HTO descriptive Type Questions

1. Fill in the blanks :

(a) Heat flow mechanism through solids is known as .... Ans. conduction

(b) The SI unit of thermal conductivity is .... Ans. W/(m·K)

(c) Thermal resistance to heat transfer by conduction has the units of ... Ans. K/W

(d) Materials having very low thermal conductivity values are called as .... Ans. Heat Insulators

(e) Heat flow by conduction is governed by .... law. Ans. Fourier's

(f) Driving force for heat flow is .... difference. Ans. temperature

(g) The SI unit of rate of heat flow is .... Ans. watts (W)

(h) Conduction under condition of constant temperature distribution is called as ..... conduction. Ans. steady state

(i) Thermal conductance is the reciprocal of .... Ans. thermal resistance

(j) For thick-walled cylinder of radii r1 and r2 , logarithmic mean radius is given by .... Ans. (r2 – r1) / ln (r2 / r1)

(k) The linear variation of thermal conductivity is given by the expression, k = ... Ans. a + bT

2. Derive an expression for heat transfer through a furnace wall made of three different materials in series. Assume k1 , k2 and k3 to be the thermal conductivities of materials and x1 , x2 and x3 the respective thicknesses. Assume hot face and cold face temperatures to be T1 and T2 respectively.

3. Derive an expression for heat flow through a thick walled cylinder by conduction. Take r1 and r2 as the inner and outer radii of cylinder, k as a mean thermal conductivity. Assume T1 as the inside temperature and T2 as the outside temperature.

4. Derive an expression for heat flow through a thick walled cylinder (with r1 as the inside radius and r2 as the outside radius) lagged with a layer of insulation. Take k1 as the thermal conductivity of material and k2 as the thermal conductivity of insulating material. Assume r3 as the outer radius of insulation, inside temperature T1 and the temperature at the outer surface of insulation as T2 .

5. What do you mean by thermal conductivity ? Write in brief on its variation with temperature.

6. The opposite faces of a plane wall of thickness, x, are maintained at T1 and T2 . The variation of thermal conductivity with temperature is given by k = ko (1 + bT). Derive an expression for heat flow Q through the plane wall. Assume that T1 > T2 .

7. Derive a relation for critical radius of insulation for a circular cross-section having length L, r1 and r2 are the inside and outside radii of the pipe and r3 as outer radius of insulation. k1 and k2 be the thermal conductivities of the pipe material and insulating material respectively. Inner temperature is T1 and the outer temperature is T2 (T1 > T2).

8. Fill in the blanks:

(a) Heat transfer in fluids occurs by mechanism known as .... Ans. convection

(b) Heat transfer from hot fluid to cold fluid in a heat exchange equipment takes place by conduction and .... modes. Ans. convection

(c) The unit of overall heat transfer coefficient in the SI system is .... Ans. W/(m2 ·K)

(d) When the hot and cold fluids flow in the same direction in a heat exchanger, then the flow is called .... flow. Ans. parallel / co-current

(e) When the hot and cold fluids flow in the opposite directions in a heat exchanger, then the flow is called as .... flow. Ans. counter current Unit Operations – II 3.77 Convection

(f) Film heat transfer coefficients are higher for .... condensation than for film wise condensation. Ans. dropwise (g) In case of .... boiling, vaporisation takes place directly from the surface. Ans. nucleate

(h) The SI unit of film heat transfer coefficient is .... Ans. W/(m2 ·K)

(i) The dirt factor / fouling factor has the units .... in SI system. Ans. (m2 ·K)/W

(j) The ratio of Cp · μ to k is known as .... number. Ans. Nusselt

(k) Thermal resistance in case of convection heat transfer has the units of .... Ans. (m2 ·K)/W

(l) In forced convection, the effect of liquid viscosity (for viscous liquids) is taken into account in case of .... equation. Ans. Sieder-Tate

9. Give the Dittus-Boelter equation for turbulent flow for heating.

10. Give the Dittus-Boelter equation for turbulent flow for cooling.

11. Give the Sieder-Tate equation used to calculate the film coefficient in case of laminar flow.

12. Give the Sieder-Tate equation used to calculate the film coefficient in case of turbulent flow.

13. What do you mean by film heat transfer coefficient ?

14. For a double pipe heat exchanger, give its equivalent diameter in terms of D1 and D2 , where D1 is the outside diameter of the inside pipe and D2 is the inside diameter of the outside pipe.

