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THE EFFECT OF CAPILLARY TUBE LENGTH ON THE PERFORMANCE OF VAPOUR COMPRESSION REFREGERATION SYSTEM

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ABSTRACT: The design of capillary tube plays a very important role in the performance of a vapour compression refrigeration system. Optimized design is possible through theoretical calculations, however may fail due to the reason that the uncertainties in the formulation of pressure drop inside the capillary tubes. Hence experimental investigations are the best in terms of optimization of certain design parameters.

Components of the vapour compression refrigeration system never work in isolation, change in performance of one component affect the performance of the other components and in turn overall performance of the system. Performance of the system also depends on the type, quantity of the refrigerant charged. In the present work, an attempt is made to optimize Length of capillary tube for refrigeration unit of capacity 30lts, with R-134a as refrigerant and hermetic sealed compressor of capacity 0.14H.P.and this study examined the effects of lengths capillary tubes on the performance of a vapor compression refrigeration system. It is found that 4.5feet Length of capillary tube gave a better performance.Both inlet and outlet pressure and temperature of the test section (capillary tube) were measured and used to estimate the coefficient of performance (COP) of the system The parameters stated above can be further optimized in order to enhance the performance of the refrigeration system.

INTRODUCTION: In 1972, Du Pont, one of the leading chloro-fluoro carbon (CFC) manufacturers, discussed the effect of their products on the environment. Ray McCarthy summarized that fluorocarbons are intentionally or accidentally vented to the atmosphere which may be either accumulating in the atmosphere and/or returning to the land or sea in pure form or as decomposed products. Du Pont, investigated the effect of these compounds due to its presence in the atmosphere on living beings, plants etc.

As a result CFC manufacturers formed the fluorocarbon panel to investigate the environmental impact of the CFC's. Molina and Rowland inferred that CFC's could destroy the stratospheric ozone. The atmospheric research programmed confirmed that CFC's were likely to deplete stratospheric ozone as predicted by Rowland and Molina, at the rate of 3% per decade. It was concluded that CFC's should be phased out, but that this could occur over a long period to minimize the economic impact on the CFC users.

In 1984, a remarkable and totally unpredicted phenomenon was discovered by the British Antarctic survey, called "ozone hole". In 1987, government negotiated in the Montreal Protocol, the first international treaty and subsequently in other international protocols to protect the global environment. This agreement originally mandated in reduction in CFC production and consumption, but, importantly allowed for future revision in light of new scientific evidence. After the Montreal Protocol, the atmospheric concentrations of the most important chlorofluorocarbons and related chlorinated hydrocarbons have either leveled off or decreased. Halon concentrations chlorinated hydrocarbons have either leveled off or decreased. Halon concentrations have continued to increased, as the halons presently stored in fire extinguisher are released, but their rate of increase has slowed down and their abundances are expected to decline by about 2020. Also, the concentration of the hydro-chloro-fluorocarbons (HCFCs) increased drastically at least partly due to the fact that usages of CFCs (e.g. used as solvents or refrigerating agents) were substituted with HCFCs. While there have been reports of attempts by individuals to circumvent the ban, e.g. by smuggling CFCs from undeveloped to develop nations, the overall level of compliance has been high.

Unfortunately, the hydro chlorofluorocarbons (HCFCs) and hydro fluorocarbons (HFCs) are now thought to contribute to anthropogenic global warming. On molecule-for-molecule bases, these compounds are up to 10,000 times more potent greenhouse gases than carbon dioxide, and their increased use significantly increases the danger that human activity will change the climate. The Montreal and subsequent Protocols currently call for a complete phase-out of HCFCs by 2030 but does not place any restriction on HFCs.

EXPANSION DEVICES:

The expansion device (also known as metering device or throttling device) is a important device that divides the high pressure side and low pressure side of refrigeration system, it is incorporated between receiver and the evaporator (if receiver not used in the system, the expansion device is introduced between condenser and evaporator). It is usual practice proved a filter and drier before the expansion device in order to prevent contaminants clogging the refrigerant flow passage. The expansion device performs the following functions:
1. It reduces the high-pressure liquid refrigerant to low pressure refrigerant before being fed to the evaporator.
2. It maintains the desired pressure difference between the high and low pressure sides of the system, so that the liquid refrigerant vaporizes at the designed pressure in the evaporator.
3. It controls the flow of refrigerant according to the load on the evaporator.

1.1TYPESOFEXPANSIONDEVICES:

1. Capillary tube,

2.Hand operated expansion valve,

3.Automatic or constant pressure expansion valve,

4.Thermostatic expansion valve,

5.Lowside float valve and

6.High side float valve.

