

GUJARAT TECHNOLOGICAL UNIVERSITY**B. E. - SEMESTER – VII • EXAMINATION – WINTER 2012****Subject code: 170502****Date: 31/12/2012****Subject Name: Process Equipment Design-II****Time: 10.30 am - 01.30 pm****Total Marks: 70****Instructions:**

1. Attempt any five questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.

- Q.1 (a) A Reactor (ID = 800 mm) with hemispherical head at the bottom. Inside working pressure is 75 kgf/cm² gauge & working temperature is 70 °C. Reactor is covered with plain jacket such that 75% length of shell & bottom hemispherical head is covered with jacket. Cooling water is circulated inside the jacket by pumping with a centrifugal pump having a shut off discharge pressure 6 kgf/cm² (g). The hemispherical head is fabricated from SA-516 Grade 70. **07**

The maximum allowable stress at design temperature is 610 kgf/cm².

Modulus of Elasticity of plate material (E) = 193 × 10³ N/mm².

Poisson's ratio (μ) = 0.3, ρ = 7.83 g/cm³, Joint efficiency (J) = 0.85.

Find: (i) Thickness of the head and (ii) weight of the fabricated hemispherical head.

$$t_h' = \left(\frac{PD_i}{(4fJ - P)} \right) + CA, \quad t_h' = 4.4r \sqrt{\frac{P}{2E}} (3(1 - \mu^2))^{\frac{1}{2}} + CA$$

- b) Discuss about various types of static and rotary equipments used in industry. **07**

- Q.2 a) Discuss the various pressure tests for the design of pressure vessels. Also explain the longitudinal and circumferential stress. **07**
- b) A tower having 4.5 m inside diameter & 8 m length from tangent line to tangent line of the end closers. Tower is operated under vacuum. Tower shell is constructed from SA-283 grade-B carbon steel plate, which has yield strength of 1898.4 kgf/cm². Determine the required thickness of shell without stiffeners. Assume 8 mm thick plate. **07**

OR

- b) A cylindrical vessel 14 ft. ID and 0.3125 inch has ring stiffeners located at 40 in spacing and it is subjected to an external pressure of 15 psi at a temperature of 700 °F. The MOC is carbon steel with yield stress of 30,000-38,000 psi. Modulus elasticity of carbon steel is 170 × 10³ N/mm². **07**
- i) Is t_s = 0.3125 inch adequate for a design with factor of safety of 4?
 - ii) What is the allowable external pressure for a factor of safety of 3?
 - iii) What is the thickness for same ID vessel based on a factor of safety 3?
 - iv) Determine the stiffener ring requirements for the vessel in (C).

- Q.3 a) What is flange? State advantages and disadvantages of flange joint and explain any two in detail. **07**
- b) Design the bracket support for vertical cylindrical vessel. The data is given as follows: **07**
- Diameter = 3.0 m, Height = 4.0 m, Clearance of vessel from bottom of vessel to foundation = 1.0 m, Weight of vessel with its content = 60,000 N, Wind pressure (P_w) = 1285 N/m², diameter of anchor bolt circle bolt = 3.15 m, No. of bracket = 6, Base plate of bracket = 150 mm × 200 mm. Permissible stress for structural steel
- Tensile σ_t = 140 N/mm², Bending σ_{bm} = 157.5 N/mm², compressive σ_{comp} = 123.3 N/mm², Permissible bearing pressure for concrete = 3.5 N/mm²

OR

- Q.3 a) Determine the shell thickness at different height of a storage tank for the given data: **07**
- Storage capacity of the tank = 1000 m³, Density ρ_{Fluid} = 950 kg/m³, joint efficiency J =

0.8, $f = 980 \text{ kg/cm}^2$, C.A. = 2, Type of welding joint = double welded full fillet lap joint, height of each course = 1, Available plate = $2 \text{ m} \times 2 \text{ m}$, $3 \text{ m} \times 2 \text{ m}$. Also calculate the total no. of plate required to fabricate the vessel.

