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EXPERIMENTAL INVESTIGATION ON VAPOUR COMPRESSION REFRIGERATION SYSTEM WITH DIFFERENT EXPANSION DEVICES FOR ITS COOLING PERFORMANCE

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Abstract – *This article presents the determination of refrigeration effect and COP of an open type vapour compression refrigeration system by allowing the refrigerant to expand in different expansion devices namely capillary tube, automatic expansion valve and thermostatic expansion valve. Comparison of the co-efficient of performance obtained when the flow of refrigerant is allowed to flow through all the three expansion devices separately.*

Key Words*: *VCR system, COP, Refrigeration effect, Capillary tube, Automatic expansion valve, Thermostatic expansion valve

1.INTRODUCTION

A typical vapour compression refrigeration system experimental setup is selected for conducting the experiment which has installed with the basic components of vapour compression refrigeration equipment with the three expansion devices namely capillary tube, automatic expansion valve and thermostatic expansion valve. The flow of the refrigerant through the expansion device is controlled and allowed to flow through only one expansion device at a time and the other two are in inactive by closing the corresponding valves. From the readings observed and calculation by using correct correlation the COP and refrigeration effect obtained in each case of flow of the refrigerant through the various expansion devices and comparative studies are to be carried out.

2.EXPERIMENTAL SETUP

The experimental setup consists of an open type reciprocating compressor driven by an electric motor through belt. An air-cooled fin and tube condenser in which fan blades are attached in the motor shaft and facilitate air flow to the condenser. A receiver in fitted which collects the liquid refrigerant coming out from the condenser. From the receiver the liquid refringent enters separately to each expansion valve namely capillary tube automatic expansion valve and thermostatic expansion valve. The expansion valve outlet is connected to the evaporator inlet. The evaporator is of circular stainless-steel tank in which coper tube spiral immersed in water. From the evaporator outlet, the line is connected to the suction side of compressor through the suction service valve. All the equipments are connected using copper tubes. Pressure gauges and temperature gauges are fitted to measure the suction side pressure and discharge side pressure as well as suction side temperature and discharge side temperature. A separate provision is made to measure the evaporator liquid temperature by a thermocouple arrangement. A watt meter is fitted to the experimental setup to measure how much power is consumed during the working of the equipment.

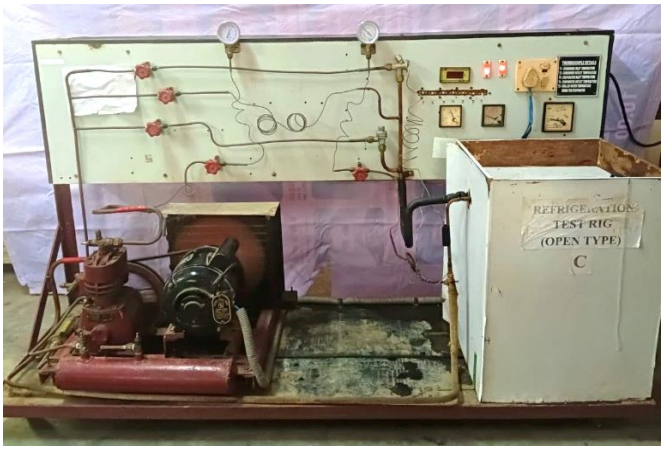


Fig.1 Experimental setup (open type VCR system)

3.EQUIPMENT SPECIFICATION

3.1.Compressor

Type : open type reciprocating compressor
Capacity : 1 ton
Piston diameter : 50 mm
Stroke length : 40 mm
No. of piston : 2

3.2.Motor

Capacity : 1.5 HP
Speed : 1375 RPM
Phase : Single
Starting circuit : CSIR
Shaft pully diameter : 5 inches

3.3.Condenser

Type : Fin and Tube
Capacity : 1 ton
Cooling medium : air
Size : 12 inches X 12 inches

3.4.Expansion device

3.4.1.Capillary tube

Length : 55 inches
Diameter : 0.044 inches

3.4.2.Automatic expansion valve

Orifice : No 4
Inlet opening : 3/8 inches
Outlet opening : 1/2 inches

3.4.3.Thermostatic expansion valve

Orifice : No 4
Inlet opening : 3/8 inches
Outlet opening : 1/2 inches

3.5.Evaporator

Type : Immersed type
Tube material : copper
Tube size : 3/8 inches
Mean coil diameter : 10 inches
Tube length : 25 feet
No.of coils :10
Water holding capacity of the tank : 20 litres