1. CAPILLARY TUBE:

The capillary tube is used as an expansion device in small capacity hermetic sealed refrigeration units such as in domestic refrigerators, water coolers, room air-conditioners, especially in small capacity installations. It is a copper tube of small internal diameter and of varying length depending upon the application. The inside diameter of the tube used in refrigeration work is generally about 0.5 mm to 2.25mm and the length varies from 0.5 m to 5 m. it is installed in the liquid line between the condenser and the evaporator. A fine mesh is provided at the inlet of the tube in order to protect it from contaminants.

In its operation, the liquid refrigerant from the condenser enters the capillary tube. Due to the frictional resistance offered by a small diameter tube, the pressure drops, since the frictional resistance offered by a small diameter tube, the pressure inversely proportional to the diameter, therefore longer the capillary tube and smaller its inside diameter, greater is the pressure drop created in the refrigerant flow, in other words, greater pressure difference between the condenser and evaporator is needed for a given flow rate of the refrigerant. The diameter and length of the capillary tube once selected for a given set of conditions and load cannot operated efficiently at other conditions.
The refrigeration system, using capillary tube, has the following advantages:
1. The cost of capillary tube is less than all other forms of expansion devices.
2. When the compressor stops, the refrigerant continues to flow into the evaporator and equalizes the pressure between the high side and low side of the system. This considerably decreases the starting load on the compressor. Thus a low starting torque motor (low cost motor) can be used to drive the compressor, which is a great advantage.
3. Since the refrigerant charge in a capillary tube system is critical, therefore no receiver is necessary.
4. Capillary tube does not have threaded or moving parts there by the cost of maintenance and repair is almost negligible. The major disadvantage of using capillary tube is the refrigerant must be free from contaminants otherwise they will block the passage and may lead to damage of the system.

The capillary tube is the simplest of the refrigerant flow controls, consisting merely of a fixed length of small diameter tubing installed between the condenser and the evaporator. Because of the high frictional resistance resulting from its length and small bore and because of the throttling effect resulting from the gradual formation of flash gas in

the capillary tube, the capillary tube acts to restrict or meter the flow of liquid from the condenser to the evaporator and also to maintain the required operating pressure differential between those two units.
For any given tube length and bore, the resistance of the tube is fixed or constant so that the liquid flow rate through the tube at any instant is proportional to the pressure differential across the tube (pressure differential is the difference between the vaporizing and condensing pressures of the system).

Since the capillary tube and the compressor are connected in series in the system, it is evident that the flow capacity of the tube must be equal to the pumping capacity of the compressor.

Fig (3.1) shows the plots of mass flow rate of compressor and the mass flow rate of capillary with varying suction pressure. At high condensing pressures, the feeding rate of capillary increases due to high pressure difference across the tube. The plots of compressor are also shown for different condensing temperature.

For example, for 30 c condensing temperature, the capillary and compressor match at a particular suction pressure which allows them to handle the same flow rate of refrigerant. Such a point is shown as B. similar matching points at 40 c and 50 c are A and C resp.,

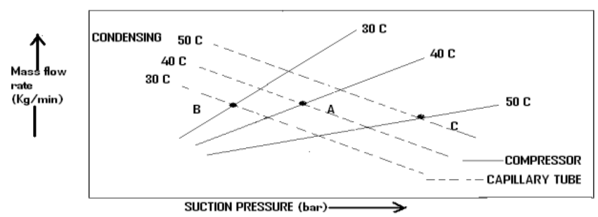

Fig: 1.1(a) Mass flow rate of capillary with varying suction pressure

Consequently, if the system is to perform efficiently and balance out at the design operating condition, the length and bore of the tube must be such that the flow capacity of the tube at the design vaporizing and condensing pressures is exactly equal to the pumping capacity of the compressor at these same conditions

In the event that the resistance of the tube is such that the flow capacity of the tube is either greater than or less than the pumping capacity of the compressor at the design conditions, a balance will be established between these two components at some operating conditions other than the system design condition s for example, if the resistance of the tube is too great (tube too long and/or bore too small),the capacity of the tube to pass liquid refrigerant from the condenser to the evaporator will be less than pumping capacity of the compressor at the design condition in which case the evaporator will become starved while the excess liquid will backup in the lower portion of the condenser at the entrance to the capillary tube. Naturally, starving of evaporator will result in lowering the suction pressures; whereas the buildup of liquid in the condenser will result in a reduction of the effective condensing surface and, consequently, an increase in the condensing temperature. Hence, the net effect of too much restriction in the capillary tube is to lower the suction pressure. Since both these conditions tend to increase the flow capacity of the tube and, at the same time, decrease the pumping capacity of the compressor, it is evident that the system will eventually establish equilibrium at some operating conditions. Where the capacity of the tube and the capacity of the compressor are exactly the same. In this instance, the point of balance will be at lower suction pressure and a higher condensing pressure than the system design pressures. Also, since the capacity of the compressor is reduced at this condition, the overall system capacity will be less than the design capacity.