15. What do you mean by natural convection ? Give example of heat transfer by natural convection.

16. Define forced convection and give its example.

17. Compare natural convection with forced convection (Three points).

18. Compare parallel flow with counter current flow in heat exchangers (Three points).

19. Define drop-wise condensation.

20. Compare drop-wise condensation with film-wise condensation (Three points).

21. Define co-current and counter current flow with neat sketches.

22. State the relationship between overall heat transfer coefficient and individual heat transfer coefficients.

23. Write the relationship between U and hi , ho, xw/k and Rd.

24. Explain in brief heat transfer to boiling liquids.

25. Derive the relationship Q = UA ΔTlm. Unit Operations – II 3.78 Convection

26. Write in brief on dirt factor / fouling factor with respect to heat transfer.

27. State various resistances in series when heat flows from one fluid to another through a solid wall in a heat exchange equipment. (Ans. Resistances are : hot fluid film resistance, solid wall resistance, cold fluid film resistance and dirt or fouling resistances.)

28. State different types of flow arrangements in heat exchanger.

29. What do you mean by counter current heat exchanger and cross flow heat exchanger ?

30. Define the terms nucleate boiling and film boiling. 24. Give the physical significance of (1) Reynolds number (2) Nusselt number and (3) Prandtl number.

31. Fill in the blanks :

(a) Radiation refers to the transport of energy through space by .... waves. Ans. electromagnetic

(b) Heat can be transmitted by .... mode across absolute vacuum. Ans. radiation

(c) The fraction of the incident radiation absorbed is known as .... Ans. absorptivity

(d) For a perfectly black body absorptivity is equal to .... Ans. one

(e) For a specular body the reflectivity is equal to .... Ans. one

(f) As per Kirchhoff's law, at thermal equilibrium for all bodies the ratio of ..... to the absorptivity will be the same. Ans. emissive power

(g) The emissivity 'e' of a body is equal to its .... 'a'. Ans. absorptivity

(h) As per the Stefan-Boltzmann law the total energy emitted by a black body is directly proportional to the fourth power of its absolute .... Ans. temperature

(i) .... Boltzmann equation is a fundamental relation for all radiant energy transfer calculations. Ans. Stefan (j) Emissivity of any body is the ratio of its ..... to that of a black body at the same temperature. Ans. emissive power

32. Define the following terms : (a) Radiation (b) Absorptivity (c) Emissivity (d) Opaque material (e) Gray body.

33. What do you mean by black body ?

34. Give examples of radiation heat transfer.

35. State Kirchhoff's law of radiation.

36. State Stefan-Boltzmann law of radiation.

37. Explain in brief the concept of black body.

38. Calculate the loss of heat per unit area from a steam pipe to the surrounding air by radiation mode. Take emissivity of 0.90. Data : Temperature of steam pipe = 398 K (125°C) Temperature of air = 303 K (30°C) Ans. 851 W/m2

39. Fill in the blanks :

(a) The centre-to-centre distance between baffles is known as baffle .... Ans. spacing or pitch

(b) The shortest centre-to-centre distance between the adjacent tubes is known as the ………. Ans. tube pitch

(c) The heat transfer equipment which consists of two concentric pipes is called as ……….. heat exchanger. Ans. double pipe

(d) External cleaning of the tubes is easy in case of ..... pitch arrangement than triangular pitch arrangement of tube lay-out. Ans. square

(e) In 1-2 shell and tube heat exchanger the ..... side fluid flows once through exchanger while ...... side fluid flows twice through exchanger. Ans. shell, tube

(f) For external cleaning of the tubes, tube bundle can be taken out of the shell in a .... heat exchanger.

