Heaven's Light is Our Guide
Rajshahi University of Engineering and Technology

Course Code
ME 3220

Course Title
Basic Mechanical Engineering Sessional

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Lab Report 5: Study of Vapor Compression Refrigeration System

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Experiment No.: 05

Experiment Name: Study of Vapor Compression Refrigeration System (VCRS).

Objectives:

i) To know the main parts of vapor compression refrigeration system.

ii) To know the working principle of VCRS cycle.

iii) To find the COP of the VCRS.

Theory:

Refrigeration is the transfer of heat to Lower the temperature in a controlled environment. A Vapor Compression Refrigeration System (VCRS) improves upon air refrigeration by using a circulating refrigerant (e.g. ammonia, CO_2, SO_2) that undergoes phase changes. The VCRS cycle consists of

1) Compression – Refrigerant is compressed, raising its temperature & pressure.

2) Condensation – Heat is released as the refrigerant Condenser.

3) Expansion – The refrigerant expands, reducing pressure & temperature.

4) Evaporation – Heat is absorbed, cooling the surrounding.

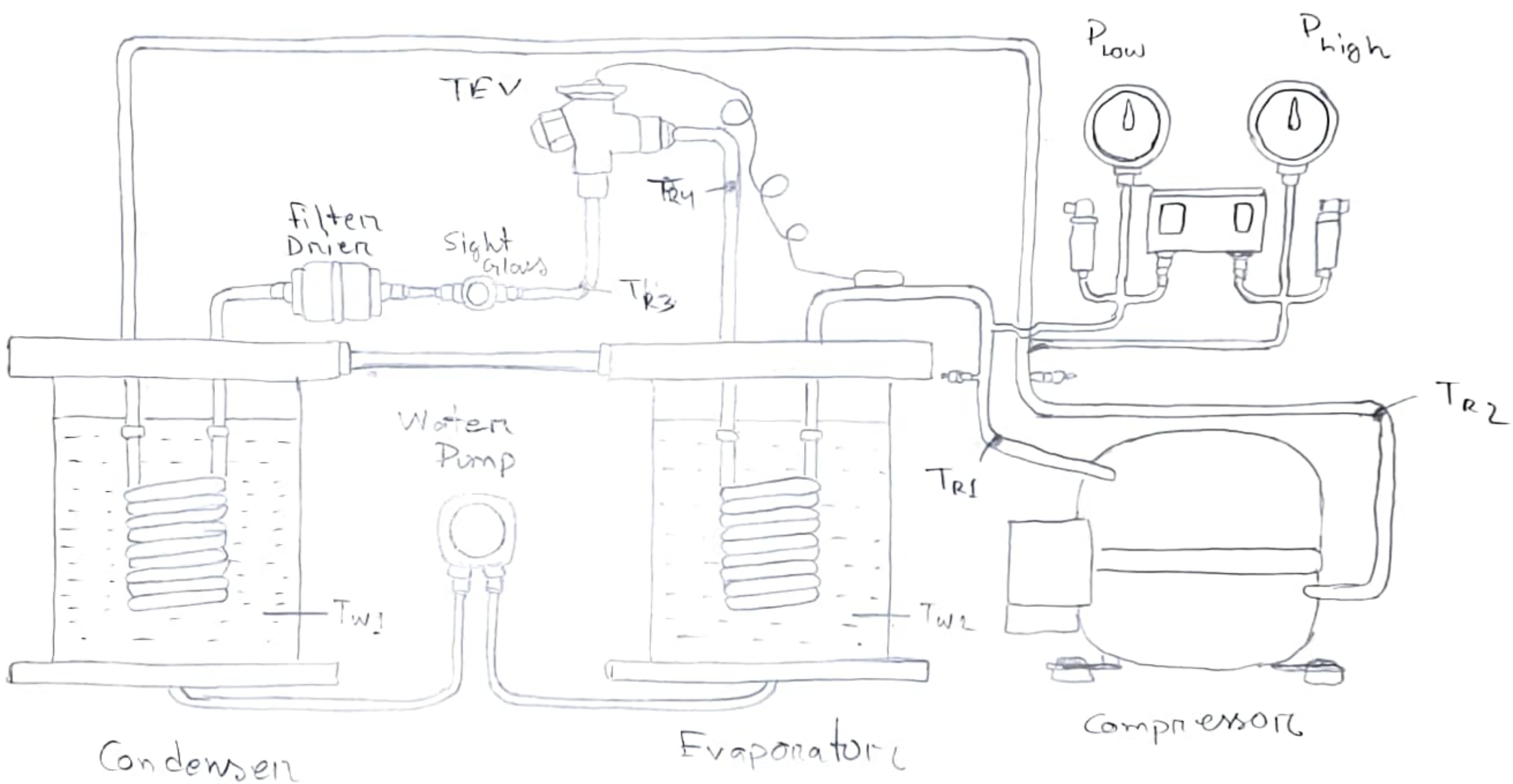

Figure: Vapor Compression Refigeration System Diagram

Main Components:

i) Compressor
ii) Condensor
iii) Reciever
iv) Expansion Valve
v) Evaporator

Study of Main Component:

i) Compressor: A mechanical device compresses gaseous fluid from low temperature & pressure to high temperature high pressure.

