BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, Pilani

APPLIED THERMODYNAMICS

TUTORIAL TEST 3 (Open Book)

Dated 2.11.2016 | Max. Marks 20 | Time: 50 Mins

Q. A food storage chamber requires a refrigeration system of 12 TR capacity when an evaporator temperature of –8°C and condenser temperature of 30°C are maintained It is sub cooled by 5°C before entering the throttle valve and the vapour is superheated by 6°C before entering the compressor. The system uses R-134a as the refrigerant with saturation property values as mentioned in the Table below. Assume constant specific heats for both liquid and vapour phases of the refrigerant in the sub-cooled and superheated zones.

Determine:

(i) Mass flow rate of refrigerant (kg/s)

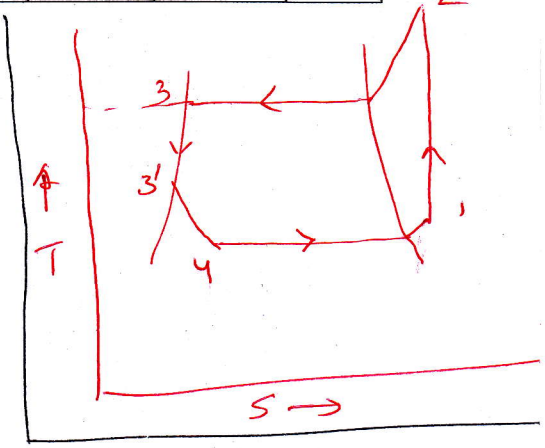
(ii) Temperature of the refrigerant at exit of compressor (°C)

(iii) Refrigeration effect/kg of refrigerant (kJ/kg)

(iv) COP of the cycle **[5+5+5+5=20]**

Temp °C	Pressure Mpa	Density kg/m³	v m³/kg	h Liquid kJ/kg	h Vapor kJ/kg	s Liquid kJ/kg K	s Vapor kJ/kg K	Specific heat Liquid C_p kJ/kg K	Specific heat Vapor C_p kJ/kg K	C_p/C_v
–8	0.21693	1320.8	0.09242	189.34	393.87	0.9606	1.7320	1.320	0.863	1.169
30	0.77020	1187.5	0.02664	241.72	414.82	1.1435	1.7145	1.446	1.065	1.249

v = Specific Volume
h = Specific Enthalpy
s = Specific Entropy



Soln

$T_4 = -8°C = 265\ K$, $T_3 = 30°C = 303\ K$

$C_{pv} = 1.230\ KJ/KgK$ $C_{pl} = 0.863\ KJ/KgK$

$T_1 = T_4 + 6 = 265 + 6 = 271\ K$

$S_1 = 1.7320 + 0.863 \ln \frac{271}{265}$

$S_1 = 1.7515\ KJ/KgK$

$1.7515 = S_1 = S_2 = 1.7145 + 1.065 \ln\left(\frac{T_2}{303}\right)$

$T_2 = 314.42\ K$ Part (ii)

Now $h_1 = 393.87 + 0.863(271 - 265)$

$= 399.05\ KJ/Kg$

$h_2 = 414.82 + 1.005(314.42 - 303)$

$= 426.98$ KJ/Kg

$h_3' = h_4 = h_{f3} - C_{pl}(\Delta T)$

$= 241.72 - 1.446(5) = 234.49$ KJ/Kg

$h_3' = h_4 = 234.49$ KJ/Kg

Part (III)

$R.E = h_1 - h_4$

$= 399.05 - 234.49 = \boxed{164.56 \text{ KJ/Kg}}$

$W.D = h_2 - h_1$

$= 426.98 - 399.05 = 27.93$ KJ/Kg

Part (IV)

$\boxed{C.O.P = \frac{164.56}{27.93} = 5.891}$

Mass flow rate $= \frac{42.204}{164.56}$

$= 0.256$ Kg/s

(a) 0.256 Kg/s
(b) 314.42 K
(c) 164.56 KJ/Kg
(d) 5.891

Marking will be based on steps.
($\pm$ 3-4 %) variation in answers leads to full marks.