Birla Institute of Technology and Science, Pilani

Semester II Session: 2021-2022

CHE F412 PROCESS EQUIPMENT DESIGN

Mid Semester Examination

Date: 15/03/2022 **Full Marks: 70**

Duration: 90 Minutes

Instructions

- **Be to the point, don't write essays**
- **Please be careful with the units. Wrong units will fetch no credit**
- **Answer all parts of a question at one place only**
- **Write assumptions wherever required with proper justifications**
- **Symbols should have proper nomenclature**

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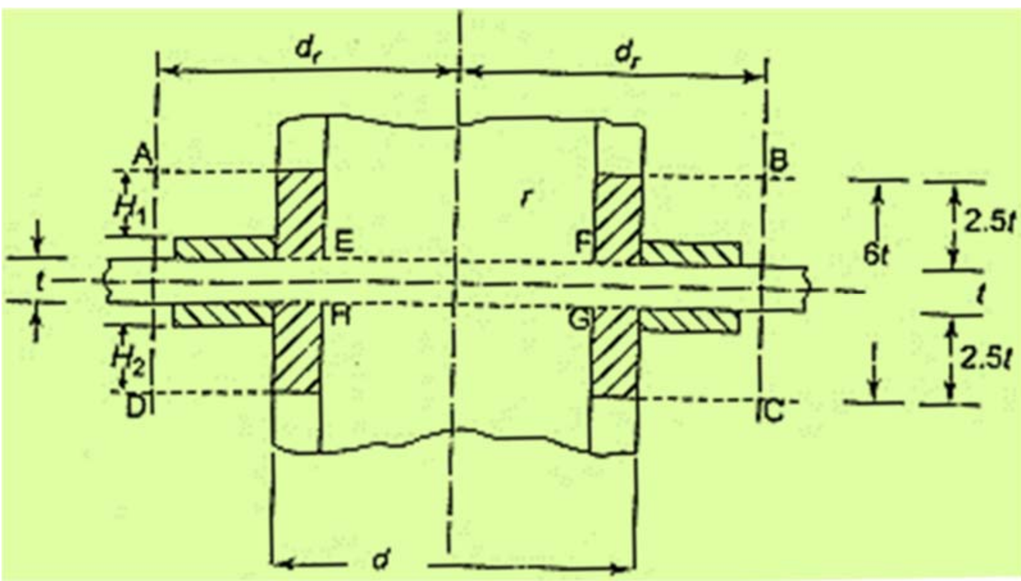
1. What is a nozzle? Discuss different types of nozzles. Refer to the following diagram, where a pressure vessel has an outer diameter of 1600 mm and operates at 7 kg/cm^2. The vessel needs to be provided with a nozzle having an internal diameter of 250 mm. The nozzle is fitted with a flange to the shell wall and projects about 10 mm inside the vessel. Permissible stress of the material used to fabricate the shell is 1100 kg/cm^2. Assume welding joint efficiency to be 85% and corrosion allowance to be 2 mm. Estimate the area of reinforcement required for the nozzle. **[3+5+12=20]**

