Chapter 10

Objective: Estimating losses from pipe fittings, valves, and size changes

Miami University

1

Examples of Minor Losses

1. Fully or partially-open valves
2. Pipe entrance & exit losses
3. Sudden or gradual pipe size changes
4. Pipe elbows, tees, bends

2

Relative Importance

1. Typically "minor" compared to losses from pipe itself
2. Significant if pipe is short and/or "loaded" with these items like in a pilot plant

3

When Quite Important

1. Partially-open valve to restrict flow
2. Even some fully-open valves (like gate, needle)

4

Why These Additional Losses

1. "Additional" above the losses from adding length to the pipe
2. Interrupt the velocity profile and streamlines
3. Change direction of flow, induce flow separation and mixing

5

Estimating with K Values

$$\frac{\text{losses}}{\text{unit weight}} = \left(\sum_{\text{fittings \& valves}} K\right)\frac{V_{ave}^{2}}{2g}$$

- K's, resistance coefficients, are tabulated in text, <u>Cameron Hydraulic Data Book</u>, <u>Crane Flow of Fluids Technical Paper No. 410</u>, etc.

6

More on K Values

- Equation implies K is a constant
- In fact, K is f (Re, precise geometry, surface roughness, mfg).
- However, in fully turbulent flow, approx constant with Re

7

Example - Exiting Pipe into Large Tank

What Happens:

- Continuity says velocity drops because flow area increases
- Bernoulli says pressure rises when velocity drops
- Is an additional loss for the pipe, but not an additional loss if we wrote Bernoulli to liquid surface

8

Example - Exiting Pipe into Large Tank

Estimating Loss:

- Lose entire velocity head
- At 5 ft/ s, loss = $v_{ave}^2/2g$ = 0.38 ft or (loss) (144γ) = 0.16 psi
- At 20 ft / s, loss = 6.2 ft = 2.7 psi

9

Text Example10.1 – Going to Larger Pipe

What happens:

- Continuity says velocity drops because flow area increases
- Bernoulli says pressure rises when velocity drops – this is the purpose of a device called a diffuser
- The pressure rise is reduced by the losses that also occur

10

How to Estimate Head Loss of Example 10.1

- K values in Table 10.1 compare D_2/D_1 and v_{ave1}
- Determine v_{ave1} = 3.32 m / s from

$$\dot{V}_1 = v_{ave1} A_1$$

11

Answer for Example 10.1

K = 0.7 for D_2/D_1 = 73.8mm / 25.3 mm = 2.9 and

$$h_L = K \frac{v_{ave1}^2}{2g} = 0.4\text{m}$$

12

Estimating Pressure Drop Of Example 10.1

- Use Bernoulli and continuity to estimate pressure change $P_1 - P_2$
- Do in class with and without calculated loss to see impact of loss: loss reduces the expected increase

13

Example of Going to Smaller Pipe – Slide 1

What Happens:

- Continuity says velocity increases
- Bernoulli says pressure drops
- Losses increase the amount of pressure drop
- Observe a vena contracta, a cross sectional flow area even smaller than that of the smaller pipe

14

Example of Going to Smaller Pipe – Slide 2

- How to Estimate Head Loss:

  $K = f(D_1/D_2, v_{ave2},$ how gradual) as shown in Table 10.7
- How to Estimate Pressure Drop:
  - Use Bernoulli and continuity to estimate pressure change $P_1 - P_2$
  - Include in equation the estimated head loss

15

Practice Problem 10.4 E in Practice Problems

- Have sudden enlargement from 2 " ID to 6" ID tube, $v_{ave1} = 4$ ft / s
- What's pressure drop? (assume horizontal)

16

Estimating with Equivalent Length

$$\frac{\text{losses}}{\text{unit weight}} = f_t \left(\sum_{\text{fittings\&valves}} \frac{L_e}{D} \right) \frac{V_{ave}^2}{2g}$$

- Where f_t is the fully turbulent friction factor (see Moody diagram)
- Where L_e = equiv. length of pipe
- Where L_e/D = equiv. diameters of pipe

17

Data Sources for Equivalent Lengths

- Frictional losses are proportional to how constricted the flow pattern is in going through the valve or fitting.
- See Table 10.4 or Cameron, Crane & turbulent friction factor (see Moody diagram)
- Text has Table 10.5 for f_t

18

Example Problem 10.8

- What is the head loss of fully open globe valve in 4 in. Schedule 40 steel pipe with 400 gpm of 0.87 s.g oil?

$$h_L = f_t \frac{L_e}{D} \frac{v_{ave}^2}{2g}$$

19

Example Problem 10.8 Continued

- where f_t.= 0.017 from Table 10.5
- where L_e/D = 340 (Table 10.4) so L_e = (340)(0.3355 ft dia) = 114 ft
- where A = 0.0884 ft^2 (Table F.1)
- where V_{ave} = Do in class

20

Example Problem 10.8 Concluded

- Where $h_{L} =$ Do in class
- Where $P_1 - P_2$ in psi = Do in class
- Where equivalent K value = Do in class

21

Homework – Chapter10

- 10.17 (Also compute length of 4 in pipe equiv. to this loss)
- 10.28
- 10.38 (treat as two 90 deg long radius elbows, compute only the psi drop)

22