Dr Laxmikant Yadav 24/11/2023

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(124)

NATIONAL INSTITUTE OF TECHNOLOGY HAMIRPUR (HP)
DEPARTMENT OF MECHANICAL ENGINEERING
END-TERM EXAMINATION NOV 2023
Refrigeration and Air Conditioning (ME-314)

Time: 3:00 hrs, **M.M.**: 50

Note: Attempt all the questions. Make necessary assumptions wherever required.

Q. 1 **(a)** a refrigerator that operates on the ideal vapour compression cycle with refrigerant R-134a to maintain the refrigerated space at -10°C while rejecting heat to the environment at 25°C. Select reasonable pressure for the evaporator and the condenser, and explain why you chose those values. **14**

(b) Consider a two-stage cascade refrigeration cycle and a two-stage compression refrigeration cycle with a flash chamber. Both cycle operates between the same pressure limits and use the same refrigerant. Which system would you favour? Why?

(c) Is it possible to obtain saturated air from unsaturated air without adding any moisture? Explain.

(d) Discuss the effect of the decrease in evaporator pressure on the clearance volumetric efficiency of the ideal reciprocating compressor with a p-v diagram.

(e) Can a vapour-compression refrigeration system with a single compressor handle more than one evaporator operating at different pressures? Explain with schematic and pressure enthalpy diagram of two evaporator single compressor system.

(f) What is effective temperature? Draw the constant effective temperature line on the psychrometric chart.

(g) Discuss the importance of critical temperature and pressure for the selection of refrigerants.

Q.2 Determine the COP of the actual vapour compression refrigeration cycle of R-134a working fluids operating between an evaporator exit pressure of 2.92 bar and condenser entry pressure of 10.16 bar. Consider the following pressure drop and effect in the analysis of the actual system. Draw a P-h or T-s diagram for your convenience. **8**

$Pressure\ drop\ in\ the\ evaporator, \Delta P_e = 0.1225\ bar$

$Pressure\ drop\ in\ the\ suction\ line, \Delta P_{sl} = 0.06\ bar$

$Pressure\ drop\ in\ the\ suction\ valve, \Delta P_{sv} = 0.12\ bar$

$Pressure\ drop\ in\ the\ discharge\ valve, \Delta P_{dv} = 0.39\ bar$

$Pressure\ drop\ in\ the\ discharge\ line, \Delta P_{dl} = 0.13\ bar$

$Pressure\ drop\ in\ the\ condenser, \Delta P_c = 0.06\ bar$

$\Delta T_{useful\ super\ heating} = 7.5°C$

$\Delta T_{useless\ super\ heating} = 7.5°C$

$\Delta T_{de-superheating\ in\ delivery\ line} = 10°C$

$\Delta T_{subcooling} = 8°C$

$Take, the\ isentropic\ efficiency\ of\ the\ compressor, \eta_{isen} = 80\%.$

Properties of R-134a are given on the next page.

Q. 3 Determine specific solution circulation rates and pump work for the NH_3-H_2O vapour absorption system (VARS) for the below two cases having generator temperature of 156°C, absorber temperature of 40°C and specific volume of solution in the absorber is 0.001155 m^3/kg. Also, denote the points of VARS in the temperature-concentration diagram for the following two cases. **10**

(a) Only pure NH_3 enters the condenser (due to the installation of the ideal separator) at 20.33 bar and is throttled to the evaporator at 2.25. In this case, the desired evaporator temperature which

Roll No:

is -17.5°C can be maintained easily because pure NH_3 takes heat from the surrounding space at a constant temperature of -17.5°C at 2.25 bar which is greater than atmospheric pressure. Further, the concentration of rich (x_r) & poor solution (x_p), and ammonia vapour (x'_{NH_3}) leaving from the generator, are as follows (obtained from the temperature concentration diagram): $x_r = 0.34, x_p = 0.2, and\ x'_{NH_3} = 0.73$.

(b) Some water vapour also enters the condenser along with NH_3, due to this phase change does not take place at constant temperature in the condenser at 20.33 bar and evaporator at 2.25 bar. As a result, a temperature of -17.5°C would not be attained in the evaporator after throttling to 2.25 bar. Therefore, to obtain the desired evaporator temperature as (a), NH_3+H_2O is expanded to 1 bar so that the average evaporator temperature would be -17.5°C. For this case, the concentration of rich solution (x_r) changes to 0.234 because of the change in evaporator pressure and the remaining concentrations are still the same because of no change in pressure temperature value.

Q.4 Using a schematic, distinguish between single-effect and double-effect Water-Lithium Bromide VARS systems. **3**

Q. 5 Draw a schematic and temperature entropy diagram of the Claude Cycle for Gas Liquefaction and explain the process of gas liquefaction for this cycle. **5**

Q. 6 (a) How do you get the final shape of the psychrometric chart (humidity ratio-DBT chart) from the phase diagram? Explain with proper logic and suitable diagrams. **4**

(b) How are the constant WBT and constant enthalpy lines constructed on a psychrometric chart? Explain with an example. **6**

Properties of Saturated Liquid and Saturated Vapour
R134a, 1, 1, 1, 2 Tetrafluoroethane, CH_2FCF_3

Temp. T °C	Pressure P, bar	Volume, v_g m³/kg	Enthalpy, kJ/kg Liquid h_f	Enthalpy, kJ/kg Vapour h_g	Entropy, kJ/kg K Liquid s_f	Entropy, kJ/kg K Vapour s_g	Sp Heat, kJ/kg K Liquid c_f	Sp Heat, kJ/kg K Vapour c_g
−4	2.5257	0.07991	194.68	396.33	0.9805	1.7297	1.323	0.866
−2	2.7206	0.07440	197.33	397.51	0.9903	1.7285	1.329	0.875
0	2.9269	0.06935	200.00	398.68	1.0000	1.7274	1.335	0.883
2	3.1450	0.06470	202.68	399.84	1.0097	1.7263	1.341	0.892
4	3.3755	0.06042	205.37	401.00	1.0194	1.7252	1.347	0.901
38	9.6301	0.02116	253.37	418.69	1.1809	1.7122	1.489	1.104
40	10.165	0.01999	256.35	419.58	1.1903	1.7115	1.500	1.120
42	10.721	0.01890	259.35	420.44	1.1997	1.7108	1.513	1.138