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B. M. S. College of Engineering, Bengaluru - 560019

Autonomous Institute Affiliated to VTU

September / October 2023 Supplementary Examinations

Programme: B.E. **Semester: V**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 19CH5DCCED **Max Marks: 100**
Course: Chemical Equipment Design **Date: 14.09.2023**

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.
3. IS 2825 code book and Perry data hand book are permitted to use.

UNIT - I

1. a) If you are a design engineer working in a chemical company and wants to design a chemical equipment, explain the various steps to be followed to attain the final design. **06**

   b) A pressure vessel is to be designed to work in a hilly station. Discuss the various stresses encountered by this pressure vessel while in operation, with equations. **06**

   c) Discuss the various pressure vessel enclosure employed to design pressure vessels, with equations. **08**

OR

2. a) How are chemical equipment classified? Discuss. **06**

   b) An evaporator drum, cylindrical in shape, 1.7 m internal diameter, and 1.9 m height is to be designed for an internal operating pressure of 400 mmHg and 90°C. The vessel is to have a Tori-spherical head (100-06). Outside pressure is atmospheric. The vessel will be fully radiographed. Material of construction: stainless steel, IS: 1570-1961: 15Cr90Mo55; Young's modulus: 19.5×10^4 N/mm^2; and Poisson ratio: 0.28. Estimate the thickness of shell and tori-spherical head based on (i) internal pressure and (ii) external pressure, using formula method. **14**

UNIT - II

3. a) With neat sketches, explain the vessel supports used for horizontal and vertical vessels in industry. **10**

   b) Pressure vessel of internal diameter 150 cm operates at 0.05 kg/mm^2. The vessel is to be provided with a nozzle 10 cm internal diameter. The nozzle is welded to the shell wall and does not project inside the vessel. Permissible stress of the material is 10.20 kg/mm^2. Corrosion allowance is 1 mm and welded joint efficiency is 85%. Estimate the reinforcement required for the nozzle. **10**

OR

4. a) A loose flange is to be provided for a pressure vessel with the following specifications. Find the thickness of the flange required. **12**

Outer diameter of shell: 80 cm
Shell thickness: 10 mm
Design pressure: 10 kg/cm^2
Gasket: Asbestos with gasket factor 2.75
Inside diameter of the gasket: 84 cm
Gasket width: 1.6 cm
Gasket seating stress: 260 kg/cm^2
Permissible stress of the flange material: 950 kg/cm^2

b) What are nozzles? Discuss the classification of nozzles. **08**

UNIT - III

5. a) In an industry, a salt is dissolved in a vessel fitted with an agitator. Discuss the purpose of mixing and agitation in this context. **04**

b) A reaction vessel to process liquid components of a reaction mixture of 1500 L with L/D ratio of 1.2 is to be designed with 1/3rd volume of reactor as free space and Tori-spherical heads. The reactor operates at 8 kg/cm^2 and is made of SS 316. It has an agitator provided with turbine type impeller rotating at 300 rpm, whose allowable stress is 9.5 kg/mm^2. For the purpose of agitator sizing, the properties of the reaction mixture may be assumed as that of water. **16**

i. Determine diameter and height of the tank
ii. Design impeller characteristics
iii. Find the power rating of motor required for agitation, including all the losses
iv. Calculate the diameter of shaft

UNIT - IV

6. a) When are the Horton-spheres used? Discuss the advantages and limitations over cylindrical storage vessels. **04**

b) A cylindrical tank is to be designed to store 2700 ton of organic liquid. The tank will be filled to 90% of its capacity. Steel plates of sizes 6300 × 1800 mm and of different thicknesses are available. **16**

a. Design the shell course (thickness of various shell courses, number of plates and weight of total shell course)
b. Bottom plate (number of plates and weight of bottom plate)
c. It is proposed to use a self-supporting roof of 6 mm thickness, including corrosion allowance. Will this thickness be suitable?

Liquid density: 800 kg/m^3; steel plate density: 7700 kg/m^3; allowable stress 14 kg f/mm^2; Young's modulus: 19 × 10^{10} N/m^2; corrosion allowance: 2 mm; and welding efficiency: 85%

UNIT - V

7. a) What are the auxiliary equipment/process vessels? Enlist at least four of them. **04**

b) Carbon dioxide is to be conveyed from the top of the stripper of ammonia plant to urea plant. **16**

i) Calculate the pipe size required based on the following data, and

ii) What is the total pressure drop in the line?

Flow rate of CO_2 = 1000 t/day

Total length of pipe = 800 m

Available pressure at inlet of pipe = 24 kPa

Required discharge pressure of CO_2 from pipe = atmospheric

Number of 90° elbows in pipe line = 8

Pressure drop offered by each 90° elbow = 241.5 Pa

Number of butterfly valve = 1

Pressure drop offered by butter fly valve = 77.28 Pa

Number of flow nozzle = 1

Temperature of gas = 60°C

Viscosity of CO_2 gas = 0.016 mPa s

Velocity of CO_2 in pipe = 20 m/s

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