Code No: RR320306 **Set No.1**

III B.Tech. II Semester Regular Examinations, April/May -2005
HEAT TRANSFER
(Mechanical Engineering)

Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
All Questions carry equal marks
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1. (a) Illustrate the importance of heat transfer in various fields of engineering.
   (b) Determine the study state heat transfer rate through wall, $5mlong \times 4mhigh \times 0.25m$ thick, with its two faces maintained at uniform temperatures of 100^0C and 30^0C. the wall is made of fire brick having thermal conductivity equal to 0.7 W/ m-deg.

2. (a) Define the overall heat transfer coefficient? Obtain the expression composite wall with three layer with convective conditions over the wall?
   (b) A wall consists of three layers of 0.2 m concreter, 0.08 m of fibre glass insulation and 0.015 m gypsum board (0.04 W/mK). The convective heat transfer oefficients at inside and outside surfaces are 15 and 45 W/m^2K respectively. The inside and outside surface temperatures are 25^0C and - 10^0C respectively. Calculate the overall heat transfer coefficients for the wall and heat loss per unit area.

3. Heat at the rate of $0.5MW/m^3$ is generated in a 50 mm thick wall having thermal conductivity 18 W/mK. One side of the wall exposed to environment at 50^0C with a heat transfer coefficient of $450W/m^2K$. Calculate the maximum temperature in the wall if the outer side of the wall is insulated?

4. (a) Explain the Buckinghams Π -Theorem for dimensional analysis.
   (b) What are repeating variables and how are they selected for dimensional analysis.

5. (a) Distinguish between filmwise and dropwise condensation. Which of the two gives a higher heat transfer coefficient? Why?
   (b) Dry saturated steam at a pressure of 2.5 bar condenses on the surface of a vertical tube of height 1.5m. The tube surface temperature is 120^oC. Estimate the thickness of the condensate film and the local heat transfer coefficient at a distance of 0.3m from the upper end of the tube.

6. (a) Derive a general expression for interchange factor for radiation between two non-black parallel surfaces of same area.
   (b) Two opposed, parallel infinite planes are maintained at 400^oC and 460^oC respectively. Calculate the net radiant heat flux between these planes if one has an emissivity of 0.6 and the other an emissivity of 0.4.

7. (a) Derive an expression for logarithmic mean temperature difference for the case of parallel flow of heat exchanger.

(b) A hot fluid enters a heat exchanger at a temperature of 200^oC at a flow rate of 2.8 Kg/Sec (sp.heat 2.0 kJ/kg-K) it is cooled by another fluid with a mass flow rate of .7 kg/sec (Sp.heat 0.4 kJ/kg-K). The overall heat transfer coefficient based on outside area of $20m^2$ is 250 $W/m^2 - K$. Calculate the exit temperature of hot fluid when fluids are in parallel flow.

8. Two identical counter flow type heat exchangers are available. Water (Cp = 4.2 KJ/Kg-K) at the rate of 1Kg/sec and at 30^oC is heated by cooling an oil ($Cp = 2.1kJ/kg - K \ \ at \ \ 90^oC$ the oil flow rate is 0.75 Kg/sec. The heat transfer area in each heat exchanger is $4m^2$. The heat exchangers are connected in series on water side and in parallel on the oil side . The oil flow rate is split in the ratio 2:1 as 0.5 kg/sec in the first and 0.25 Kg/sec in the second exchanger .Water enters the first heat exchangers at 30^oc. Calculate the final water and oil temperature. Overall heat transfer coefficient in each heat exchangers is $300W/m^2 - K$.

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Code No: RR320306 **Set No.2**

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HEAT TRANSFER
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Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
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1. (a) Write the fourier rate equation for heat transfer by conduction. Give the physical significance of each term.
   (b) Determine the steady heat transfer per unit area through a 3.8 cm thick homogenious slab with its two faces maintained at uniform temperatures of 35^0C and 25^0C. The thermal conductivity of wall material is $1.9x10^{-4}kw/m-deg$.
2. (a) Derive the expression for temperature distribution with solid slab with heat generation of 1. Both surface temperature of the slab are T_wK and at the center is T_oK.
   (b) A iron pipe of outside diameter 100 mm and the surface temperature is 0^0C is covered with 50 mm thick asbestos material of 0.2 W/mK thermal conductivity and 25 mm thick glass wool ($k = 1.2 \times 10^{-4}W/mK$). Which insulation should be provided next to the pipe surface to achieve maximum insulating effect, if the outer surface temperature is 50^0C in either instance?
3. Determine the heat transfer rate through a spherical copper shell of thermal conductivity 386 W/mK, inner radius of 2- mm and outer radius of 60 mm. The inner surface and outer surface temperatures are 200^0C and 100^0C respectively.
4. The coefficient of free convection at the surface of horizontal pipe may be computed from the relation:
   $N_u = \frac{hd}{k} = 0.053(P_r)^{0.5} * (P_r + 0.955)^{-0.25} * (G_r)^{0.25}$
   where, all the properties are evaluated at the surface temperature and coefficient of cubical expansions, $\beta = 1/T$, T being the Absolute air temperature, use this relation to calculate the heat loss by natural convection per meter length from horizontal pipe of 15 cm diameter. The surface temperature of the pipe is 275^0c and the surroundings are at 17^0c. At the surface temperature of 275^0c, the thermo-physical property of air is:

   $P_r = 0.675$
   $\rho = 0.6445kg/m^3$
   $k = 3.81 \times 10^{-2}$ kcal/m-hr-deg .
   $\mu = 2.91 \times 10^{-6}kgf - s/m^2$.
5. (a) Show the various regimes in flow boiling and discuss in detail the heat transfer mechanisms in each region.

(b) Water at 5 atm flows inside a tube of 2cm diameter under flow boiling conditions where the tube wall temperature is 15^oC above the saturation temperature. Compute the heat transfer for 1m length of the tube.

6. (a) Define irradiation and radiosity.
   (b) What does radiation shape factor mean?
   (c) Two parallel black plates 0.5 by 1.0m are separated by 0.5m distance. One plate is at 1100^oC and the other at 600^oC. What is the net radiant heat exchange between the two plates?
   (d) Calculate the shape factor for a hemispherical surface closed by a plane surface.

7. (a) Derive an expression for logarithmic mean temperature difference for the case of counter flow exchanger.
   (b) A liquid chemical flows through a thin walled copper tube of 12 mm diameter at the rate of 0.5 kg/sec water flows in opposite direction at the rate 0.37 kg/sec through the annular space formed by this tube and a tube diameter of 20 mm . The liquid chemical enters and leaves at 100^oC and 60^oC, while water enters at 10^oC. Find the length of tube required. Also find the length of tube required if the water flows in the same direction as liquid chemical. The properties of water and liquid chemical are

PROPERTIES	LIQUID CHEMICAL AT 80^oC	WATER AT 27^oC
$\rho, Kg/m^3$	1078	995
$\mu.Kg/m - Sec^2$	3200×10^{-6}	853×10^{-6}
Cp, J/Kg-K	2050	4180
K, W/mK	0.261	0.614

8. In a heat exchanger hot fluid enters at 180^oC and leaves at 118^oC. The cold fluid enters at 99^oC and leaves at 119^oC. Find the LMTD and effectiveness in the following cases.
   (a) counter flow
   (b) one shell passes and multiple tube passes
   (c) two shell passes and multiple tube passes
   (d) cross flow both fluid unmixed
   (e) cross flow , the cold fluid unmixed Also find NTU values.

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Set No.3

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Time: 3 hours **Max Marks: 80**

Answer any FIVE Questions
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1. Identify the different modes of heat transfer in the following systems/ operations.
   (a) Steam raising in a steam boiler.
   (b) Air/ water cooling of an I.C. engine cylinder.
   (c) Condensation of steam in a condenser.
   (d) Heat loss from a thermos flask.
   (e) Heating of water in a bucket with an immersion heater.
   (f) Heat transfer from a room heater.
   (g) Heating of earth surface by sun.

2. (a) Develop an expression for the steady state temperature distribution in a long hollow cylinder, r_i < r < r_0 in which heat generated at a rate of $q(r) = q_0(1 + Ar)W/m^3$, where A and q_0 are constants while the boundary surfaces are kept at zero temperature.
   (b) An electric resistance wire of radius 0.001 m with thermal conductivity of 25 W/m K is heated by a passage of electric current which generates heat within the wire at a constant rate of $2 \times 10^7 W/m^3$. Determine the center line temperature rise above the surface temperature of the wire if the surface is maintained at constant temperature.

3. A refrigerant at -40^0C flows into a copper pipe (400 W/mK) of 10 mm ID and 14mm OD. A 40 mm thick shell of thermo Cole (0.03 W/mK) is put on the pipe to reduce losses. Estimate the heat leakage to the refrigerant per meter length of pipe, if the ambient temperature is 40^0C. Assume the external and internal heat transfer coefficients are $5W/m^2K$ and $500W/m^2K$ respectively. Calculate the amount of refrigerant evaporated per hour taking its latent heat at -40^0C as 1390 kJ/kg.

