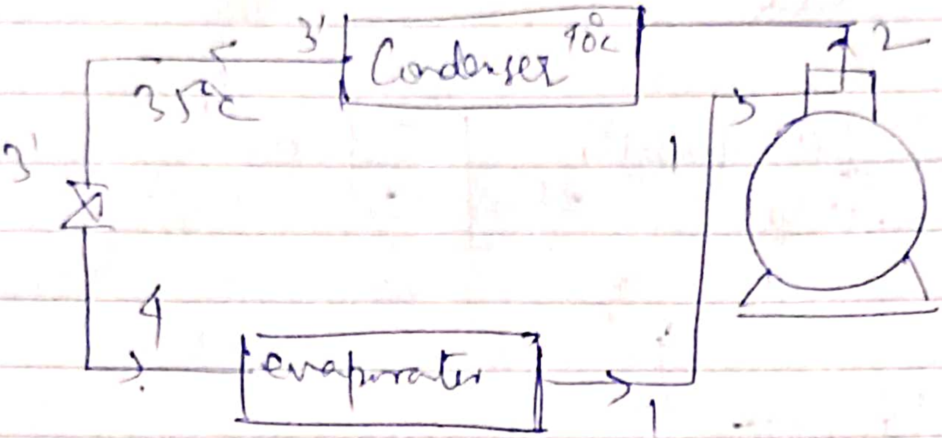
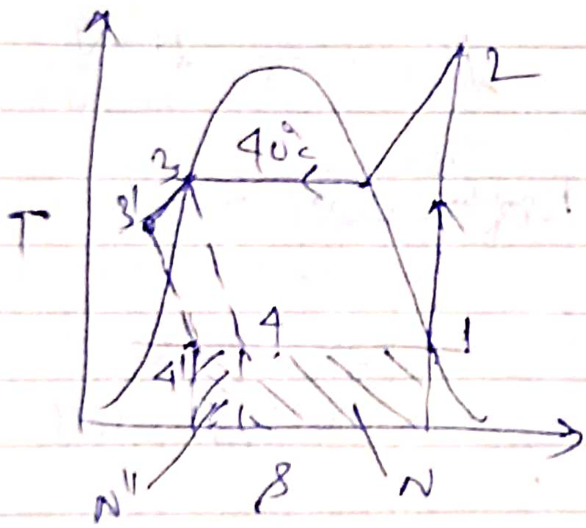
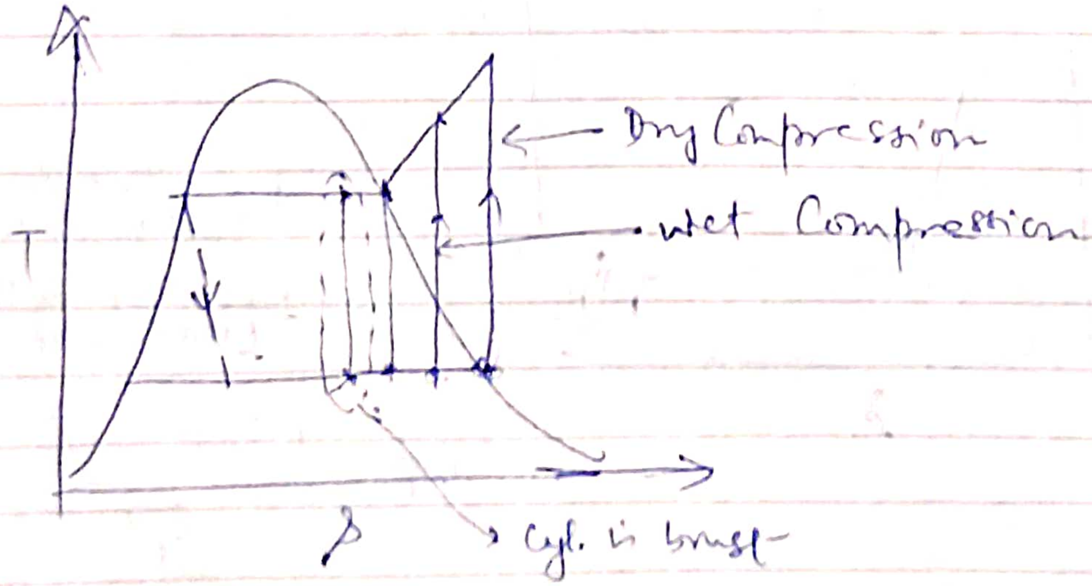
(iv) Effect of Subcooling before throttling.





