EX/PG/MEC/T/113I/2025

Master of Mechanical Engg. Ist yr. Ist Semester Examination, 2025

Theory of Pressure Vessels

Time: Three Hours **Full Marks: 100**

Answer any five

All questions carry equal marks

1. Prove that, for a thick Spherical pressure vessel which is subjected to internal pressure p_i, $\sigma_r = \frac{p_i a^3}{b^3 - a^3}\left(1 - \frac{b^3}{r^3}\right)$ and $\sigma_t = \frac{p_i a^3}{b^3 - a^3}\left(1 + \frac{b^3}{2r^3}\right)$, where the terms have usual meaning.
2. (a) An industrial pressure vessel is to be designed based on various failure theories. Internal pressure = 150 MN/m^2 . Internal diameter : 800 mm. Yield point stress 450 MN/m^2. Calculate the wall thicknesses required according to Maximum normal stress theory, Maximum shear theory. Maximum strain theory, maximum strain energy theory.
   (b)Derive the expression of wall thickness as per maximum distortion energy theory & calculate the thickness with the help of data given in 2(a)
3. A cylinder of outer radius 'b' and inner radius 'a' is subjected to autofrettage where entire cylinder wall has been plastically penetrated. Derive the expression for the residual stress and explain graphically assuming b/a=2.
4. Prove the expression of tangential and radial stress in a thick cylinder subjected to internal pressure p_i.
   Draw the stress distribution diagram for external pressure p_o assuming radius ratio =2.2
5. A pipe made of C.I. [inner diameter 250 mm, 15 mm thick] is wound closely with a single layer of circular steel wire of 5 mm diameter, under a tension of 70 N/mm^2. Find the compressive stress in the pipe section. Also find the stresses set up in the pipe and steel wire, when water under a pressure of 3.5N/mm^2 is admitted into the pipe. Take Young's modulus E for cast iron (C.I.) is 10^5 N/mm^2 and E for steel is 2X10^5 N/mm^2. Poission's ratio is 0.3. Sketch different types supports of pressure vessel.
6. A pressure vessel is to be designed for a maximum operating pressure of 475 kN/m^2. Nomonal diameter of the pressure vessel is 1.2m , Length (tangent to tangent) = 2.4m. Allowable stress = 120 N/mm^2. Corrosion allowance = 2 mm. Assume class II standard pressure vessel, having weld joint efficiency = 85 %., (a) calculate standard plate thickness to fabricate the vessel (b) If a spherical pressure vessel having same diameter and same thickness for the same material, what will be the maximum internal pressure? Use ASME Equation of PV.

[Turn over

7. Design a cylindrical shell PV including head and check for different loadings, with the help of following data:
   Outer Diameter = 1,25 m, Allowable stress = 125 N/mm2, Internal pressure = 0.5 N/mm2, Joint efficiency = 0.85, C.A = 0 , Torque = 450 N-m, Weight of the vessel = 30 kN, Head = Torispherical

8. (a) Design the skirt thickness of a vessel for the following data:
   Outer diameter of vessel: 3.3 m
   Height of the vessel: 40 m
   Weight of the vessel: 2 x 10^6 N
   Diameter of the skirt : 3.3 m
   Height of the skirt : 5 m
   Wind pressure : 1400 N/mm^2
   Allowable tensile stress : 150 N/mm^2
   Allowable compressive stress : 75 N/mm^2
   Minimum thickness of the skirt = 20 mm.
   (b) Derive the expression for Bending Moment due to earthquake at a distance X from the top of a skirt is given by:
   $$M = C_s W X^2 \frac{(3H - X)}{3H^2},$$ W being weight of the vessel, C_s =Seismic coefficient, H = height of the vessel

9. Write short notes on:
   I) Autofrettage
   II) Industrial classification of PV
   III) Potential of Autofrettage
   IV) ASME equation of elliptical head
   V) Sphere is an ideal Pressure Vessel

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