ii) Condenser: Set of pipes immersed into cooler environment; condenses the vapor refrigerant to liquid.

iii) Reciever: Refrigerant gets stocked.

iv) Expansion Valve (TEV): Expands the refrigerant's volume to reduce pressure; acts as a throttle valve.

v) Evaporator: The space from where the refrigerant absorbs latent heat & vaporizes.

Working Principle:

1) Compression – Low pressure, low temperature refrigerant vapor from the evaporator enters the compressor through the suction valve. It is compressed to a high pressure & temperature before being discharged to the condenser.

2) Condensation — Here, in the condenser, the high pressure refrigerant release heat to the surrounding medium & condenses into a high-pressure liquid.

3) Expansion — The condesed liquid refrigerant is stored in a reciever & then passed through the expansion valve, where its pressure and temperature drop suddenly. Partial evaration occurs here.

4) Evaporation — The remaining liquid Refrigerant enters the evaporator, where it absorbs heat from the surrounding medium & fully evaporates. This cools the desired space.

5) Cycle Completion :— The low pressure refrigerant vapor returns to the compressor, repeating the cycle.

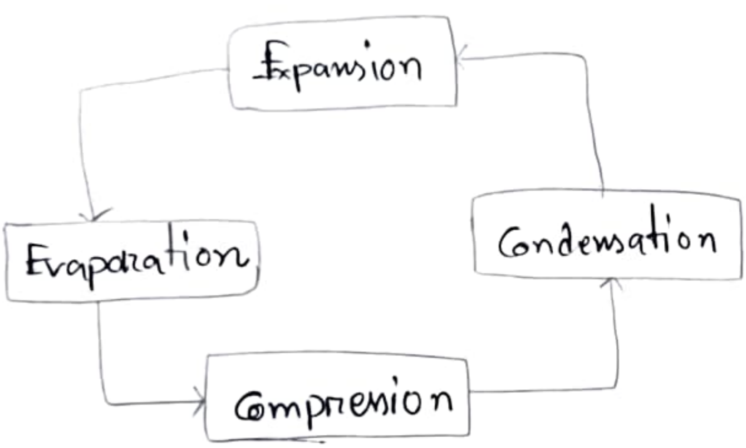

Figure: VCRS Cycle

Data: Refrigerant used: R134a

Reading No.	T_{R1} (°C)	T_{R2} (°C)	T_{R3} (°C)	T_{R4} (°C)	T_{W1} (°C)	T_{W2} (°C)	P_{Low} (bar)	P_{High} (bar)
1	21.0	20.9	20.8	20.6	20.3	20.4	-0.98	3.65
2	18.2	32.1	35.6	0.2	23.3	20.4	-0.98	8.52
3	14.3	41.2	38.4	1.7	26.4	18.4	-0.99	9.28
4	10.1	43.9	40.5	2.2	29.3	16.2	-0.99	9.85
5	8.3	45.8	42.2	0.6	32.3	14.3	-0.98	10.43
6	6.0	47.9	43.9	-0.4	35.3	12.7	-0.98	11.06
7	5.9	50.1	45.2	-2.3	38.4	11.2	-0.98	11.73
8	6.1	51.1	45.4	-2.9	40.0	10.4	-0.98	12.08
9	5.9	51.3	44.8	-3.2	40.4	10.1	-0.98	12.17

Calculation:

Point 1 ($T_{R1} = 5.9°C$, $P_{Low} = -0.98$ bar)

Approximate Enthalpy, $h_1 = 410$ kJ/kg

Point 2 ($T_{R2} = 51.3°C$, $P_{high} = 12.17$ bar)

Approximate Enthalpy, $h_2 = 430$ kJ/kg

Point 3 ($T_{R3} = 44.8°C$, $P_{high} = 12.17$ bar)

Approximate Enthalpy, $h_3 = 250$ kJ/kg

Point 4 ($T_{R4} = -3.2^\circ C$, $P_{Low} = -0.98$ bar)

Approximate Enthalpy, $h_4 = h_3 = 250$ kJ/kg

$$\therefore COP = \frac{h_1 - h_4}{h_2 - h_1} = \frac{410 - 250}{430 - 410} = 8$$

Result:

Coefficient of Performance, COP = 8

Discussion:

This experiment involved recording the temperature & pressure at each stage of the cycle. Using the refrigerant table, the enthalpies to calculate COP was approximated. The calculated COP was 8. This suggests that for every unit of work input, the system provides 8 units of cooling. The result aligns with typical VCRS though approximation introduces errors.

