LABORATORY MANUAL
ON
REFRIGERATION TEST RIG

Prepared

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AIM OF THE EXPERIMENT:

1. To Demonstrate the Vapour Compression Refrigeration Cycle.
2. To study the Basic Components of Simple Vapour Compression Refrigeration Cycle. i.e. Compressor, Condenser, Expansion Valve, and Evaporator.
3. To Plot the vapour compression Refrigeration Cycle on Pressure Enthalpy Chart.
4. To determine Refrigerating effect, Coefficient of Performance (COP) of a Refrigeration Test Rig.

REFRIGERATION:

Refrigeration may be defined as the process of achieving and maintaining temperature of a system below that of the surroundings, the aim being to cool some product or space to the required temperature.

Refrigeration is a process of removing heat from a low-temperature reservoir and transferring it to a high-temperature reservoir. To satisfy the Second Law of Thermodynamics, mechanical work must be performed to accomplish this.

UNIT OF REFRIGERATION:

The practical unit of refrigeration is expressed in the terms of " Tonne of refrigeration ".

A "tonne of refrigeration" is defined as the amount of refrigeration effect produced by the uniform melting of one US ton of ice from and at 0°C in 24 hours.

1 US ton = 2000 lb = 2000 x 0.453592 kg =907.1847 kg

The latent heat of ice is 335kJ/kg and therefore one tonne of refrigeration

1TR = 907.1847 X 335 KJ / 24 hours

= 907.1847 X 335 / 24 X 60

= 211 kJ/min

In actual practice, one tonne of refrigeration is taken as 210 kJ/min or 3.5 kW

VAPOUR COMPRESSION REFRIGERATION CYCLE:

A Vapour Compression Refrigeration System is an improved type of Air Refrigeration System in which a suitable working substance, termed as Refrigerant is used. It Condenses and evaporates at temperatures and Pressures close to the atmospheric Conditions.

The Refrigerant used does not leave the System but is circulated throughout the system alternately condensing and evaporating. The Vapour Compression Refrigeration system is now days used for all-purpose refrigeration. It is used for all industrial purpose fr0om a small domestic refrigerator to a big air conditioning plant.

The vapour compression refrigeration cycle is based on the following factor:

- Refrigerant flow rate.
- Type of refrigerant used.
- Kind of application viz air-conditioning, refrigeration, dehumidification etc.
- The operation design parameters.
- The system equipments/ components proposed to be used in the system.

The vapour compression refrigeration cycle is based on a circulating fluid media, viz, a refrigerant having special properties of vapourising at temperatures lower than the ambient and condensing back to the liquid form, at slightly higher than ambient conditions by controlling the saturation temperature and pressure.Thus, when the refrigerant evaporates or boils at temperatures lower than ambient, it extracts or removes heat from the load and lower the temperature consequently providing cooling.

The super-heated vapour pressure is increased to a level by the compressor to reach a saturation pressure so that heat added to vapour is dissipated/ rejected into the atmosphere, using operational ambient conditions, with cooling medias the liquid from and recycled again to form the refrigeration cycle.

The components used are:

1. **Evaporator**
2. **Reciprocating device**
3. **Condenser and receiver**
4. **Throttling device**

The refrigeration cycle can be explained schematically in the two diagrams i.e.. Pressure Enthalpy diagram

Temperature Entropy diagram

The working of vapour compression refrigeration cycle and function of each above components is given below.

(A) Evaporator:

The liquid refrigerant from the condenser at high pressure is fed through a throttling device to an evaporator at a low pressure. On absorbing the heat to be extracted from Media to be cooled, the liquid refrigerant boils actively in the evaporator and changes state. The refrigerant gains latent heat to vaporizes at saturation temperature/ pressure and further absorbs sensible heat from media to be cooled and gets fully vaporized and super heated. The "Temperature-Pressure Relation Chart" Table can determine the pressure and temperature in the evaporator.

These are different type of evaporators used for different application and are accordingly designed. These are in the form of cooling coils (finned or prime surface type) made out of copper or steel, or shell and tube coolers (flooded or Direct Expansion type), Raceway type of Baud let coolers, for ice Accumulation or Ice Banks etc.

(B) Compressor

The compressor is known as the heart of the refrigeration system. It pumps the refrigerant vapour in refrigeration cycle as the heart pumps blood in the body. The low temperature, pressure, superheated vapour from the evaporator is conveyed through suction line and compressed by the compressor to a high pressure, without any change of gaseous state and the same is discharge into condenser. During this process heat is added to the refrigerant and known as heat of compression ration to raise the pressure of refrigerant to such a level that the saturation temperature of the discharge refrigerant is higher than the temperature of the available cooling medium, to enable the super heated refrigerant to condense at normal ambient condition.

Different types of compressors are reciprocating, rotary and centrifugal and are used for different applications.

