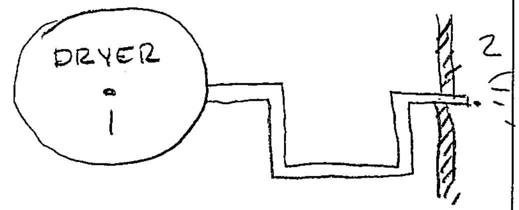
EXAMPLE 8.8 / 307

GIVEN: AIR @ 100° F AND STD. PRESSURE LEAVES CLOTHES DRYER THRU 4" DIA. GALVANIZED PIPE W/ NO MORE THAN 20' OF PIPE AND 4 - 90° ELBOWS. PRESSURE IN DRYER IS 0.20" WATER



FIND: AIR FLOWRATE

SOLUTION:

TYPE II PROBLEM: FIND $V = \phi(f)$

$\mathbb{R}e = \phi(V)$

guess f in wholly turbulent zone

find V, $\mathbb{R}e$, new f

$$z_1 + \frac{P_1}{\gamma} + \frac{V_1^2}{2g} = z_2 + \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + h_L$$

IGNORE ELEVATION DIFFERENCES; $\frac{P_2}{\gamma} = 0$, ASSUME $V_1 = 0$

$$\Rightarrow \frac{P_1}{\gamma} = \frac{V_2^2}{2g} + h_f + \left(\Sigma K_L\right)\left(\frac{V_2^2}{2g}\right)$$

$$\frac{P_1}{\gamma} = \frac{V_2^2}{2g}\left(1 + f\frac{L}{D} + \Sigma K_L\right) \qquad (1)$$

$$\frac{P_1}{\gamma_w} = 0.2 \text{ in} \times \frac{1 \text{ ft}}{12 \text{ in}} = 0.0167 \text{ ft water}$$

$\gamma_w = 62.4 \text{ lb/ft}^3$ (TABLE 1.4)

$$\Rightarrow P_1 = (0.0167 \text{ ft})(62.4 \text{ lb/ft}^3) = 1.04 \frac{\text{lb}}{\text{ft}^2}$$

$\nu_{air} = 1.79 \cdot 10^{-4} \text{ ft}^2/\text{s}$

$\gamma_{air} = 7.09 \cdot 10^{-2} \text{ lb/ft}^3$

} Table B.3

$$\frac{P_1}{\gamma_{air}} = \frac{1.04 \text{ lb/ft}^2}{7.09 \cdot 10^{-2} \text{ lb/ft}^3} = 14.67 \text{ ft air}$$

$$\frac{L}{D} = \frac{20\,ft}{4\,in \times \frac{1\,ft}{12\,in}} = 60$$

LOSSES: $K_{entrance}$ assume 0.5 Fig. 8.11
K_{elbow} assume threaded = 1.5 Table 8.2

$$\Sigma K_L = 0.5 + 4(1.5) = 6.5$$

from (1), solve for V:

$$V = \left[\frac{\frac{P_1}{\gamma_{air}} \times 2g}{1 + f\frac{L}{D} + \Sigma K_L}\right]^{1/2} = \left[\frac{14.67\,ft \times 64.4\,ft/s^2}{1 + f(60) + 6.5}\right]^{1/2}$$

$$V = \left[\frac{945}{7.5 + 60f}\right]^{1/2} \quad (2)$$

$$Re = \frac{VD}{\nu} = \frac{V\left(4\,in \times \frac{1\,ft}{12\,in}\right)}{1.79 \cdot 10^{-4}\,ft^2/s} = 1862V \quad (3)$$

solution - assume completely turbulent flow.

ε = 0.0005 ft (Table 8.1)

$$\frac{\varepsilon}{D} = \frac{0.0005\,ft}{4\,in \times \frac{1\,ft}{12\,in}} = 0.0015 \Rightarrow f_1 = 0.0215$$

Table:

f	eqn (2) V ft/s	eqn (3) Re	new f
0.0215	10.4	$1.9 \cdot 10^4$	0.029
0.029	10.1	$1.9 \cdot 10^4$	0.029 done!

$$A_{pipe} = \frac{\pi}{4}\left(4\,in \times \frac{1\,ft}{12\,in}\right)^2 = 0.087\,ft^2$$

$$Q = V \cdot A = \left(10.1\,\frac{ft}{s}\right)\left(0.087\,ft^2\right) = 0.88\,ft^3/s \text{ air}$$

8.57/359 Type III

GIVEN: $Q = 2000$ gal/min. gasoline
$\Delta p = 5$ psi / 100 ft
$\Delta z = 0$
steel pipe, commercial

FIND: Diameter

SOLUTION:

$$2000 \frac{gal}{min} \times \frac{1 min}{60 s} \times \frac{1 ft^3}{7.48 gal} = 4.46 \text{ cfs}$$

$\varepsilon = 0.00015$ ft (TABLE 8.1, p. 324
$\rho = 1.32$ slugs/ft^3
$\nu = 4.9 \cdot 10^{-6}$ ft^2/s } TABLE 1.4
$\gamma = 42.5$ lb/ft^3

$$\cancel{z_1} + \frac{p_1}{\gamma} + \cancel{\frac{V_1^2}{2g}} = \cancel{z_2} + \frac{p_2}{\gamma} + \cancel{\frac{V_2^2}{2g}} + f\frac{L}{D}\frac{V^2}{2g}$$

$$p_1 - p_2 = \gamma f \frac{L}{D}\frac{V^2}{2g} \Rightarrow f = \frac{(p_1 - p_2)2gD}{\gamma L V^2}$$

(1) $V = \frac{Q}{A} = \frac{4.46 ft^3/s}{\pi D^2/4} = 5.68/D^2$

(2) $Re = VD/\nu = (5.68/D^2)(D)/4.9 \cdot 10^{-6} ft/s^2 = 1.16 \cdot 10^6/D$

$$f = \frac{\left(5 \frac{lb}{in^2} \times \frac{144 in^2}{ft^2}\right)(2)(32.2 ft/s^2) D}{42.5 \, lb/ft^3 \, (100 ft)(5.68/D^2)^2} = 0.338 D^5 \text{ or}$$

(3) $D = (2.96 f)^{1/5} = 1.24 f^{1/5}$

f	D, ft	ε/D	Re	f
0.02	0.57	0.00026	$2 \cdot 10^6$	0.0145
0.0148	0.54	0.00028	$2.1 \cdot 10^6$	0.015
0.015	0.535	"	$2.2 \cdot 10^6$	0.015