Faculty of Engineering & Technology

Fifth Semester B.E.(Mechanical Engg.)/Power 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 :

(i) Que. No.-1 **OR** Que. No.-2

(ii) Que. No.-3 **OR** Que. No.-4

(iii) Que. No.-5 **OR** Que. No.-6

(iv) Que. No.-7 **OR** Que. No.-8

(v) Que. No.-9 **OR** Que. No.-10

(vi) Que. No.-11 **OR** Que. No.-12

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

(4) Illustrate your answers with necessary figures/ drawings wherever necessary.

(5) Use of Steam tables / Thermodynamic tables for moist air / Psychrometric / Heat Transfer data book / Mollier's / Refrigeration charts is permitted.

(6) Assume suitable data wherever necessary.

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1. (a) Explain the different modes of heat transfer with their governing laws. 3

(b) Derive three dimensional steady state heat conduction equation in cylindrical co-ordinates. 8

(c) Explain critical thickness of Insulation. 3

OR

2. (a) A wire of 6.5 mm diameter at a temperature of 60°C is to be insulated by a material having K = 0.174 w/m°C. Convection heat transfer co-efficient (h_o) = 8.722 w/m² °C. The ambient temperature is 20°C. For maximum heat loss what is the minimum thickness of insulation and heat loss per metre length ? Also find percentage increase in heat and dissipation. 6

(b) A steam to liquid heat exchanger surface of 3200 cm² face area is constructed of 0.7cm nickel with a 0.2cm plating of copper on the steam sides. The resistivity of a water scale deposit on the steam side is 0.0017 m²K/w and the steam and liquid surface conductance 5465 w/m²K and 580 w/m²K respectively. The heated steam is at 111°C and the heated liquid is at 75°C. Calculate :

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(i) Overall steam to liquid heat transfer co-efficient.

(ii) Temperature drop across the scale deposit

(iii) Temperature at the copper-nickel interface.

Take K (Copper) = 384 w/mK

K (nickel) = 58 w/mK 8

3. (a) A plate shaped nuclear fuel element of 24 mm thickness exposed on the sides to convection at 200°C with a convective heat transfer co-efficient of 900 w/m^2K generates heat at 20 MW/m^3. Determine :

(i) The surface temperature

(ii) The maximum temperature in the plate and

(iii) The temperature gradient at the surface.

Thermal conductivity of the material is 25w/mK. 7

(b) State the function of the fin. Derive the expression for temperature distribution and heat transfer rate from the fin for finite long fin with convective heat losses from its free end. 6

OR

4. (a) What is Heisler charts ? Explain the significance of Biot and Fourier number. 3

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(b) A thermometer pocket , 2.2 cm in diameter 0.5 mm thick is made of steel (K = 27 w/mK) and it is used to measure the temperature stream flowing through a pipe. Calculate the minimum length of pocket so that the error is less than 0.5% of the applied temperature difference. Take stream at 250°C and h = 98 w/m²K. 5

(c) A piece of material is to be dried in an oven. The mass is 0.5 kg, Sp heat = 2999 Kj/kgK.The surface area is 0.085m². In the process the material gets heated and additionally 45 J/sec of heat is used up in evaporation of moisture. The oven is at 180°C and the convection co-efficient is 16w/m²K. Determine the time required to heat up the material from 30°C to 90°C. 5

5. (a) Explain the following dimensionless numbers and their physical significance :

(i) Reynolds number

(ii) Prandtl number

(iii) Nusselt number 6

(b) Nitrogen at a pressure of 0.1 atm flows over a flat plate with a free stream velocity of 8m/sec. The temperature of the gas is -20°C. The plate temperature is 20°C. Determine the length for the flow to turn turbulent. Assume 5×10^5 as Critical

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Reynolds number. Also determine the thickness of thermal and velocity boundary layers and the average convection co-efficient for a plate length of 0.3m. 7

OR

6. (a) What do you mean by hydrodynamic and thermal boundary Layers ? Explain with reference to flow over a flat heated plate. 5

(b) A bank of tubes consists of 10mm tubes 100 numbers arranged in a square array of 15mm pitch. The tube ware is at 40°C and air enters at 20°C with a velocity of 4m/sec. Determine the value of convection co-efficient and the heat transferred to the air for 1m length of the tubes in array. 8

7. (a) Explain Regimes of pool boiling with neat sketch. 4

(b) A plate heater 0.4×0.4m using electrical elements, has a constant heat flux of 1.2 KW/m^2. It is placed in room air at 20°C with hot side facing up. Determine the value of h and average plate temperature. 9

OR

8. (a) What is the significance of Grashof's number and Rayleigh number ? 4

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(b) Refrigerant -12 is to be condensed at the rate of 10,000 kg/hr at 35°C using water at 25°C. The condenser uses a square array of 25×25 tubes of 12 mm OD, calculate the Length of the tube bundle. 9

9. (a) Write short notes on :

(i) Shape factor

(ii) Radiation shield

(iii) Reciprocity theorem. 6

(b) The net radiation from the surfaces of two parallel plates maintained at T_1 and T_2 is to be reduced by 99%. Calculate the number of screens to be placed between the two surfaces to achieve this reduction in heat exchange assuming the emissivity of the screens as 0.05 and that of surfaces as 0.8. 7

OR

10. (a) Write short notes on :

(i) Radiosity, irradiation and emissive power

(ii) Absorptivity, reflectivity and transmissivity. 6

(b) Calculate the following for an industrial furnace in the form of a black body and emitting radiation at 2500°C :

(i) Maximum emissive power

(ii) Total emissive power. 7

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11. A shell and tube heat exchanger is used as an ammonia condenser with ammonia vapour entering the shell at 50°C as saturated vapour. Water enters the single pass tube arrangement at 20°C and total heat transfer required is 200 KW. The overall heat transfer co-efficient is estimated to be 1000 w/m²K. Determine area to achieve a heat exchanger effectiveness to 60 % with an exit temperature of 40°C. What % reduction in heat transfer would result if water flow is reduced in half while keeping heat exchanger and overall heat co-efficient 'U' same ?

Given : Effectiveness = 1–exp[-NTU] 14

OR

12. The condenser of a large steam power plant is a shell and tube heat exchanger having a single shell and 30,000 tubes, with each tube making two passes. The tubes are thin-walled with 25 mm diameter and steam condenses on the outside of the tubes with h_o = 11 Kw/m²K. The cooling water flowing through the tubes is 30,000 kg/sec and the heat transfer rate is 2GW. Water enters at 20°C, while steam condenses at 50°C. Find the length of the tubes in one pass. Properties of water are :

Cp = 4.18 KJ/kgK

μ = 855×10^{-6} N^{-5}/m^2

K = 0.613 w/mK

P_r = 5.83

Take LMTD correction factor as 1 14