Enrolment No./Seat No_____

GUJARAT TECHNOLOGICAL UNIVERSITY

BE - SEMESTER–VII EXAMINATION – SUMMER 2025

Subject Code:3170514 Date:23-05-2025

Subject Name: Mechanical Design of Process equipments

Time:02:30 PM TO 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.**
4. **Simple and non-programmable scientific calculators are allowed.**

			MARKS
Q.1	**(a)**	Describe graphical method to find out the thickness of pressure vessel subjected to external design pressure with the help of qualitative graphs.	**03**
	(b)	List different types of heads that are used as a closure for pressure vessel. Suggest the head that will require the least thickness to withstand 20 kg_f/cm^2 and 150 ^oC temperature. Justify your answer. Consider stainless steel as a Material of Construction (MOC) of head.	**04**
	(c)	Discuss about different types of agitators and their selection criteria.	**07**
Q.2	**(a)**	Discuss merits and demerits of flanged joint over welding joint.	**03**
	(b)	Appreciate/criticize the following statement: "Circumferential stress is always less than axial stress for the cylindrical vessel subjected to the internal design pressure". Justify your answer with derivation.	**04**
	(c)	Define the following terms: i. Toughness ii. Yield stress iii. Resilience iv. Ultimate stress v. Creep vi. Modulus of Elasticity vii. Poisson's ratio	**07**
		OR	
	(c)	Discuss step wise design procedure of structural supported roof for non-pressure storage tank.	**07**
Q.3	**(a)**	Explain Normal and Emergency venting for storage vessel.	**03**
	(b)	Discuss in brief about different types of gasket used in chemical industries.	**04**
	(c)	Find different thickness of shell courses of closed storage tank. Storage tank is to be designed to store non volatile material. Use following data for calculation purpose.	**07**

D/H (Diameter to Height ratio)	1
Volume of liquid to be stored	10,000 m^3
Density of liquid	1045 kg/m^3
Size of plate	3.0 m width X 7.0 m length
Material of construction (MOC)	Carbon steel
Specific gravity of MOC	7.8
Permissible stress	165 N/mm^2
Corrosion allowance	1.5 mm
Welding joints and Joint efficiency	Double Welded Butt joints, 0.85

OR

Q.3 **(a)** Provide full form of following abbreviations in context of current course: ASME, TEMA, API. **03**

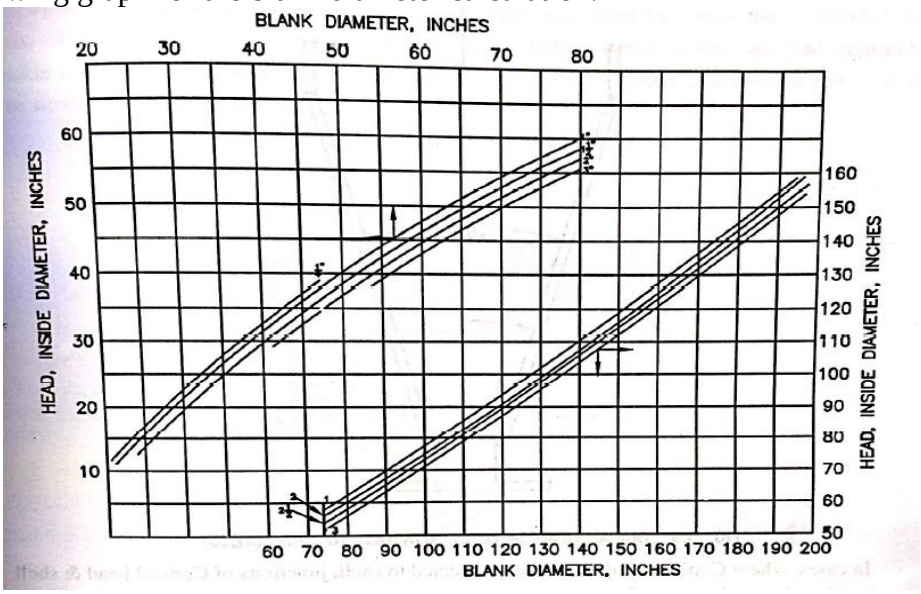
(b) Discuss in detail regarding radiography test for welding. **04**

(c) A nozzle having inside diameter 400 mm is fabricated from SA-516 Gr 70 plate. It is attached by welding to a vessel shell that has an inside diameter of 1500 mm. Internal design pressure of vessel is 10 kg_f/cm^2 and design temperature 200 ^oC. Vessel is also made of same MOC as of nozzle. Check whether this nozzle requires reinforcement pad or not. If reinforcement pad is required than decide its dimension. Maximum allowable stress of MOC at design temperature is 650 kg_f/cm^2. Assume appropriate values for corrosion allowance and welding joint efficiency. **07**

Q.4 Cylindrical reactor is having elliptical ends at the both ends. 70% of the length of cylindrical shell and bottom head is surrounded by jacket. Inside the reactor maximum operating pressure and temperature are 25 atm(g) and 40 ^oC respectively. Reactor can be subjected to vacuum as well. Inside jacket saturated steam is supplied at 6 $kg_f/cm^2(g)$ pressure. Design shell and bottom elliptical head of reactor. Use analytical method for thickness calculation of shell. Elliptical head and shell is fabricated from SA-516 Gr 70 plate. Assume appropriate values for corrosion allowance and welding joint efficiency. Use following data for calculation. **14**

Maximum allowable of material of construction (MOC)	615 kg_f/cm^2
Inside diameter of reactor	500 mm
Modulus of elasticity of MOC	19300 kg_f/mm^2
Poisson's ratio	0.33
Length of reactor	2 m
Major axis/minor axis	2
Equivalent radius of curvature	0.9*ID of reactor

Use following graph for the blank diameter calculation.



OR

Q.4 Calculate the thickness of shell plate for the entire distillation column, having following specifications: **14**

Shell outside diameter at top = 2 m
Shell length (tangent line to tangent line) = 35 m
Internal design pressure = 3 kg_f/cm^2
Design temperature = 120 ^oC
Shell material = SA -283 Grade C
Type of welding joint = Double welded butt joint with 10% radiography
Skirt height = 4 m
Total trays = 106

Tray spacing = 0.3 m
Top disengaging space = 1.2 m
Weight of liquid and tray = 120 kg/m^2
Weight of attachment (pipes, ladders and platform) = 150 kg/m
Wind pressure = 130 kg_f/m^2
Insulation thickness = 100 mm
Density of insulation = 500 kg/m^3
Maximum allowable stress of shell plate at design temperature = 890 kg_f/cm^2
Modulus of elasticity = $2X10^6$ kg_f/cm^2
Poission's ratio = 0.3
Specific gravity of shell plate material = 7.865
Top head = Torispherical
Weight of top head = 316.56 kg

Q.5 **(a)** Differentiate between design pressure and operating pressure of pressure vessel. **03**

(b) Describe various types of jackets and their selection criteria. **04**

(c) Discuss about different types of flanges facings with neat figure. Also mention merits of each flange over others. **07**

OR

Q.5 **(a)** Discuss the function of (i) Tie rods (ii) Spacers and (iii) Expansion joints in shell and tube heat exchanger. **03**

(b) Define following terms for agitation: Power number, Froude number, and Reynold's number. **04**

(c) Discuss stepwise procedure for the design of skirt support. **07**

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