Reg. No.										

MANIPAL INSTITUTE OF TECHNOLOGY

MANIPAL

(A Constituent Institution of MAHE, Manipal)

VII SEMESTER B.TECH. (CHEMICAL ENGINEERING)

END SEMESTER EXAMINATIONS, NOV 2018

SUBJECT: DESIGN AND DRAWING OF CHEMICAL EQUIPMENTS [CHE 4102]

REVISED CREDIT SYSTEM

Time: 3 Hours MAX. MARKS: 50

Instructions to Candidates:

- Answer **ALL** the questions.
- Missing data may be suitably assumed.
- Code books are permitted

1.	Consider a standard vertical short tube evaporator (calandria type), evaporator drum operated at 1.3317 bar pressure, Amount of water to be evaporated = 7000 kg/hr, heating surface required =115m^2 , Steam is available to first effect at 3.433 bar pressure, Density of 5% feed liquid (ρ_l)= 1050 kg/m^3 (assumed), Density of water vapor (ρ_v)= 0.757 kg/m^3 Design pressure (P) = 5% more than the maximum working pressure = 3.605 bar, Volumetric flow rate of water vapor (V): 2.57 m^3 /s **,** Evaporator shell: low carbon steel (IS-2062), Tube material: brass. Permissible stress for low carbon steel = 980 kgf/cm^2 , Conical head at bottom: cone angle =120°. Torispherical head at top (100-10). Design (mechanical) a short tube evaporator. ***Calendria with vertical tubes:*** **-** Tubes and tube lay out: Tube diameter (outside): 100 mm, Tube thickness : 1.5 mm, Tube length : 1220 mm, the effective tube length : 1165 mm, Tube lay out : triangular pitch : 125 mm. ***Drum Specifications:*** **-** Length of drum – 4000 mm, operating temperature 120^{o}C, Top head connected with drum : Flange (IS-2004-1962 Class -2). ***Bottom flange of the calendria:*** **-** Flange material – IS-2004-1962 Class 2, Bolting material : 5% Cr Mo Steel, Gasket material : asbestos composition (1.6mm thickness), Out side diameter : 3894 mm, bolt circle diameter : 3825 mm, Number of bolts : 112.	**10**
2.	Water at a flow rate of 5,000 kg/h will be heated from 20°C to 35°C by hot water at 140°C. A 15°C hot water temperature drop is allowed. A number of 3.5 m hairpins of 3 in. (ID = 0.0779 m) by 2 in. (ID = 0.0525 m, OD = 0.0603 m) counter flow double-pipe heat exchangers with annuli and pipes, each connected in series, will be used. Hot water flows through the inner tube. Fouling factors are: R_{fi} = 0.000176 m^2.K/W, R_{fo} = 0.000352 m^2.K/W. Assume that the pipe is made of carbon steel (k = 54 W/m.K). The heat exchanger is insulated against heat losses. 1. Calculate the number of hairpins. 2. Calculate the pressure drops (both side). P.T.O	**10**

3.	A heat exchanger is to be designed to heat raw water by the use of condensed water at 67°C and 0.2 bar, which will flow in the shell side with a mass flow rate of 50,000 kg/hr. The heat will be transferred to 30,000 kg/hr of city water coming from a supply at 17°C (*Cp* = 4184 J/kg.K). A single shell and a single tube pass is preferable. A fouling resistance of 0.000176 m^2K/W is suggested and the surface over design should not be over 35%. A maximum coolant velocity of 1.5 m/s is suggested to prevent erosion. A maximum tube length of 5 m is required because of space limitations. The tube material is carbon steel (*k* = 60 W/m.K). Raw water will flow inside of ¾ in. straight tubes (19 mm OD with 16 mm ID). Tubes are laid out on a square pitch with a pitch ratio of 1.25. The baffle spacing is approximated by 0.6 of shell diameter, and the baffle cut is set to 25%. The permissible maximum pressure drop on the shell side is 5.0 psi. The water outlet temperature should not be less than 40°C. Find length of heat exchanger and pressure drops (both side).	**10**
4.	Design shell and tube heat exchanger (2 pass STHE) with the help of following data **Shell side** MOC: carbon steel Number of shell : 1 Number of passes : 1 Fluid : liquid Working pressure : 0.33 N/mm^2 Design pressure : 0.50 N/mm^2 Temperature inlet : 30° C Temperature outlet : 50°C Segmental baffles (25% cut) with tie rods spacers Head Crown radius : 400 mm Knuckle radius : 40 mm Shell flange : female facing Gasket : flat metal – jacketed asbestos filled Bolts – steel Nozzles – inlet and outlet – 75 mm Vent – 25 mm Drain – 25 mm Opening for relief valve – 50 mm Permissible stress for carbon steel -95 N/mm^2 Permissible stress for bolt –140.6 N/mm^2 **Tube side** Tube and tube sheet material : stainless steel (SS 304) Number of tubes – 54 Outside diameter – 18 mm Length (maximum U) – 12 m Pitch (square) – 25 mm Fluid – gas Working pressure – 19 N/mm^2 Design pressure – 21.5 N/mm^2 Inlet temperature – 150°C Outlet temperature – 55°C Permissible stress – 100.6 N/mm^2 **Channel and channel cover** Material – carbon steel (IS-2062) Joint with tube sheet – ring facing Gasket – steel jacked asbestos Nozzle – inlet and outlet dia. – 75mm Permissible stress – 95 N/mm^2	**10**
5.	Water-cooled shell and tube Freon condenser with in-tube condensation will be designed to satisfy the following specification, cooling load of the condenser 12kW, refrigerant-22, condensing temperature is 37°C, coolant water (city water) with inlet temperature 18°Cand outlet temperature 26°C, mean pressure – 0.4MPa, brass tubes (k= 110.7 W/m.k) with ¾'' O.D 20BWG. It is proposed that the following heat exchanger parameter are fixed: one tube pass with a shell diameter 15.25 inch, pitch size is 1inch, with baffle spacing of 35cm number of tubes 137. a. Calculate the shell and tube side heat transfer co-efficient. b. Assuming proper fouling factor, calculate the length of the condenser. c. Space available 6m, is this design acceptable? Condenser properties (Psat =14.17 bar): , ν_L = 8.7334x 10^{-4} m^3 /g , ν_g = 0.0164 m^3 /g, K_L = 0.082 W/m.K , μ_L = 1.86 X 10^{-4} Pa.S. μ_g = 1.39 x 10^{-5}Pa.S hfg = 169 KJ/Kg, C_{PL}=1.305KJ/kg.K. Prandtl number – 2.96 use Travis theory.	**10**