DEPARTMENT OF MECHANICAL ENGINEERING
REFRIGERATION & AIR CONDITIONING LAB

VAPOUR COMPRESSION REFRIGERATION UNIT

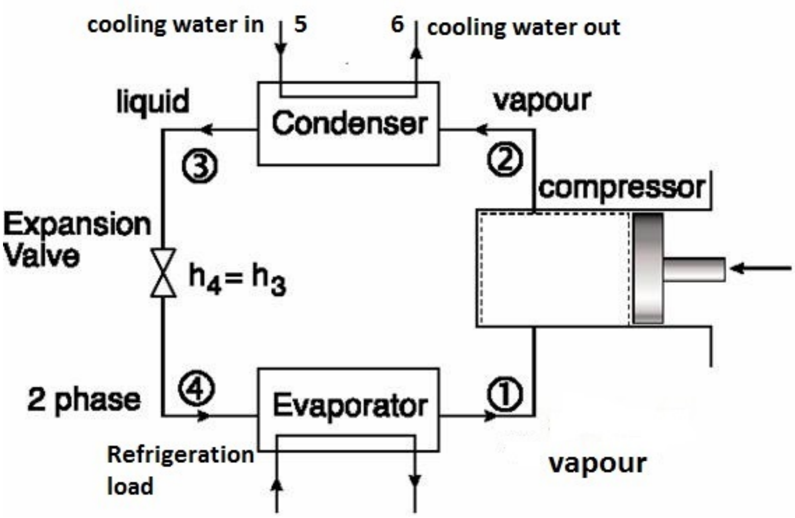
Aim: To verify heat balance on Vapour Compression Refrigerationsystem at different evaporator load and to plot the graphs for the following

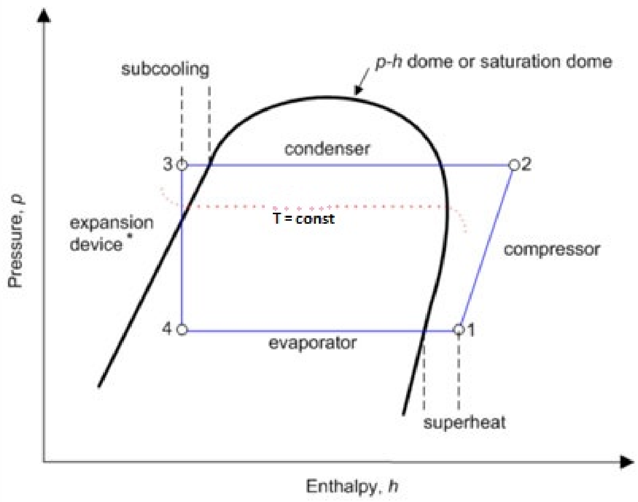
1. Overall COP v/s evaporator temperature
2. Refrigerant flow rate v/s Overall COP
3. Superheat v/s evaporator temperature
4. Refrigeration load and Power input v/s evaporator temperature

Theory:

