Sub Code: RME502/RME502A

Paper Id: 140507 Roll No:

B.TECH
(SEM -V) THEORY EXAMINATION 2019-20
HEAT AND MASS TRANSFER

Time: 3 Hours ***Total Marks: 70***

Note: 1. Attempt all Sections. If require any missing data; then choose suitably.

SECTION A

1. Attempt *all* questions in brief. 2 x 7 = 14

a. What is thermal contact resistance? How is it related to thermal contact conductance?

b. What is lumped system analysis? When is it applicable?

c. Define the following:
   (i) Prandtl Number
   (ii) Grashoff number

d. Define the following properties of the material:
   (i) Reflectivity and
   (ii) Transmissivity
   (iii) Reflectivity

e. What are the common approximations made in the analysis of heat exchangers?

f. What is the difference between sub-cooled and saturated boiling?

g. Define the Fick law of mass diffusion.

SECTION B

2. Attempt any *three* of the following: 7 x 3 = 21

a. Derive an expression for general heat conduction equation in Cartesian coordinate system.

b. One end of long rod 3.5 cm in diameter is inserted into furnace with outer 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 180^0C and 145^0C. The atmospheric temperature is 25^0C. If the heat transfer co-efficient is 65W/m^0C, calculate the thermal conductivity of the rod.

c. Explain the following
   (i) Boundary layer thickness
   (ii) Displacement thickness
   (iii) Thermal boundary layer thickness

d. Two very large parallel plates are maintained at uniform temperatures T_1 = 800 K and T_2 = 500 K and have emissivities ε_1 = 0.2 and ε_2 =0.7, respectively. Determine the net rate of radiation heat transfer between the two surfaces per unit surface area of the plates.

e. Show Under what conditions will the temperature profile of both cold and hot fluid along its length, will be parallel in counter flow heat exchanger.

SECTION C

3. Attempt any *one* part of the following: 7 x 1 = 7

(a) A 20 cm thick slab of Aluminum (k = 230 W/m.K) is placed in contact with a 15 cm thick stainless steel plate (k = 15 W/m.K). Due to roughness, 40 percent of the area is in direct contact and the gap (0.0002 m) is filled with air (k = 0.032 W/m.K). The difference in temperature between the two outside surfaces of the plate is 200°C Estimate (i) the heat flow rate, (ii) the contact resistance, and (iii) the drop in temperature at the interface

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(b) Calculate the critical radius of insulation for asbestos (k=0.172 W/m.K) surrounding a pipe and exposed to room air at 300K with h=2.8W/m2K. calculate the heat loss from a 475K, 60 mm diameter pipe when covered with critical radius of insulation and without insulation.

4. Attempt any *one* part of the following: 7 x 1 = 7

(a) Derive an expression for temperature distribution for a very long fin.

(b) A person is found dead at 5 PM in a room whose temperature is 20°C. The temperature of the body is measured to be 25°C when found, and the heat transfer coefficient is estimated to be h =8 W/m2 °C. Modeling the body as a 30-cm-diameter, 1.70-m-long cylinder, estimate the time of death of that person. Properties of human body at the average temperature can be taken as k= 0.617 W/m ·°C, ρ= 996 kg/m3, and Cp = 4178 J/kg · °C. Assume human body as a lumped body and the initial temp can be taken as 37°C.

5. Attempt any *one* part of the following: 7 x 1 = 7

(a) A flat plate 1m wide and 1.5m long is to be maintained at 90°C in air when free stream temperature is 10°C. Determine the velocity at which air must flow over the plate so that the rate of energy dissipation from the plate is 3.75kW.

Use correlation $\overline{\mathrm{Nu}} = [.036(\mathrm{Re_L})^{0.8} - 836]\mathrm{Pr}^{1/3}$

(b) A steam pipe 7.5 cm in diameter is covered with 2.5 cm layer of thick insulation, which has a surface emissivity of 0.9. The surface temp of insulation 80°C and the pipe is placed in a atmospheric air at 20°C. Considering heat loss by both radiation and convection, Calculate

(i) Heat loss from 6 m length of the pipe

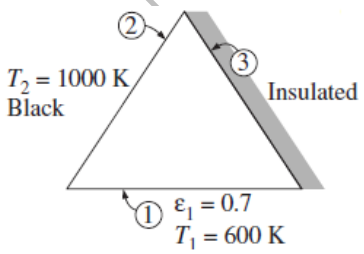
(ii) Overall heat transfer coefficient.

Thermo-physical properties of air can be taken as ρ=1.092kg/m3 μ=19.57x10-6 kg/ms , k=27.81x10-3 W/m°C

Use correlation $\overline{\mathrm{Nu}} = 0.53(\mathrm{Gr.Pr})^{1/4}$

6. Attempt any *one* part of the following: 7 x 1 = 7

(a) A furnace is shaped like a long equilateral triangular duct, as shown in Figure. The width of each side is 1 m. The base surface has an emissivity of 0.7 and is maintained at a uniform temperature of 600 K. The heated left-side surface closely approximates a blackbody at 1000 K. The right-side surface is well insulated. Determine the rate at which heat must be supplied to the heated side externally per unit length of the duct in order to maintain these operating conditions.



(b) Derive an expression for the theorem of reciprocity.

7. Attempt any *one* part of the following: 7 x 1 = 7

(a) Explain the following with neat sketch:

(i) Film-wise condensation

(ii) Drop-wise condensation

(b) A thin-walled double-pipe counter-flow heat exchanger is to be used to cool oil (Cp =2200 J/kg ·°C) from 150°C to 40°C at a rate of 2 kg/s by water (Cp =4180 J/kg · °C) that enters at 22°C at a rate of 1.5 kg/s. The diameter of the tube is 2.5 cm, and its length is 6 m. Determine the overall heat transfer coefficient of this heat exchanger.