(g) The .... baffles are the drilled plate with heights equal to 75% of the inside diameter of the shell. Ans. segmental

(h) Kettle reboilers generally incorporates a .... head arrangement or a ……………. arrangement as a heating element. Ans. floating, U-tube

(i) The metal pieces examployed to extend or increase the heat transfer surface are called…………….. Ans. fins

(j) In case of .... fins, long metal strips are attached to the outside of the pipe. Ans. longitudinal

40. Define the following terms : (a) condenser (b) cooler (c) vaporiser (d) heater (e) reboiler (f) chiller

41. Give the classification of shell and tube heat exchanger.

42. Explain in brief double pipe heat exchanger.

43. Draw a neat sketch of fixed tube sheet heat exchanger and label its parts.

44. Explain in brief plate heat exchanger.

45. Explain in brief scrapped surface heat exchanger.

46. Draw a neat sketch of kettle reboiler and explain its construction.

47. Draw a neat sketch of floating heat exchanger and explain its construction.

48. What do you mean by the term fins ? Draw neat sketches of longitudinal and transverse fins.

49. Explain in brief finned tube heat exchanger.

50. Draw a neat sketch of U-tube heat-exchanger and explain briefly its construction.

51. Draw a neat sketch of kettle reboiler and explain in brief its working.

52. Draw a neat sketch of 1-2 shell and tube heat exchanger and label its parts.

53. State the advantages of a floating head heat exchanger.

54. State the advantages of a double pipe heat exchanger and its drawbacks.

55. Fill in the blanks :

(a) The weak liquor to be fed to the evaporator is composed of a non-volatile .... and a .... solvent. Ans. solute, volatile

(b) In most of the evaporation operation .... are condensed and discarded. Ans. water vapour

(c) .... is carried out by supplying heat to a solution to vaporise the solvent. Ans. Evaporation

(d) In case of evaporation generally the .... is the valuable product. Ans. concentrated solution / thick liquor

(e) In the .... feed system, vapour and liquor flow in counter current fashion. Ans. backward

(f) Economy of a single-effect evaporator is always less than .... Ans. one

(g) Economy of a multiple effect evaporator system is always .... than one. Ans. more or greater

(h) In .... evaporator, the velocity of liquid entering the tube is of the order of 2 to 6 m/s. Ans. forced circulation

(i) .... tube vertical evaporator is commonly used for handling solutions that tend to foam. Ans. Long

(j) In case of Calendria type evaporator the solution to be evaporated is .... the tubes and steam flows .... the tubes in the steam chest. Ans. inside, outside

56. Define the following terms : (i) evaporation (ii) boiling point elevation (iii) capacity of an evaporator and (iv) economy of an evaporator.

57. Why the economy of single effect evaporator is less than one ?

58. State the method of increasing the economy of an evaporator. 5. What do you mean by multiple-effect evaporation system ?

59. What do you mean by double-effect evaporator ?

60. State the method of feeding multiple-effect evaporation system.

61. Compare forward feed arrangement with backward feed arrangement in case of a multiple effect evaporation system. 9. State the advantages of forced circulation evaporators and its application.

62. Explain the construction with a neat sketch of standard vertical tube evaporator.

63. Draw neat diagrams of forward feed arrangement and backward feed arrangement for feeding multiple effect evaporation system. 12. State some examples of evaporation operation.

64. Draw a neat sketch of long tube evaporator and explain briefly its construction and working.

65. Explain in brief forced circulation evaporator with an external horizontal heating surface with reference to its construction and working.

66. Explain in brief vapour recompression with a neat sketch.

67.What is meant by heat transfer process? Write its 3 types.

68 Write any 2 important differences between conduction and convection.

69.Write Fourier law of heat conduction and explain the terms in it.

