Example

A cylinder has internal diameter of 1m and its walls are 1.5cm thick. This cylinder is 1.5m long. Find out change in volume if a fluid under 15 kg/cm² pressure is introduced into it. $E = 2 \times 10^6$ kg/cm²; poisson's ratio = 0.3.

Solution

Radius of cylinder $r = \frac{1}{2} m = 50\,cm$; wall thickness $t = 1.5\,cm$

Length of cylinder $L = 1.5\,m = 150\,cm$; fluid pressure $p = 15\,kg/cm^2$

Volume of cylinder $= \pi r^2 l$

$$= \pi \cdot 50^2 \cdot 150 = 11.781 \times 10^5\, cm^3$$

Volumetric strain $e_v = \frac{pr}{tE}\left(\frac{5}{2} - \frac{2}{m}\right)$

$$= \frac{15 \times 50}{1.5 \cdot 2 \times 10^6}\left(\frac{5}{2} - 2 \cdot 0{,}3\right)$$

$$= 0{,}475 \times 10^{-3}$$

$\therefore$ Change in Volume $\delta V = e_v \cdot V = 0{,}475 \times 10^{-3} \cdot 11{,}781 \times 10^5$

$$= \underline{559{,}6\ cm^3}$$

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Example

A thin cylindrical shell with the following dimensions has been filled with a liquid at atmospheric pressure: Length = 1.2 m, External diameter = 20 cm. Thickness of metal = 8 mm.

Assuming values of Modulus of elasticity and Poisson's ratio as 21×10^6 kg/cm^2 and 0.33 respectively, find the value of pressure exerted by the fluid on the wall of the cylinder and the hoop stress induced if an additional 25 cm^3 of the liquid is pumped into the cylinder.

Solution

Inner radius of shell $\quad r = \dfrac{20 - 2 \times 0{,}8}{2} = 9.2$ cm

Change in volume $\quad \delta V = 25 \text{ cm}^3$

Original volume of shell $\quad V = \pi r^2 \cdot l$

$$= \pi \cdot 9{,}2^2 \cdot 120 = 31908.5 \text{ cm}^3$$

Volumetric strain $\quad e_v = \dfrac{\delta V}{V} = \dfrac{25}{31908.5} = 0{,}0007834$

If e_h and e_l are the hoop strain and longitudinal strain resp., then we have:

$$e_v = \frac{pr}{tE}\left(\frac{5}{2} - \frac{2}{m}\right) = \frac{p \cdot 9.2}{0.8 \cdot 2{,}1 \times 10^6}\left(\frac{5}{2} - 2 \cdot 0{,}33\right) = 0{,}0007834$$

$\therefore$ Fluid pressure is $\quad \underline{p = 77{,}75 \text{ kg/cm}^2}$

Hoop stress $\quad p_h = \dfrac{pr}{t} = \dfrac{77{,}75 \cdot 9{,}2}{0.8} = \underline{894{,}125} \text{ kg/cm}^2$