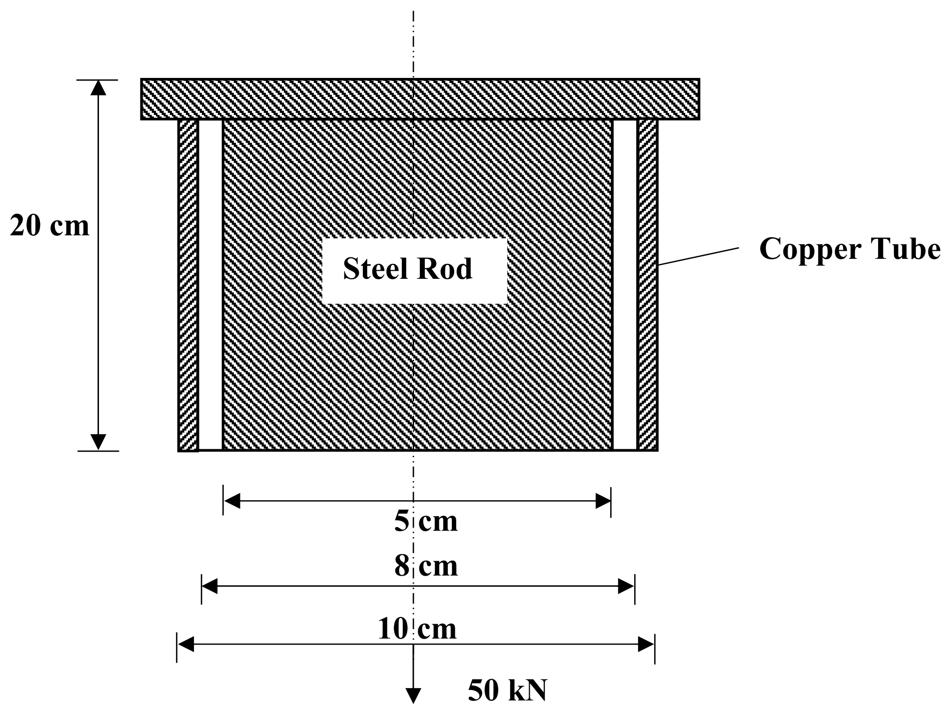


2. Discuss about the following terms: (a) Galvanic corrosion; (b) Passivation; (c) Solid modelling and (d) Butt welded joints **[1+1+2+1=5]**

3. How do you determine whether a process vessel is thick or thin from its geometrical identity? Derive the expressions for circumferential and longitudinal stress for a thin cylindrical pressure vessel with a neat diagram. In case of spherical vessel, derive the expression for longitudinal stress. **[2+10+8=20]**

4. A cylindrical pressure vessel, having length of 6 m and 3 m internal diameter is designed for a distillation process. Operating pressure is 4 kg/cm^2. A special alloy has been used for fabricating the vessel. It has an allowable stress of 1200 kg/cm^2. Consider the weight of the vessel to be 1654 tonnes. There is a strong wind blowing in that area which exerts a torque of 8.2×10^9 kg-cm over the vessel. Bending moment induced can be neglected. Assume welded joint efficiency as 70% and corrosion allowance as 2 mm. Obtain (i) minimum thickness required for the vessel, (ii) all types of stresses (both compressive and tensile) induced in the vessel and (iii) check if the equivalent resultant stress is less than permissible stress. **[2+10+3=15]**

5. A steel rod of diameter 5 cm is enclosed centrally in a hollow copper tube of external diameter 10 cm and internal diameter 8 cm. Hence, this structure becomes a composite bar and it is subjected to an axial pull of 50 kN force. Length of each bar is 20 cm. Assume elastic modulus for steel as 2.1×10^5 N/mm^2 and that of copper to be 1.1×10^5 N/mm^2. (i) Estimate the stress in the rod and the tube; (ii) Load carried by each bar. **[5+5=10]**



~All the Best; Happy Holi and Gudi Padwa in Advance~

Supplementary Information

Table for standard thickness

APPENDIX B — STANDARD VALUES

Table B-1 Steel Plates

Thickness : (mm)	5, 5.5, 6, 7, 8, 9, 10, 11, 12, 14, 16, 18, 20, 22, 25, 28, 32, 36, 40, 45, 50, 56, 63, 71, 80.
Width : (mm)	160, 180, 200, 220, 250, 280, 320, 355, 400, 450, 500, 560, 630, 710, 800, 900, 1 000, 1 100, 1 250, 1 500, 1 600, 1 800, 2 000, 2 200, 2 500.
Length :	6 m — 10 m easily available.

Table B-2 Strip Steels

Thickness : (mm)	0.8, 0.9 1.0, 1.1, 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.5 2.8, 3.2, 3.5, 4.0, 4.5.
Width : (mm) :	100, 110, 125, 140, 160, 180, 200, 220, 250, 280, 320, 355, 400, 450, 500, 560, 630, 710, 800, 900, 1 000.

For problem 1, you may take the help of the following formulas: $t_s = \frac{pD_0}{2fJ+P} = \frac{pD_i}{2fJ-P}$; *AB=2*$d_n$*; AD=6*$t_s$ *or 3.5*t_s*+2.5*t_n*, whichever is smaller;* $H_1=2.5t_n$*;* H_2*=nozzle projection inside the vessel;* $A= d_n \times t_s^{/}$*;* $A_s= d_n \times (t_s- t_s^{/}-c)$*;* $A_0= 2H_1 \times (t_s- t_s^{/}-c)$*;* $A_1=2H_2 \times t_n$

For problem 4, You may use the following formulas: $\sigma_t = \frac{p(D_i+t)}{2t}$; $\sigma_1 = \frac{pD_i}{4t}$; $\sigma_2 = \frac{W}{\pi t(D_i+t)}$; $\sigma_3 = \pm\frac{M}{Z} = \frac{M}{\pi D_i^2 t}$; $\sigma_s = \frac{2T}{\pi t D_i(D_i+t)}$; $\sigma_R = (\sigma_t^2 - \sigma_t\sigma_a + \sigma_a^2 + 3\sigma_s^2)^{\frac{1}{2}}$ Take 1 ton to be equal to 907.185 kg.