S. Y. B. Tech Chemical

Subject :HEAT TRANSFER OPEATIONS

QUESTION BANK

Unit : 1: CONDUCTION

1. Define Fourier number, Biot number in heat conduction problems and state their physical significance.
2. What is thermal diffusivity? Write its unit.
3. Define 'Thermal Conductivity'. Write its S.I. unit.
4. How does thermal conductivity vary with temperature for solid, liquids and gases?
5. Write unsteady state heat conduction equation (three dimensional) in Cartesian co-ordinates for a solid metallic slab.
6. State Fourier's law of heat conduction and explain why negative sign is present before 'k'.
7. What are the three modes of heat transfer? Mention about the mechanism in each mode
8. Derive the one-dimensional steady state heat conduction for a hollow cylinder
9. Derive the equation steady state heat transfer conduction through composite wall of three layers in series having thermal conductivity k1, k2 and k3.
10. What is transient heat conduction (Unsteady state)?
11. What is thermal resistance and how is it calculated for conduction?
12. What is critical thickness of insulation for a cylinder? How is it calculated?
13. What is Fourier number and explain its significance
14. A furnace wall is made up of brick wall of 15 cm thickness (k = 4.6 W /m 0C) lined on inside with silica brick 25 cm thick(k = 1.2 W /m 0C) & next layer of magnesite brick 35 cm thick (k = 1.8 W /m 0C). Inside temp of wall is 2600C & on outside 300C . Calculate,
   a) Rate of heat flow through wall.
   b). Interface temp
15. A furnace wall made up of steel plate 7 cm thickness (k= 40 W /m 0C) lined on inside with fire clay brick 25 cm thick(k_1 = 0.270 W /m ^{0}C) & on outside magnesite brick 35 cm thick(k_2= 1.6 W /m ^{0}C). Inside temp of wall is 7500C & on outside 400C Calculate,
   A) Rate of heat flow through wall.
   B)Interface temp.
   C)If the heat flow is to be reduced to 60% by means of air gap between steel plate and magnesite brick, calculate width of air gap required.

Data: Thermal conductivity of air is 0.028 W/ m^{O}C

16. A steam pipe 150 mm ID & 164 mm OD is covered with two layers of insulation. The thickness of first layer is 50 mm (k= 0.75 w /m ^{0}C).& that of second layer is 40mm (k = 0.450 w /m ^{0}C). The inside temp is 320 0C & outside temp is 40 0C . Calculate heat loss and interface temp. Thermal conductivity of pipe is k = 15. W /m 0C
17. A long steel rod 3 inch dia initially at 550 ^{0}C is suddenly immersed in quenching bath at 45^{0}C. calculate its average temp after 1 min. & 4min.
    Properties of steel are;
    k= 36 w /m ^{0}C, ρ= 7700 kg/m^3 Cp= 0.65 KJ/kg^{0}C
18. A steel ball 2 in diameter and initially at an uniform temperature 400+ (Roll No) OC is suddenly kept in quenching bath where temperature is maintained at 100 OC. convective heat transfer coefficient is 9 W/ m2 OC. Calculate the time require to reduce the temperature to 150 OC