However, when the tube does not have enough resistance (tube too short and/or bore too large),the flow capacity of the tube will be greater than the pumping capacity of the compressor at the design conditions, in which case overfeeding of the evaporator will the result with danger of possible liquid flood back to the compressor. Also, there will be no liquid seal on the condenser at the entrance to the tube and, therefore, uncondensed gas will be allowed to enter the tube along with the liquid, obviously, the introduction of latent heat into the evaporator in the form of uncondensed gas will have the effect of reducing the system capacity. Furthermore, because of the excessive flow rate through the tube; the compressor will not be able to reduce the evaporator pressure to the desired low level.

A system employing a capillary tube will operate at maximum efficiency only at one set of operating conditions. At all other operating conditions, the efficiency of the system will be somewhat less than the maximum. Normally, as the load on the system increases or decreases, the flow capacity of the capillary tube increases or decreases, resp., partially because of the change in condensing pressure that ordinarily accompanies this change in system loading and partially because of the change in the amount of liquid sub cooling taking place in the condenser.

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For example, as the load on the evaporator is increased, liquid refrigerant will be vaporized in the evaporator and condensed in the condenser at a rate momentarily higher than that at which the capillary tube is passing liquid to the evaporator, with the result that the excess will accumulate in the end of the condenser. With the condenser partially filled with liquid, the condensing pressure will be increased. At the same time, the liquid sin the end of the condenser will be subject to a greater degree of sub cooling. So that there will be less flash gas formed in the capillary tube. Both of these conditions tend to increase the flow capacity of the tube and thereby bring the system capacity more in the line with the increased system load. However, as the system load diminishes the condensing pressure and the degree of sub cooling decreases so that the flow capacity of the tube decreases.

2.0 EXPERIMENTAL INVESTIGATIONS

Experimental study on a system helps to evaluate its performance experimentally under varying operating conditions. Comparing this performance with that of the theoretical studies help in understanding the acceptability limits. In this line, the performance of the helical capillary tubes is studied experimentally. Effects of various parameters like mass flow rate, inner diameter, length, coil diameter, etc over a range of operating conditions are studied. The detailed description of the experimental system, various components of the system, controls and measurement systems and experimental procedure are presented in this chapter.

2.1 DESCRIPTION OF THE EXPERIMENTAL SETUP:

Test rig is a single stage vapour compression refrigeration system of 30 LTRS capacity. Figure 4.1 shows the schematic diagram of the experimental setup. This test rig mainly consists of compressor, condenser, expansion device, and evaporator.
The high-pressure gas from compressor flows through an oil separator where the compressor lubricant oil and refrigerant are separated and oil is fed back to the compressor. Compressed high-pressure gas is condensed in an air cooled condenser. The liquefied and subcooled refrigerant from the receiver enters into the expansion valve. A manually controlled needle valve with a capillary in parallel is used to maintain constant pressure in the evaporator.

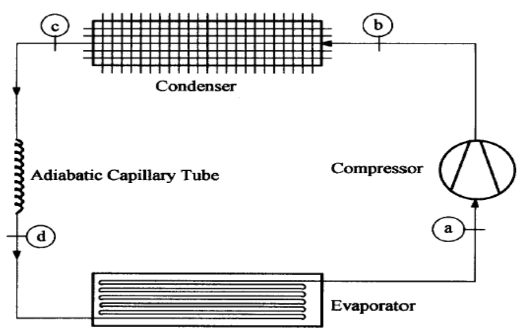

Fig. 2.1 Schematic diagram of the experimental setup

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Experiemental setup

2.2 CONFIGURATION OF CAPILLARY TUBES:

1	Lengths	4 feet	4.5 feet	5 feet	5.5 feet	6 feet
2	Diameter	0.8 mm				

2.3 EXPERIMENTATION:

2.3.1 CHARGING THE SYSTEM:

The entire system was pressure tested using nitrogen gas pressurizing to 30 bar. The system was left at that pressure for a period of 24 hours. System was evacuated using a vacuum pump. By adapting triple vacuum technique it was ensured that the non-condensable gases present in the VCR system were removed. Vacuum was held for 24 hours and finally estimated quantity of

R134a in liquid form was charged into the system and ensured that the pressure is measured while system is at steady state operating condition.

