Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VII (NEW) EXAMINATION – WINTER 2018

Subject Code: 2170502 **Date: 19/11/2018**

Subject Name: Process Equipment Design -II

Time: 10:30 AM TO 01:30 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)** A reaction vessel is operated at 5 atm absolute and 150°C. The heat of reaction 2583.54 kJ is supplied using the steam at pressure 5 atm gauge. Calculate the design pressure for wall of reaction vessel and jacket. **03**

(b) Compare head thickness for torrispherical and elliptical heads using following data: **04**
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

(c) For a fixed conical roof cylindrical storage tank, determine the wall thickness 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
Standard plate size available is 6300 x 1800 mm
Type of butt joint = double welded butt joint.

Q.2 **(a)** Discuss the tubesheet design. **03**

(b) Define the following properties of materials: **04**
Toughness, Hardness, Fatigue, Creep.

(c) Calculate the shell thickness based on resultant stress theory for vessel having inside diameter 3 m, subjected to internal operating pressure of 7.7 atm g and 400°C temperature. The weight of vessel is 5520 kg. Maximum wind load applicable to vessel and torque due to offset of piping are 9000 N.m and 625 N.m respectively. The material of construction is CS grade 70 [UTS: 418 N/mm^2, FOS = 3] with modulus of elasticity 185 x 10^3 N/mm^2, Poisson's ratio 0.32 and corrosion Allowance = 2 mm. **07**

OR

(c) Discuss the design of structurally supported roof for cylindrical storage vessel. **07**

Q.3 **(a)** Determine the thickness of shell of distillation column at various heights based on following data. **14**
Shell O.D. at top = 2000 mm
Length of Shell = 27 m
Internal design pressure = 3 kgf/cm^2
Design temperature = 120 °C
Shell Material = SA-283 Grade C
Type of shell plate joint = Double welded butt joint with 10% radiography

Skirt height = 4 m
Tray spacing = 0.3 m
Top disengaging space = 1.2 m
Weight of head = 317 kg
Weight of one tray plus wt. of liquid over the same =120 kg/m^2
Wt. of attachments (pipes, ladders & platforms) = 150 kg/m
Wind pressure = 130 kgf/m^2
Insulation thickness = 100 mm
Density of insulation = 500 kg/m^3
Maximum allowable stress of shell material at 120 °C = 890kgf/cm^2
Modulus of elasticity = 2 x 10^6 kgf/cm^2
Poisson's ration = 0.3
Corrosion allowance = 2 mm
Specific gravity of SA-283 Grade C = 7.865

Neglect the stress created by eccentric load and seismic load.

OR

Q.3 **(a)** Derive the equation for longitudinal and axial stresses generated due to operating pressure in cylindrical vessel. **03**

(b) Discuss various types of jackets with neat sketch. **04**

(c) Discuss the design of Tray and tray support in detail. **07**

Q.4 **(a)** Discuss the calculation of tube side pressure drop for shell and tube heat exchanger. **03**

(b) Discuss the design of half coil and plain jacket. **04**

(c) Design a bracket of the support welded on outside surface of the shell, to support a vertical cylindrical reaction vessel based on following available details: **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
Diameter of bolt circle = 1.51 m
Size of base 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 cm^2
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

Q.4 **(a)** Discuss the calculation of shell side pressure drop for shell and tube heat exchanger. **03**

(b) 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, Suggest Rated power required for motor to run agitator. **04**

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
For N_{Re} >10000 N_p =6 and N_{Re} <10000 N_p =5

(c) Discuss the design of skirt support for tall vertical vessel. **07**

Q.5 For reaction vessel, discuss design calculations for following components used for the flange connecting head and shell

(a) Gasket **03**

(b) Bolts **04**

(c) Flange diameter and thickness. **07**

OR

Q.5 **(a)** Discuss the selection criteria for nozzles. **03**

(b) Classify the flanges based on its facings and give application for each. **04**

(c) Examine the data given below to evaluate the requirement of compensation for the nozzle opening in a cylindrical shell. If compensation ring (Reinforcement pad) is required then find its dimensions and weight. **07**

Outside diameter of shell = 2 m
Max. Working pressure within shell = 3.5 MN/m^2
Wall thickness for the shell = 0.05 m
Corrosion allowance = 3 mm
Joint efficiency = 1 (for shell and nozzle)
MOC of shell, nozzle and reinforcement pad = IS 2002
Density of IS 2002 = 7800 kg/m^3
Allowable stress of IS 2002 = 96 MN/m^2
OD of nozzle (seamless) = 0.25 m
Nozzle wall thickness = 0.016 m
Length of nozzle = 100 mm

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