Problem 5.1: A cylindrical pipe of diameter 1.5m and the thickness1.5 cm is subjected to an internal fluid pressure of 1.2N/mm^2 Determine (i) Longitudinal stress developed in the pipe, and (II)circumferential stress developed in the pipe.

Given data:

Diameter of pipe $d=1.5$ m = 1.5×10^3 mm

Thickness $t=1.5$cm = 15 mm

Internal fluid pressure $p=1.2$ N/mm^2

To find:

Longitudinal stress $\sigma_2 = ?$

Circumferential stress $\sigma_1 = ?$

Solution:

As the ratio $\frac{t}{d} = \frac{1.5\times10-2}{1.5} = \frac{1}{100}$, which is less than $\frac{1}{20}$ hence this is a case of thin cylinder.

Here unit of pressure (p) in N/mm^2 Hence the unit of σ_1 and σ_2 will also be in N/mm^2

(i)The longitudinal stress(σ_2) is given by equation

$$\sigma_2 = \frac{pd}{4t} = \frac{1.2\times1.5\times10^3}{4\times15} = 30\ \text{N/mm}^2$$

(ii)The circumferential stress (σ_1) is given by equation

$$\sigma 1 = \frac{pd}{2t} = \frac{1.2\times1.5\times10^3}{2\times15} = 60\ \text{N/mm}^2$$

Result:

Longitudinal stress σ_2 = **30 N/mm^2**

Circumferential stress σ_1 = **60 N/mm^2**

Problem5.2: A cylinder of internal diameter 2.5m and of thickness 5 cm contains a gas. If the tensile stress in the material is not to exceed 80 N/mm^2 determine the internal pressure of the gas.

Given data:

Internal diameter of cylinder $d = 2.5$m = 2.5×10^3 mm

Thickness of the cylinder $t = 5$cm=50 mm

Maximum permissible stress =80 N/mm^2

To find:

Internal pressure of the gas p =?

Solution:

Maximum permissible stress is available in the circumferential stress (σ_1)

$\therefore$ circumferential stress (σ_1) $= \frac{pd}{2t}$

$$80 = \frac{p \times 2.5 \times 10^3}{2 \times 50}$$

$\gg$ $p = 3.2 N/mm^2$

Result:

Internal pressure of the gas p =**$3.2 N/mm^2$**

Problem 5.3: A cylinder of internal diameter 0.50 m contains air at a pressure of $7 N/mm^2$(gauge). If the maximum permissible stress induced in the material is $80 N/mm^2$, find the thickness of the cylinder.

Given data:

Internal dia of cylinder d=0.50m = 500 mm

Internal pressure of air, $p = 7\ N/mm^2$

Circumferential stress, $\sigma_1 = 80 N/mm^2$ ($\because$ maximum permissible stress)

To find:

Thickness of cylinder t =?

Solution:

Wkt Circumferential stress (σ_1) $= \frac{pd}{2t}$

$$80 = \frac{7 \times 500}{2 \times t}$$

$\gg$ $t = 21.88 mm$

If the value t is taken more than 21.875 mm(sat t=21.88 mm), the stress induced will be less than $80 N/mm^2$.

Hence take t=21.88 mm or say 22 mm

Result:

Thickness of cylinder t = **22 mm**

Problem 5.4: A thin cylinder of internal diameter 1.25m contains a fluid at an internal pressure of $2N/mm^2$. Determine the maximum thickness of the cylinder if (i) The longitudinal stress is not to exceed $30N/mm^2$ and (ii)The circumferential stress is not to exceed $45N/mm^2$

Given data:

Internal dia of cylinder, $d = 1.25\ m = 1.25\times10^3$ mm

Internal pressure of fluid, $p = 2N/mm^2$

Longitudinal stress $\sigma_2 = 30n/mm^2$

Circumferential stress, $\sigma_1 = 45N/mm^2$

To find:

Thickness of cylinder t =?

Solution:

Wkt Circumferential stress $(\sigma_1) = \frac{pd}{2t}$

$$45 = \frac{2 \times 1.25\times10^3}{2\times t}$$

$\gg$ $t = 27.7$ mm

Wkt, longitudinal stress $\sigma_2 = \frac{pd}{4t}$

$$30 = \frac{2 \times 1.25\times10^3}{4 \times t}$$

$\gg$ $t = 28.0$ mm

from the above two thickness value it is clear that t should not be less than 27.7mm. Hence take t=28. mm.

Result:

Thickness of cylinder t = 28 mm

Problem 5.5: A water main 80 cm diameter contains water at a pressure head of 100m. If the weight density of water is $9810N/m^3$, find the thickness of the metal required for the water main given the permission stress as $20N/mm^2$.

Given data:

Diameter of main, d=80 cm = 800 mm

Pressure head of water, $h=100\ m = 100 \times 10^3\ mm$

Weight density of water $\omega = \rho \times g = 1000 \times 9.81 = 9810\ N/m^3$

Permissible stress $= 20 N/mm^2$

To find:

Thickness of the metal $t = ?$

Solution:

Permissible stress is equal to circumferential stress($\sigma 1$)

Pressure of water inside the water main,

$$p = \rho \times g \times h = \omega.h = 9810 \times 100\ N/m^2$$

Here σ_1 is in N/mm^2 hence pressure (p) should be N/mm^2. The value of p in N/mm^2 is given as

$$P = 9810 \times 100/1000^2$$

$$= 0.981 N/mm^2$$

Wkt Circumferential stress $\sigma_1 = \frac{pd}{2t}$

$$20 = \frac{0.981 \times 800}{2 \times t}$$

$\gg$ $t = 20\ mm$

Result:

Thickness of the metal $t = 20\ mm$

5.6. EFFICIENCY OF A JOINT

The cylindrical shells such as boilers are having two types of joints namely longitudinal joint and circumferential joint. In case of a joint, holes are made in the material of the shell for the rivets. Due to the holes, the area offering resistance decreases. Due to the decreases in area, the stress developed in the material of the shell will be more.

Hence in case of riveted shell the circumferential and longitudinal stresses are greater than what are given by eqn. If the efficiency of a longitudinal joint and circumferential joint are given then the circumferential and longitudinal stresses are obtained as:

Let η_l = Efficiency of a longitudinal joint, and