Master of Mechanical Engg Examination, 2024

(Ist Semester)

Theory of Pressure Vessels

Time: Three Hours

Full Marks: 100

Answer any five questions

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. 20

2. (a) What do you mean by autofrettage?
(b) A cylinder of outer radius 'a' and inner radius b 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=2.2

4 +16

3. 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.

4. Prove that the thermal stress in a long hollow cylinder, when heated uniformly throughout its thickness is given by

$$\sigma_r = \frac{\alpha E}{(1-\mu)r^2}\left[\frac{r^2 - a^2}{b^2 - a^2}\int_a^b Trdr - \int_a^r Trdr\right]$$

$$\sigma_t = \frac{\alpha E}{(1-\mu)r^2}\left[\frac{r^2 + a^2}{b^2 - a^2}\int_a^b Trdr - \int_a^r Trdr - Tr^2\right]$$

Where 'T' represents temperature distribution and other terms have the usual meaning

5. Prove that thermal stress developed in a hollow cylindrical pressure vessel for logarithmic temperature distribution is given by: [r_e and r_i are inner and outer radius a = r_e/ r_i]

$$\sigma_t = \frac{E\alpha\Delta t}{2(1-\mu)}\left[\frac{a^2 + \left(\frac{r_e}{r}\right)^2}{a^2 - 1} - \frac{1 + \ln\left(\frac{r}{r_i}\right)}{\ln a}\right] \qquad \sigma_r = \frac{E\alpha\Delta t}{2(1-\mu)}\left[\frac{a^2 - \left(\frac{r_e}{r}\right)^2}{a^2 - 1} - \frac{\ln\left(\frac{r}{r_i}\right)}{\ln a}\right]$$

Draw the stress distribution for centrifugal heat flux and centripetal heat flux. Find the resultant stress distribution by superimposing the mechanical stress due to internal pressure p_i. 20

6. (a) Prove that, for a thick Cylindrical pressure vessel which is subjected to internal pressure p_i, $\sigma_r = \frac{p_i a^2}{b^2 - a^2}\left(1 - \frac{b}{r^2}\right)$ and $\sigma_t = \frac{p_i a^2}{b^2 - a^2}\left(1 + \frac{b}{r^2}\right)$,

(b) According to the maximum Distortion Energy Theory of failure, find the thickness of cylinder wall. 12+8

7. (a) Prove that shrink fit stresses developed in compound cylinder $P = \frac{E\partial}{b}\frac{\left(b^2 - a^2\right)\left(c^2 - b^2\right)}{\left(c^2 - a^2\right)2b^2}$ Where 'a' and 'b' are inner and outer radii of the cylinder, and 'c' is the outer radius of the jacketed cylinder.

(b) Write short notes (any two) :

I. Why sphere is an ideal pressure vessel?
II. Industrial classification of Pressure vessel
III. Why cracks are likely to appear at outer surface in furnace.
IV. Thermal stress in a rectangular body when three directions are restrained.