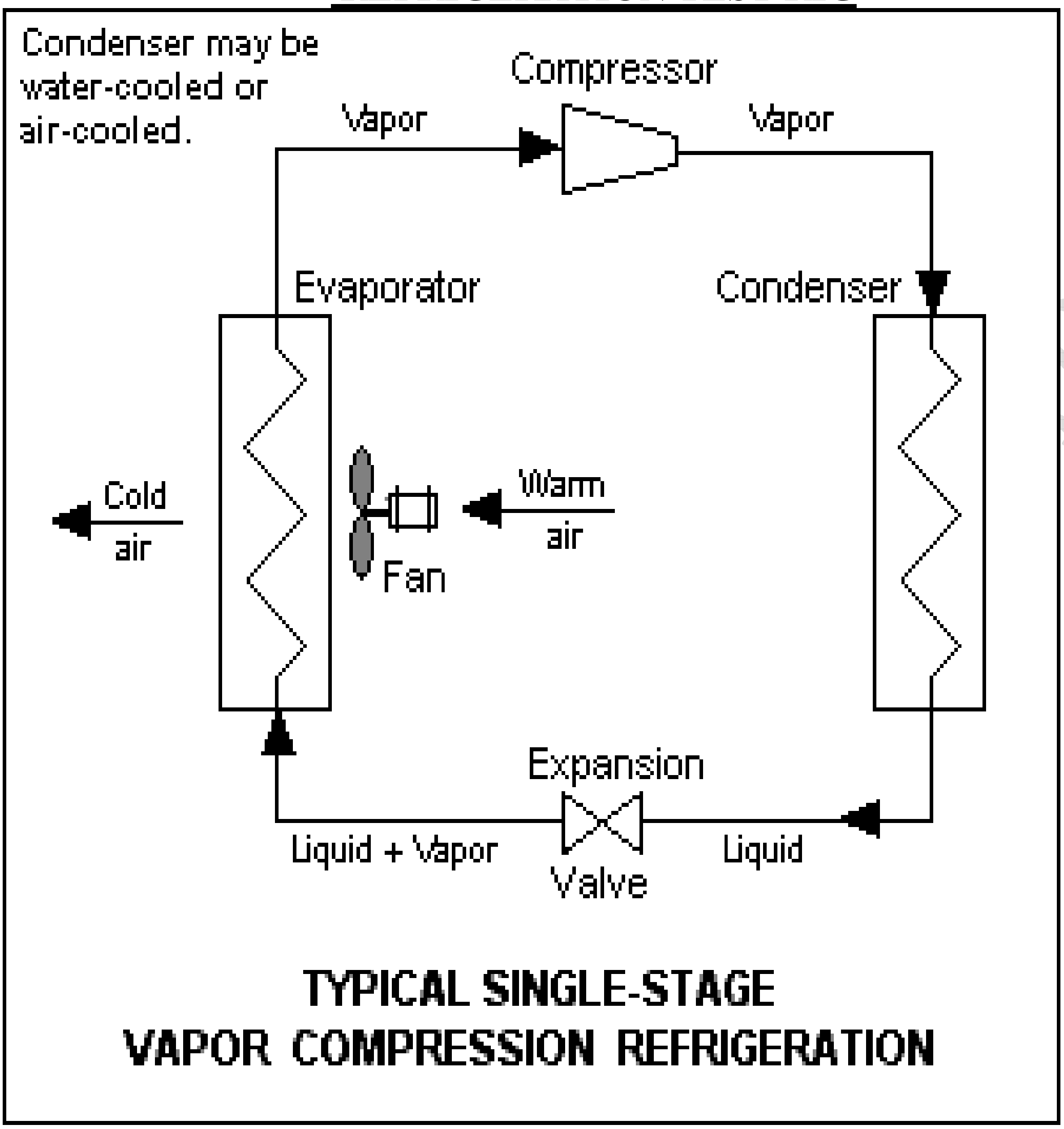
(C) Condenser

The heat added in the evaporator and compressor to the refrigerant is rejected in condenser at high temperature/ high pressure. This super heated refrigerant vapour enters the condenser to dissipate its heat in three stages. First on entry the refrigerant loses its super heat, it then loses its latent heat at which the refrigerant is liquefied at saturation temperature pressure. This liquid loses its sensible heat, further and the refrigerant leaves the condenser as a sub cooled liquid. The heat transfer from refrigerant to cooling medium (air of water) takes place in the condenser. The sub-cooled liquid from condenser is collected in a receiver (wherever provided) and is then fed through the throttling device by liquid line to the Evaporator.

There are several methods of dissipating the rejected heat into the atmosphere by condenser. These are water-cooled, air cooled or evaporative cooled condensers.

In the water-cooled condenser there are several types viz. Shell and tube, Shell and coil, Tube in tube etc. In evaporative cooled condenser, both air and water are used. Air-cooled condensers are prime surface type, finned type or plate type.

