Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VII • EXAMINATION – SUMMER 2013

Subject Code: 170502 **Date: 24-05-2013**

Subject Name: Process Equipment Design – II

Time: 02.30 pm - 05.30 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)** Design a shell for fixed conical roof cylindrical storage tank for following data: **07**

Tank diameter = 30 m Tank height = 18 m
Specific gravity = 1.24 Slope of conical roof = 1/6
Super imposed live load = 1250 N/m^2
MOC – Carbon steel
Maximum allowable stress f = 157.5 N/mm^2
Density = 7.8 gm/cc Modulus of Elasticity E = 2 x 10^5 N/mm^2
Corrosion Allowance = 2 mm
Standard plate size available is 6300 x 1800 mm
Type of butt joint = double welded butt joint with 85% efficiency.

(b) Describe general design steps for shell and tube heat exchanger. **07**

Q.2 **(a)** Design the shell of pressure vessel subjected to internal operating pressure of 7.7 atmg **07**

Inside dia. 3 m;
Operating Temperature 400° C;
MOC – CS grade 70 [UTS: 418 N/mm^2, FOS = 3];
E – 185*10^3 N/mm^2; μ= 0.32; corrosion Allowance = 2 mm
Weight of vessel = 5520 kg;
Maximum wind load applicable to vessel = 9000 N.m;
Torque due to offset of piping = 625 N.m;

(b) Design a bracket support for reaction vessel based on following data. Brackets are welded with outside surface of the reactor shell. **07**

OD of reactor shell = 1.3 m Thickness of the shell =12 mm
Height of the vessel = 2.5m
Clearance from vessel bottom to foundation = 1 m
Weight of vessel with contents = 3750 kg
Wind pressure = 130 kgf/m^2
No of brackets = 4 Diameter of bolt circle = 1.51 m
Size of base plate for bracket = 150 mm x 150 mm
Size of gusset plate for bracket = 150 mm x 150 mm
Height of the C channel from foundation = 2.625 m
Size of C channel = 150 mm x 75 mm
Area of cross section = 22 cm2 Modulus of section = 24.6 cm^3
Radius of gyration = 2.43 cm
MOC for support = IS 800
Max. allowable tensile stress = 1400 kgf/cm^2
Max. allowable compressive stress = 1233 kgf/cm^2
Max. allowable bending stress = 1575 kgf/cm^2

OR

(b) Find the thickness of a straight cylindrical skirt support for distillation column based on following data. **07**

Diameter of column = 2500 mm

Height of distillation column = 40 m
Max. wt of vessel, its attachment & contents = 300000 kg
Diameter of skirt =2500 mm
Height of skirt = 5 m
Wind pressure at the top of column =128.5 kgf/m^2
Material used for skirt support = IS 800 structural steel
Max. allowable tensile stress = 1400 kgf/cm^2
Max. allowable compressive stress = 666 kgf/cm^2
Max. allowable bending stress = 1575 kgf/cm^2
Seismic coefficient =0.08
Minimum wt of empty vessel = 250000 kg

Q.3 **(a)** Compare head thickness for torrispherical, elliptical and hemispherical heads using following data: **07**

Operating pressure = 15 Atm;
Crown radius = 1000 mm; Knuckle radius = 100 mm;
MOC – CS (f = 142 N/mm^2, CA = 2 mm);
J = 0.85; Shell ID = 1000 mm;
Inside depth of the elliptical dish = 200 mm

(b) Discuss the steps for the design of reinforcement pad for a nozzle. **07**

OR

Q.3 For a ring flange, design a flat ring type gasket and check the bolt size is appropriate or not. **14**