Properties of steel are; k = 36 W/ m OC, Cp = 0.46 KJ/ Kg ^{O}C P= 7700 Kg/m^3

Unit No : 2 : HEAT TRANSFER TO LIQUIDS , H T WITHOUT PHASE CHANGE ,

1. Define the number of transfer units and discuss its importance in rating heat exchanger performance.
2. Define thermal diffusivity and discuss the effect of thermal diffusivity on the rate of heat propagation.
3. What is thermal boundary layer? How its thickness is changing with Prandtl number.
4. What is the relationship between dimensioniess groups, obtained by dimensional analysis for free convective heat transfer operations?
5. Write the physical significance of Nusselt number.
6. Derive the relationship between individual and overall heat transfer coefficients for a double pipe heat exchanger with hot and cold working fluids.
7. Define fouling factor. How it is taken in to account for calculation of Over all Heat Transfer coefficient?
8. Define surface heat transfer coefficient**.** Write its unit.
9. Name two molten metals. State their important properties as heat transfer Media.
10. Write the equation giving the individual heat transfer coefficients as a function of relevant variables in the case of natural convection
11. Is a counter flow heat exchanger more efficient than a parallel heat exchanger? If so, why?
12. How does a scale deposit affect the heat transfer rate?
13. Explain the concept of log mean temperature difference and derive expression to calculate LMTD.
14. Discuss Grashof number and Rayleigh's number in natural convection process.
15. Discuss various theoretical and empirical equations available to predict natural convection heat transfer coefficient.
16. State Dittus-Boelter equation and Colburn equation for heat transfer and discuss their application.
17. Define natural or free convection.
18. In forced convection, Nusselt number is a function of which dimensionless groups.
19. Define Prandtl number. What is its physical significance?
20. What is forced convection?
21. How heat transfer coefficient is calculated in forced convection for laminar flow, turbulent flow and in transition region.
22. A double pipe heat exchanger is used to cool the hot fluid flowing at 8000 Kg/hr from 90OC to 55OC, using cold water available at 25 OC and at a rate of 7500 kg/hr. Specific heat of hot fluid is four digit Roll No. J/Kg K and that of water is 4180 J/Kg K. calculate
   a) LMTD if counter flow arrangement is used.
   b) If parallel flow is used what is LMTD?
   c) Calculate LMTD for Cross flow if correction factor Fc= 0.92

23. Calculate overall coefficient based on outside area required to heat water from 25 oC to 70oC, which is flowing in 20 mm ID tube with 2 mm thickness. The saturated steam is condensing on outside surface at 105 oC. Water velocity 2m/sec. Calculate amount of steam required.
24. Data: hi = 1950 W/m^2 ^{O}C, ho = 2100W/m^2 ^{O}C, hdi = 17300 W/m^2 ^{O}C, hdo = 2100 W/m^2 ^{O}C, Cp=4180 J/Kg OC, km = 37 W/m, λ= 2200KJ/kg
25. A light oil in a tank is maintained at 80 0C by means of condensing steam inside a 100 mm OD tube having length 5 m . Steam maintains pipe surface temp. at 1200C. Assuming that pipe is kept horizontal calculate outside heat transfer coefficient and heat transfer rate. If tube is kept vertical calculate % change in heat transfer rate.

Properties of oil: ρ = 880 kg / m3, μ = 6.9 cp , k = 0.25 W / k , Cp= 2110 J/Kg^{0}C.

26. Water flows through a 22 mm ID pipe having length 10 m , at a velocity 0.05 m/s. The water enters at 30 ^{O}C & the pipe surface is maintained at 100 ^{O}C by means of condensing steam. Calculate outlet temp. of water. Properties of water: ρ = 998 kg / m^3, μ = 0.86cp , k = 0.36 W /m ^{O}C , Cp= 4184J/kg ^{O}C
27. Air at a temperature 45 0C flows through a rectangular duct with a velocity 10 m/sec, The duct is 30 cm x 20 cm in size. Air leaves at 25 0C . Calculate heat lost by air when it is passed through 10 m length of duct.

