

GUJARAT TECHNOLOGICAL UNIVERSITY**BE- VIIth SEMESTER-EXAMINATION – MAY/JUNE- 2012****Subject code: 170502****Date: 08/06/2012****Subject Name: Process Equipment Design - II****Time: 02:30 pm – 05:00 pm****Total Marks: 70****Instructions:**

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

- Q.1 (a) A vessel having an inside diameter of 5 m is to operate under an internal pressure of 3 kgf/cm²g. Conical head is to be used as bottom head with an apex angle of 60°. Material has an allowable stress of 935 kgf/cm² at design temperature and joint efficiency of 80 %. Vessel can be subjected to vacuum. Take 2 mm corrosion allowance & 150 °C as design temperature. (i) Design the conical head without using stiffening rings. (ii) Design the conical head using the suitable stiffening rings. Poisson's ratio for plate material (μ) = 0.3, Specific gravity of material = 7.83, Modulus of elasticity (E) = 2×10^6 kgf/cm². 14

P/fJ	0.001	0.002	0.003	0.004	0.005	0.006
Δ	13	18	22	25	28	31

$$t_h' = \frac{PD_i}{2 \cos \alpha (fJ - 0.6P)} + CA, A_c = \left(\frac{P}{fJ} \right) \left(\frac{D_o^2 \tan \alpha}{8} \right) \left(1 - \frac{\Delta}{\alpha} \right), I_{r \max} = \left(\frac{P_{cm} D_o^3 L_{\max}}{24E} \right)$$

- Q.2 (a) Explain the function of the following parts for the shell and tube heat exchanger. 07
 (i) Baffles (ii) Tie rods (iii) Spacers (iv) Expansion joint (v) Tube side pass partition (vi) Tube sheet (vii) Support.
- (b) Define (i) Elasticity (ii) Toughness (iii) Fatigue (iv) Creep (v) Poisson's ratio (vi) Moment of inertia (vii) Welding joint efficiency factor. 07

OR

- (b) A vacuum distillation column is to operate under a top pressure of 50 mm Hg (ab). Trays of distillation column are supported on periphery rings having 10 mm thickness and 75 mm width. The OD of column is 1 m and the tray spacing is 0.5 m. Check if the support rings will act as effective stiffening rings. The material of construction is carbon steel and the maximum operating temperature is 50 °C. If the shell thickness is 10 mm, check if this is sufficient. The modulus of elasticity at 50 °C is 200×10^3 N/mm².

$$\text{Critical Buckling Pressure } P_c = \frac{2.42E}{(1 - \mu^2)^{3/4}} \frac{\left(\frac{t}{D_o} \right)^{5/2}}{\left(\frac{L}{D_o} \right) - 0.45 \left(\frac{t}{D_o} \right)^{1/2}}$$

- Q.3 (a) Define Gasket seating stress and gasket factor. State the different types of gaskets and explain any three of them. 07
- (b) It is desired to design a bracket support for a vertical cylindrical reaction vessel installed indoor. Following data are available. 07
 Vessel diameter = 1.5 m
 Vessel height = 2.0 m
 Clearance from vessel bottom to foundation = 0.8 m
 Weight of vessel with content = 4,000 kg

Number of brackets = 6

Height of bracket from the foundation = 2.0 m

Diameter of anchor bolt circle = 1.65 m

Base plate dimension for bracket:

Distance between vessel wall and bracket end = 150 mm

Gusset plate are 140 mm apart from each other

Web plates dimensions for bracket height = 0.707

Channel size = 150 × 75 (Area = 21 cm²)

Modulus of section = 19 cm³, Radius of gyration = 2.2 cm

Weight = 170 N/m

Eccentricity = 7.5 cm

Base plate size = Extends 20 mm on either side of channel

Permissible stresses:

Tensile stress = 140 N/mm²

Compressive stress = 128 N/mm²

Bending stress = 158 N/mm²

Permissible bearing pressure of concrete = 5.0 N/mm²

Assuming wind pressure = 1285 N/m²

Calculate the base plate and gusset plate thickness.

Maximum stress at the rectangular plate,
$$f = 0.7P_{av} \frac{B^2}{T_1^2} \left(\frac{a^4}{B^4 + a^4} \right)$$

Stress at the age
$$f = \frac{3PC}{T_2 \times h^2 \cos \theta}$$

OR

- Q.3 (a) Explain the various types of flanges used in industry. 07
(b) Determine the thickness skirt and bearing plate for the distillation column based on the following data. 07

