For sheet steel, take $\varepsilon \approx 0.00015$ ft, hence $\varepsilon/D_h \approx 0.000346$. Now relate everything to the input power:

$$\text{Power} = 1\text{ hp} = 550\ \frac{\text{ft}\cdot\text{lbf}}{\text{s}} = \rho g Q h_f = (0.00234)(32.2)Q[54.4fQ^2],$$

$$\text{or:}\quad fQ^3 \approx 134 \quad \text{with Q in ft}^3\text{/s}$$

$$\text{Guess}\quad f \approx 0.02,\quad Q = (134/0.02)^{1/3} \approx 18.9\ \frac{\text{ft}^3}{\text{s}},\quad \text{Re} = \frac{\rho(Q/A)D_h}{\mu} \approx 209000$$

Iterate: $f_{better} \approx 0.0179$, $Q_{better} \approx 19.6$ ft^3/s, $Re_{better} \approx 216500$. The process converges to

$$f \approx 0.01784,\ V \approx 80.4\text{ ft/s},\ \mathbf{Q \approx 19.6\ ft^3/s}. \quad \textit{Ans.}$$

6.91 Heat exchangers often consist of many triangular passages. Typical is Fig. P6.91, with L = 60 cm and an isosceles-triangle cross section of side length a = 2 cm and included angle β = 80°. If the average velocity is V = 2 m/s and the fluid is SAE 10 oil at 20°C, estimate the pressure drop.

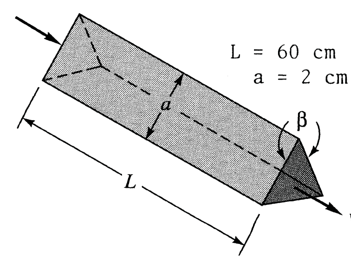

Fig. P6.91

Solution: For SAE 10 oil, take ρ = 870 kg/m^3 and μ = 0.104 kg/m·s. The Reynolds number based on side length a is Re = $\rho Va/\mu$ ≈ **335**, so the flow is *laminar*. The bottom side of the triangle is 2(2 cm)sin40° ≈ *2.57* cm. Calculate hydraulic diameter:

$$A = \frac{1}{2}(2.57)(2\cos 40°) \approx 1.97\text{ cm}^2;\quad P = 6.57\text{ cm};\quad D_h = \frac{4A}{P} \approx 1.20\text{ cm}$$

$$\text{Re}_{D_h} = \frac{\rho V D_h}{\mu} = \frac{870(2.0)(0.0120)}{0.104} \approx 201;\quad \text{from Table 6.4, } \theta = 40°,\quad f\text{Re} \approx 52.9$$

$$\text{Then}\quad f = \frac{52.9}{201} \approx 0.263,\quad \Delta p = f\frac{L}{D_h}\frac{\rho}{2}V^2 = (0.263)\left(\frac{0.6}{0.012}\right)\left(\frac{870}{2}\right)(2)^2$$

$$\approx \mathbf{23000\ Pa} \quad \textit{Ans.}$$
