Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VI • EXAMINATION – SUMMER 2015

Subject Code:161906 **Date:18/05/2015**

Subject Name: Heat and Mass Transfer **Total Marks: 70**

Time:10:30 am to 01:00 pm

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Explain thermal Contact resistance. How contact pressure effects thermal contact resistance? **06**

(b) A composite wall has three layers of material held together by 3 cm diameter aluminium rivet per $0.1m^2$ of surface. The layer of material consists of 10 cm thick brick with hot surface at 200^oC, 1cm thick wood with cold surface at 10^oC. These two layers are interposed by third layer of insulating material 25cm thick. The conductivity of the material are: **08**

k_{brick} = 0.93 W/mK, $k_{insulation}$ = 0.12 W/mK

k_{wood} =0.175 W/mK, $k_{aluminium}$ =20.4W/mK

Assuming one dimensional heat flow, calculate the percentage change in heat transfer rate due to rivets.

Q.2 **(a)** For cylinder, prove that critical radius of insulation, $r_{critical}$ = k/h, where k=thermal conductivity of insulation and h=convective heat transfer coefficient. Explain effect of thickness of insulation on heat transfer. **06**

(b) A pipe carrying the liquid at -20^oC is 10mm in outer diameter and is exposed to ambient at 25^oC with convective heat transfer coefficient of $50W/m^2K$. It is proposed to apply the insulation of material having thermal conductivity of 0.5W/mK. Determine the thickness of insulation beyond which the heat gain will be reduced. Also calculate the heat loss for 2.5mm, 7.5mm and 15mm thickness of insulation over 1m length. Which one is more effective thickness of insulation? **08**

OR

(b) A potato with mean diameter of 4cm is initially at 30^oC. It is placed in boiling water for 5 minute and 30 seconds and found to be boiled perfectly. For how long should be a similar potato for the same consumer be boiled when taken from cold storage at 4^oC. Use lumped system analysis and take thermophysical properties of potato as **08**

ρ= 1250 kg/m^3, k=12 W/mK, h=125 W/m^2K, and C=2000 J/kgK

Q.3 **(a)** Define : **06**

(1) Emissivity

(2) Monochromatic emissive power

(3) Opaque body

(4) Radiosity

(5) Radiation intensity

(6) Solid angle

(b) Calculate the net radiation heat transfer per m^2 area of two large plates placed **08**

parallel to each other at temperatures of 427°C and 27°C respectively. $\varepsilon_{(Hot\ plate)}$= 0.9 and $\varepsilon_{(Cold\ plate)}$=0.6. If a polished aluminum shield is placed between them, find the % reduction in heat transfer, $\varepsilon_{(Shield)}$=0.04.

OR

Q.3 **(a)** For counter flow heat exchanger, prove that $\varepsilon = \dfrac{1-\exp[-NTU(1-C)]}{1-C\exp[-NTU(1-C)]}$, where ε is effectiveness, C is Capacity ratio and NTU is Number of Transfer Unit. **07**

(b) In a pipe in pipe heat exchanger, hot water flow at a rate of 5000 kg/hr and gets cooled from 95°C to 65°C. At the same time, 5000 kg/hr of cooling water at 30°C enters the heat exchanger. The overall heat transfer coefficient is 2270 W/m^{2}K. Determine the heat transfer area required and the effectiveness of heat exchanger, assuming two streams are in parallel flow. Assume C_P=4.2 KJ/kgK for both streams. **07**

Q.4 **(a)** For natural convection heat transfer, prove that Nu=ϕ(Pr)(Gr), where Nu=Nusselt number, Pr=Prandlt number and Gr=Grashoff number. **07**

(b) 750 kg/hour of cream at 10°C is pumped through 1.75 m length of 8 cm inner diameter tube which is maintained at 95°C. Estimate the temperature of cream leaving the heated section and the rate of heat transfer from the tube to the cream. The relevant thermo physical properties of cream are: **07**

ρ=1150 kg/m^3 μ=22.5 kg/ms

C_P=2750 J/kg-deg k=0.42 W/m-deg

Use the following correlation for flow of cream inside a tube:

$$Nu = 3.65 + \frac{0.067\left(\frac{D}{L}\mathrm{R}_{e_D}\ \mathrm{Pr}\right)}{1+0.04\left(\frac{D}{L}\mathrm{R}_{e_D}\ \mathrm{Pr}\right)^{1/3}}$$

OR

Q.4 **(a)** Derive an equation for heat transfer from very thin and long enough fin so that the heat loss from the fin tip may be assumed negligible. **07**

(b) Two rods A and B of equal diameter and equal length, but of different materials are used as fins. The both rods are attached to a plain wall maintained at 160°C, while they are exposed to air at 30°C. The end temperature of rod A is 100°C and that of the rod B is 80°C. **07**

If the thermal conductivity of rod A is 380 W/mK, calculate the thermal conductivity of rod B. This fin can be assumed as short with end insulated.

Q.5 **(a)** (1) Why houses are painted white in hot country? **02**

(2) Why is shiny foil blanket wrapped around marathon runner at the end of race? **02**

(3) Why does metal feel colder than wood, even if both are at the same temperature? **02**

(4) Why is it windy at the seaside? **02**

(5) Why we feel hotter than outside atmosphere in a parked car with closed windows? **02**

(b) Explain fick's law of diffusion. **04**

OR

Q.5 **(a)** What is physical significance of dimensionless parameters? Explain in brief. **07**

(b) Explain nucleate boiling with mechanism of nucleate boiling. **07**

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