Internal design pressure = 12 kgf/cm^2
Design temperature = 150 ^oC
Flange material = SA 240 Gr S type 304
Max. allowable stress at design temp = 1020.7 kgf/cm^2
Max. allowable stress at atmospheric condition = 1275.9 kgf/cm^2
Bolt material = SA 193 Gr B8 type 304
Max allowable stress at 150 ^oC = 816.5 kgf/cm^2
Max. allowable stress at atmospheric condition = 1020.7 kgf/cm^2
Bolt size ¾ inch Root area of the bolt = 0.302 in^2
Edge clearance = 35 mm Bolt spacing = 61 mm
Gasket material = asbestos composition
Gasket thickness = 1.5875 cm Gasket factor = 2.75
Maximum gasket seating stress = 251.77 kgf/cm^2
Shell OD = 900 mm
Shell thickness = 10 mm

Q.4 **(a)** A fixed conical roof storage tank is fabricated from structural carbon steel plate. Based o the following data find the thickness of conical roof plate and size of roof curb angle. Storage tank is classified as Class A tank. **07**

Tank diameter = 7 m Tank height = 5 m
Slope of conical roof = 1 in 6
Superimposed live load on roof = 125 kgf/m^2
Modulus of elasticity =2 x 10^6 kgf/cm^2
Density of plate material = 7800 kg/m^3
Poisson's ration = 0.3 Thickness of top most course =10 mm

(b) Calculate the weight of tubes and tube sheet for AEM type shell and tube heat exchanger using following data: **07**

Inside diameter of shell = 580 mm Thickness of the shell =5 mm
Tube diameter = 19.05 mm Number of tubes required = 446
Minimum thickness required according to TEMA standards = 1.5 mm
Length of the shell = length of tube =2.4384 m
Operating pressure on tube side = 600 kPa
Operating pressure on shell side = 1 atm
MOC of tubes = SS 304
Maximum allowable stress at op. temperature (150 ^oC)= 104 N/mm^2

MOC of tube sheet =SA 240 Gr S plates
Maximum allowable stress at operating temperature = 110N/mm^2
Depth of pass partition groove = 5 mm
Gasket mean diameter for fixing of the tube sheet = 673 mm
Density of MOC = 8000 Kg/m^3
Tube sheets are integral part of the shell of HE.

OR

Q.4 **(a)** Discuss the design of trays and tray supports for a tray tower. **07**

(b) Describe the steps for structurally supported roof design. **07**

Q.5 A flat blade turbine agitator with six blades is installed centrally in vertical tank. The tank is 1.5 m in diameter; turbine is 0.5 m in diameter. Based on the given following data, Calculate (1) Power required for agitator, (2) shaft diameter. **14**

Height of liquid in tank = 1.5 m
Viscosity of liquid = 20 cp Density of liquid = 1200 kg/m^3
Speed of agitator = 120 rpm
Length of agitator shaft between bearing and agitator = 2 m
Width of blade R_b = 120 mm
No. of baffles at tank wall = 4
Shaft & agitator blade material = IS 2062 Gr ST 42 W
Ultimate tensile stress = 4200 kgf/cm^2
Max. allowable shear stress in shaft = 550 kgf/cm^2
Modulus of elasticity = 19.5 10^5 kg/cm^2
For N_{Re} >=10000, N_p =6 and N_{Re} <10000, N_p =5

OR

Q.5 **(a)** Write a short note on "Pressure Relieving Devices". **07**

(b) Determine the shell thickness for the entire tower height based on the following data: **07**

Shell diameter = 3500 mm
Working pressure = 2 N/mm^2 Design temperature = 200 ^{o}C
Base chamber height = 3200 mm
Top chamber height = 2000 mm
Feed chamber height = 800 mm
Sp. Gr. Of the material = 7.7
Permissible tensile stress = 95 N/mm^2
Insulation density = 7700 N/m^3
Corrosion allowance= 3 mm
Poisson's ratio = 0.3 Density of MOC = 1.93 x10^3 kg/m^3
Insulation thickness = 148 mm
Weight of head = 2800 N
Weight of attachments (pipes, ladders, platforms) = 1600 N/m
Weight of column = 3x10^6 N
Weight of tray and liquid = 900 N/m^2
Wind pressure =1600 N/mm^2
Neglect the seismic load and eccentricity
Number of trays = 60 Tray spacing = 0.7 m
Joint efficiency is 85 %.

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