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

Autonomous Institute Affiliated to VTU

February / March 2023 Semester End Main Examinations

Programme: B.E. **Semester: V**
Branch: Chemical Engineering **Duration: 3 hrs.**
Course Code: 19CH5DCCED **Max Marks: 100**
Course: Chemical Equipment Design **Date: 03.03.2023**

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.
3. Use of IS code book 2825 is permitted.

UNIT - I

1 a) Explain the operating conditions of pressure vessel and different pressure vessel codes. **08**

b) Write the empirical formulae used to calculate weight of cylindrical shell, elliptical head, hemispherical head and tori-spherical head. **04**

c) A cylindrical steel pressure vessel 400 mm in diameter with a wall thickness of 20 mm, is subjected to an internal pressure of 4.5 N/m^2. (a) Calculate the tangential or circumferential and longitudinal stresses in the steel. (b) To what value may the internal pressure be increased if the stress in the steel is limited to 120 N/m^2? **08**

OR

2 a) Stainless steel jacketed reactor vessel with standard tori-spherical dished closures. The vessel has a nominal (outer) diameter of 1200 mm and the length of 2000 mm (tangent to tangent). The top cover bolted to the shell. The vessel is to be operated at a pressure of 3.0 kgf/cm^2 (gauge pressure). Calculate the vessel thickness and validate using the factor B method with trial and error for internal pressure. Data: Allowable stress of stainless-steel materials =1300 kgf/cm^2, joint efficiency, J = 0.85, assume the design pressure as 1.1 times the operating pressure and the corrosion allowance as nil., Poisson ratio = 0.3 and Youngs modulus, E = 2×10^6 kgf/cm^2. **14**

b) Explain the different stresses induced in pressure vessel. **06**

UNIT - II

3 a) With neat sketches, explain the different pressure vessel supports. **08**

b) If a flange is not of standard size, determine the thickness of the flange for the following data: Nominal diameter of the flange = 1200 mm, inside diameter of flange = 1202 mm, outside diameter of flange = 1315 mm, outside diameter of stainless steel lining ring (raised face) = 1240 mm, bolt or pitch circle diameter = 1310 mm, design pressure, P = 0.33 N/mm^2, permissible tensile stress of bolt materials under atmospheric and operating conditions are 5870 and 5450 N/cm^2, respectively, permissible stress of flange material, f = 95 N/mm^2, assume number of bolts 48 and M18 bolt and corrosion allowance = 1mm. **12**

OR

4 a) Discuss the different types of closures/heads for cylindrical pressure vessel with design equations and sketches. **08**

b) A pressure vessel of I.D. 1500 mm operates at 5 kg/cm^2. The vessel has to be provided with nozzle 100 mm ID. The Nozzle is welded for the shell wall and does not project inside the vessel (A_3=0). The permissible stress of materials is 1020 kg/cm^2. Estimate the reinforcement or compensation ring thickness required for nozzle. Corrosion allowance is 1 mm. Weld joint efficiency is 85 %. **12**

UNIT - III

5 a) Calculate the diameter of the shaft used in agitation system torque acting over the shaft is T=1,15,00 kg-cm, while bending moment acting over the shaft is 34,600 kg-cm. Ultimate tensile strength of shaft material = 6900 kg/cm^2. Ultimate shear stress f_s = 75 % of the ultimate tensile stress. The factor of safety used is 6.0 for ultimate tensile stress. **10**

b) Justify the need of agitation in process industries. With neat sketches, explain the various designs of agitators. **10**

UNIT - IV

6 A storage tank is to be designed to store 2650 m^3 of liquid, assume H/D =1.0. Steel plates of size 1.5 × 5.0 m, and a different thickness are available. **20**

(a) Design the shell course

(b) Design the annular, bottom plate, self-supporting sloping roof, and curb angle.

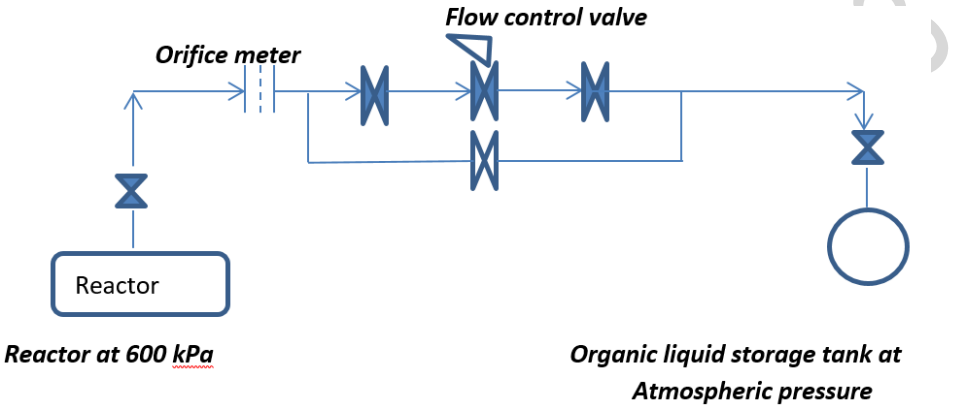
(c)Estimate the bill of quantities and cost by considering Rs. 20,000/ton

Data: Liquid density = 1000 kg/m^3, MS plate density = 8000 kg/m^3, allowable stress of MS = 960 kgf/cm^2, weld joint efficiency (J) = 0.85, corrosion allowance = 1 mm

UNIT – V

7 a) Estimate the optimum pipe diameter for carbon steel for water flowing at the rate 10 kg/s at 20°C using the carbon steel empirical equation and also check the velocity. **04**

b) An organic liquid is discharged at the rate of 5000 kg/h from a reactor to a storage tank at 50°C as shown in figure. Reactor is under pressure at 600 kPa. Density of the organic liquid is 930 kg/m^3 and viscosity is 0.91 mPa. Assume that no flashing of the organic liquid occurs across the control valve. **16**



Piping system details

Linear length of straight pipe = 50 m

No. of 90° elbows of standards radius = 6

No. of Tees = 2

Pressure drop in orifice meter = 40 kPa

No. of gate valves = 4

No. of globe valve = 1

No. of flow control valve = 1

Determine the pipe size.

Assume the pipe to be uniform throughout. Find the residual pressure drop and rating of pump that must be taken by the flow control valve. Data: Equivalent length of pipe for 90° elbow= 30 D_i, Tees = 22 D_i, and gate valve =10 D_i.

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