Seat No.: _____ Enrolment No._____

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/cm^2 gauge & working temperature is 70 ^{0}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/cm^2 (g). The hemispherical head is fabricated from SA-516 Grade 70. **07**

The maximum allowable stress at design temperature is 610 kgf/cm^2.

Modulus of Elasticity of plate material (E) = 193 × 10^3 N/mm^2.

Poisson's ratio (μ) = 0.3, ρ = 7.83 g/cm^3, Joint efficiency (J) = 0.85.

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

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

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/cm^2. 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 ^{o}F. The MOC is carbon steel with yield stress of 30,000-38,000 psi. Modulus elasticity of carbon steel is 170 × 10^3 N/mm^2. **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 (Pw) = 1285 N/m^2, 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/mm^2, Bending σ_{bm} = 157.5 N/mm^2, compressive σ_{comp} = 123.3 N/mm^2, Permissible bearing pressure for concrete = 3.5 N/mm^2

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 m^3, Density ρ_{Fluid} = 950 kg/m^3, joint efficiency J =

0.8, f = 980 kg/cm^2, C.A. = 2, Type of welding joint = double welded full fillet lap joint, height of each course = 1, Available plate = 2 m × 2 m, 3 m × 2 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 ρ = 1250 kg/m^3, Viscosity μ = 250 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 × 10^6 kgf/cm^2, f = 550 kgf/cm^2, NP = 6, for NRe < 4500, NP = 5 for NRe > 4500

Calculate the horse power and shaft diameter.

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

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 ^{o}C, maximum allowable stress at design temperature = 980 kgf/cm^2, Modulus of elasticity E = 19 × 10^5 kgf/cm^2, Poisson's ratio μ = 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 ^{o}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 Pw = 130 kgf/m^2, Insulation thickness t_{ins} = 100 mm, Density of insulation ρ_{ins} = 500 kg/m^3, Maximum allowable stress of shell plate material at design temperature = 890 kgf/cm^2, Modulus of elasticity E = 2 × 10^6 kgf/cm^2, Poisson's ratio μ = 0.3, Corrosion allowance = 2 mm, specific gravity of material = 7.865. Neglect the stress created by eccentric load and seismic load.

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