CE 3105 - Mechanics of Fluids Laboratory

Experiment 5: Minor Losses in a Pipe Network

bit.ly/CE3105MinorLoss

1 Objectives

- To understand and calculate the losses in pipe networks due to bends, changes in diameter, junctions and valves.
- To evaluate characteristics of flow in different pipe fittings and determine minor loss coefficients.

2 Theory

Large pipe networks usually have various, e.g., : mitre bend, elbow bend, large radius bend, sudden expansion and sudden contraction. There will be losses due to these settings which is known as minor loss and it causes pressure losses. Pressure loss across a fitting is the difference between the manometer readings at the upstream and downstream of that fitting.

When fluid is flowing through a 90^0 bend, depending on the ratio of radius of curvature to diameter of the pipe (R/D), amount of loss differs. Lesser loss is associated with easier flow path and lower the minor loss coefficient, K value is. Following table summarizes the typical K values for different bends:

Theoretical K Values		
Mitre	Elbow	Large Radius
1.4 to 1.6	1.1 to 1.4	0.20 to 0.80

In a sudden contraction, the flow splits when it is entering to the bigger diameter pipe from the smaller diameter pipe. Head is lost due to the diffusion and eddies in the corners. In sudden contraction, flow area is contracted which is known as vena contracta because of the jet formation. Head loss is occurred due to vortices and eddies. Figure 1 illustrates loss at a pipe fitting:

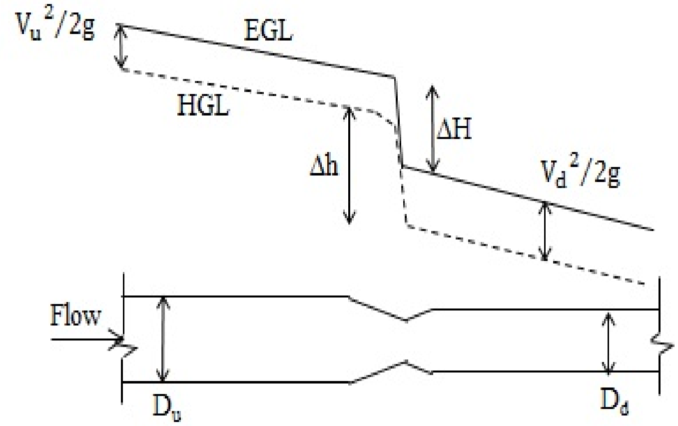

Figure 1: Loss at a Pipe Fitting

For the fitting above, the total head loss:

$$\Delta H = \Delta h + \frac{V_u^2}{2g} - \frac{V_d^2}{2g} \tag{1}$$

Loss coefficient K is defined as

$$K = \frac{\Delta H}{V_d^2/2g}$$

or,

$$K = \frac{\Delta H}{V_u^2/2g} \tag{2}$$

In this experiment, the mitre and elbow have constant pipe diameters. Therefore, V_u and V_d become same. For the sudden enlargement, the upstream velocity represents the velocity head. For the sudden contraction, the downstream velocity characterizes the velocity head.

2.1 Equations

Mitre and Elbow and Bend:

$$K = \frac{\Delta h}{V_1^2/2g} \tag{3}$$

Sudden Enlargement:

$$\Delta H = \Delta h + \frac{V_1^2}{2g} - \frac{V_2^2}{2g} \tag{4}$$

$$K = [1 - \frac{A_u}{A_d}]^2$$

or,

$$K = \frac{\Delta H}{V_1^2/2g} \tag{5}$$

The value of K for sudden expansion varies from 0 to 1.00.

Sudden Contraction:

$$\Delta H = \Delta h + \frac{V_2^2}{2g} - \frac{V_1^2}{2g} \tag{6}$$

$$K = [\frac{A_d}{A_c} - 1]^2$$

or,

$$K = \frac{\Delta H}{V_2^2/2g} \tag{7}$$

The value of K for sudden contraction varies from 0 to 0.44.

