BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: BE **SEMESTER : IV**
BRANCH: CE/C&P **SESSION : SP/19**

SUBJECT: CL4001 HEAT TRANSFER OPERATIONS

TIME: 3.00 Hrs. **FULL MARKS: 60**

INSTRUCTIONS:
1. The question paper contains 7 questions each of 12 marks and total 84 marks.
2. Candidates may attempt any 5 questions maximum of 60 marks.
3. The missing data, if any, may be assumed suitably.
***4*. Before attempting the question paper, be sure that you have got the correct question paper.**
5. Tables/Data hand book/Graph paper etc. to be supplied to the candidates in the examination hall.

Q.1(a) Explain heat conduction heat transfer through composite wall. [2]

Q.1(b) Derive the general heat conduction equation of Fourier-Biot in Cartesian coordinates [4]

Q.1(c) Derive the expression for heat conduction infinitely long rectangular fin. A plate having a thickness of 4.0 mm has an internal heat generation of 200MW/m^3 and a thermal conductivity of 25 W/m. ^{0}C. One side of the plate is insulated and the other side is maintained at 100^{0}C. Calculate the maximum temperature in the plate. [6]

Q.2(a) Explain Transient heat transfer and periodic variation system with example. [2]

Q.2(b) A thermocouple junction is in the form of 8mm diameter sphere. Properties of material are: k=40W/m. ^{0}C, density=8000kg/m^3, c=420J/kg. ^{0}C, h=40W/m^2.^{0}C. This junction is initially at 40^{0}C and inserted in a steam of hot air ay 300^{0}C. Find: **(a)** Time constant of the thermocouple, **(b)** Thermocouple is taken out from the hot air after 10 seconds and kept in still air at 30^{0}C. Assuming HTC in air 10w/m^2. ^{0}C, find temperature attained by the junction 20 seconds after removing from hot air. [4]

Q.2(c) Describe the all methods of unsteady state non periodic heat conduction. [6]

Q.3(a) Explain the convection heat transfer and correlate with dimensionless numbers. [2]

Q.3(b) Explain and give the significance of these dimensionless numbers: Nusselt number, Prandtl number, Grashof number and Stanton number. [4]

Q.3(c) Derive the expression for Reynold's analogy. Air flow over a heated plate at velocity 50m/sec. the local skin friction coefficient at a point on a plate is 0.004. Estimate the local heat transfer coefficient at this point. Data given for air: k=0.035W/m.^{0}C, density=0.88kg/m^3, c=1.001kJ/kg.^{0}C, μ=0.0000228kg/m.sec. Use St. $Pr^{2/3} = C_{fx}/2$. [6]

Q.4(a) State and explain the Kirchhoff's law of radiation. [2]

Q.4(b) Derive the expression for net heat exchange between two infinitely long parallel gray planes. [4]

Q.4(c) Two large parallel plate one at 727°C with emissivity $\varepsilon_1 = 0.8$ and another at 227°C with emissivity $\varepsilon_2 = 0.4$. An aluminium radiation shield with an emissivity $\varepsilon_3 = 0.05$ on both sides is placed between the plates. Calculate the percentage reduction in heat transfer rate between the two plates as a result of the shield. Use $\sigma = 5.67 \times 10^{-8}$ W/m^2.K^4. [6]

Q.5(a) What is fouling? What is its effect on Heat exchanger? [2]

Q.5(b) Starting from basic derive an expression for effectiveness of parallel flow heat exchanger in terms of NTU and capacity ratio when cold fluid is treated as the minimum fluid. [4]

Q.5(c) A counter flow double – pipe Heat exchanger operates with hot water flowing inside the inner pipe and a polymer fluid flowing in the annular space between the two pipes. The water flow rate is 2 kg/s and it enters at a temperature of 90°C. The polymer enters at a temperature of 10°C and leaves at a temperature of 50°C while the water leaves the exchanger at a temperature of 60°C. Calculate the value of the overall heat-transfer coefficient expressed in W/m^2.°C by both methods i) LMTD approach and ii) effectiveness-NTU method, if the area for the heat exchanger is 20m^2. Given NTU = 0.9 for effectiveness, ε = 0.5 and Capacity rate ratio, C = 0.75. [6]

Q.6(a) Sketch a 2-4 shell-tube heat exchanger with baffles and show fluid flow path. [2]

Q.6(b) Write the main steps of Kern's method for the design of shell and tube heat exchanger. [10]

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Q.7(a) Write short notes on film wise and drop wise condensation. [4]

Q.7(b) A single effect evaporator is to concentrate 20000 lb / hr of 20% NaOH solution to 50% strength. Steam is available at a gauge pressure of 1.37 atm. The absolute pressure in the vapour space is 100 mmHg. The overall heat transfer coefficient is 1200 kcal/hr-m^2-K. The feed temperature is 100 ^{0}F. Calculate the heating surface required, and steam requirements. [8]

Data-
Boiling point of water at 100 mmHg = 51.1 ^{0}C
Boiling point of 50% NaOH solution = 91.6 ^{0}C
Enthalpy of feed at 37.8 ^{0}C = 30.47 kcal/kg
Enthalpy of thick liquor at its boiling point = 122.38 kcal/kg
Enthalpy of water vapour at 91.6 ^{0}C and 100 mmHg pressure = 635.7 kcal/kg
Heat of vaporization of steam at 1.37 atm gauge pressure = 2185 KJ/kg.

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