Birla Institute of Technology and Science, Pilani

Second Semester, Session: 2022-2023

CHE F412 PROCESS EQUIPMENT DESIGN

Mid Semester Examination

Date: 13/03/2023 **Full Marks: 60**

Duration: 90 Minutes

Instructions

- **Be to the point, don't write essays**
- **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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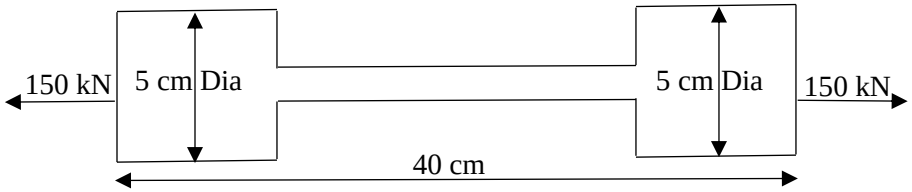
1. A pressure vessel having an inside diameter of 2 m and a plate thickness of 5 mm is operating at 2 kg/cm^2. This vessel has an opening which is to be fitted by flanges and gasket. Inside diameter of this flange is 2.3 m. The gasket, which is provided over the flange face has an inside diameter of 2.4 m, factor of 1.5 and seating stress of 150 kg/cm^2. Bolts (diameter: 24 mm, each) which are used to tighten the flange and gasket has a permissible stress of 650 kg/cm^2, under atmospheric condition and 580 kg/cm^2, under operating conditions. Assume that the diameter due to gasket load reaction is mean of inner and outer gasket diameter. Calculate: (a) bolt load at atmospheric conditions and operating conditions (in kg); (b) Bolt area at atmospheric conditions and operating conditions (in cm^2); (c) Number of bolts required and (d) Bolt circle diameter (in m) **[4×5=20]**

2. Steel plate is sold in the market at a rate of 600 INR/mm. A firm has been asked to fabricate a spherical and cylindrical pressure vessel, where the operating pressure can reach up to 250 N/m^2. Maximum allowable pressure for the steel plate is 1.2 kN/m^2. Internal diameter of the vessel is 10 cm. Assuming a joint efficiency of 85% and a corrosion allowance of 2 mm, estimate the net cost of the plates (in INR) for these two types of vessels. Which vessel has got more cost? **[9+9+2=20]**

3. A bar assembly (Young's modulus- 2.1×10^5 N/mm^2) is made by joining two blocks with a rod. Detailed diagram is presented below. It is subjected to a tensile load of 150 kN. Stress in the middle portion of the rod is 130 N/mm^2. Total elongation of the bar is restricted to 0.3 mm. Estimate diameter (in cm) and length (in cm) of the middle portion. **[5+5=10]**



4. Write in brief about the following items and draw illustrations wherever possible: (1) Riveted lap joint; (b) Hencky-Von Mises Theory; (c) Austenitic stainless steel; (d) cathodic and anodic protection; (e) Stress-strain diagram for a brittle material. **[5×2=10]**

~All the Best~

Supplementary Information

Table for standard thickness

Standard thickness available (in 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*

List of necessary formulas

- $\frac{G_o}{G_i} = \sqrt{\frac{Y_a - pm}{Y_a - p(m+1)}}$;
- b=b_0, when $b_0 \leq 6.3$ mm and b=$2.5(b_0)^{0.5}$, when $b_0 > 6.3$ mm; $N = \frac{G_0 - G_i}{2}$; b_0=N/2
- $W_{m1} = \pi b G Y_a$; $H = \frac{\pi}{4} G^2 P$; $W_{m2} = H + H_p, where\ H_p = 2\pi b G m p$; $A_{m1} = \frac{W_{m1}}{f_a}$; $A_{m2} = \frac{W_{m2}}{f_b}$; $A_b = \frac{2\pi Y_a G N}{f_a}$
- $Bolt\ area = \frac{\pi}{4} d_b^2$; $H = \frac{A_{m2}}{Bolt\ Area}$ $Bolt\ circle\ diameter = G_0 + (2 \times d_b) + 12\ mm$
- $t = \frac{pD_i}{2fJ - P} = \frac{pD_o}{2fJ + P}$; $t = \frac{pD_i}{4fJ - P} = \frac{pD_o}{4fJ + P}$
- $dl = \frac{P}{E}\left[\sum_{i=1}^{n} \frac{L_n}{A_n}\right], n\ is\ the\ number\ of\ the\ parts\ in\ the\ assembly$