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MANIPAL INSTITUTE OF TECHNOLOGY

III SEMESTER B.TECH (MECHATRONICS ENGINEERING)

END SEMESTER EXAMINATIONS, DEC/JAN 2015

SUBJECT: ENGINEERING THERMODYNAMICS AND HEAT TRANSFER [MTE 2103]

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

1A. A milk chilling unit can remove heat from milk at a rate of 41.87 MJ/h. Heat leaks into the milk from the surrounding at an average rate of 4.187MJ/h. Find the time required for cooling a batch of 500kg of milk from 45˚C to 5˚C. Take C_p=4.187KJ/kgK. **(02)**

1B. A gas has an initial volume of 0.05m^3 and expands to a final volume of 0.1m^3 by heating the gas. The initial pressure of gas is 200KPa and is maintained with the help of weights. Considering the gas in the chamber as a system, calculate **(04)**

a. Work done by the system while heating is going on
b. Weights are removed from the piston, as the gas expands according to the following relations, calculate work done if initial conditions are same and final volume is 0.1m^3.
    i. $PV=c$
    ii. $PV^{1.4}=c$

1C. A reversible heat engine operates between 2 reservoirs at temperature of 600˚C and 40˚C. The engine drives a reversible refrigerator which operates between reservoirs at temperature of 40˚C and -20˚C. The heat transfer to the heat engine is 2000KJ and the net - work output of the combined engine **(04)**

refrigerator plant is 360KJ.

a. Evaluate the heat transfer to the refrigerant and the net heat transfer to the reservoir at 40˚C
b. Calculate (a) above, given that the efficiency of heat engine and the COP of the refrigerator are each 40%of their maximum values.

2A. Air flows steadily at a rate of 0.5kg/s through an air compressor entering at 7m/s velocity, 100KPa pressure and 0.95 m^3/kg volume and leaving at 5m/s, 700KPa and 0.19m^3/kg. The internal energy of air leaving is 90KJ/kg greater than that of air entering. Cooling water absorbs heat from the air at a rate of 58KW. Compute **(04)**

a. Rate of shaft work input to the air in KW
b. Ratio of inlet pipe diameter to outlet pipe diameter.

2B. A simple R12 plant is to develop 5 tons of refrigeration. The condenser and evaporator temperatures are to be 40˚C and -10˚C respectively. Determine **(06)**

a. the refrigerant flow rate
b. Pressure ratio
c. Heat rejected to the condenser in KW.
d. Dryness fraction after throttling
e. COP
f. Power required to drive the compressor

3A State Kelvin Planck's statement of second law and explain it. Also show that violating Kelvin Planck's law, violates Clausius statement of second law. **(05)**

3B. Derive an expression for heat transfer through an extended surface when the length of the extended surface is infinity. Also, write the assumptions taken into considerations for deriving the expression. **(05)**

4A. A double-pipe heat exchanger is constructed of a copper (k =380 W/m · °C) inner tube of internal diameter D_i =1.2 cm and external diameter D_o=1.6 cm and an outer tube of diameter 3.0 cm. The convection heat transfer coefficient is reported to be h_i =700 W/m² °C on the inner surface of the tube and h_o =1400 W/m² °C on its outer surface. For a fouling factor $R_{f,i}$= 0.0005 m² °C/W on the tube side and $R_{f,o}$ = 0.0002 m² °C/W on the shell side, determine (a) the thermal resistance of the heat exchanger per unit length and (b) the overall heat transfer coefficients U_i and U_o based on the inner and **(04)**

outer surface areas of the tube, respectively.

4B. Consider steady heat transfer between two large parallel plates at constant temperatures of T_1 = 290 K and T_2 =150 K that are L=2 cm apart. Assuming the surfaces to be black (emissivity ε = 1), determine the rate of heat transfer between the plates per unit surface area assuming the gap between the plates is (a) filled with atmospheric air, (b) evacuated, and (c) filled with superinsulation having an apparent thermal conductivity of 0.00015 W/m · °C. **(04)**

4C. Discuss the cooling technique employed in the following: (i) Ships and Submarines. (ii). Space Vehicles. **(02)**

5A. Discuss the design of chip carrier with appropriate diagram. **(03)**

5B. A double-pipe counter-flow heat exchanger as shown in figure Q5.A below, is to cool ethylene glycol (C_p= 2560 J/kg · °C) flowing at a rate of 3.5 kg/s from 80°C to 40°C by water (C_p = 4180 J/kg · °C) that enters at 20°C and leaves at 55°C. The overall heat transfer coefficient based on the inner surface area of the tube is 250 W/m² · °C. Determine (a) the rate of heat transfer, (b) the mass flow rate of water, and (c) the heat transfer surface area on the inner side of the tube. (Use LMTD Method). **(04)**

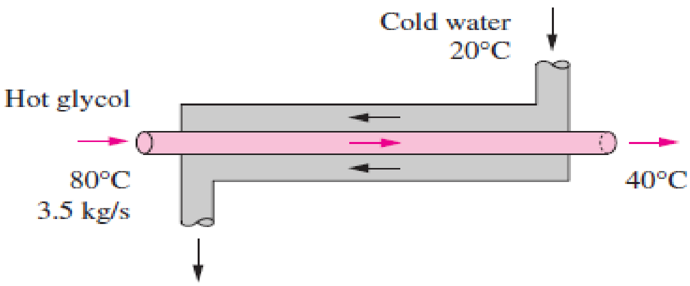

Fig. Q 5.A

5C. 2-kg of air at 10 bar pressure and 600˚C temperature expands isothermally to five times its original value. Calculate the following: **(03)**

i. The Original Volume
ii. Final Pressure
iii. Change in Entropy