(4 Hours) [ Total Marks : 80

N. B. : (1) Question No.1 is **compulsory**.
(2) Attempt any **three** questions from question Nos. 2 to 6.
(3) Assume any suitable data wherever required.
(4) Draw figures wherever needed.
(5) **Figures** to the **right** indicate **full** marks.

1. Write short notes on any **four**. 20
   (a) Expansion provision in heat exchanger
   (b) Entrainment separators
   (c) Material of construction of high pressure vessels
   (d) Buried pipeline
   (e) Design considerations for crystallizers

2. Design a U-tube heat exchanger for the following data:
   Shell side:
   Design pressure= 0.8 N/mm$^2$
   Permissible stress for shell material= 100 N/ mm$^2$
   Standard torispherical head with knuckle radius as 6% of crown radius
   25% cut segmental baffles are provided
   Gasket on shell side- Flat metal jacketed asbestos filled
   Gasket factor= 3.75
   Gasket seating stress= 53 N/mm$^2$
   Tube side:
   Number of tubes= 40
   Tube outside diameter= 20 mm
   Design pressure of tube side fluid = 2.0 N/mm$^2$
   Permissible stress of tube material= 120 N/mm$^2$
   Tube pitch =square
   Channel and channel cover:
   Material of construction- same as shell
   Joint with tube sheet- Ring facing with 18mm width
   Gasket factor = 5.5
   Gasket seating stress= 126 N/mm$^2$
   Allowable stress for bolt material = 140 N/mm$^2$

[ TURN OVER

(a) Design

- (i) Shell (diameter and thickness) — 3
- (ii) Head — 2
- (iii) Flange joint between shell and tubesheet — 3
- (iv) Flange joint between channel and tubesheet — 3
- (v) Tube sheet thickness — 2
- (vi) Channel and channel cover thickness for a flat cover — 2

(b) Draw to a recommended scale the assembly drawing of the above designed U-Tube heat exchanger. 5

(a) Write the design procedure of shell wall of a tall column. Design must include all the stresses working on a tall vessel. 12

(b) Describe various types of constructions for high pressure vessels with neat sketches. 8

Design a calendria type evaporator with the following data assuming that it has wire mesh for entrainment separation.

| | |
|---|---|
| Evaporator drum under vacuum | = external pressure 0.1 $N/mm^2$ |
| Amount of water to be evaporated | = 3000 kg/hr |
| Heating surface required | = 350 $m^2$ |
| Steam pressure | = 0.2 $N/mm^2$ |
| Density of liquid | = 995 $kg/m^3$ |
| Density of vapor | = 0.83 $kg/m^3$ |
| Effective Tube length | = 1750 mm |
| Tube outside diameter | = 40 mm |
| Tube thickness | = 1.5 mm |

Tubes laid on triangular pitch

Top head is torispherical

Modulus of elasticity for shell material = $20 \times 10^4$ $N/mm^2$

Modulus of elasticity for tube material = $9.5 \times 10^4$ $N/mm^2$

Assume downtake pipe as 50% of the total tube cross sectional area

Permissible stress for evaporator material = 98 $N/mm^2$

(a) Design the

- (i) Calendria (Diameter and thickness) — 4
- (ii) Tubesheet thickness — 4
- (iii) Vapor drum (Diameter and thickness) — 4
- (iv) Top torispherical head — 2

(b) Draw to a recommended scale the sectional front view of the above designed calendria. 6

5. (a) Show the symbols for the following components 6

(i) Needle valve
(ii) Filter press
(iii) Centrifuge
(iv) Autoclave
(v) Ball mill
(vi) Centrifugal pump

(b) Write notes on 8

(i) Process flow diagram
(ii) Piping and Instrumentation Diagram

(c) Estimate the optimum pipe diameter for a water flow rate of 12 kg/s at 20°C. Carbon steel pipe is used. Density of water is 995 $kg/m^3$ and viscosity of water at 20°C is $1.1 \times 10^{-3}$ $Ns/m^2$. Also find whether flow is laminar or turbulent. 6

(a) A high pressure compound cylinder consists of an inner tube of inside diameter as 200 mm and outside diameter as 250 mm. A tube of 300 mm external diameter is shrunk fit on it. The contact pressure at the 2 tube surfaces after shrink fit is 7.85 $N/mm^2$. The combination of the cylinder assembly is then subjected to an internal pressure of 83 $N/mm^2$. Design the original dimensions required for the tubes and determine the stress distribution. If the co-efficient of thermal expansion is $12 \times 10^{-6}/°C$ determine what temperature the outer cylinder should be heated to achieve the necessary shrink fit. 12

Assume $E = 2 \times 10^5$ $N/mm^2$. 

(b) Plot the stress distribution along the wall of the above designed high pressure vessel. 8

---