(Revised Course)

(3 Hours)                                             [Total Marks: 80

**N.B. :**

1. **Question – 1 is compulsory**. Answer any **three** questions from remaining.

2. Use of "**Heat Exchanger databook**"is permitted.

3. Assume data if necessary and **specify the assumptions** clearly.

4. Draw neat sketches wherever required.

5. Answer to the sub-questions of an individual question should be grouped and written together i.e. one below the other.

1.  (a) Explain different fouling mechanisms.                                                [05]

    (b) What are the limitations of Wilson, Lobo and Hottel method?                          [05]

    (c) Explain different streams in shell with neat sketch.                                 [05]

    (d) What are the advantages and disadvantages of plate heat exchangers, compared with conventional shell and tube heat exchanger?   [05]

2. 80,000 kg/h benzene is cooled from 70°C to 50°C using cold process stream available at 30°C. A shell and tube heat exchanger is designed using commercial software for this duty.Shell side pressure drop is predicted by software is 0.2767 bar. Compare this output with Bell-Delaware method and comment on result.   [20]

Tube mean temperature is maintained at 50.51°C.

| Properties of Benzene | | | | | |
|---|---|---|---|---|---|
| | In | out | | In | Out |
| $Cp, kJ/kg \cdot K$ | 1.8840 | 1.8280 | $\mu, cP$ | 0.3371 | 0.4314 |
| $k, W/m \cdot K$ | 0.1308 | 0.1373 | SG | 0.8320 | 0.8510 |

| Shell and Tube heat exchanger configuration. | | | | | |
|---|---|---|---|---|---|
| Number of tubes | 136 | | Pitch 1.25△ | 23.81 | mm |
| Tube OD | 19.05 | mm | Tube length | 6096 | mm |
| Shell ID | 336.55 | mm | | | |
| Bundle diameter | 323.85 | mm | Sealing strips pairs | 1 | |
| Tube sheet thickness (each) | 38 | mm | No. of baffles | 16 | |
| Baffle spacing (centre-centre) | 342.9 | mm | Baffle cut | 37.74 | % |

3. (a) Explain construction and working of Box type furnace with neat sketch.               [10]

   (b) Draw all TEMA shells and explain applications of each in brief.                       [10]

4. (a) Explain construction working of once through Thermosyphon reboiler.                   [10]

   (b) What are the principle kinds of baffles? Explain in brief with neat sketch.           [10]

1

**[TURN OVER**

5.  (a) A kettle type reboiler is operated over 14.22°C temperature difference. Overall  [10]
        heat transfer coefficient is 797 W/m$^2$-K. Critical pressure of evaporating liquid is
        38.29 bar and shell side operating pressure is 17.24 bar. There are 366 tubes (183
        U-tubes) of 25.4 mm OD and 4800 mm length are used over square pitch of 31.75
        mm. Check whether operating flux is within safe limit.

    (b) Explain limitations of horizontal and vertical condensers.  [10]

6.  (a) Plate type Heat Exchanger, with 855 numbers of PL22 plates, cools 150000 kg/h  [10]
        of a ethanol from 70 to 30°C using 88297 kg/h Cooling water.Plate are made of
        stainless steel (k = 15 $W/m \cdot K$) plates of 0.5 mm thick. Calculate the overall
        heat transfer coefficient and also pressure drop in both the fluids at these service
        condition.

    **Data:**

| Property | Cooling water | Ethanol |
|---|---|---|
| Specific heat, $kJ/kg \cdot K$ | 4.179 | 2.46 |
| Viscosity, $cP$ | 0.705 | 0.67 |
| Thermal conductivity, $W/m \cdot K$ | 0.62 | 0.171 |
| Density, $kg/m^3$ | 995.0 | 772.0 |
| Fouling factor, $m^2 - K/W$ | 0.00012 | 0.0001 |

    (b) What is the importance of Bridgewall temperature in furnace design?  [10]

*********************