Properties of air at average temperature are,

k= 0.02571 W/ m K. Cp = 1007 J/ kg K, Pr = 0.705, ρ = 1. 247 kg / m3

μ = 17.65 x 10-6 pa.s

Unit No. : 3 : CONDENSATION & BOILING, EVAPORATION

1. Explain film boiling, nucleate boiling and sub-cooled boiling.
2. Write a note on maximum heat flux and critical temperature drop.
3. Derive Nusselt equation for condensation of pure saturated vapors on a vertical tube.
4. What is Nusselt Equation. Explain its practical use.
5. Discuss briefly the difference between film-wise and drop-wise condensation. What are the methods employed to promote drop-wise condensation?
6. Discuss briefly the phenomenon of nucleate and film boiling. Explain with a neat diagram the various zones of boiling.
7. Condensing equipments are always designed for film-wise condensation - why?
8. Differentiate between nucleate and film boiling.
9. Explain 'Leiden frost' phenomenon during boiling.
10. Explain Pool Boiling curve and comment on difference in curve of flux verses temperature drop and heat transfer coefficient verses temperature drop.
11. Explain the various types of evaporators used in chemical industry. Give figures wherever possible.
12. Indicate the various methods of improving the overall efficiency of evaporators.
13. Discuss the operation and advantages of a multiple effect evaporator.
14. What is Duhring's rule? Explain its application.
15. What is 'Boiling Point Elevation'? How will you account it during evaporator design?
16. Define 'Capacity' and 'Economy, of a steam-heated tubular evaporator.
17. Why is multiple effect evaporation preferred over a single effect operation?
18. Explain different feeding methods of multiple effect evaporators.
19. Saturated steam at 110 OC is condensing on outside of a bank of 64 horizontal tubes of 25 mm OD & 1m long arranged on 8x8 square array. calculate average heat transfer coefficient if surface temp. of tube is maintained at , 50 ^{O}C,

    Condensate Properties at average temperature are : ρL = 997 kg/m^3 , λ = 2250 KJ/ Kg , μ f = 0.5 cp . kf = 0.6 w/m ^{O}C ρL = 994 kg/m3 . Also calculate Rate of condensation.

20. Dry saturated steam at atmospheric pressure is condensing on a vertical tube 5 m long and 10 cm outer diameter , calculate surface temperature of tube, if heat transfer coefficient is 3.6 KW/ m^2 ^{O}C, ρL = 997 kg/m3 , λ = 2290 KJ/ Kg , μ f = 0.4 cp . kf = 0.6 w/m ^{O}C ρL = 997 kg/m3 Also calculate temp. if tube is kept horizontal

21. Saturated steam at 108 ^{O}C condenses on outside of a horizontal tube of 10 cm OD. and length L, maintained at 81 ^{O}C . When tube is kept vertical the rate of condensate is same as that of horizontal. Find length of tube. What is rate of condensate?

ρL = 996 kg/m^3 , λ = 2250kJ/kg , μ f = 0.45 cp , ,kf = 0.63 w/m ^{O}C

22. It is desired to concentrate 6500 kg/hr of an organic solution from 10% to 50% solids in a single effect evaporator. Steam is available at 110 ^{o}C and vapor space is maintained at 415 mm of Hg . The boiling point of water at this pressure is 85 ^{o}C and solution has 11 ^{o}C BPR. The enthalpy of feed liquor and concentrated solution are, 370 kJ/kg and

    555 kJ/kg, enthalpy of vapor is 2735 kJ/kg and latent heat of condensation is 2255 kJ/kg. Feed enters at its boiling point. Calculate,

    I . Steam consumption per hour and economy.

    II. Heating surface area required if overall coefficient is 1200 W/m^{2} ^{o}C .

23. It is desired to concentrate 6000 kg/hr of an NaOH solution from 10% to 50% solids in a single effect evaporator. Steam is available at 128 ^{o}C with latent heat of 2140 kJ/kg. The boiling point of solution is 82 ^{o}C . The enthalpy of feed liquor and concentrated solution are, 135KJ/kg & 575 kJ/kg, enthalpy of vapor is 2700 kJ/kg and latent heat of condensation is 2240 kJ/kg. Feed enters at its boiling point. Calculate,

    a. Steam consumption per hour and economy.

    b. Heating surface area required if overall coefficient is 2005 W/m^{2} ^{o}C

Unit No : 4 : RADIATION

1. Discuss the main laws of block body radiation.
2. Derive an expression for view factor between an elemental surface and finite surface.
3. Define view factor and discuss its importance.
4. Explain the terms "Black body" and "Grey body" with reference to radiant heat transfer.
5. What is Stefan - Boltzmann's law of thermal radiation?
6. Define the terms emissivity and absorptivity in radiation heat transfer.
7. Show that absorptivity of a radiating body is equal to its emissivity.
8. What is a grey body?
9. Define radiation shape factor or View factor
10. Differentiate black body and grey body
11. State and explain Kirchhoff's law
12. Sate and explain Stefan Boltzmann Law and Planks Law
13. Sate and explain Stefan Boltzmann Law and Planks Law and Wien's displacement law.
14. Define emissive power and intensity of radiation

