EXAMPLE 3.4 A strip of lead with initial dimensions 24 mm × 24 mm × 150 mm is forged between two flat dies to a final size of 6 mm × 96 mm × 150 mm. If the coefficient of friction between the job and the dies is 0.25, determine the maximum forging force. The average yield stress of lead in tension is 7 N/mm^2.

Given

$\sigma_y = 7\ N/mm^2$, $M = 0.25$, $2l = 96\ mm$, $h = 6\ mm$

$l = 48\ mm$

l_s (strip) = 150

$[24 \times 24 \times 150 \quad 6 \times 96 \times 150]$

$h \quad 2l \quad l_s$

$$\rightarrow K = \frac{\sigma_y}{\sqrt{3}} = \frac{7}{\sqrt{3}} = 4.04\ N/mm^2$$

$$x_s = \frac{h}{2M} \ln\left(\frac{1}{2M}\right) = \frac{6}{2 \times 0.25} \ln\left(\frac{1}{2 \times 0.25}\right) = 8.31\ mm$$

$$\therefore P_1 = 2Ke^{\frac{2M}{h}x} = 2 \times 4.04\, e^{0.083x} = 8.08\, e^{0.083x}\ N/mm^2 \quad [0 \le x \le 8.31]$$

$$\therefore P_2 = 2K\left[\frac{1}{2M}\left\{1 - \ln\left(\frac{1}{2M}\right)\right\} + \frac{x}{h}\right]$$

$$= 8.08[0.614 + 0.167x] = 4.961 + 1.349x\ N/mm^2 \quad [8.31 \le x \le 48]$$

l

Forging Force per unit length $= 2\left[\int_0^{8.31} 8.08\, e^{0.083x}\, dx + \int_{8.31}^{48} (4.961 + 1.349x)\, dx\right]\ N/mm$

$= 3602.5\ N/mm$

Total forging force $= l_s \times 3602.5 = 0.54 \times 10^6\ N$