Conclusion:

The expriement successfully demonstrated the basic operation of VCRS. COP of 8 indicates a relatively efficient system. Future studies could enhance the accuracy by using more precise & considering real-life inefficiencies.

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System Diagram:

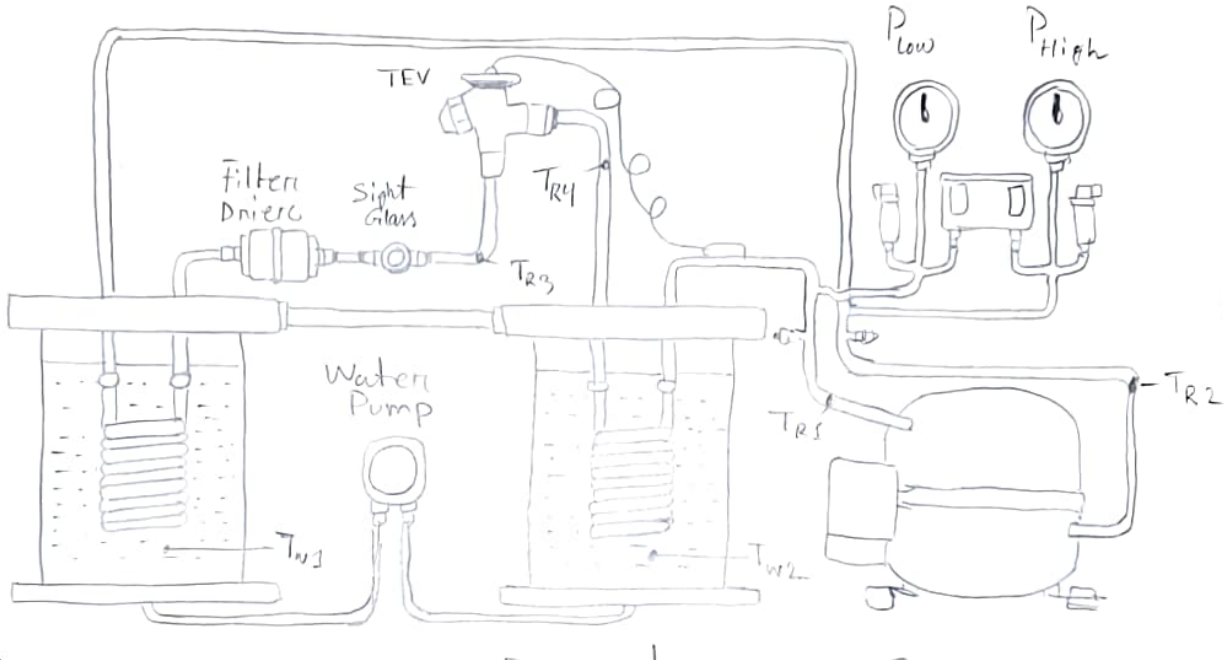

Fig: VCRS Diagram

T_1

T_2

T_3

T_4

T_{w1}

T_{w2}

T_1, T_2, T_3, T_4, T_{w1}, T_{w2}, P-low, P-High

	TR1 °C	TR2	TR3	TR4	TW1	TW2	PL bar	PH bar
1	21.0	20.9	20.8	20.6	20.3	20.4	-.98	3.65
2	18.2	32.1	35.6	0.2	23.3	20.4	-.98	8.52
3	14.3	41.2	38.4	1.7	26.4	18.4	-.99	9.28
4	10.1	43.9	40.5	2.2	29.3	16.2	-.99	9.85
5	9.9	44.0	40.6	2.2	29.4	16.1	-.98	9.87
6	8.3	45.8	42.2	0.7	32.2	14.3	-.98	10.41
7	8.3	45.8	42.2	0.6	32.3	14.3	-.98	10.43
8	8.3	45.9	42.3	0.6	32.4	14.2	-.98	10.45
9	6.0	47.9	43.9	-0.4	35.3	12.7	-.98	11.06
10	5.9	47.9	44.0	-0.5	35.4	12.6	-.98	11.10
11	5.7	50.1	45.2	-2.3	38.4	11.2	-.98	11.73
12	6.1	51.1	45.4	-2.9	40.0	10.4	-.98	12.08
13	5.9	51.3	44.7	-3.0	40.3	10.2	-.98	12.16
14	5.9	51.3	44.8	-3.2	40.4	10.1	-.98	12.17

$$COP = \frac{h_1 - h_4}{h_2 - h_1}$$