8.5 *Two long pipes convey water between two reservoirs whose water surfaces are at different elevations. (pipe has a diameter twice that of the other; both pipes have the same length and the same value of f . minor losses are neglected, what is the ratio of the flow rates through the two pipes?*

N

Eq. 8.13: $\Delta\text{elev} = h_f = f(L/D)V^2/(2g)$ where $V = Q/A = Q/(\pi D^2/4)$

$\therefore \quad h_f = f(L/D)[Q/(\pi D^2/4)]^2/2g = fL4^2Q^2/(2gD\pi^2D^4)$

Thus $h_f \propto Q^2/D^5$; $(h_L)_1 = (h_L)_2$; $\therefore$ $Q_1^2/D_1^5 = Q_2^2/D_2^5$ and $Q_2/Q_1 = (D_2/D_1)^{5/2} = 2^{5/2} = 5.66$

The flow in the larger pipe will be 5.66 times that in the smaller pipe. ◄

8.6 *Tests were made with 60°F water flowing in a 9-in-diameter pipe. They showed that, when V = 12 fps, = 0.0165. Find the unit shear at the pipe wall and at radii of 0, 0.25, 0.4, 0.6, 0.85 times the pipe radius.*

BG

Table A.1 for water at 60°F: $\rho = 1.938$ slugs/ft^3

(*a*) Eq. 8.19: $\tau_0 = (0.0165/4)1.938(12^2/2) = 0.576$ psf, at wall ◄

(*b*) Stress distribution is linear (Eq. 8.18):

r/r_0	τ (psf)
0	0
0.25	0.1439
0.4	0.230
0.6	0.345
0.85	0.489

▲

Sec. 8.6: Friction in Noncircular Conduits – *Exercises (2)*

8.12 *For laminar flow between two parallel, flat plates a small distance d apart, at what distance from the centerline (in terms of d) will the velocity be equal to the mean velocity?*

N

Let y_m = distance from centerline where $u = V_{mean}$. From solution to Exer. 8.7.3, $V_{mean} = (2/3)V_c$.

So when $y = y_m$, $u = (2/3)V_c$, i.e. $(2/3)V_c = V_c(1 - y_m^2/y_0^2)$; $y_m^2 = (1/3)y_0^2 = (1/3)(d/2)^2$;

$y_m = 0.289d$ ◄

8.16. In a 36-in-diameter pipe velocities are measured as 18.5 fps at $r=0$ and 18.0 fps at $r=4.0$ in. Approximately what is the flow rate? Assume laminar flow.

SOLUTION

For laminar flow, $u = V_c\left(1-\left(\frac{r}{r_0}\right)^2\right)$

with $r_0 = 36$ in, and $u = 18.5$ fps at $r=0$ Ⓐ

$u = 18.0$ fps at $r = 4.0$ in Ⓑ

Ⓐ $\Rightarrow$ $18.5 \text{ fps} = V_c\left[1-\left(\frac{0}{36}\right)^2\right] \Rightarrow 18.5 \text{ fps} = V_c$

Also, for laminar flow $\frac{V}{V_c} = 0.5 \Rightarrow V = 0.5 \times 18.5 = 9.25$ fps

$$Q = \pi r_0^2 V = \pi \times \left(\frac{36}{12} \text{ ft}\right]^2 \times 9.25 \text{ fps} = 261.54 \text{ cfs}.$$

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