2.3.2 EXPERIMENTAL CONDITIONS:

Experiments were carried out for various capillary tubes using refrigerant R134a. Extensive data were collected and tabulated for various operating conditions. Flow behaviour of refrigerant flow in capillary tubes depends on capillary tube length, capillary tube diameter, capillary coil diameter, capillary tube inlet pressure and the type of refrigerant.

Experiments were conducted at the following conditions

1.All the measurements were taken only after the system reached the steady state

2.Set of experiments is done by keeping evaporator temperature at a specified level and varying the condensing temperature and vice versa

3.Measurement of all operating parameters were taken at every 20 min .

2.3.3 EXPERIMENTAL PROCEDURE:

Experimental procedure, which is carried out during the experiment, is given below:

1.The vapour compression refrigeration unit is switched on

2.The required evaporator temperature is attained, by adjusting the expansion valve and maintained constant

The data acquisition system at frequent intervals

1.Temperature at inlet and outlet for the components.

2. Pressure at the inlet and exit for the components.

Parameters which affect the performance of the system are flow rate of refrigerant, capillary inner diameter, tube length, and capillary coil diameter, condensing pressure, and subcooling.

3.0 PERFORMANCE EVALUATION:

With the data collected in experiments, different performance parameters are calculated as follows

1).Net Refrigeration Effec (NRE) = H1 – H2   KJ/Kg

WHERE

H1 = Enthalpy of Suction line

H2 = Enthalpy of Discharge line

2) Mass flow rate obtain, one TR, Kg/min (mr) = 210 / NRE Kg/min

WHERE

NRE = Net Refrigeration Effect

3) Work of compressionW = H2 – H1 KJ/Kg

WHERE

H1 = Enthalpy of Suction line

H2 = Enthalpy of Discharge line

4) Heat equivalent of work of compression per TR = mr X(h2-h1) KJ/min

WHERE

mr = Mass flow rate

H1 = Enthalpy of Suction line

H2 = Enthalpy of Discharge line

5) Theoretical power of compression

= KJ/min / 60 KW

6) Co-efficient of performance

(COP) = NRE / work of compression

WHERE

NRE = Net Refrigeration Effect

7) Heat to be rejected in the condenser

= H2- H3 KJ/Kg

WHERE

H2 = Enthalpy of Discharge line

H3 = Enthalpy of Liquid line

8) Heat rejection per ton of refrigeration (TR)

= (210/NRE) X (H2- H3) KJ/min

WHERE

NRE = Net Refrigeration Effect

H2 = Enthalpy of Discharge line

H3 = Enthalpy of Liquid line

9) Compression pressure ratio = Pd / Ps

WHERE

Pd = Discharge pressure

Ps = suction pressure

CALCULATIONS

READING NO.1

For capillary tube Length of 4 feet (1219.2mm)

Compressor suction		
Pressure	P1	0.965 bar
Temperature	T1	10.5ºC
Compressor discharge		
Pressure	P2	9.998bar
Temperature	T2	62.1ºC
Condenser parameters		
Pressure	P3	9.653bar
Temperature	T3	38.3ºC
Evaporator parameters		
Temperature	T4	19.0ºC

From P-H chart, we can find out the values of h1, h2, h3, and h4 in KJ/Kg

h1	411 KJ/Kg
h2	445 KJ/Kg
h3= h4	256 KJ/Kg

CALCULATINGPERFORMANCE PARAMETERS:

1. Net Refrigeration Effect (NRE) = h1-h4
= 411-256 = 155 KJ/Kg
2. Mass flow rate obtain, one TR, Kg/min
'mr' = 210 / NRE = 1.355 Kg/min
3. Work of compressionW = h2-h1
= 445 - 411 = 34 KJ/Kg
4. Heat equivalent of work of compression per TR
= mr X(h2-h1) = 46.07 KJ/min
5. Theoretical power of compression = 46.07 / 60
= 0.768 KW
6. Co-efficient of performance (COP)
= NRE / work of compression = 4.559
7. Heat to be rejected in the condenser = h2-h3
= 445 – 256 = 189 KJ/Kg

8. Heat rejection per ton of refrigeration (TR)
=(210/NRE) X (h2-h3) = 256.095 KJ/min
9. Compression pressure ratio = Discharge pressure / suction pressure = Pd / Ps= 10.35

READING NO: 2

For capillary tube Length of 4.5 feet (1371.5mm)