3.6.Insulation

Foam insulation is provided in the liquid line and in the suction line

4. REFRIGERANT

The refrigerant used in this experimental setup is MO49 plus also known as R437A. MO49 plus is a HFC blend suitable for use as a retrofit replacement refrigerant for R12. R337A is compatible with traditional and new lubricants, in most cases no change of lubricant is required during retrofit. About 2500 grams ofMO49 refrigerant is charged in this experimental setup. Main advantages of using MO49 plus are

1) Replaces R12 and HCFC containing blends such as MP39, MP66, R409A
2) Non flammable with a safety classification of A1, GWP1805
3) With the introduction of R437A, R413A production was faced out with all other HCFC blends

5.EXPERIMENTAL PROCEDURE

- Test duration : 30 minutes
- Ensure 20 litres of water is in the evaporator condenser.
- Switch on the compressor motor of the VCR system.
- Ensure that the refrigerant flows through the capillary tube expansion device and ensure automatic expansion valve and thermostatic expansion valve are to be in inactive mode by closing the corresponding valves
- Note down the following readings from the test rig
  - The initial temperature (T_i) of the water in the evaporator tank.
  - Suction side pressure (P_s) from the suction pressure gauge.
  - Discharge side pressure (P_d) from the discharge pressure gauge.
  - Suction side temperature (T_s) from the suction thermometer gauge.
  - Discharge side temperature (T_d) from the discharge temperature gauge.
  - Watt meter reading.
- Allow the unit to run for 30 minutes and note down the temperature of water in the evaporator tank for every 5 minutes.
- Tabulate the readings.
- The same procedure is adopted for to run the VCR unit by allowing the refrigerant to flow through automatic expansion valve only by keeping the other two expansion devices in an inactive mode.
- Similarly, the same procedure is adopted for to run the VCR unit by allowing the refrigerant to flow through thermostatic expansion valve only by keeping the other two expansion devices in an inactive mode.

6.OBSERVATIONS

6.1 Refrigerant flow through capillary tube

Mass of water in evaporator tank (m_w) : 20 kg
The initial temperature (T_i) of the water in the evaporator tank : 29^0C
Suction side pressure (P_S) : 20 psig
Discharge side pressure (P_d) : 155 psig
Suction side temperature (T_s) : 8^0C
Discharge side temperature (T_d) : 70^0C
Watt meter reading : 1200 watts

Sl.no	Time (minutes)	Temperature of water in evaporator (^{0}C)
1	0	29
2	5	28
3	10	22

4	15	18
5	20	9
6	25	7
7	30	4

Table.1 Drop in temperature with respect to time

6.2Refrigerant flow through automatic expansion valve

Mass of water in evaporator tank (m_w) : 20 kg
The initial temperature (T_i) of the water in the evaporator tank : 30^0C
Suction side pressure (P_S) : 35 psig
Discharge side pressure (P_d) : 210 psig
Suction side temperature (T_s) : 12^0C
Discharge side temperature (T_d) : 75^0C
Watt meter reading : 1200 watts

Sl.no	Time (minutes)	Temperature of water in evaporator (^{0}C)
1	0	30
2	5	20
3	10	18
4	15	14
5	20	11
6	25	9
7	30	6

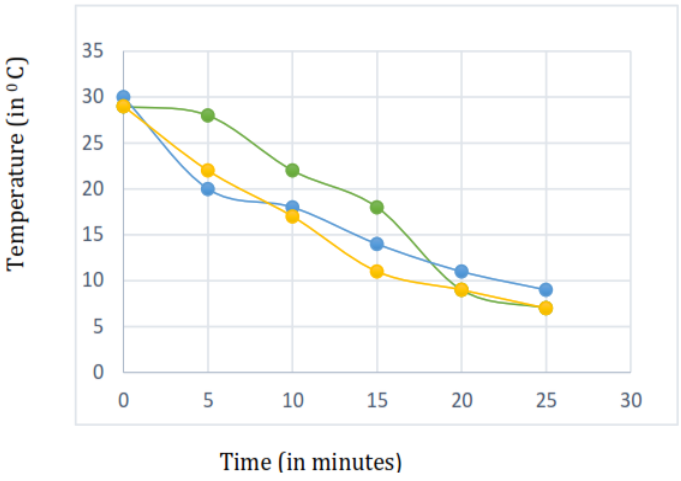
Table.2 Drop in temperature with respect to time

