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BTECH
(SEM V) THEORY EXAMINATION 2018-19
HEAT AND MASS TRANSFER

Time: 3 Hours ***Total Marks: 100***

Notes: *Assume any missing data.*

SECTION A

1. **Attempt *all* questions in brief.** **(2x10=20)**

(a) How do thermal conductivities of gases and liquids vary with temperature?
(b) Derive the expression for logarithmic mean area for the hollow sphere.
(c) What do you mean by effectiveness of a fin? Discuss the physical significance of effectiveness.
(d) What do you understand by lumped system, explain it with suitable example?
(e) Show with neat sketch, unstablised flow and entrance length in tube flow.
(f) Explain one-seventh power law over a flat plate.
(g) Write down the assumptions which are taken in to consideration for radiation heat transfer between different types of surfaces.
(h) Write short note on the following:
(i) Opaque body (ii) Colored body.
(i) Write short note on fouling or scaling.
(j) Differentiate between regenerator and recuprator type of heat exchangers with suitable example.

SECTION-B

Note: **Attempt any five questions from this section.** **(10X5=50)**

2. Derive the expression for overall heat transfer co-efficient for a composite sphere whose inner-surface is at higher temperature and outer surface is at lower temperature.

3. The steam at 300^0C is passing through a steel tube. A thermometer pocket of steel (k=45 W/m.k) of inside diameter 14 mm, and 1 mm thick is used to measure the temperature. Calculate the length of the thermometer pocket needed to measure the temperature within 1.8% permissible error. The diameter of steam tube is 95 mm. Take heat transfer coefficient as 93 W/m^2k and tube wall temperature as 100^0C.

4. What do you mean by radiation shield? Derive the expression of net heat transfer rate for a system of two parallel plates separated by n-shields of emissivity's ϵ_{s1} , ϵ_{s2} ,ϵ_{s3} …….ϵ_{sn}.

5. What do you mean by condensation heat transfer? Derive the expression for laminar and turbulent film condensation on vertical plate.

6. Write short note on the following:

(i) Fick's law (ii) Schmidt number (iii) boiling regimes.

7. An oil is cooled to 100 ^{0}C in a concurrent heat exchanger by transferring its heat to cooling water, that leaves the exchanger at 30 ^{0}C. However, it is now required that the oil must be cooled down to 75 ^{0}C by increasing the length of heat exchanger, while oil and water flow rates, there inlet temperatures and other dimensions of the exchanger keeping constant. The inlet temperatures of water and oil being 15 ^{0}C and 150 ^{0}C, respectively. If the original cooler was 1m long, calculate

(i) Outlet temperature of water in new cooler,

(ii) Length of new cooler.

8. Atmospheric air at 25 ^{0}c flows at 50 m/s velocity past a flat plate 0.6 m long with its surface maintained at 295 ^{0}c .Under these conditions, the air may be treated as incompressible. Make calculation for heat transferred to air from entire plate length taking into account both laminar and turbulent portion of boundary layer. Presumes unit width of the plate and the critical Reynolds's number to be $5x10^5$ .What % error would be introduced if the boundary layer is presumed to be of turbulent nature from the very leading edge of the plate? Take thermo-physical properties of air at mean bulk temperature is- k=0.1310 kj /m-hr-k , $\nu=30.9x10^{-6}$ m^2 /s, Pr=0.682 .

Use following co-relations- $h=0.664\ k/x\ (Re)^{0.5}\ (Pr)^{0.33}$ …… for laminar boundary layer.

And $h=0.036\ k/x\ (Pr)^{0.33}\ (Re)^{0.8}$ …… for turbulent boundary layer.

9. Two parallel discs 50 cm in diameter are spaced 40 cm apart with one disc located directly above the other disc. One disc is maintained at 500^{0}Cand other is at 227^{0}C. The emissivities of the discs are 0.2 and 0.4, respectively. The discs are located in a very large room whose walls maintained at 67^{0}C.Determine the heat loss by radiation from the inside surfaces of each disc.

SECTION-C:

10. Attempt any two questions from this section. (15X2=30)

(a) Derive the general heat conduction equation in cylindrical co-ordinate for homogeneous and isotropic material.

(b) A layer of 5 cm refractory brick (k =2 W/m K) is to be placed between two 4 mm thick steel (k=40 W/m K) plates. The both faces of brick adjacent to the plates have rough solid to solid contact over 20% of the area, where the average height of asperities are 1 mm. The outer surface temperature of steel plates is 400 ^{0}C and 100 ^{0}C, respectively.

(i) Find the rate of heat flow per unit area and assume that the cavity area is filled with air (k=0.02 W/m K).

(ii) Find the rate of heat flow if the faces of brick are smooth and have solid to solid perfect contact over entire area.

11.

(a) Write down the name of some common types of fin with neat sketch. Also derive the expression for heat dissipation through rectangular fin insulated at the tip.

(b) Consider two long cylinder rods (A and B) (assume infinite fins) of the same diameter but different materials. One end of each rod is attached to a base surface at 100^{0}C, and the rods

are exposed to the ambient air at 20^0C. By traversing the length of each rod by a thermocouple, it was observed that the temperature of the rod were equal at the positions X_A=0.15m and X_B=0.075m, where x is measured from the base surface. If the thermal conductivity of rod A is known to be k_A = 70W/m k , determine the value of k_B for rod B.

12.

(a) Write down the mechanism of formation of thermal boundary layer over hot and cold plate with neat sketch.

(b) An egg with mean diameter of 4 cm is initially at 25 ^{0}c .It is placed in boiling water for 4 minute and found to be consumers taste. For how long should be a similar egg for same consumer be boiled when taken from refrigerator at 2 ^{0}c .Use lumped system analysis and take thermo-physical properties of egg as – K=12 W/m k, h=125 w/m^{2}k , c=2000 j/kg k , and ρ=1250 kg/m^3.