12. Write short notes on (any **THREE**) :

(i) Shape factor

(ii) Compact heat exchanger

(iii) Mass transfer

(iv) Ablative heat transfer. 14

Faculty of Engineering & Technology

Fifth Semester B.E. (Aeronautical Engg.) (C.B.S.) Examination

HEAT TRANSFER

Time—Three Hours] [Maximum Marks—80

INSTRUCTIONS TO CANDIDATES

(1) All questions carry marks as indicated.

(2) Solve **SIX** questions as follows :

- Question No. **1** **OR** Question No. **2**.
- Question No. **3** **OR** Question No. **4**.
- Question No. **5** **OR** Question No. **6**.
- Question No. **7** **OR** Question No. **8**.
- Question No. **9** **OR** Question No. **10**.
- Question No. **11** **OR** Question No. **12**.

(3) Due credit will be given to neatness and adequate dimensions.

(4) Illustrate your answers wherever necessary with the help of neat sketches.

(5) Retain Construction Lines.

(6) Use of Drawing instruments is permitted.

(7) Use of Non-programmable calculator is permitted.

(8) Use of Steam Table/Thermodynamic Tables for moist air/Psychrometric/Mollier's/Refrigeration Charts is permitted.

(9) Assume suitable data wherever necessary.

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(b) Consider a cylindrical furnace with outer radius = height = 1 m. The top (surface 1) and the base (surface 2) of the furnace have emissivities 0.8 and 0.4 and are maintained at uniform temperatures of 700 K and 500 K respectively. The side surface closely approximates a black body and is maintained at a temperature of 400 K. Find the net rate of radiation heat transfer at each surface during steady state operation. Assume the view factor from the base to the top surface as 0.38. 9

9. (a) Explain briefly fouling in heat exchangers. 5

(b) Hot gases enter a finned tube, cross flow heat exchanger with a flow rate of 1.5 kg/s and a temperature of 250ºC. The gases are used to heat water entering the exchanger at a flow rate of 1 kg/s and an inlet temperature of 35ºC. On the gas side, the overall heat transfer coefficient and the area are 100 W/m^2K and 40 m^2 respectively. What is the rate of heat transfer by the exchanger and what are the gas and water exit temperatures ? Assume C_p of gas as 1.0 kJ/kg-K. 8

OR

(b) A vertical cylinder 1.5 m high and 180 mm in diameter is maintained at 100ºC in an atmosphere of 20ºC. Calculate the heat loss by free convection from the surface of the cylinder. Assume properties of air at mean temperature as $\rho = 1.06$ kg/m^3 and $\nu = 18.97 \times 10^{-6}$ m^2/sec, $C_p = 1.004$ kJ/kgºC and k = 0.1042 kJ/m.h.ºC. 8

OR

4. (a) Briefly explain the various regimes of pool boiling. 5

(b) A 350 mm long glass plate is hung vertically in the air at 24ºC while its temperature is maintained at 80ºC. Calculate the boundary layer thickness at the trailing edge of the plate. If a similar plate is placed in a wind tunnel and air is blown over it at a velocity of 5 m/sec. Find the boundary layer thickness at its trailing edge. Also determine the average heat transfer coefficient, for natural and forced convection for the above mentioned data. 8

5. (a) Define Reynold's, Prandtle, Nusselt and Grashoff number and give their expressions. 4

(b) Air at 27ºC and 1 bar flows over a plate at a speed of 2 m/s. (i) Calculate the boundary layer thickness at 400 mm from the leading edge of the plate. Find the mass flow rate per unit width of the plate. For air $\mu = 19.8 \times 10^{-6}$ kg/m sec at 27ºC. (ii) If the plate is maintained at 60ºC, calculate the heat transferred per hour. The properties of air at mean temperature of (27 + 60)/2 = 43.5ºC are given as :—

$\nu = 17.36 \times 10^{-6}$ m²/sec; k = 0.02749 W/mºC;

C_p = 1006 J/kgK; R = 287 Nm/kgmK; Pr = 0.7. 9

OR

6. Consider two large isothermal plates separated by 2 mm thick oil film. The upper plate moves at a constant velocity of 12 m/s, while the lower plate is stationary. Both plates are maintained at 20ºC.

(i) Obtain relation for the velocity and temperature distribution in the oil.

(ii) Determine the maximum temperature in the oil and the heat flux from the oil to each plate.

(iii) Consider the two plates to be at different temperatures, i.e. upper plate at 30ºC and lower plate at 15ºC. Thus, obtain the above two relations values for this condition. 13

7. (a) Define the following :

(i) Black body

(ii) Grey body

(iii) Opaque body

(iv) White body

(v) Specular reflection

(vi) Diffuse reflection. 6

(b) Calculate the net radiant heat exchanger per m² area for two large parallel plates at temperatures of 427ºC and 27ºC respectively. The emissivity of hot and cold plates is 0.9 and 0.6 respectively. If a polished aluminium shield is placed between them, find the percentage reduction in the heat transfer. The emissivity of shield is 0.4. 7

OR

8. (a) Distinguish between irradiation and radiosity. 4

1. (a) Explain the different modes of heat transfer with appropriate expressions. 6

   (b) A composite wall consists of 10 cm thick layer of building brick, k = 0.7 W/mK and 3 cm thick plaster, k = 0.5 W/mK. An insulating material of k = 0.08 W/mK is to be added to reduce the heat transfer through the wall by 40%. Find its thickness. 8

OR

2. A steel tube k = 43.26 W/mK of 5.08 cm inner diameter and 7.62 cm outer diameter is covered with 2.5 cm of asbestos insulation k = 0.208 W/mK. The inside surface of the tube receives heat by convection from a hot gas at temperature of 316ºC with heat transfer coefficient h_a = 284 W/m²K while the outer surface of insulation is exposed to atmosphere air at 38ºC with heat transfer coefficient of 17 W/m²K. Calculate heat loss to atmosphere for 3 m length of the tube and temperature drop across each layer. 14

3. (a) Draw the profile of boundary layer on a flat plate showing the velocity profiles and explain the significance of boundary layer. Define thermal boundary layer. 5

10. (a) Explain how heat exchangers are classified. 6

    (b) The flow rates of hot and cold water streams running through a parallel flow heat exchanger are 0.2 kg/s and 0.5 kg/s respectively. The inlet temperatures on the hot and cold sides are 75ºC and 25ºC respectively. The exit temperature of hot water is 45ºC. If the individual heat transfer coefficients on both sides are 650 W/m ºC, calculate the area of the heat exchanger. 7

11. A turbine installation consists of a combustion chamber, into which oil is injected at constant pressure, a set of nozzle and impulse turbine. The air is taken in at 2.5 bar and 27ºC and it is then compressed to 4 bar with an adiabatic efficiency of 86%. Heat is added by the combustion to raise the temperature to 570ºC. The combustion efficiency of the nozzle and turbine is 85%. The calorific value of oil used is 10,000 K cal/kg. Find for air flow of 80 kg/min. (i) The A/F ratio of the turbine. (ii) The final temp. of the exhaust gases. (iii) Net horse power of installation. Given upto the point of entry to the turbine : C_P = 0.238; C_V = 0.17 and after that point, take C_P = 0.25; C_V = 0.19. 14

OR