M.TECH/RE/1ST SEM/REEN 5141/2016

DESIGN OF HEAT TRANSFER EQUIPMENT
(REEN 5141)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) A furnace is made of brick wall of thickness 0.5m and thermal conductivity 0.75W/mK. For the same heat loss and temperature drop what should be the thickness of diatomite earth of thermal conductivity 0.15 W/mK
(a) 0.05 m (b) 0.1m (c) 0.2 m (d) 0.5 m.

(ii) Critical thickness of insulation on cylindrical surface is given by
(a) k/h (b) h/k (c) 2k/h (d) 2h/k.
where k is the thermal conductivity of insulating material and h is the surface film heat transfer coefficient.

(iii) Fins are provided on heat transferring surface in order to increase
(a) heat transfer area
(b) heat transfer Coefficient
(c) mechanical strength of the equipment
(d) the driving force.

(iv) Heat transfer by radiation is least encountered in
(a) boiler furnace (b) insulated steam pipe
(c) electric bulk (d) nuclear reactor.

(v) In a counter flow heat exchanger, cold fluid enters at 25°C and leaves at 45°C where as, the hot fluid enters at 145°C and leaves at 125°C. Driving force in this heat exchanger will be
(a) 0°C (b) 100°C (c) $\propto$ (d) 80°C.

(vi) Expansion bellow is provided in the shell of a tubular exchanger in order to
(a) facilitate increase in length of boiler shell.
(b) reduce shell side pressure drop.
(c) account for uneven expansion of shell and tube bundle.
(d) imparts structural strength to the exchanger.

(vii) Parallel flow heat exchanger becomes equally efficient to a counter flow heat exchanger when
(a) heat transfer occurs between two gases.
(b) heat transfer occurs between two liquids.
(c) heat transfer occurs between one liquid and one gas.
(d) when one of the fluid undergoes isothermal phase change.

(viii) Limiting value of LMTD correction factor is
(a) 0.5 (b) 0.7 (c) 1.0 (d) 2.0.

(ix) Baffles are provided on the shell side of a shell and tube heat exchange
(a) to increase turbulence of the shell side fluid
(b) to increase turbulence of the tube side fluid
(c) as a support to the tube bundles
(d) both (a) and (c).

(x) Three fins of equal length and diameter but made of aluminium, brass and mild steel are heated to 200°C at one end. If the fins dissipate heat to surrounding air at 25°C, the temperature at the free end will be least in case of
(a) aluminium fin.
(b) brass fin.
(c) mild steel fin.
(d) each fin will have the same temperature at free end.

Group – B

2. (a) Consider a straight rectangular fin protruding from a wall surface. The length of the fin is L, cross sectional area is A_c, width is b and thickness is δ. The temperature at the contact between wall and fin is T_0 and the surrounding temperature is T_a. If the free end of the fin is perfectly insulated, show that the rate of heat transfer from the fin to the surrounding is given by
$Q_{fin}=\sqrt{PhkA_c}(T_0-T_a)\tanh mL$

where P = perimeter of the fin = 2 (b+δ)
h = surrounding film coefficient
k = thermal conductivity of the material of the fin and
$m = \sqrt{Ph/kA_c}$

(b) Define efficiency and effectives of fin. Show that the efficiency of a fin increases with decrease in length of the fin.

8 + 4 = 12

3. (a) A furnace wall is made up of steel plate 10mm thick (k = 62.8 KJ/m hrK) lined on inside with silica bricks 150mm thick (k = 7.32 KJ/m hrK) and outside with magnesia bricks 200 mm thick (k = 18.84 KJ/M hrK). Inside and outside wall temperatures are 650°C and 125°C respectively. Find rate of heat loss per unit area of the wall.

(b) It is required that heat loss be reduced to 10 MJ/hr by means of air gap between steel and magnesia bricks. Estimate the necessary width of the air gap if the thermal conductivity of air is 0.126 KJ/m hrK.

(c) Application of insulation on a curved surface may lead to an increase in heat loss – justify.

5 + 4 + 3 = 12

Group – C

4. (a) Discuss relative merits and demerits of parallel flow and counter flow heat exchangers.

(b) Heat is exchanged between a hot fluid and a cold fluid through the wall of a tube. The inside and outside film coefficient are h_i and h_o respectively. Deduce an expression for overall heat transfer coefficient based on outside surface area of the tube. Assume negligible tube wall resistance to heat transfer.

(c) What is fouling factor? What does it account for?

(d) A hot fluid is to be cooled from 120°C to 60°C using cooling water at 25°C to be heated to 40°C. Find LMTD when the flow is (i) parallel and (ii) counter.

2 + 4 + (1 + 1) + (2 + 2) = 12

5. (a) Define capacity ratio, effectiveness and NTU of a heat exchanger.

(b) Show that effectiveness (∈)of a parallel flow heat exchanger is given by
$\in = \{1+ e^{-NTU(1+C)}\} / (1+C)$, where
C = Capacity Ratio.

6 + 6 = 12

Group – D

6. (a) What are the adverse effect of increasing no. of passes in a shell and tube heat exchanger?

(b) Discuss relative merits and demerits of triangular pitch and square pitch arrangement of heat exchanger tubes.

(c) Derive an expression for shell side equivalent diameter when the tubes are arranged in (i) square pitch and (ii) triangular pitch.

(d) What do you mean by floating head shell and tube heat exchanger?

(e) Differentiate between recuperator and a regenerator.

2 + 2 + (2 + 2) + 2 + 2 = 12

7. Discuss how you proceed step by step to design a shell and tube heat exchanger by Kern Method.

12

Group – E

8. (a) What do you mean by Compact Heat Exchanger?

(b) Name different types of Compact Heat Exchangers mentioning temperature and pressure range in which each type can operate.

(c) Mention advantages and limitations of Compact Heat Exchangers.

2 + 6 + 4 = 12

9. (a) What is a Cooling Tower? How do you classify Cooling Towers by (i) use, (ii) build, (iii) heat transfer methods, (iv) air flow generation method.

(b) Discuss design aspects of evaporative condensers.

(2 × 4) + 4 = 12