Worked Example
2D Strain Analysis

A thin cylinder of internal diameter 300 mm is manufactured from 6 mm thick steel plate. The steel has a Young's modulus of 208 GN/m^2 and a Poisson's ratio of 0.28. The cylinder is subjected to an internal pressure 'p' and the 60° delta strain gauge rosette attached to the cylinder surface gave the strain readings as shown in Figure Ex.1. Determine:

(a) the principal strains in the cylinder wall;
(b) the longitudinal stress developed in the cylinder wall;
(c) the magnitude of the internal pressure.

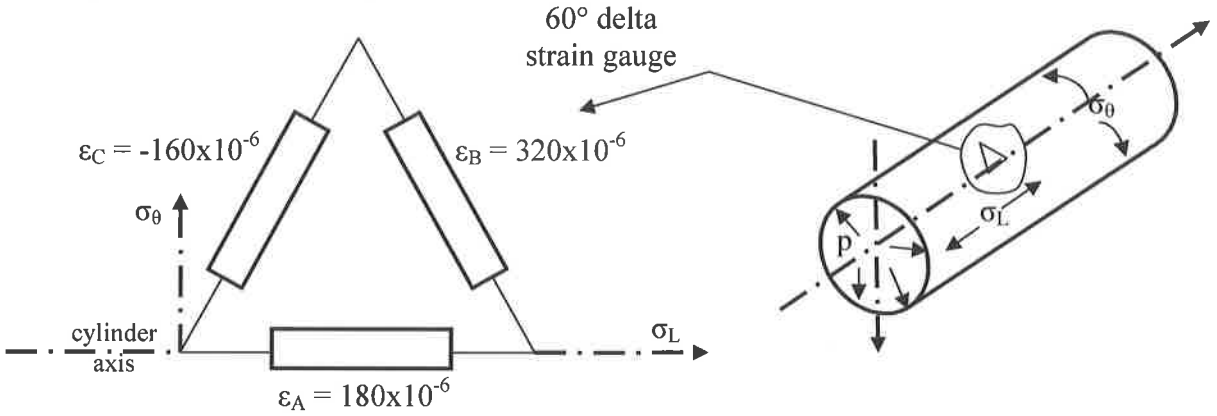
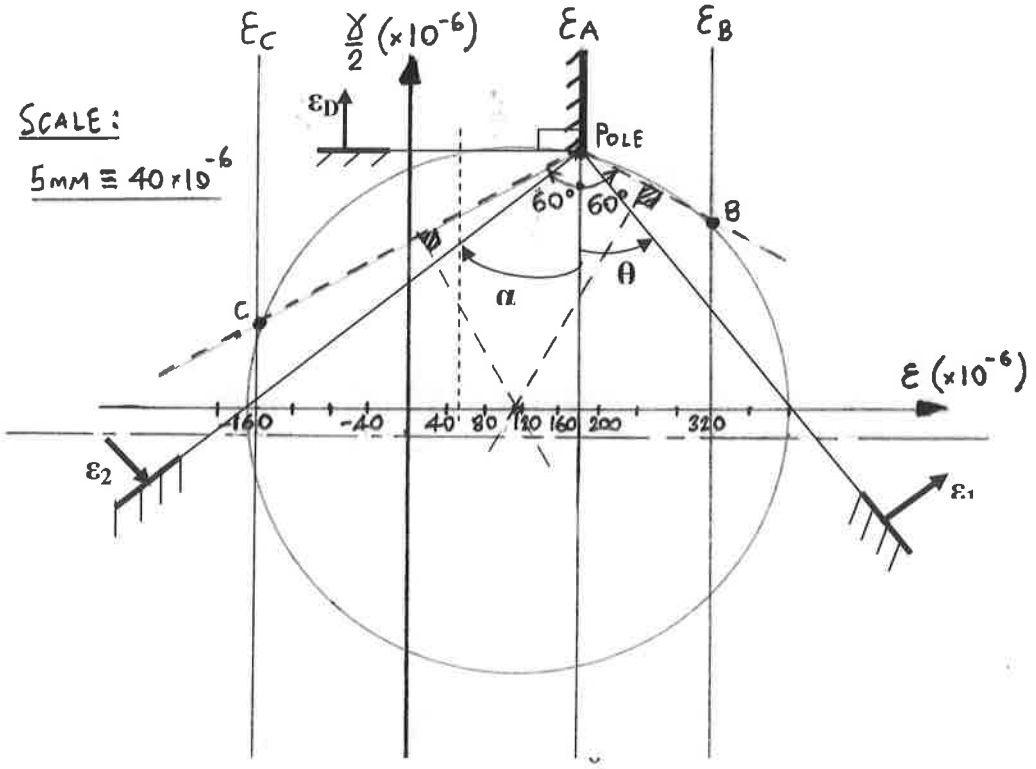


Figure Ex.1

Solution



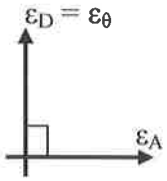
(a) Principal strains:

$\varepsilon_1 = 400 \times 10^{-6}$ at $\theta = 38°$ to gauge A

$\varepsilon_2 = -168 \times 10^{-6}$ at $\alpha = 52°$ to gauge A

(b) Longitudinal Stress:

From the Mohr Circle of Strain: $\varepsilon_D = \varepsilon_\theta = 56 \times 10^{-6}$ at 90° to gauge A (as shown)



Also, as given: $\varepsilon_A = 180 \times 10^{-6}$ (= ε_L)

$\therefore$ Longitudinal stress, $\sigma_L = \frac{E}{1-\nu^2}[\varepsilon_A + \nu\varepsilon_D]$ (= axial stress!)

$$= \frac{208x10^9}{1-0.28^2}\left[(180x10^{-6}) + 0.28(56x10^{-6})\right]$$

$$= \mathbf{44.16\ MN/m^2}$$

(c) Internal Pressure:

Longitudinal stress, $\sigma_L = \frac{pd}{4t}$

$\therefore$ $$p = \frac{\sigma_L x 4t}{d} = \frac{44.16x10^6 x4x0.006}{0.3} = \mathbf{3.53\ MN/m^2}$$