- b) Explain in brief about classification of unfired vessel as per IS-2825 07

- Q.4 (a) State the various types of agitators. Discuss the design aspects of any two in details 07

- (b) A turbine agitator is used in a process vessel of 1.5 m diameter and data is given as follows. 07

Tank diameter = 1.5 m, impeller diameter = 0.5 m, Impeller Speed = 120 rpm, Density of liquid $\rho = 1250 \text{ kg/m}^3$, Viscosity $\mu = 250 \text{ cP}$, Overhang of the shaft between the bearing and agitator = 2 m, Elastic limit in tension = 2500 kgf/cm^2 , Modulus of Elasticity $E = 2 \times 10^6 \text{ kgf/cm}^2$, $f = 550 \text{ kgf/cm}^2$, NP = 6, for $\text{NRe} < 4500$, NP = 5 for $\text{NRe} > 4500$

Calculate the horse power and shaft diameter.

$$\tau_c = \frac{\text{hp of motor} \times 60}{2\pi N}, \quad \delta = \frac{Wl^3}{3EI}, \quad N_p = \frac{P g_c}{\rho n^3 D_a}$$

OR

- Q.4 a) Discuss the design steps for column supported conical roof. 07

- b) Find out the thickness of shell of the reactor & thickness of jacket for the following three available options: i) Reactor with plain jacket ii) Reactor with channel jacket, iii) Reactor with half coil jacket. 07

Given data:

Inside diameter of shell = 1500 mm, Inside diameter of jacket = 1600 mm, Shell length = 1500 mm, diameter of half coil = 75 mm, Width of channel jacket = 75 mm, Internal design pressure of shell = 4 kgf/cm^2 , Internal design pressure of jacket = 3 kgf/cm^2 , Design temperature of both shell & jacket = 150°C , maximum allowable stress at design temperature = 980 kgf/cm^2 , Modulus of elasticity $E = 19 \times 10^5 \text{ kgf/cm}^2$, Poisson's ratio $\mu = 0.3$, Joint efficiency $J = 0.85$.

- Q.5 a) Discuss about safety relief valves used in industry. 07

- b) Examine the data given below to evaluate the requirement of reinforcement pad for the nozzle opening in cylindrical shell. 07

OD of shell = 2 m, maximum working pressure within shell = 3.5 MN/m^2 , thickness of shell = 0.05 m, corrosion allowance = 3 mm, joint efficiency of nozzle and shell = 1, MOC = IS 2002, Allowable stress = 96 MN/m^2 , Density = 7800 kg/m^3 , OD of nozzle = 0.25 m, Nozzle wall thickness = 0.016 m, length of nozzle = 100 mm.

OR

- Q.5 A distillation column is to be fabricated & installed, having following specifications: 14

Shell O.D. at top = 2000 mm, Shell length tangent line to tangent line = 35 m, External design pressure = 1.003 kgf/cm^2 , Design temperature = 120°C , Type of shell plate joint = double welded butt joint with 10% radiography, Skirt height = 4 m, tray spacing (106 trays) = 0.3 m, Top disengagement space = 1.2 m, Weight of liquid and tray = 120 kg/m^2 , weight of attachment = 150 kg/m, wind pressure $P_w = 130 \text{ kgf/m}^2$, Insulation thickness $t_{\text{ins}} = 100 \text{ mm}$, Density of insulation $\rho_{\text{ins}} = 500 \text{ kg/m}^3$, Maximum allowable stress of shell plate material at design temperature = 890 kgf/cm^2 , Modulus of elasticity $E = 2 \times 10^6 \text{ kgf/cm}^2$, Poisson's ratio $\mu = 0.3$, Corrosion allowance = 2 mm, specific gravity of material = 7.865. Neglect the stress created by eccentric load and seismic load.