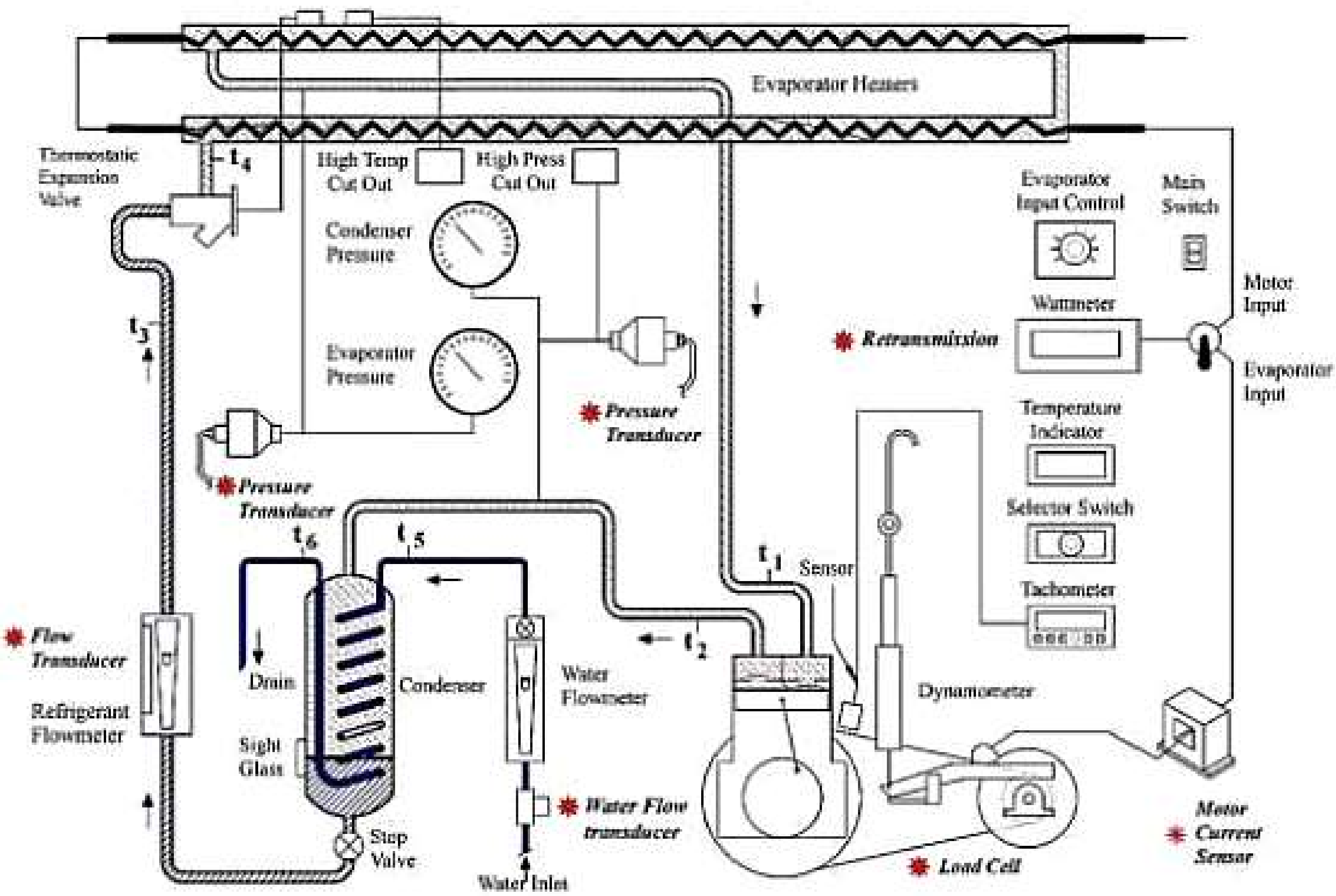
The purpose of a refrigerator is removal of heat from a low temperature medium. Among the various cycles developed, vapour compression refrigeration cycle is most widely used. It has four stages:

A) Evaporation; B) Compression; C) Condensation and D) Expansion.





EXPERIMENTAL SET UP



Specifications of the Unit:

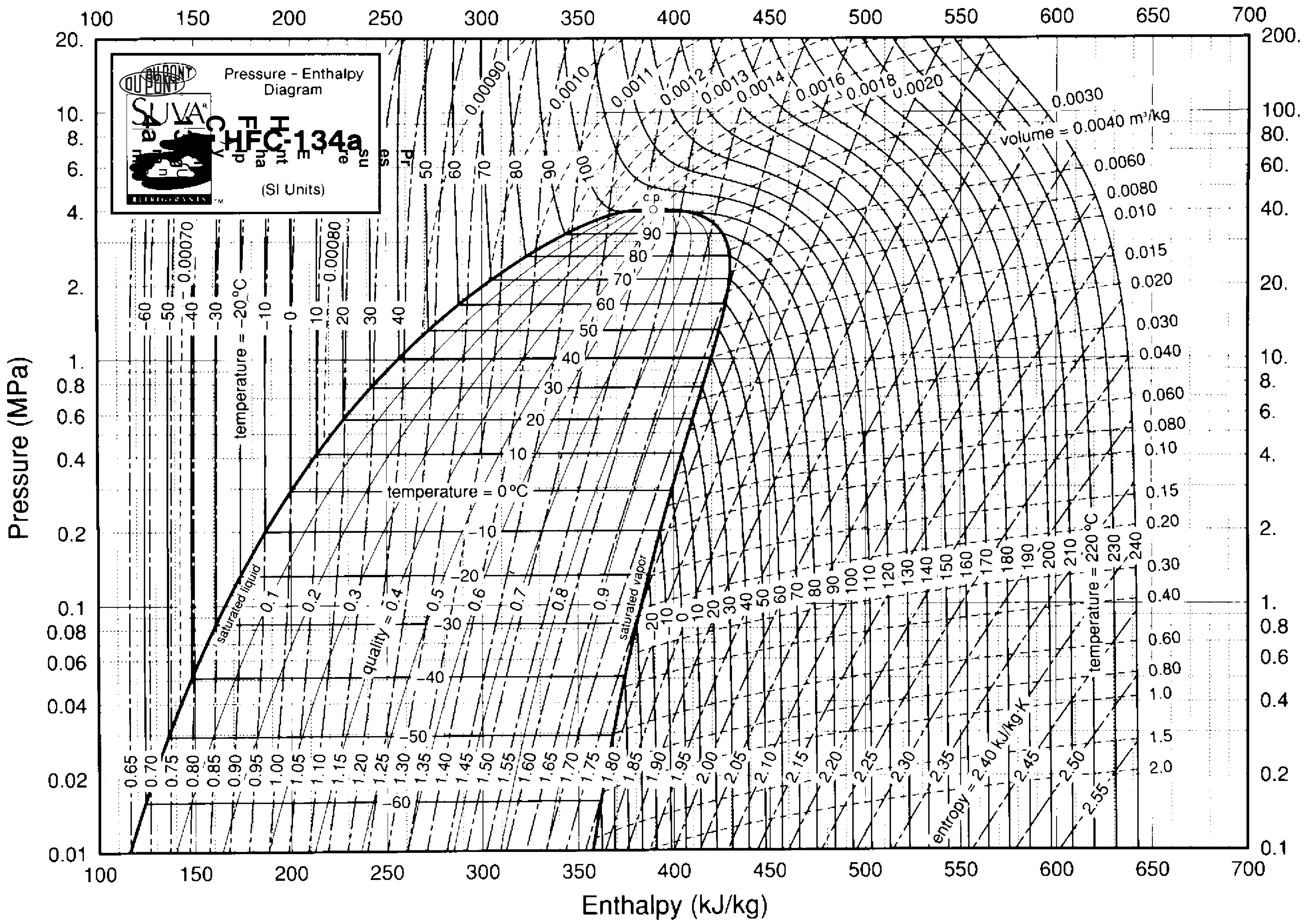
Refrigerant	: R-134a Tetrafluoroethane CF_3CH_2F
Refrigeration rate	: 1400W (max).
Condensing Temperature	: 50°C (max).
Evaporating Temperature	: -40 to +10°C.
Compressor Type	: Twin cylinder, reciprocating type
Bore	: 38mm
Stroke	: 19mm
Swept Volume	: 43.0cm^3/rev.
Rotational speed	: 740 rev/minute.
Condenser	: Shell and Coil type: Heat transfer area 0.075m^2
Evaporator	: Compact one through concentric tube with refrigeration load supplied by two separate electrical heating elements.
Cooling medium	: Water
Expansion valve	: Thermostatically controlled internally equalized valve, controlled by superheat at evaporator outlet.

Instrumentation:

Water Flowmeter	: One variable area water flow meter with needle control valve.
Refrigerant Flowmeter	: One variable area R134a flow meter.
Pressure Gauges	: 2 Bourdon tube gauges to indicate pressure in condenser and evaporator.
Compressor Speed	: A digital electronic tachometer with inductive sensor to measure rotational speed of compressor pulley wheel.
Motor Speed	: Motor speed from pulley belt diameter ratio = 1.98.
Torque	: Dynamometer fitted to motor to indicate 0-20N at 165mm radius.
Temperature	: A digital multi channel thermometer indicating temperatures from 'K' type thermocouples at important points.