Compressor suction		
Pressure	P1	0.896 bar
Temperature	T1	10.2ºC
Compressor discharge		
Pressure	P2	10.324bar
Temperature	T2	62.9ºC
Condenser parameters		
Pressure	P3	9.998bar
Temperature	T3	39.6ºC
Evaporator parameters		
Temperature	T4	16.8ºC

From P-H chart, we can find out the values of h1, h2, h3, and h4 in KJ/Kg

h1	410.3 KJ/Kg
h2	443 KJ/Kg
h3= h4	255 KJ/Kg

CALCULATING PERFORMANCE PARAMETERS:

1. Net Refrigeration Effect (NRE) = h1-h4 = 410.3 – 255

= 155.3 KJ/Kg

2. Mass flow rate obtain, one TR, Kg/min '

mr' = 210 / NRE = 1.352 Kg/min

3. Work of compression W = h2-h1 = 443 – 410.3

= 32.7 KJ/Kg

4. Heat equivalent of work of compression per TR

= mr X (h2-h1) = 44.21K J/min

5. Theoretical power of compression = 44.21 / 60

= 0.737 KW

6. Co-efficient of performance

(COP) = NRE / work of compression = 4.749

7. Heat to be rejected in the condenser = h2-h3

= 443 – 255 = 188 KJ/Kg

8. Heat rejection per ton of refrigeration (TR) =(210/NRE) X (h2-h3) =254.176 KJ/min

9. Compression pressure ratio= Discharge pressure / suction pressure = Pd / Ps = 11.54

READING NO: 3

For capillary tube Length of 5 feet (1524mm)

Compressor suction		
Pressure	P1	1.103 bar
Temperature	T1	11.5ºC
Compressor discharge		
Pressure	P2	11.032bar
Temperature	T2	63.6ºC
Condenser parameters		
Pressure	P3	10.687bar
Temperature	T3	41.1ºC
Evaporator parameters		
Temperature	T4	15.9ºC

From P-H chart, we can find out the values of h1, h2, h3, and h4 in KJ/Kg

h1	411 KJ/Kg
h2	443.7 KJ/Kg
h3= h4	258 KJ/Kg

CALCULATING PERFORMANCE PARAMETERS:

1.Net Refrigeration Effect(NRE) = h1-h4 = 411 – 258 = 153 KJ/Kg

2.Mass flow rate obtain, one TR, Kg/min ‘mr’ = 210 / NRE = 1.372 Kg/min

3.Work of compression W = h2-h1 = 443.7 – 411 = 32.7 KJ/Kg

4.Heat equivalent of work of compression per TR = mr X (h2-h1) = 44.86 KJ/min

5.Theoretical power of compression = 0.748 KW

6.Co-efficient of performance (COP) = NRE / work of compression = 4.679

7.Heat to be rejected in the condenser = h2-h3 = 443.7 – 258 = 185.7 KJ/Kg

8.Heat rejection per ton of refrigeration (TR)=(210 / NRE) X (h2-h3)= 54.78 KJ/min

9.Compression pressure ratio = Pd / Ps = 10

READING NO: 4

For capillary tube Length of 5.5 feet (1676.4mm)

Compressor suction		
Pressure	P1	1.344 bar
Temperature	T1	12.3ºC
Compressor discharge		
Pressure	P2	11.72bar

Temperature	T2	64.4ºC
Condenser parameters		
Pressure	P3	11.373bar
Temperature	T3	42.5ºC
Evaporator parameters		
Temperature	T4	12.2ºC

From P-H chart, we can find out the values of h1, h2, h3, and h4 in KJ/Kg

h1	411.5 KJ/Kg
h2	444 KJ/Kg
h3= h4	260 KJ/Kg

CALCULATING PERFORMANCE PARAMETERS:

1. 1.Net Refrigeration Effect(NRE) Refrigeration Effect (NRE) = h1-h4

= 41 =411.5 – 260 = 151.5 KJ/Kg

2.Mass flow rate obtain, one TR, Kg/min 'mr' = 210/NRE = 1.386 Kg/min

3.Work of compression W = h2-h1 = 444 – 411.5

= 32.5 KJ/Kg

4.Heat equivalent of work of compression per TR =

mr X (h2-h1) = 45.04 KJ/min

5.T 5.Theoretical power of compression = 0.751 KW

6.C 6.Co-efficient of performance (COP) = NRE / work of compression = 4.661

7.Heat to be rejected in the condenser = h2-h3 = 444 – 260 = 184 KJ/Kg

8.Heat rejection per ton of refrigeration (TR)=(210/NRE) X (h2-h3) = 255.02 KJ/min

9.Compression pressure ratio = Pd / Ps = 8.72

READING NO: 5

For capillary tube Length of 6 feet (1828.8mm)

