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MANIPAL INSTITUTE OF TECHNOLOGY
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II SEM. MTech. (ADVANCED THERMAL POWER AND ENERGY SYSTEMS)
DEGREE END SEMESTER EXAMINATIONS MAY/JUNE 2016

SUBJECT: REFRIGERATION AND CRYOGENIC SYSTEMS (MME-586)
REVISED CREDIT SYSTEM

Time: 3 Hours. MAX.MARKS: 50

Instructions to Candidates:
- Answer **ANY FIVE FULL** questions.
- Missing data, if any, may be suitably assumed.
- Use of thermodynamics data hand book/cryogenic data handbook is permitted.

1A) Explain with p-h diagram how the COP of vapour compression refrigeration system is improved with the use of flash chamber. What factors are to be considered in the design of flash chamber. (04)

1B) A reduced ambient air refrigeration system used for an aircraft consist of two cooling turbines with heat exchanger in between. The output of both the turbines is used to run the exhaust fan. The ambient air pressure and temperature are 0.25 bar and – 40^0C. The compressed air is cooled to 50^0C in the heat exchanger. The pressure ratio of the main compressor is 4. There is a pressure loss of 0.05 bar at the supply air nozzle to the cabin. The cabin condition is maintained at 1 bar and 25^0C. The aircraft is moving at 1500 km/hr. Ram efficiency is 90%. Isentropic efficiency of main compressor is 85% and that of both turbines is 80%. Determine; (06)

i) Mass flow rate of air supplied to the cabin if the cooling load is 25 TR.
ii) Air flow rate of ram air passed over heat exchanger if its maximum rise in temperature is limited to 12^0C.

2A) Explain the working principle of multi-evaporator system with multiple compressors and flash gas removal. Obtain an expression for its COP. What are the merits and De-merits of this system. (05)

2B) A compound refrigeration system with R22 refrigerant uses a flash chamber for flash gas removal and intercooling. The saturation temperature in the evaporator, intercooler and condenser are -30^0C, -10^0C and 30^0C resp. Assuming isentropic compression, dry saturated vapor and saturated liquid in the cycle, calculate for 50 TR of refrigeration load

i) The mass flow rate in each cylinder in kg/s
ii) Power required to run the system
iii) Piston displacement for each cylinder in m^3/s
iv) COP of the system. (05)

3A) Stating the assumptions made, obtain expressions for heat transfer in absorber, generator, condenser and evaporator of a lithium bromide-water absorption refrigeration system. (04)

3B) In a aqua-ammonia absorption refrigeration system of 20 TR capacity, the vapours leaving the generator are 100% pure NH3 saturated at 45^0 C. The evaporator, absorber, condenser and generator temperatures are -25^0 C, 32^0 C, 42^0 C & 75^0 C resp. At absorber exit, the concentration of NH3 in solution is 0.36 and enthalpy is 22 kJ/kg. At generator exit, the concentration is 0.08 and enthalpy is 695 kJ/kg.
i) Determine mass flow rate of NH3 in the evaporator (06)
ii) Carryout overall mass conservation and mass conservation of NH3 in absorber to determine mass flow rates of strong and weak solution
iii) Determine the heat rejection in absorber and condenser
iv) Determine the heat added in generator
v) COP

4A) Explain the factors to be considered for the thermal design of evaporators. Explain the working principle of flooded evaporators and obtain an expression for recirculation factor. (06)

4B) A thermostatic expansion valve uses R12 as the power fluid, and is used in a R12 based system operating at an evaporator temperature of 3^oC. The adjustable spring is set to offer a resistance equivalent to a pressure of 50 kPa. What is the degree of superheat? If there is a pressure drop of 20 kPa in the evaporator, what will be the degree of superheat. (04)

5A) Explain the working of Dilution refrigerator with schematic diagram. Mention any 2 application area for this refrigerator. (05)

5B) Air enters a reversible Claude system at 0.101 MPa and 293 K and is compressed isothermally to 2.02 MPa. At a condition of 2.02 MPa and 233 K, 70% of the main flow is diverted through the reversible adiabatic expander. The remainder flows through the heat exchangers and expands through the expansion valve to 0.101 MPa. Determine the liquid yield, work output of the expander per unit mass compressed, and the net work of the system per unit mass liquefied assuming that the expander work is utilized for compression. If this system is utilized as a refrigerator, determine the refrigeration effect, COP and FOM.
The following properties of air may be taken for calculation
At 0.101 MPa and 293 K, enthalpy is 421 kJ/kg and entropy is 3.867 kJ/kg K

At 2.02 MPa and 293 K, enthalpy is 417 kJ/kg and entropy is 2.986 kJ/kg K

At 2.02 MPa and 233 K, enthalpy is 354 kJ/kg and entropy is 2.749 kJ/kg K (05)

At the end of isentropic expansion, enthalpy is 223 kJ/kg and temperature is 98 K.

6A) With schematic and T-S diagram, explain the working of simple Linde dual pressure system for liquefaction of gases. Obtain expressions for fraction liquefaction and work of liquefaction (05)

6B) A Philips refrigerator is used to maintain a refrigeration temperature of 90 K while operating from an ambient temperature of 290 K. Helium is used as the working fluid. The system operates from a low pressure of 0.101 MPa to a maximum pressure of 1.01 MPa. What is the refrigeration per kg of helium compressed, COP and FOM if all of the process steps in the system are assumed to be ideal and helium behaves as an ideal gas. (05)