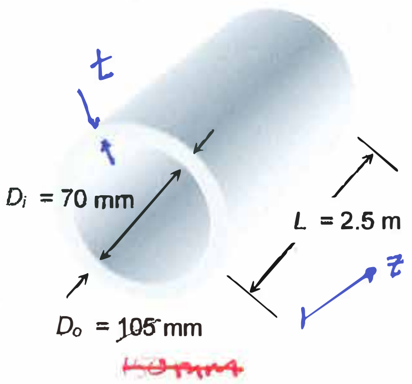
Example

A cast iron pipe has inside and outside diameters of 70 mm and ~~150~~ 105 mm, respectively. The length of the pipe is 2.5 m and the coefficient of thermal expansion is $\alpha = 12.1\times10^{-6}/°C$. For a 70°C increase in temperature, find the new pipe dimensions.



$$\varepsilon_{T,z} = \alpha \Delta T = \frac{\delta_L}{L}$$

$$= \frac{12.1\times10^{-6}}{°C}(70°C) = 0.000847$$

$$\Rightarrow \delta_L = \varepsilon_{T,z} \cdot L = (0.000847)(2.5m)$$

$$= 0.00212 \text{ m}$$

$$L_2 = L + \delta_L = \boxed{2.002 \text{ m}}$$

$$\varepsilon_{T,D_i} = \alpha \Delta T = \ldots = 0.00847$$

$$= \frac{\delta_{D_i}}{D_i}$$

$$\delta_{D_o} = \varepsilon_{T_i} D_o = 0.00847(105 \text{ mm}) = 0.0889 \text{ mm}$$

$$D_{i_o} = D_o + \delta_{D_o} = 150 + 0.0889 = \boxed{150.09 \text{ mm}}$$

$$\ldots \delta_{D_i} = \varepsilon_T D_i = 0.00847(70 \text{ mm}) = 0.0593 \text{ mm}$$

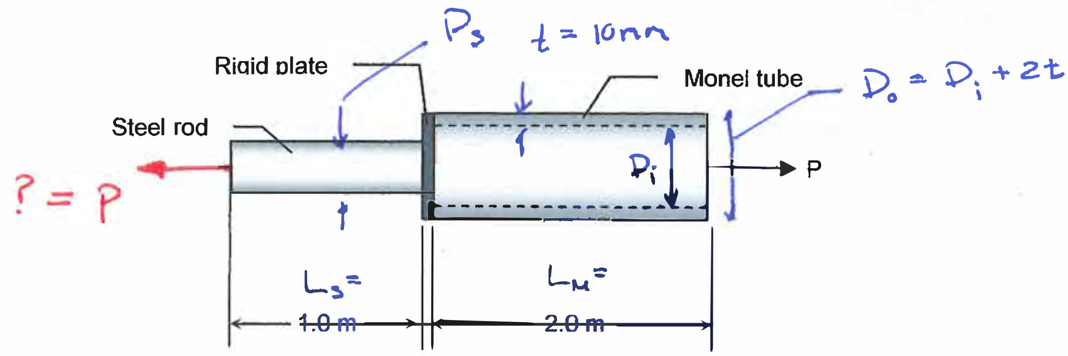
$$D_{i,2} = D_i + \delta_{D_i} = \boxed{70.06 \text{ mm}}$$

WOULD $\varepsilon_{T,t} = \frac{\delta_t}{t} = \alpha \Delta T$ WORK? YES!!

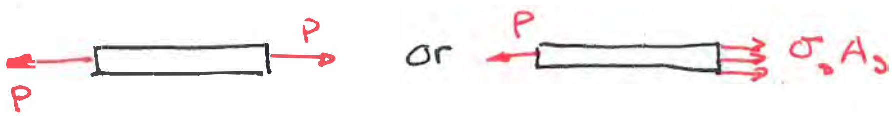
Example

A steel (E = 200 GPa) rod with diameter 30 mm and length 1.0 m is attached to a 2.0-m long Monel (E = 180 GPa) *tube* via a rigid plate. The Monel tube has internal diameter of 40 mm and a wall thickness of 10 ~~m~~. Determine the total axial load required to stretch the total assembly 3.00 mm.

10mm



F.B.D. STEEL



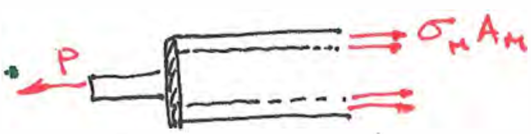
$$\sigma_s = \frac{P}{A_s}$$

HOOKE'S LAW

$$\sigma_s = E_s \varepsilon_s \qquad \frac{P}{A_s} = E \frac{\delta_s}{L_s} \qquad \delta_s = \frac{P L_s}{A_s E_s} \left(= \frac{P}{K} \right)$$

FORMULA SHOWS UP A LOT.

F.B.D. MONEL



$$\sigma_M = E_M \varepsilon_M$$

$$\frac{P}{A_M} = E \frac{\delta_M}{L_M} \qquad \delta_M = \frac{P L_M}{A_M E_M}$$

$$\delta = \delta_s + \delta_M = 0.003\,m = \frac{P L_s}{A_s E_s} + \frac{P L_M}{A_M E_M}$$

$$P = \frac{\delta}{\frac{L_s}{A_s E_s} + \frac{L_M}{A_M E_M}} = \frac{\delta}{\frac{L_s}{\frac{\pi D_s^2}{4} E_s} + \frac{L_M}{\frac{\pi (D_o^2 - D_i^2)}{4} E_M}}$$

$$= \frac{\delta}{\frac{L_s}{\frac{\pi D_s^2}{4} E_s} + \frac{L_M}{\frac{\pi}{4}\left[(D_i + 2t)^2 - D_i^2\right] E_M}} = \frac{0.003\,m}{\frac{1.0m}{\frac{\pi}{4}(0.030)^2 m^2 \cdot 200\times10^9 \frac{N}{m^2}} + \ldots}$$

...

$= 2.12 \times 10^5$ N