New C.O.P = $\frac{N + N'}{W}$

i.e. C.O.P increases.

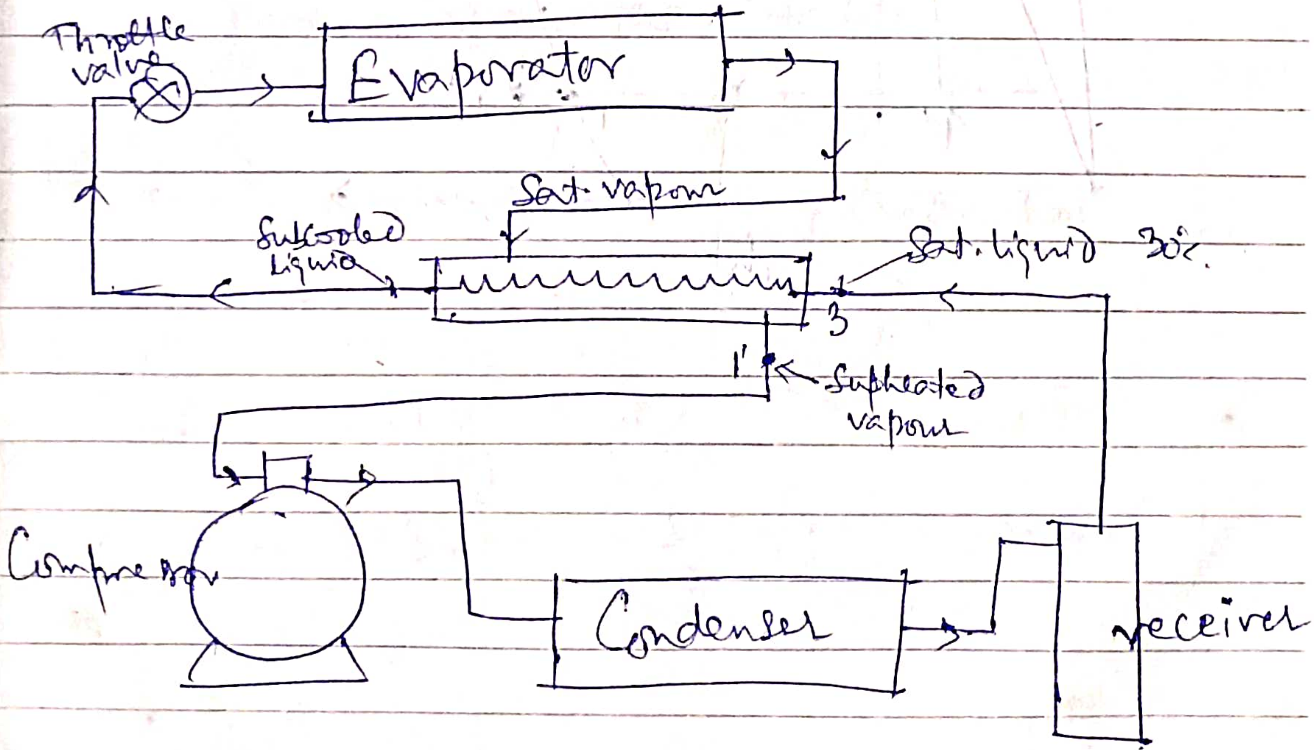


(*) Liquid hammer, occurs on the cyl. head.

To avoid it, liquid ~~entry~~ should not enter in the Compressor.

