
Evaporator outlet temp(°C)	13	14	17
Ambient temp(°C)	30	30	30

Data reduction

Standard vapour compression refrigeration system can be carried by assuming

1. steady flow
2. Negligible kinetic and potential energy across each component
3. No heat transfer in connecting pipes

The steady flow energy equation is applied to compressor, condenser, evaporator

A. Evaporator

Heat transfer across evaporator
Qe = Mr(h1 – h4)

B. Compressor

Power input to compressor
Wc = Mr(h2 – h1)

C. Condenser

Heat transfer at condenser
Qc = Mr(h2 – h3)
Where
h1 = Specific enthalpy at compressor inlet (Kj/Kg)
h2 = Specific enthalpy at compressor outlet (Kj/Kg)
h4 =Specific enthalpy at evaporator inlet (Kj/Kg)
Mr = Mass flow rate of refrigerant (Kg/sec)

$$COP = \frac{Qe}{Wc} = \frac{\mathrm{Mr(h1 - h4)}}{\mathrm{Mr(h2 - h1)}} = \frac{\mathrm{(h1 - h4)}}{\mathrm{(h2 - h1)}}$$

Actual COP

$$COP = \frac{R.E.}{W.D.} = \frac{\mathrm{M * Cp * (Ta - Te)}}{\mathrm{V * I}}$$

Where
M = Mass flow rate of water
Cp = Specific heat of water in (KJ/kg k)
V = Voltage
I = Current
Ta = Ambient temperature of water
Te = Evaporator inlet temperature

IV. RESULT AND DISCUSSION

The diameter of capillary tube used in refrigeration cycle work is generally about 0.5mm and 2mm diameter. by decrease in diameter below 0.5mm the coefficient of performance is decrease as shown in both graph . We know that the frictional resistance is offer at capillary inlet due to small in diameter. hence there is sudden pressure drop. since the frictional resistance is directly proportional to length and inversely proportion to diameter. above graph shows that the theoretical coefficient of performance of vapour compression refrigeration system according to test result maximum coefficient of performance for the diameter of 0.50mm and length 0.8m.

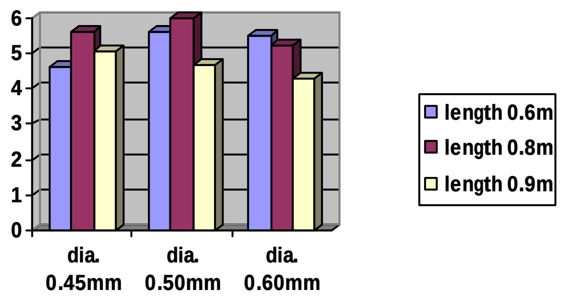

Figure 3. graph- theoretical cop vs. diameter of capillary

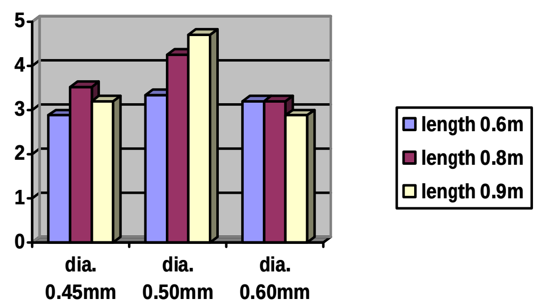

Figure 4. graph -actual cop vs. diameter of capillary

from graph it is observe that the actual coefficient of performance is maximum for diameter of capillary 0.50mm and length 0.9m. also it is observe that the value of coefficient of performance is minimum for 0.45mm and 0.60mm diameter capillary.

longer capillary tube and small in diameter , greater pressure drop, but below 0.5mm diameter the coefficient of performance is decrease. Above 0.5mm diameter we get the maximum coefficient of performance.

V. CONCLUSION

in this experimental analysis it is observe that coefficient of performance of vapour compression refrigeration system is vary by change in the dimensions of capillary. also observe that effect of working parameter like condenser inlet and outlet temprature, evaporator inlet outlet temperature, which affect the coefficient of performance of vapour compression refrigeration system.

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