The selecting of the type depends upon the application and availability of soft water.



Vapour compression Refrigeration Cycle

(D) Throttling Device

The high-pressure liquid from the condenser is fed to evaporator through device, which should be designed to pass maximum possible liquid refrigerant to obtain a good refrigeration effect. The liquid line should be properly sized to have minimum pressure drop.

The throttling device is a pressure-reducing device and a regulator for controlling the refrigerant flow. It also reduces the pressure from the discharge pressure to the evaporator pressure without any change of state of the pressure refrigerant.

The types of Throttling Devices are:

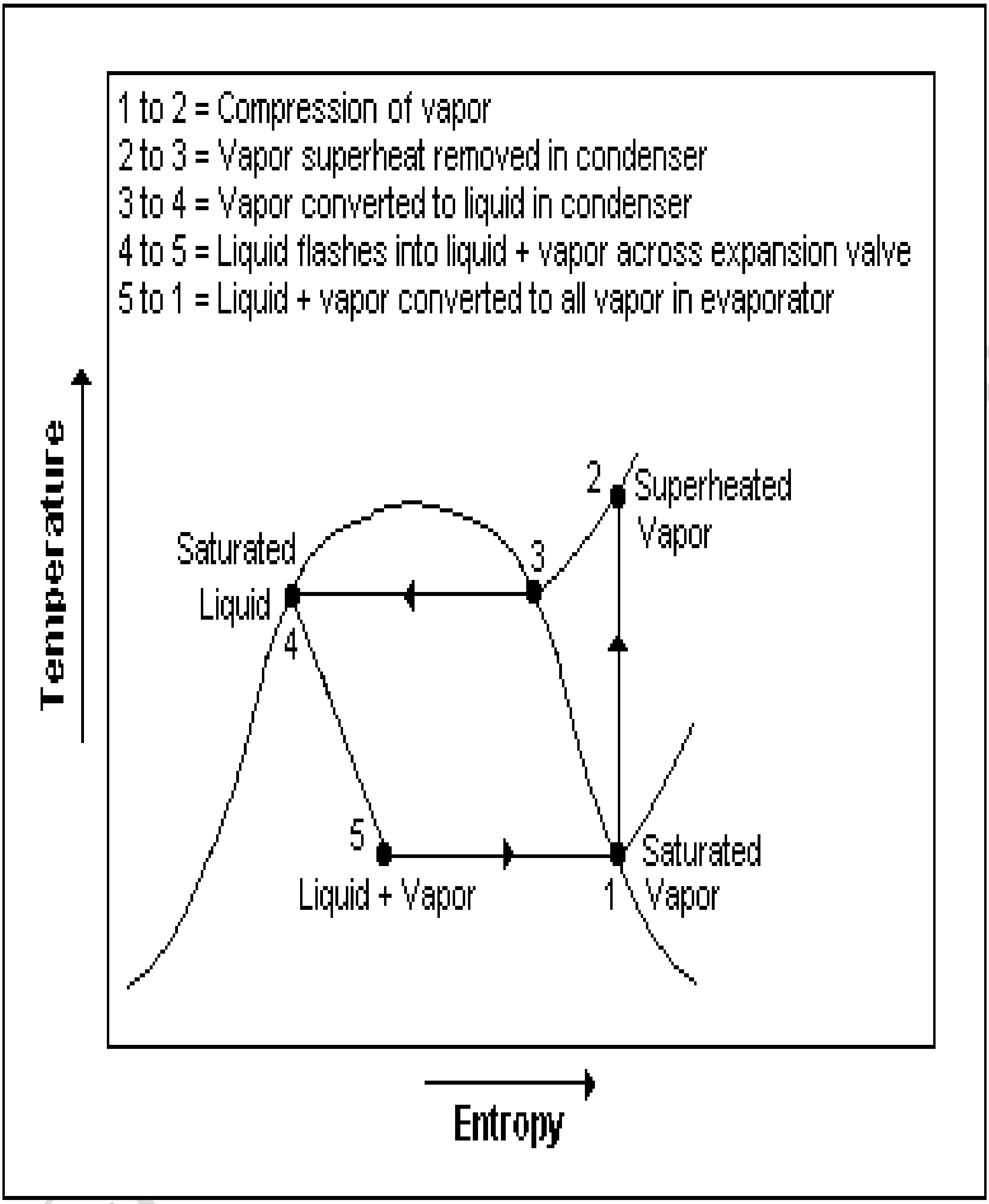
Capillary tubes

- Thermostatic expansion valves
- Hand expansion valves
- Hand valves.

