(Following Paper ID and Roll No. to be filled in your Answer Book)

PAPER ID : 4018 Roll No.

B.Tech.

FIFTH SEMESTER EXAMINATION, 2004-2005

HEAT AND MASS TRANSFER

Time : 3 Hours *Total Marks : 100*

Note : *(i) Attempt **ALL** the questions.*

(ii) All questions carry equal marks.

(iii) All symbols have usual meaning.

1. Attempt ***any two*** of the following :– **[10x2=20]**

(a) Device general heat conduction equation in cylindrical coordinates for homogeneous and isotropic material.

(b) The total thickness of a furnace wall, which is made of an inner layer of fire brick covered with a layer of insulation, is 32cm. Thermal conductivities of fire brick and the insulation are 0.84 and 0.16W/m°C respectively. The furnace temperature is 1325°C and the temperature of surroundings is 25°C. Calculate the thickness of the fire brick and that of the insulation for minimum heat loss through the wall. Assume that the maximum temperature in the insulating material should not exceed 1200°C.

(c) A plate made of material of thermal conductivity 10 W/m°C is heated from bottom surface at constant rate such that the upper surface, which is exposed to the surroundings, is maintained at constant temperature of 250°C. The upper surface convects and radiates heat to the surroundings. The surroundings temperature is 110°C. The convection coefficient and radiation factor are 75 W/m°C and unity respectively. Calculate the temperature gradient between upper and lower surfaces of the plate.

2. Attempt **any two** of the following : **[10x2=20]**

(a) A refrigerator having inside dimension of 0.5m×0.5m base and 1.0m height is maintained at 6°C. The walls of the refrigerator are constructed of two mild steel sheets 3 mm thick (k=46.5 W/m°C) with 50mm glass wool insulation (k=0.046 W/m°C) between them. The average heat transfer coefficients at the inner and outer surface are 11.6 and 14.5 W/m°C respectively. The surrounding temperature is 25°C. Find the rate at which heat must be removed from the interior to maintain specified temperature and the temperature at outer surface of the refrigerator.

(b) A standard iron pipe having 5cm inner diameter and 2.5 mm wall thickness is insulated with magnesium insulation (k=0.02 W/m°C). Temperature at the interface between the pipe and the insulation is 300°C. The permissible heat loss through the pipe is 600 Watt per meter length of the pipe and the temperature of the outer surface of the

insulation is not allowed to exceed 100°C. If the thermal conductivity of the pipe material is 20 W/m°C. Calculate the minimum thickness of insulation required and the temperature of inside surface of the pipe.

(c) A board is composed of three layers, middle being of packed saw Dust (k=0.02 W/m°C) with the side layers made of plywood each of 2 cm thickness (k=0.12 W/m°C). The three layers are joined together by bolting using four steel bolts of 1cm diameter at the corners (k=40 W/m°C). Calculate the heat flow per m^2 area if one surface is at 35°C and the other at 20°C.

3. Attempt **any two** of the following : **[10x2 = 20]**

(a) One end of a long rod 3.5 cm in diameter, is inserted into a furnace with other end projected outside the furnace in air. After steady state is reached, the temperature of the rod is measured at two points 180mm apart and found to be 180°C and 145°C. The atmospheric temperature is 25°C. If the heat transfer coefficient is 65 W/m°C, calculate the thermal conductivity of rod. Assume that the end of the fin is insulated.

(b) A mercury thermometer is placed in a oil well for measurement of temperature of air flowing in a pipe. The well is made of steel (k=50 W/m°C) and is 14 cm in length and 1mm in thickness. The temperature recorded by well is 100°C while pipe wall temperature is 50°C. If the heat transfer coefficient between the air and well wall is 30 W/m°C, calculate the true temperature of air.

(c) A steel ball 5 cm in diameter is heated to a temperature of 900°C and placed in still surrounding atmosphere for cooling. If the atmospheric temperature is 30°C, Calculate the initial cooling rate of the ball in °C/min. For steel take ρ=7800 kg/m^3, C_p=2 kJ/kg°C. Assume heat transfer Coefficient (h)=30 W/m°C

4. Attempt **any two** of the following : **[10x2 = 20]**

(a) A plate is heated and its temperature is maintained at 60°C.Air at 27°C and 1 bar flows over this plate at 2.0 m/s velocity. Calculate the heat transferred per hour per unit width upto 400mm from leading edge of the plate. For air at mean temperature of 43.5°C take

ν =17.36×10^{-6} m^2/s, k=0.02749 W/m°C, Cp=1.006 kJ/kg°K,

R=287 Nm/kgmK and Pr=0.7. Assume the equation

$Nu = 0.664 . Re^{1/2} . Pr^{1/3}$

(b) A cylindrical body having 30 cm diameter and 1.6 m height is maintained at constant temperature of 36.5°C in the still surrounding air. The surroundings temperature is 13.5°C. Calculate the amount of heat required to be supplied to the body in kJ/hour to maintain the specified temperature. For air take ρ =1.025 kg/m^3, C_p=0.96 kJ/kg°C ν =15.06×10^{-6} m^2/s, k=0.0892 kJ/mhr°C and ß=1/298 K^{-1}. You may use the following equation.

$Nu = 0.12 (Gr.Pr)^{1/3}$

(c) Two rectangular black surface 2m long and 1m wide are placed parallel to each other at a distance of 4m between them. If the surfaces are maintained at temperature 100°C and 200°C respectively. Calculate the heat exchange by radiation between the two surfaces. The shape factor between the two surfaces is 0.043.

5. Attempt **any two** of the following: **[10 x 2 = 20]**

(a) 1000 kg/hr of oil (C_p=2.09 kJ/kg°C) is to be cooled from 80°C to 40°C in oil cooler by using water flow of 1000 kg/hr at 30°C. Give your choice for a parallel flow or counter flow heat exchange, with reasons. Calculate the surface area of heat exchanger, if the overall heat transfer coefficient is 24 $W/m^{2o}C$. For water take C_p=4.18 kJ/kg°C.

(b) Explain the various regimes of the saturated pool boiling.

(c) State Fick's law of diffusion. What are its' limitations ?

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