Compressor suction		
Pressure	P1	1.448 bar
Temperature	T1	12.8ºC
Compressor discharge		
Pressure	P2	11.93bar
Temperature	T2	63ºC
Condenser parameters		
Pressure	P3	11.58bar
Temperature	T3	42.3ºC
Evaporator parameters		
Temperature	T4	12ºC

From P-H chart, we can find out the values of h1, h2, h3, and h4 in KJ/Kg

h1	412 KJ/Kg
h2	445 KJ/Kg
h3= h4	260.8 KJ/Kg

CALCULATING PERFORMANCE PARAMETERS:

1. Net Refrigeration Effect (NRE) = h1-h4 = 412 – 260.8 = 151.2 KJ/Kg

2. Mass flow rate obtain, one TR, Kg/min
'mr' = 210 / NRE = 1.389 Kg/min
3. Work of compression W = h2-h1 = 445 – 412
= 33 KJ/Kg
4. Heat equivalent of work of compression per TR =
mr X (h2-h1) = 45.83 KJ/min
5. Theoretical power of compression = 45.83 / 60
= 0.764 KW
6. Co-efficient of performance (COP)
= NRE / work of compression = 4.582
7. Heat to be rejected in the condenser = h2-h3
= 445 – 260.8 = 184.2 KJ/Kg
8. Heat rejection per ton of refrigeration (TR)
=(210/NRE) X (h2-h3= 255.854 KJ/min
9.Compression pressure ratio = Pd / Ps = 8.24

TABLE 4.0 TABULAR COLUMNS OF PERFORMANCE PARAMETERS:

SL .NO	PERFORMANCE PARAMETER	LENGTH OF CAPILLARY TUBE IN FEETS				
		4	4.5	5	5.5	6
1	COMPRESSOR SUCTION PRESSURE P1(bar)	0.965	0.896	1.103	1.344	1.448
2	COMPRESSORSUCTION TEMPERATURE T1 (ºC)	10.5	10.2	11.5	12.3	12.8
3	COMPRESSOR DISCHARGE PRESSURE P2 (bar)	9.998	10.342	11.032	11.72	11.93
4	COMPRESSOR DISCHARGE TEMPERATURE T2 (^{0}C)	62.1	62.9	63.6	64.4	63
5	CONDENSER PRESSURE P3 (bar)	9.653	9.998	10.687	11.373	11.58
6	CONDENSER TEMPERATURE T3 (^{0}C)	383	39.6	41.1	42.5	42.3
7	EVAPORATOR TEMPERATURE T4(^{0}C	19.0	16.8	15.9	12.2	12
8	ENTHALPHY OF SUCTION h1(kJ/kg)	411	410.3	411	411.5	412
9	ENTHALPHY OF DISCHARGE h2(kJ/kg)	445	443	443.7	444	445
10	ENTHALPHY OF CONDENSER h3(kJ/kg)	256	255	258	260	260.8
11	NET REFRIGERATING EFFECT (NRE)(kJ/kg)	155	155.3	153	151.5	151.2
12	MASS FLOW RATE OF REFRIGERANT (m_r) (kg/min)	1.355	1.352	1.372	1.386	1.389
13	WORK OF COMPRESSION(W) (kJ/kg)	34	32.7	32.7	32.5	33
14	HEAT EQUIVALENT OF WORK OF COMPRESSION(kJ/min)	46.07	44.21	44.86	45.04	45.83
15	THEORETICAL POWER OF COMPRESSION (Kw)	0.768	0.737	0.748	0.751	0.764
16	C.O.P	4.559	4.749	4.679	4.661	4.582
17	HEAT TO BE REJECTED IN CONDENSER(kJ/kg)	189	188	185.7	184	184.2

18	HEAT REJECTION PER T.R (kJ/min)	256 .09 5	254 .17 6	25 4.7 8	25 5.0 2	255 .85 4
19	COMPRESSION PRESSURE RATIO	10. 35	11. 54	10	8.7 2	8.2 4

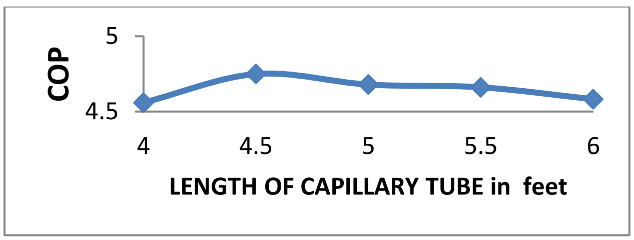
RESULT AND DISCUSSIONS

PERFORMANCE OF A SIMPLE VAPOUR COMPRESSION REFRIGERATION CYCLE:

The performance of vapour compression refrigeration cycle varies considerably with the length of capillary tube has greater effect. To illustrate these effects the calculated values for different length of capillary tube have been plotted on the graphs. The relationships between length of capillary tube and performance parameter have been compared and shown in the following graphs.