The most commonly used throttling device is the capillary tube for application upto approx. 10 refrigeration tons. The capillary is a copper tube having a small dia-orifice and is selected, based on the system design, the refrigerant flow rate, the operating parameters (such as suction and discharge pressures), type of refrigerant, capable of compensating any variations/ fluctuations in load by allowing only liquid refrigerant to flow to the evaporator.

Summary

The working pressures, temperatures and states of the refrigerant in different parts of the refrigeration cycle are shown. In fig. 1 There are mainly two pressures operating in the refrigeration cycle, commonly known as the high side and the low side. The "high side" is referred to high pressure prevailing from compressor onward right up to the inlet of the throttling device and from the throttling device up to the suction of the compressor is called the "low side".



Temperature–Entropy diagram

TECHNICAL DETAIL

1. **COMPRESSOR: -** Hermetically sealed compressor1/3 Tr to work on 220V AC50HZ Operate on **Refrigerant R-134 A** with standard electrical accessories.

2. **CONDENSER: -** Fins and Tube type Air-cooled condenser.
3. **FAN MOTOR: -** 1/10 H.P condenser Fan motor with fan.
4. **EXPANSION VALVE: -**

   Capillary tube Expansion Valve
5. **EVAPORATOR:-** The tank is fabricated out of Stainless steel from outer and Inner. Heavy duty Glass Wool Insulation is Provided to minimize the heat losses.

CONTROLS AND STANDARD ACCESSORIES

1. Energy meter for compressor.
2. Filter drier.
3. Pressure gauges suction and discharge imported especially for R 134 a refrigerant.
4. HP LP cut out
5. Digital temperature indicator **(Eutech Make)** at various points in ^{0}C with PT. 100 probes.
6. Digital voltmeter.
7. Digital AMP meter for compressor.
8. Gas charging valve.

OBSERVATION TABLE

S.NO.	*P1*	*P2*	*T1*	*T2*	*T3*	*T4*

1. ***2.*** ***3.***						

Where,

P_1 = Suction Pressure

P_2 = Discharge Pressure

T_1 = Temperature Before Entering To Compressor

T_2 = Temperature After Exit From Compressor

T_3 = Temperature After Condensor

T_4 = Temperature After Expansion Valve

CALCULATIONS:

Coefficient of Performance: - *The Coefficient of Performance is defined as the ratio of heat extracted in the Evaporator to the work done on the Refrigerant.*

$$C.O.P. = \frac{Q}{W}$$

Using Points (P1,T1) ; (P2,T2) ;T3and T4 Locate Points 1,2,3,4 on the P-H. Chart for R-134and obtain the Enthalpy ValuesH1, H2, H3, H4

$$C.O.P. = \frac{(H_1 - H_4)}{(H_2 - H_1)}$$

Work done by Compressor:-

Work input by Compressor can also be measure by the Energy Meter.

$$\text{Electrical input power, IP} = \frac{10}{t_e} \times \frac{3600}{EMC}$$

Where, Energy Meter constant (EMC) = 3200 Imp / kw / hr.

t_e = Time revolution for Indications to Complete 10 revolutions

Taking motor efficiency as 75% we have input shaft power

SP = Elect. I.P x 0.75

PRECAUTIONS

1. Check Voltage, It should not be less than 220 Volts.
2. Always start condenser Fan Motor Before staring the compressor.
3. Check the amp. Meter for compressor. Initially it shall be 5-6 Amp. And then it will gradually decreases to 2-3 Amp. If it indicates more than 5 Amp. Check voltage for condenser fan Motor. More Amp. means more Load on the compressor.

4. Note down the readings of Suction and discharge Pressure Gauges. Absence of any reading will indicates the blockage of Pipe Line.
5. Do not disturb the internal settings of L.P.H.P. Cut Out.
6. While Switching Off the machine, First Switch off the Heaters of in service , switch Off the Compressor, condenser Fan motor, Components Fitted on the Panel Board then Switch off the Main switch.

SAMPLE CALCULATIONS

P_1 = 20Psi = 20 x 6895x10e^{-6} = .14Mpa (Gauge) = 0.14 + 0.1 = 0.24Mpa (Absolute)

P_2 = 150Psi = 150x6895x10e^{-6} = 1.03Mpa(Gauge) = 1.03 + 0.1 = 1.13Mpa (Absolute)

$T_1 = 24^0C$

$T_2 = 71^0C$

$T_3 = 39^0C$

$T_4 = -6^0C$

Locate Points 1,2,3,4 on the P-H. Chart for R-134and obtain the Enthalpy Values

H_1 =370KJ/Kg

H_2 = 390KJ/Kg

$H_3 = H_4$ = 239KJ/Kg

C.O.P.= $(H_1 - H_4) / (H_2 - H_1)$ = (370 - 239) / (390-370) = 131/20 = 6.55

CONCLUSIONS: Experiment on Refrigeration Test Rig was performed and the Coefficient of Performance (COP) of the Refrigeration Test Rig was found to be 6.55.