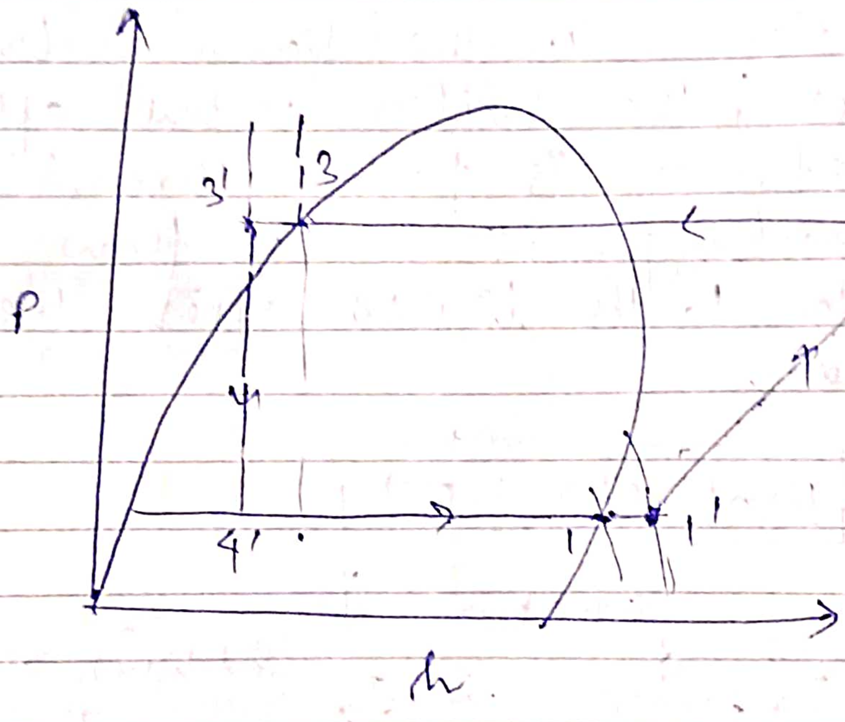
(3) Liquid suction heat exchangers

One method of subcooling the liquid is to have exchange of heat between hotter liquid after the condenser and the colder suction vapour after the evaporator. In the liquid suction heat exchanger, the suction vapour after the evaporator is passed through the heat exchanger in counter flow direction to the liquid after the condenser.



This results in the liquid getting cooled further or subcooled and the suction vapour getting warmed up or superheated.

Assuming no heat loss from the heat exchanger, the heat absorbed by vapour in getting superheated is equal to the heat rejected by the liquid in getting subcooled.



Q-13 An Ammonia refrigerating machine has the working temp. are 35°c in Condenser & −15°c in the evaporator. Consider the following two Cases: Dry Compression 1-2-3-4 and wet Compression 1'-2'-3-4. Draw the Cycles on T-S plane. Calculate for each case
(i) Theoritical piston displacement/TR in m^3/min.
(ii) Theoritical power reqd/TR.
(iii) - C.O.P
(iv) Dryness fraction of refrigerant at evaporator inlet.
(v) use the Property data of NH_3 given in the table.

