Master of Mechanical Engg, Ist Semester, Examination, 2017

(Ist Semester)

Theory of Pressure Vessel

Time: Three Hours Full Marks: 100

Answer any five questions

All questions carry equal marks

1. (a)What is 'autofrettage'? What are the different methods of autofrettaging a pressure vessel.
   (b) 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 65 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 3.9N/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. Poisson's ratio is 0.29. 5 +15
2. [redacted] A cylinder of outer radius 'a' and inner radius 'b' is subjected to autofrettage where entire cylinder wall has been plastically penetrated. Calculate amount of pressure required for autofrettaging the whole thickness of the cylinder. Further draw the plots to show the stress distribution after autofrettage and final residual stress distribution. Assume b/a = 2.0
3. 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.
4. Prove that the thermal stress in a long hollow cylinder, when heated uniformly throughout its thickness is given by

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

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

5. (a) Prove that the shrink-fit stresses in built up cylinders is given by:

   $P = \frac{E\partial}{b}\frac{(b^2 - a^2)(c^2 - b^2)}{(c^2 - a^2)2b^2}$ Where 'a' and 'b' are inner and outer radii of the cylinder,

   and 'c' is the outer radius of the jacketed cylinder.

(b)) According to the distortion energy theory of failure: $\sigma = \sqrt{\frac{1}{2}\left[(\sigma_1 - \sigma_2) + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2\right]}$, where $\sigma_1, \sigma_2, \sigma_3$ are the three principal stresses. Apply this theory to thick cylinder with closed ends and prove that the cylinder wall thickness (t) is given by: $t = a\left[\sqrt{\frac{\sigma}{\sigma - \sqrt{3}p_i}} - 1\right]$, p_i being the internal pressure and ' a' being the inner radius.

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

$$\sigma_t = \frac{E\alpha\Delta t}{(1-\mu)}\left[\frac{r_e}{(a-1)r} - \frac{2a}{a^2-1}\right] \text{ and } \sigma_r = 0$$

. Plot the variation of stress distribution both for centrifugal and centripetal heat flux. Also study the combined effect of mechanical stresses and thermal stresses for σ_t.

7. 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.

4 X 5 = 20

8. Write short notes: (any four)
   I. Potential of autofrettaged Pressure Vessel.
   II. Thermal stress in a rectangular body when three direction are resisted.
   III. Why cracks are likely to appear at outer surface in furnace.
   IV. The sphere is an ideal pressure vessel.
   V. Difference in Thermal stress and Mechanical stress