5.0 RESULTS AND DISCUSSIONS FROM THE FOLLOWING GRAPHS:

1. EFFECT OF LENGTH OF CAPILLARY TUBE ON COEFFICIENT OF PERFORMANCE:

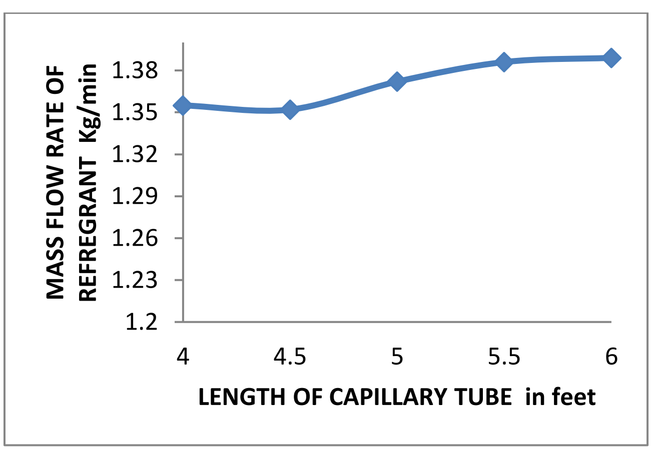


Graph 1.Effect of Length of capillary tube on coefficient of performance

EFFECT OF LENGTH OF CAPILLARY TUBE ON COEFFICIENT OF PERFORMANCE:

Referring to graph-1, it is seen that the performance of the Refrigeration system increases as the length of the capillary tube increases. But at the length = 4.5 feet's the performance of the system starts to decrease, because of further increase in pressure due to friction, the specific volume, and velocity increase in the capillary tube. It increases the mass flow rate of refrigerant and unbalanced conditions can be avoided.

2. EFFECT OF LENGTH OF CAPILLARY TUBE ON THE MASS FLOW RATE OF REFRIGERANT:

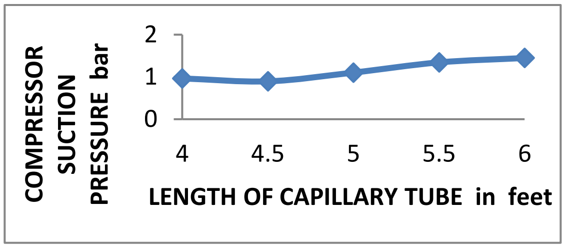


Graph 2. Effect of Length of capillary tube on the mass flow rate of refrigerant

EFFECT OF LENGTH OF CAPILLARY TUBE ON THE MASS FLOW RATE OF REFRIGERANT:

Referring to the graph-2, it is seen that mass flow rate of refrigeration system decreases as the length of capillary tube increases. But at the length = 4.5 feet's the performance of the system starts to decrease, because of further increase in pressure due to friction, the specific volume, and velocity increase in the capillary tube. It increases the mass flow rate of refrigerant.

3. EFFECT OF LENGTH OF CAPILLAR TUBEON COMPRESSOR SUCTION PRESSURE:

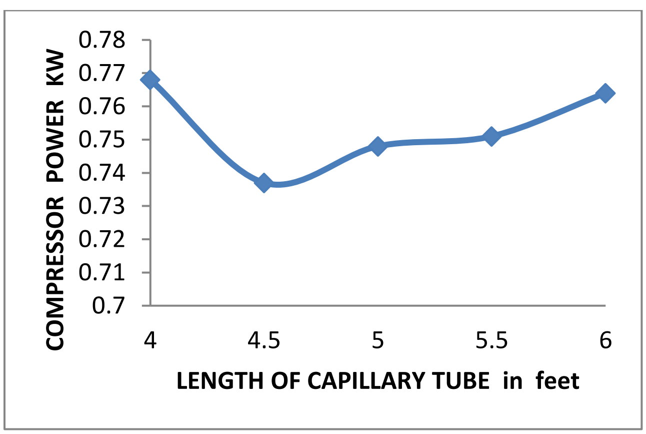


Graph 3. Effect of Length of capillary tube on Compressor suction pressure

EFFECT OF LENGTH OF CAPILLARY TUBE ON COMPRESSOR SUCTION PRESSURE:

Referring to the graph-3, the compressor pressure decreases as the length of the capillary tube increases. But at the length = 4.5 feet's the performance of the system starts to decrease, because of further increase in pressure due to friction, the specific volume, and velocity increase in the capillary tube. It increases the compressor suction pressure.