Test Observations

Series		Test No.	1	2	3	4	5	6
Condenser Pressure(abs.)	P_c	kN/m^2						
Evaporator Pressure(abs.)	P_e	kN/m^2						
Compressor Suction	t_1	^oC						
Compressor Delivery	t_2	^oC						
Liquid leaving Condenser	t_3	^oC						
Evaporator inlet	t_4	^oC						
Water inlet	t_5	^oC						
Water outlet	t_6	^oC						
Water flow rate	m_w	g/s						
R134a flow rate	m_r	g/s						
Evaporator Wattage	Qe_{el}	W						
Motor Wattage	Qm_{el}	W						
Spring Balance	**F**	N						
Compressor speed	n_c	rpm						
M otor speed(n_m=n_c X Pulley ratio) (Pulley ratio =1.98)	n_m	rpm						



Pressure - Enthalpy Diagram
HFC-134a
(SI Units)
Pressure (MPa)
Pressure (bar)
Enthalpy (kJ/kg)
volume = 0.0040 m³/kg
temperature = 0°C
temperature = −20°C
temperature = 220°C
quality = 0.4
entropy = 2.40 kJ/kg·K
saturated liquid
saturated vapor
c.p.

CALCULATIONS

1. Refrigeration Load $Q_e = m_r \text{x} (h_1 – h_4) =$

2. Evaporator Heat input = Qel_e=

3. Shaft Power:
   Torque T = force (F)* arm length for dynamometer (0.165 m) =

   $\omega = 2\pi N_m/60 =$

$P_s = T\omega =$

4. Friction Power:
   $P_f = T\omega$ and F_f =5N (for no load condition)

   $P_f = 0.165 * F_f * (2\pi N_m/60) =$

5. Indicated Power:

   $P_i = Ps - P_f =$

6. COP based on electrical power or overall COP:

   $COP_{ep} = Q_e / Q_{mel} =$

7. COP based on Shaft power :

   $COP_{sp} = Q_e / P_s =$

8. COP based on Indicated Power :

   $COP_{ip} = Q_e / P_i =$

9. Degree of superheat at evaporator outlet

(t_{sat} =saturation temperature at evaporator pressure =t_4)

$= t_1 - t_{sat} =$

10. Volumetric efficiency:

$$\textit{volumetric efficiency} = \frac{actual\ \dot{V}}{\dot{V}_{swept}}$$

$$\eta_{vol} = \frac{\dot{m}_r * v_1}{\dot{V}_{swept}}$$

$$\dot{V}_{swept} = V_{swept} \times RPS\ of\ compressor$$

Heat Balance:

1. Verify:

$$W_{in} + Q_e = Q_{condensor} \ (\pm 10\% \text{ error})$$

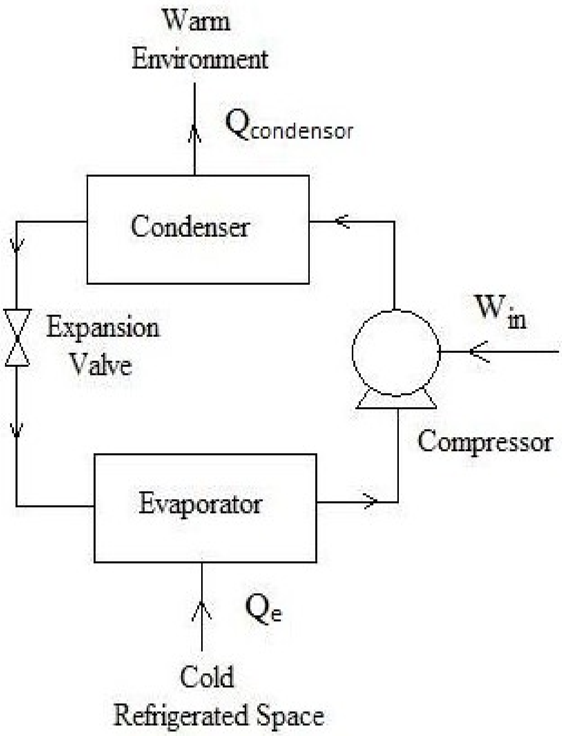
2. Actual work done in compressor:
W_{in}= indicated pressure$\times \dot{V}$

$$= IP \times \dot{V}_{swept} \times \eta_{vol}$$

$$= P_i \times \eta_{vol} =$$

3. $Q_{condensor}$ = Heat lost to cooling water

$$= \dot{m}_w C_P (T_6 - T_5)$$



<u>Sample graphs:</u>