T.E IV / Rev / Heat & Mass Transfer 21/12/10

P4-Con No-23 mech

Con. 5708–10. (REVISED COURSE) GT–6648

(3 Hours) [Total Marks : 100

N.B. : (1) Question No. **1** is **compulsory**.
(2) Answer any **four** out of remaining **six** questions.
(3) Make **suitable** assumption, if any.
(4) Use of steam table is **permitted**.

1. Solve any five 20

a) Define thermal conductivity, thermal resistance, and thermal conductance. What is the approximate range of thermal conductivity of solids, liquids and gases?

b) What are the various types of fins? Discuss some of the important applications of fins.

c) Explain non-dimensional numbers used in convection heat transfer.

d) Define and explain mass transfer processes.

e) Why does a cavity with a small hole behave as a black body? Thermal radiation strikes a surface, which has a reflectivity of 0.55 and a transmissivity, of 0.032. The absorbed flux as measured indirectly by heating effect works out to be 95 W/m^2. Determine the rate of incident flux.

f) What is mean by fouling factor? How does it affect the performance of a heat exchanger?

2. a) Explain critical thickness of insulation and its importance. 4

b) Write construction and working of heat pipe. 6

c) During heat treatment, cylindrical pieces of 25 mm diameter, 30 mm height and at 30°C are placed in a furnace at 750°C with convection coefficient 80 W/m^2-deg. Calculate the time required to heat the pieces to 600°C. What will be the shortfall in temperature if the pieces are taken out from the furnace after 280 seconds? Assume the following property values: density 7850 kg/m^3; specific heat 480 J/kgK; conductivity 40 W/m-deg. 10

3. a) Derive an expression for heat flow through a composite cylinder (2 layers) taking into account the film heat transfer coefficients on the inside and outside surface of the cylinder. 8

b) The interior of a refrigerator has inside dimensions 60 cm x 45 cm base area and 120 cm high. The composite wall is made of two 3mm mild steel sheets (k=145 kJ/m-hr-deg) with 6 cm of glass wool (k=0.188 kJ/m-hr-deg) insulation sandwiched between them. The average values of convective heat transfer coefficients at the interior and exterior wall are 40.8 and 52.3 kJ/m^2-hr-deg respectively. 12

i) Draw the thermal circuit.

ii) Calculate the individual resistance of this composite wall and the resistance at the surface, and the overall conductance.

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iii) For the air temperature inside the refrigerator at 6.5°C and outside of 25°C, determine the rate at which heat must be removed from the refrigerator. Also, calculate the temperature on the outer surface of the metal sheet.

4. a) State and prove Kirchoff's law of radiation. 6

b) An Aluminum rod 2.5 cm in diameter and 10 cm long, protrudes from a wall which is maintained at 250°C. The rod is exposed to an environment at 15°C. The convection heat transfer coefficient is 15 W/m^2 K. Calculate the heat lost by rod. Assume rod end is insulated. Take k for Aluminum =200 W/mK. Also find the fin efficiency and temperature at the end of fin. 8

c) State and explain Fick's law of diffusion mass transfer. 6

5. a) With the help of dimensional analysis method prove that for forced convection :-

$$Nu = \text{constant} \times (Re)^m \times (Pr)^n$$ 8

b) Prove that the total emissive power of black surface is π times the intensity of radiation. 6

c) Air at 1 atm and 25°C, containing small quantities of iodine, flows with a velocity of 5.25 m/s inside a 3 cm diameter tube. Determine mass transfer coefficients for iodine transfer from the air stream to the weak surface. Assume the following thermo-physical properties of air. D= 0.82 x 10^{-5} m^2/s, ν =15.5 x 10^{-6} m^2/s. 6

6. a) Derive the relationship between the effectiveness and the number of transfer units for a parallel flow heat exchanger. 10

b) Air at atmospheric pressure and 20°C flows with 6m/s velocity through main trunck duct of air conditioning system. The duct is rectangular in cross-section and measures 40 cm x 80 cm. Determine heat loss per meter length of duct corresponding to unit temperature difference. The relevant thermo-physical properties of air are: k = 0.026 W/m-deg ; ν = 15 x 10^{-6} m^2/s; α = 7.7 x 10^{-2} m^2/hr Use $Nu = 0.023 (Re)^{0.8} \times (Pr)^{0.4}$ 10

7. a) What is condensation and when does it occur? Distinguish between mechanism of filmwise condensation and dropwise condensation. 4

b) State the advantages and limitations of dimensional analysis. 4

c) Write short notes on any three of the following:- 12

i) Various modes of heat transfer

ii) Significance of dimensionless groups

iii) Lumped heat capacity analysis

iv) Shape factor and its properties