Diameter of column = 2500 mm

Height of distillation column = 40 m

Maximum weight of vessel, its attachment and contents = 3,00,000 kg

Type of skirt support = Straight cylindrical

Diameter of skirt = 2500 mm

Height of skirt = 5 m

Wind pressure at the top of column = 128.5 kgf/m²

Material used for skirt support = IS 800, Structural steel

Allowable tensile stress of material = 1400 kgf/cm²

Allowable compressive stress of material = 666 kgf/cm²

Allowable bending stress of material = 1575 kgf/cm²

Allowable compressive stress of concrete = 35 kgf/cm²

Seismic coefficient = 0.08

Minimum weight of empty vessel W = 250000 kg

Bolt material = SA 193 Gr B

Allowable tensile stress of bolt material = 1020.7 kgf/cm²

$$f_{db} = \frac{\Sigma W}{\pi D_o k t_{sk}}, f_{wb} = \frac{M_{wb}}{Z}$$

$$M_{wb} = \frac{0.7P_1 h_1 D_o}{2} + 0.7P_2 D_o h_2 \left(h_2 + \frac{h_2}{2} \right)$$

$$f_{sb} = \frac{M_{sb}}{Z}, M_{sb} = \frac{2}{3}CW,$$

$$f_{cmax} = \frac{\Sigma W}{A} + \frac{M_W \text{ or } M_S}{Z}$$

$$t_B = \sqrt{\frac{3f_{cmax}l^3}{f}}$$

- Q.4 A flat blade turbine agitator with six blades is installed centrally in vertical tank. The tank is 1.83 m in diameter; turbine is 0.61 m in diameter and is positioned at 0.61 m from the bottom of tank based on the following data. 14

Height of liquid in tank = 1.83 m

Viscosity of liquid = 15 cp

Density of liquid = 1500 kg/m³

Speed of agitator = 90 rpm

Length of agitator shaft between bearing & agitator = 2.1 m

Width of blade = 120 mm

Nos. of baffles at tank wall = 4

Shaft and agitator blade material = IS 2062 Grade ST 42

Ultimate tensile stress = 4200 kgf/cm²

Yield stress = 2300 kgf/cm²

Maximum allowable shear stress in shaft = 550 kgf/cm²

Modulus of elasticity = 19.5 × 10⁵ kgf/cm²

Calculate (i) power required for agitation (ii) shaft diameter and (iii) thickness of agitator blade.

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

OR

- Q.4 (a) Discuss in detail the various types of jackets used for heating and Cooling. 07
(b) Calculate the thickness of shell of the reactor and thickness of jacket for the following available options (i) Reactor with plain jacket and (ii) Reactor with channel jacket. 07
Following data are available.

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 for shell = 4 kgf/cm²,

Internal design pressure for jacket = 3 kgf/cm²,

Design temperature for both shell and jacket 150 °C

Max. Allowable stress = 980 kgf/cm²

Modulus of elasticity E = 19 × 10⁵ kgf/cm², Poisson's ratio μ = 0.3

Joint Efficiency J = 0.85

$$\text{Thickness of Shell } t = \frac{P D_i}{2fJ - P} + CA, \text{ Thickness of plain jacket } t = \frac{P r_i}{fJ - 0.6P} + CA$$

$$f_{PS} = \frac{P' D_i}{2t_{s'}} + \frac{P d_i}{4t_{c'} + 2.5t_{s'}}, f_{AS} = \frac{P' D_i}{4t_{s'}} + \frac{P d_i}{2t_{c'}} + \frac{2\Delta P d_o^2}{3t_s^2}$$

- Q-5 (a) Write a short note on safety valves. 07
(b) A fixed conical roof storage tank is fabricated from structural carbon steel plate. 07
Based on the given following data find out the thickness of conical roof plate and size of roof curbe angle. The following data are given.

Tank diameter = 7.0 m

Tank height = 5.0 m

Slope of conical roof = '1 in 6'

Superimposed live load on roof = 125 kgf/m²

Modulus of Elasticity = 2×10^6 kgf/cm²

Density of plastic material = 7800 kg/m³

Poisson's ratio = 0.3

Thickness of top most shell course = 10 mm

$$t_r = \frac{D}{\sin \theta} \sqrt{\left(\frac{P}{0.204E} \right)} + CA, \quad A = \frac{W \cos \theta}{2\pi f_{ac}}, \quad f_{ac} = \frac{1}{12} \frac{E}{\sqrt{3(1 - \mu^2)}} \frac{t \sin \theta}{R}$$

OR

- Q-5 (a) Write a short note on Rupture disks. 07
- (b) A nozzle having an inside diameter of 400 mm is fabricated from SA 516 Gr 70 plate. 07
It is attached by welding to a vessel shell that has an inside diameter of 1500 mm.
Internal design pressure of the vessel is 10 kgf/cm² and design temperature is 300 °C.
Vessel shell is also fabricated from SA 516 Gr 70 plate. Check whether this nozzle
requires reinforcement pad or not. If reinforcement pad is required then decide its
dimension. Maximum allowable stress of SA 516 Gr 70 plate at design temperature is
612.4 kgf/cm². Take joint efficiency 0.85 for both shell & nozzle. The corrosion
allowance is 1.5 mm.