4. EFFECT OF THE LENGTH OF CAPILLARY TUBE ON COMPRESSOR POWER:

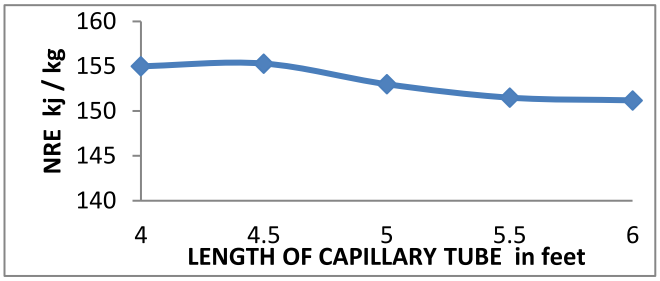


Graph 4. Effect of Length of capillary tube on compressor power

EFFECT OF THE LENGTH OF TUBE ON COMPRESSOR POWER:

Referring to the graph-4, it is seen that compressor power decreases as the length of the capillary tube increases. But at the length = 4.5 feet's, the compressor power starts to increase due to further pressure drop in suction vapour, temperature and increase the specific volume of the
suction vapour to the compressor, thus increases the volume of vapour compressed.

5. EFFECT OF THE LENGTH OF CAPILLARY TUBE ON NET REFRIGERATING EFFECT:

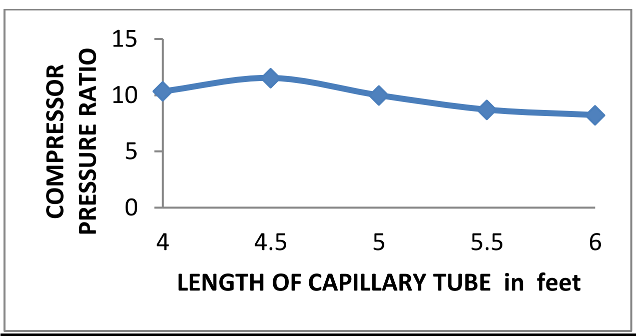


Graph 5. Effect of Length of capillary tube on net refrigerating effect

EFFECT OF THE LENGTH OF CAPILLARY TUBE ON NET REFRIGERATING EFFECT:

Referring to the graph-5, it is seen that the net refrigerating effect increases as the length of the capillary tube increases. But at the length = 4.5 feet's, the net refrigerating effect starts to decrease because of choked flow the mass flow rate of refrigerant also decreases up to certain level again it starts to increase.

6. EFFECT OF LENGTH OF CAPILLARY TUBE ON COMPRESSOR PRESSURE RATIO:



Graph 6. Effect of Length of capillary tube on compressor pressure rati

EFFECT OF LENGTH OF CAPILLARY TUBE ON COMPRESSOR PRESSURE RATIO:

Referring to the graph-6,it is seen that the compressor pressure ratio increases as the length of capillary tube increases, But at the length = 4.5 feet's the performance of the system starts to decrease, because of further increase in pressure due to friction, the specific volume, and velocity increase in the capillary tube. It increases the compressor pressure ratio

CONCLUSIONS

Experimental studies have been carried out to evaluate the system performance under various operating conditions. A separate Experimental set up has been used for determining the pressure, temperature and coefficient of performance along the length of the coiled capillary tubes. From the investigations, the following conclusions are drawn:

- In the present work the length of capillary tube is optimized for a vapour compression refrigeration unit of capacity 30lts, with R-134a as refrigerant through experimental investigations.
- This study investigated the performance of capillary tube geometries having R-134a as the working fluid.
- Experimental computations are made and compared and found that the optimum length of capillary tube is 4.5 feet. At length = 4.5feet, the performance of the system is good in all aspects i.e... Coefficient of performance, refrigeration effect, power of compressor, mass flow rate of refrigerant and compressor pressure ratio.
- Test results shows significant improvement in the performance of the Refrigeration system for the length of capillary tube 4.5 feet.
- It is seen that mass flow rate of refrigeration system decreases as the length of capillary tube increases.
- The compressor pressure decreases as the length of the capillary tube increases. It is seen that compressor power decreases as the length of the capillary tube increases.
- Test results shows significant improvement in the net refrigerating effect increases as the length of the capillary tube increases.
- It can be concluded that at length = 4.5feet, the performance of the system is good in all aspects i.e... Coefficient of performance, refrigeration effect, power of compressor, and mass flow rate of refrigerant.
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