6.3 Refrigerant flow through thermostatic expansion valve

Mass of water in evaporator tank (m_w) : 20 kg
The initial temperature (T_i) of the water in the evaporator tank : 29^0C
Suction side pressure (P_S) : 35 psig
Discharge side pressure (P_d) : 215 psig
Suction side temperature (T_s) : 8^0C
Discharge side temperature (T_d) : 60^0C
Watt meter reading : 1200 watts

Sl.no	Time (minutes)	Temperature of water in evaporator (^{0}C)
1	0	29
2	5	22
3	10	17
4	15	11
5	20	9
6	25	7
7	30	4

Table.3 Drop in temperature with respect to time



Graph.1 A plot of evaporator water temperature vs time

When the flow through capillary tube
When the flow through AEV
When the flow through TEV

7.CALCULATION FOR COP OF THE SYSTEM

7.1 When the flow through capillary tube

Test duration t = 1800 sec
Refrigeration effect = $m_{water} \times C_{p\ water} (T_i - T_f)/ t$
= 20 x 4.187 x (29 – 4)/1800 = 1.163 KJ/sec
COP = Refrigeration effect / work input
= 1.163 KW / 0.6 KW = 1.938
Capacity = Refrigeration effect(in KJ /sec) / 3.5
= 1.163 / 3.5 = 0.33 Tons

7.2 When the flow through AEV

Test duration t = 1800 sec
Refrigeration effect = $m_{water} \times C_{p\ water} (T_i - T_f)/ t$
= 20 x 4.187 x (30 – 6)/1800 = 1.116 KJ/sec
COP = Refrigeration effect / work input
= 1.116 KW / 0.6 KW = 1.86
Capacity = Refrigeration effect(in KJ /sec) / 3.5
= 1.116 / 3.5 = 0.31 Tons

7.3 When the flow through TEV

Test duration t = 1800 sec
Refrigeration effect = $m_{water} \times C_{p\ water} (T_i - T_f)/ t$
= 20 x 4.187 x (29 – 4)/1800 = 1.163 KJ/sec
COP = Refrigeration effect / work input
= 1.163 KW / 0.6 KW = 1.938
Capacity = Refrigeration effect(in KJ /sec) / 3.5
= 1.163 / 3.5 = 0.33 Tons

8.RESULT AND DISCUSSION

While conducting the experiment on the typical open type VCR system the following observation were noted

- When refrigerant is allowed to expand in the capillary tube the refrigerating effect, system capacity and COP were found to be 1.163 KW, 0.33 Tons and 1.938 respectively. When compared with AEV and TEV better results where obtained. Due to this for smaller capacity applications like refrigerator, air-conditioner, water-cooler etc., use capillary tube as the expansion device

- When refrigerant is allowed to expand through automatic expansion valve the refrigerating effect, system capacity and COP were found to be 1.116 KW, 0.31 Tons and 1.86 respectively. Even though the results are closer to capillary tube and TEV this device not popularly used in many applications dur-e to its poor efficiency of operations.

- When refrigerant is allowed to expand in the TEV the refrigerating effect, system capacity and COP were found to be 1.163 KW, 0.33 Tons and 1.938 respectively. In this experimentation the results obtained is similar to what obtained when the flow is through capillary tube. This is because the TEV operation based on degree of super heat at evaporator outlet. This is most widely used refrigerant control device due to its high efficiency and its ability to provide effective use of all evaporator surface under all load conditions

9. CONCLUSIONS

This article concluded with

1. Better results were obtained when the flow of refrigerant is through capillary tube and TEV.

2. The time duration taken in this experimentation is half an hour only , if extended to another half an hour, the system may be optimized.

3. Research areas were identified by changing the capillary tube sizes, evaporator load, using different refrigerants the system performance can be evaluated by conducting experiment on this open type VCR system

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BIOGRAPHIES

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