4. Calculate the heat transfer rates by over convection free a 0.3 m high vertical plate maintained at a uniform temperature $T_w = 80^0c$ to an ambient at T $\acute{\alpha} = 24^0c$ containing air at 1.0 and 3.0 atm.

5. (a) Distinguish between
      i. Subcooled boiling and Saturated boiling
      ii. Nucleate boiling and film boiling.

(b) Water at atmospheric pressure is boiled in a Kettle made of copper. The bottom of the Kettle is flat, 35 cm in diameter and maintained at a temperature of 115^oC by an electric heater. Calculate the rate of heat required to boil water. Also estimate the rate of evaporation of water from the Kettle.

6. (a) Define the terms
   i. absorptivity
   ii. reflectivity and
   iii. transmissivity.

   (b) Differentiate between specular and diffuse reflections.

   (c) Derive Stefan-Boltzmann's law from Plank's law.

7. (a) Obtain an expression for the overall heat transfer coefficient of a shell and tube exchanger taking into Consideration scale formation on the inside surface and film coefficients on the inside and outside Surface of the tube.

   (b) A steam condenser works at a temperature of 60^oC transferring 250 kW of energy.The cooling water enters the condenser at 20^oC with a flow rate of 2kg/sec.find the logarithmic mean temperature difference.

8. (a) Derive an expression for effectiveness of a counter flow heat exchanger using NTU method.

   (b) Water (Cp = 4200 J/kg K) enters a counter flow double pipe heat exchanger at 39^oC at the rate of 273.6 kg/hr .It is heated by oil (Cp = 1880 J/kg-K) flowing at the rate of 547.2 kg/hr from an inlet temperature of 118^oC find the total heat transfer rate per m^2. Take $U = 342W/m^2 - K$.

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1. (a) What are the different modes of heat transfer? Give suitable example to illustrate your answer.
   (b) What are the various laws of heat transfer? Explain in detail.

2. (a) What is the critical thickness of insulation and explain its physical significance?
   (b) Derive its equation for a hollow cylinder and a hollow sphere?

3. A composite slab consists of 250 mm fire clay brick (k=1.09 W/mK) inside, 100 mm fired earth brick(0.26 W/mK) and outer layer of common brick (0.6 W/mK) of thickness 50 mm. If inside surface is at 1200^0C and outside surface is at 100^0C, find
   (a) heat flux,
   (b) the temperature of the junctions and
   (c) the temperature at 200 mm from the outer surface of the wall.

4. (a) Explain for fluid flow along a flat plate.
      i. Velocity distribution in hydrodynamic boundary layer.
      ii. Temperature distribution in thermal boundary layer.
      iii. Variation of local heat transfer co-efficient along the flow.
   (b) Under forced flow conditions how does the prandtl number affect relative thickness of thermal Boundary layer and velocity Boundary layer. Show that the velocity and temperature distributions within the Boundary layer are going to be similar in nature.

5. (a) Differentiate between pool boiling and flow boiling.
   (b) Show the various regimes in pool boiling and discuss the heat transfer mechanisms in each region in detail.
   (c) A heated brass plate at 160^oC is submerged horizontally in water at a pressure corresponding to a saturation temperature of 120^oC. What is the heat transfer per unit area? Calculate also the heat transfer coefficient in boiling.

6. (a) Distinguish between a black body and grey body.
   (b) Prove that intensity of radiation is given by $I_b = E_b/\pi$.

(c) State and explain Kirchoff's identity? What are the condition's under which it is applicable.

7. It is required to design a shell and tube heat exchanger for heating 9000 kg/hr of water from 15^oC to 88^oC by hot engine oil (Cp = 2.35 kJ/kg-K) flowing through the shell of the heat exchanger . The oil makes a single pass , entering at 150^oC and leaving at 95^oC with an average heat transfer coefficient of $400W/m^2 - K$, the water flow through 10 thin walled tubes of 25mm diameter with each tube making 8 passes through the shell . The heat transfer efficient on the water side is $3000W/m^2 - K$. Find the length of the tube required the heat exchanger.

8. (a) Derive an expression for effectiveness of a parallel flow heat exchanger using NTU method.

   (b) A hot gas at the rate of 16.2 Kg/Sec at 648^oC (Cp = 3.52 KJ/Kg-k) is used to heat 20.2 kg /sec of The increasing fluid from 100^oc (Cp = 4.2 KJ/Kg K) in a heat exchanger . If the overall heat transfer Coefficient is $0.92KW/m^2 - K$ for an effective area of $43.8m^2$, find the fluid outlet temperatures for counter flow and parallel flow arrangements.

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