15. Determine in Watts the radiation heat loss per meter length of 20 cm OD steam pipe at 410 K temperature, when it is placed centrally in a brick-duct having sides 36 cm With square cross section. The surface temperature of brick duct is 300 K, emissivity of pipe surface is 0.093 and emissivity of brick surface is 0.93

16. Two large parallel planes are at temp. 350 ^{o}C & 65 ^{o}C respectively. The emissivity of first plane $\in 1$= 0.75 and emissivity of the second plane $\in 2$ = 0.35

What is net radiation heat transfer from plane 1to 2 ?
If a radiation shield having emissivity 0.25 is introduced between two planes, what is percentage

reduction in heat transfer ?

17. Determine in Watts the radiation heat loss per meter length of 20 cm OD steam pipe at 410 K temperature, when it is placed centrally in a brick-duct having sides 36 cm With square cross section. The surface temperature of brick duct is 300 K, emissivity of pipe surface is 0.093 and emissivity of brick surface is 0.93

Unit No. : 5 : HEAT EXCHANGER DESIGN.

1. Define LMTD and explain the reason for which this concept is introduced in heat exchanger design. Explain why correction factors are being used when applying this technique for the design of multi-pass heat exchangers.
2. Under which conditions, fins are used on the heat transfer surface?
3. Write two applications for heat transfer in packed beds in chemical industry
4. What are the advantages of plate heat exchanger?
5. What are the advantages of plate heat exchanger?
6. Which flow arrangement gives maximum efficiency in shell and tube heat exchanger and why?
7. Define 'Effectiveness' of a heat exchanger.
8. How will you calculate LMTD correction factor?
9. Draw a neat sketch of 1-2 counter-flow heat exchanger & explain Temperature profile.
10. List out the various types of heat exchangers
11. What is use of baffles in shell and tube heat exchangers? What is minimum and maximum baffle spacing
12. What patterns of arranging tubes in shell and tube exchanger? What is tube pitch?
13. What are compact heat exchangers?
14. When do you use double pipe and when do you use shell and tube heat exchanger?
15. What are recuperators and regenerators?
16. A horizontal water heater is required to heat 17 tons/hr of water from 35 ^{o}C to 86 ^{o}C by means of condensing steam at 110 ^{o}C in shell. The heater is to consist 16. mm ID and 19 mm OD tubes 3.5 m long. The velocity of water is not to exceed 1 m/s through the tubes. The shell side coefficient for steam is 6500 w / m^{2} ^{o} C and latent heat of steam at 110 ^{o}C is 2230 KJ / Kg. If the tube side coefficient is 3200 w / m^{2} ^{o} C, determine number of passes and number of tubes in each pass neglecting tube wall resistance.. density of water is 996 Kg/ m^{3} and specific heat of water is 4180 J/Kg ^{o} C, LMTD correction factor is 0.95.
17. An oil cooler consists of tubes having 18 mm ID and 21 mm OD. Oil flows through the tubes at 5 Kg/sec and is cooled from 150 ^{0} C to 80 ^{0} C and its velocity is limited to 0.75 m/s. oil side heat transfer coefficient is 2200 w / m^{2} ^{o} C . The cooling liquid is available at 35 ^{0} C , flowing through the shell side at a rate 6.0 Kg/sec .Shell side heat transfer coefficient is 3600 w / m^{2} ^{o} C. Determine number of passes and number of tubes in each pass , neglect the tube wall resistance. Specific heat of oil = 2200 J /Kg ^{o}C

    Specific heat of cooling liquid = 4400 J /Kg ^{o}C, Length of tubes = 2.5 m

    LMTD correction factor = 0.91, Density of oil is 900 kg/m^{3}