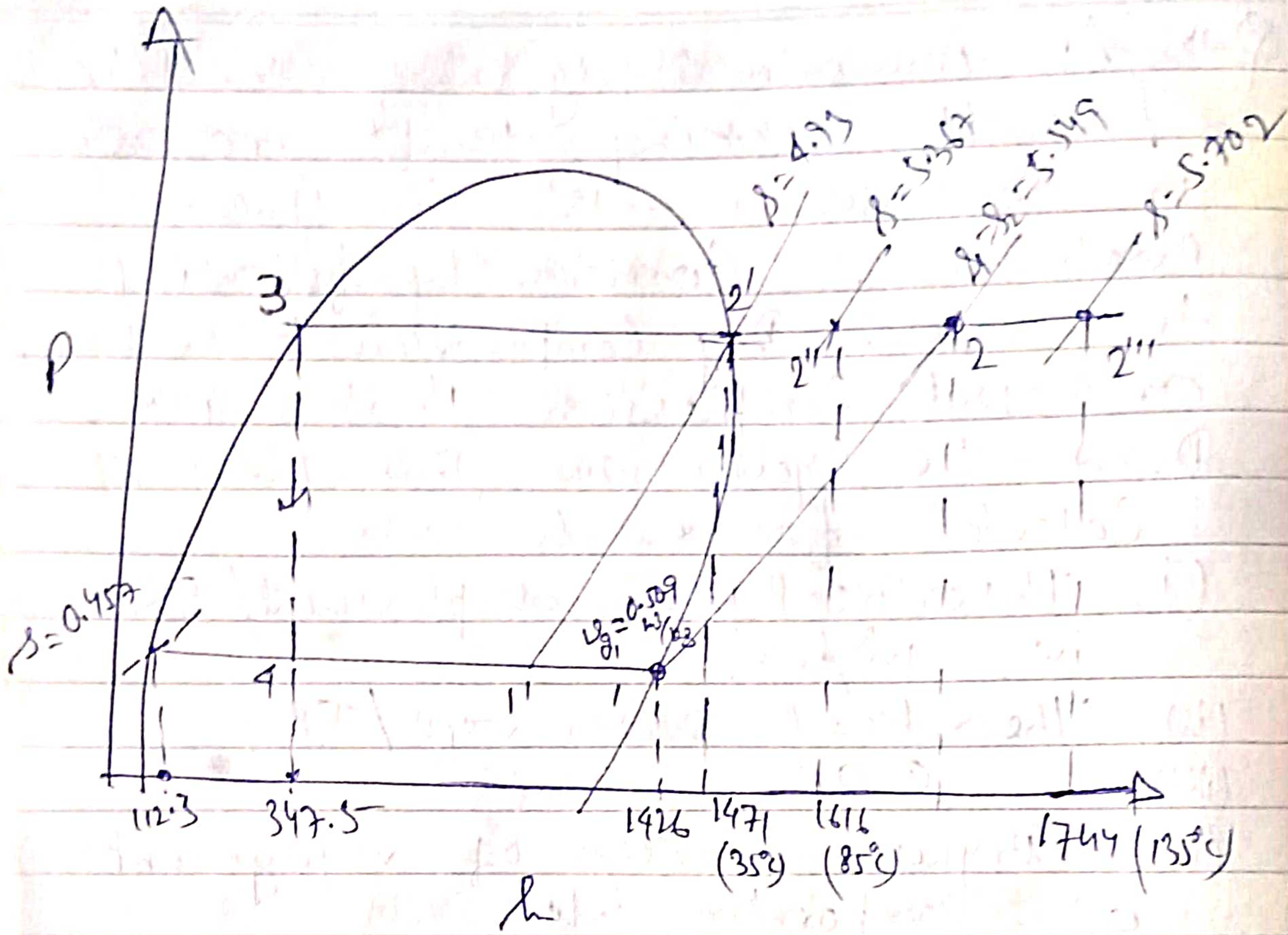
Soln.- 1-2-3-4 Dry Compression

$h_1 = 1426$ kJ/kg

$h_2 = ?$

$h_3 = h_4 = 347.5$ kJ/kg

S→	5.367	5.549	5.702
t→	85°c	?	135°c
h→	1616	?	1744



$$h_2 = 1616 + \left(\frac{1744 - 1616}{5.702 - 5.367}\right) \times (5.549 - 5.367)$$

$$\boxed{h_2 = 1685.54 \text{ kJ/kg}}$$

$$m(h_1 - h_4) = 1 \text{ TR} = 210 \text{ kJ/min}$$

$$m = \frac{210}{1426 - 347.5} = 0.1947 \text{ kg/min}$$

(i) Piston displacement $= m \times v_{g1}$

$$= 0.1947 \times 0.509$$

$= 0.08810 \ m^3/min.$

(ii) Power reqd $= \frac{m}{60}(h_2 - h_1)$

$= \frac{0.1942}{60}(1685.54 - 1426)$

$= 0.8422$ kW.

(iii) $C.O.P = \frac{N}{W} = \frac{h_1 - h_4}{h_2 - h_1}$

$= \frac{210}{0.8422 \times 60} = 4.1557$

(iv) $h_3 = h_4$

$(h_f)_3 = (h_f + x\, h_{fg})_4$

$347.5 = 112.3 + x(1426 - 112.3)$

$x = 0.1790$

Wet Compression:

(*) See next page

$h_1' = (h_f + x\, h_{fg})_{1'}$

$= 112.3 + x_1'(1426 - 112.3)$

$= 112.3 + 0.8784(1426 - 112.3)$

$= 1266.25 \ kJ/kg$

$h_2' = 1471 \ kJ/kg$

$h_3 - h_4 = 347.5$ kJ/kg

$s_1' = s_2' = 4.93$

$(s_f + x s_{fg})_1' = 4.93$

$0.457 + x_4' (5.549 - 0.457) = 4.93$

$x_4' = 0.8784$

$m' = \dfrac{210}{1266.25 - 347.5} = 0.2286$ kg/min

$v_1' = v_f + x_1'(v_g - v_f)$

$= 0.0015185 + 0.8784 (0.508013 - 0.0015185)$

$= 0.44642$ m³/kg

Theoritical piston displacement

$= 0.2286 \times 0.44642$ m³/min

$= 0.10205$ m³/min.

Q → A four cylinder single acting R12 Compressor 30 cm / 40 cm runs at 960 rpm. The Compressor clearance factor is 0.03 & law of Compression is $PV^{1.1} = C$, The operating temp^r for the vapour Compression refrigeration system are 8.47 bar (35°C) & 1.0047 bar (−30°C). The refrigerant temp^r are entering Compressor is −20°C & leaving Compressor is 50°C. Entering Condenser is 45°C & leaving Condenser is 25°C. Entering Expansion valve = 30°C. leaving Evaporator − Dry saturated ~~Assuming~~ heat removed in the Compressor 25 kJ/sec.

