EXAMPLE 3.1 **A strip with a cross-section of 150 mm × 6 mm is being rolled with 20% reduction of area, using 400-mm-diameter steel rolls. Before and after rolling, the shear yield stress of the material is 0.35 kN/mm^2 and 0.4 kN/mm^2, respectively. Calculate (i) the final strip thickness, (ii) the average shear yield stress during the process, (iii) the angle subtended by the deformation zone at the roll centre, and (iv) the location of the neutral point θ_n. Assume the coefficient of friction to be 0.1.**

SOLUTION (i) As no widening is considered during rolling, 20% reduction in the area implies a longitudinal strain of 0.2 with consequent 20% reduction in the thickness. Therefore, the final strip thickness is given as

$$t_f = 0.8t_i = 0.8 \times 6 \text{ mm} = 4.8 \text{ mm}.$$

(ii) The average shear yield stress during the process is taken to be the arithmetic mean of the initial and the final values of the yield stress. So,

$$K = (K_i + K_f)/2 = \frac{0.75}{2} \text{ kN/mm}^2 = 0.375 \text{ kN/mm}^2.$$

(iii) From Fig. 3.8a, it is clear that

$$\theta_i = \sqrt{\frac{t_i - t_f}{R}}.$$

Substituting the values, we get

$$\theta_i = \sqrt{\frac{6 - 4.8}{200}} \text{ rad} = 0.0775 \text{ rad}.$$

$$\lambda_i = \left(2\sqrt{\frac{R}{t_f}} \tan^{-1}\left(\sqrt{\frac{R}{t_f}}\, \theta_i\right)\right.$$

$$\lambda_i = 2\sqrt{\frac{200}{4.8}} \tan^{-1}\left(\sqrt{\frac{250}{4.8}} \times 0.0775\right)$$

$$\lambda_i = 5.99$$

$$\lambda_n = \frac{1}{2}\left[\frac{1}{\lambda_i} \ln\left(\frac{t_f}{t_i}\right) + \lambda_i\right]$$

$$= 1.88$$

Now

$$\lambda_n = 2\sqrt{\frac{R}{t_f}} \tan^{-1}\left(\sqrt{\frac{R}{t_f}} \times \theta_n\right)$$

$$\Rightarrow \frac{\lambda_n}{2} \times \sqrt{\frac{t_f}{R}} = \tan^{-1}\left(\sqrt{\frac{R}{t_f}} \times \theta_n\right)$$

$$\Rightarrow \theta_n = \sqrt{\frac{t_f}{R}} \tan\left(\frac{\lambda_n}{2}\sqrt{\frac{t_f}{R}}\right)$$

$$= 0.023 \text{ rad.}$$