Calculate

(i) Refrigerating Capacity

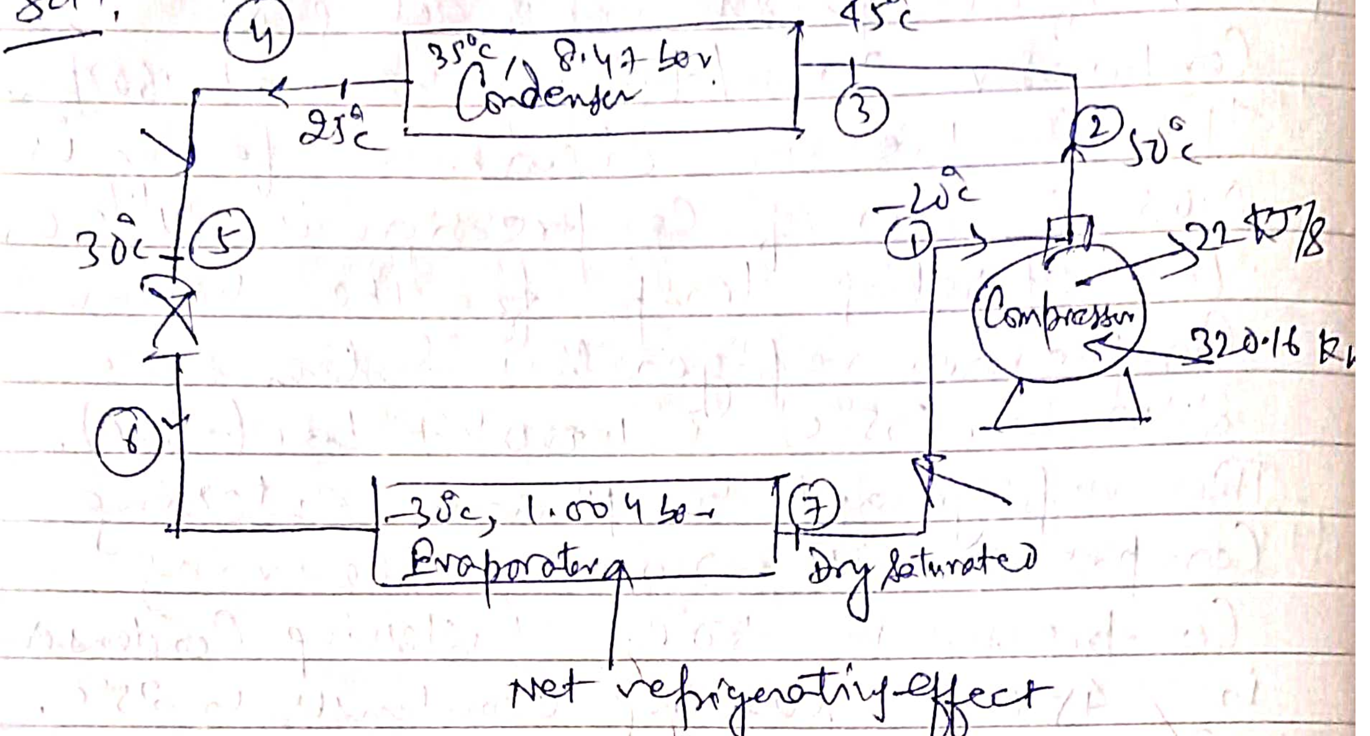
(ii) Compressor power

(iii) C.O.P

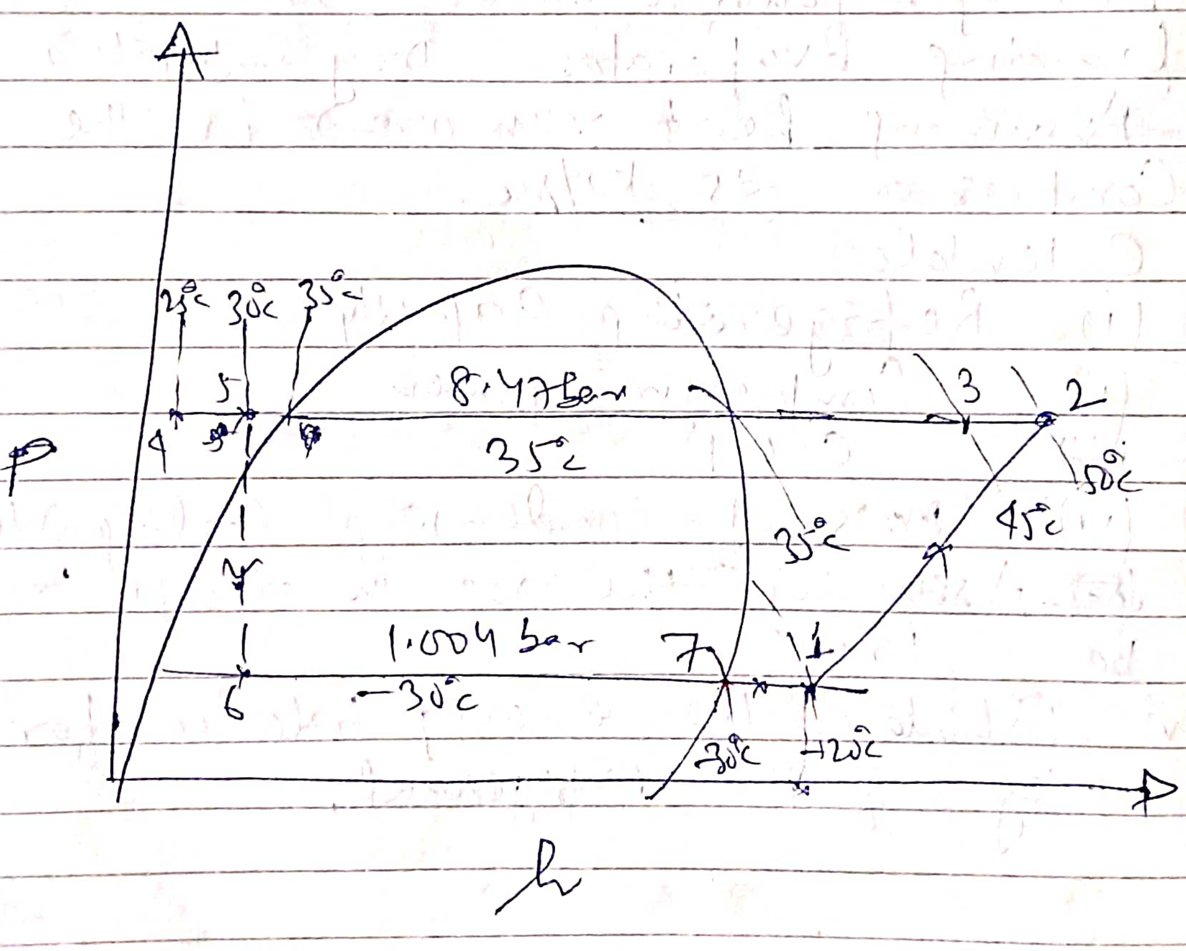
(iv) Mass of Condensing Cooling water ~~Assuming~~ Assuming the rise in temp^r to be 10°C.

(v) Tabulate the energy balance for 1 kg of the refrigerant.

Soln!



35°c, 8.47 bar
Condenser
45°c
25°c
50°c
-20°c
30°c
Compressor
320.16 kW
-30°c, 1.004 bar
Evaporator
Dry saturated
Net refrigerating effect



25°c 30°c 35°c
8.47 bar
35°c
P
50°c
45°c
1.004 bar
-30°c
-30°c
-20°c
h

$\frac{(V_C)\ \text{Clear vol.}}{(V_S)\ \text{Swept vol}} = 0.03$

$$\eta_{vol} = 1 - c\left[\left(\frac{P_2}{P_1}\right)^{\frac{1}{n}} - 1\right]$$

$$= 1 - 0.03\left[\left(\frac{8.47}{1.604}\right)^{\frac{1}{1.1}} - 1\right]$$

$$= 0.8215$$

$$\eta_{vol} = \frac{\text{vol. of vapour sucked in}}{\text{Swept volume}}$$

$$\Rightarrow 0.8215 = \frac{\text{vol. of vapour sucked in}}{4 \times \frac{\pi}{4} \times 0.3^2 \times 0.4 \times 960}$$

$\therefore$ vol. of vapour sucked in

$$= 89.19\ m^3/min$$

$$m = \frac{V}{v} = \frac{89.19}{0.16593} = 537.5\ kg/min$$

$$= 8.958\ \frac{kg}{s}$$

at low pressure,
Super saturated vapour behaves like a gas.

$$\frac{v_7}{T_7} = \frac{v_1}{T_1}$$

$$v_1 = \frac{v_7}{T_7} \times T_1 = 0.159375 \times \frac{253}{243}$$

$$= 0.16593\ m^3/kg$$