Figure 2 shows the arrangement of the fittings in greater detail:

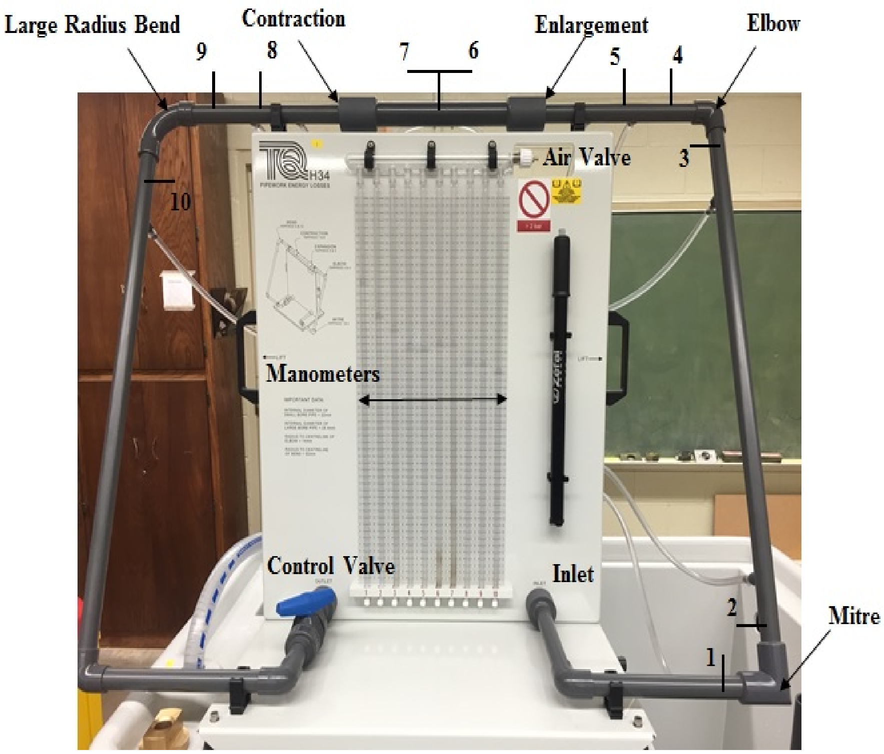

Figure 2: Arrangement of the Fittings

3 Variables/Units

Variables	Description (Units)
K	Loss coefficient
Δh	Measured head loss between two points (ft)
V_1, V_2	Velocity (in smaller and larger bore pipe) (ft/s)
V_u, V_d	Velocity (at u/s and d/s) (ft/s)
A_u, A_d	Cross-sectional area (at u/s and d/s) (ft/s)
g	Gravity (ft/s^2)
ΔH	Total head loss (ft)
A_c	Cross-sectional area at vena contracta (ft^2)
D_1	Smaller Bore Diameter (0.072 ft)
D_2	Larger Bore Diameter (0.093 ft)

4 Procedure

1. Close the exit valve on the left side of the flow circuit, and then turn on the water source
2. Slowly open the exit valve on the apparatus, and watch the water levels in the manometer tubes
3. Determine the flow rate of the liquid by measuring the time it takes to fill a known volume.
4. Record the differential pressure readings across each of the fittings
5. Repeat step 3 and 4 to obtain data for at least five different flow rates by adjusting the exit valve

5 Calculations

1. For the mitre, elbow and bend, plot the measured head loss (y- axis) vs. the velocity head for the smaller bore pipes (x- axis) on the same plot
2. For the sudden expansion and contraction, plot the total head loss (y-axis) vs. the velocity head for the smaller bore pipes (x- axis) on the same plot
3. Add a best fit line through the data points and determine the "slope" of the line, which is the empirical value of the loss coefficient. Remember to ignore any excess scatter at the lower and higher flow rates for the expansion and contraction

6 Interpretation Questions (for Report)

1. Explain the calculated loss coefficient values for different fittings. How do they differ?

2. Compare the calculated loss coefficient values with the theoretical values. How do they differ?

3. Which fitting is best to design a pipe system?

4. Describe the characteristics of flow through bends where loss coefficient, K is a function of the geometric ratio R/D

CE3105 Mechanics of Fluids Laboratory
Department of Civil Engineering
Texas Tech University

Experiment: Pipework Energy Losses - Data Sheet
Date of Experiment: .... ,Name:...................
Experimental Data:
Temperature of water, T= celsius
Water density, $\rho =$ (lb/ft^3)
Gravity, g= 32.2 (ft/s^2)

Volume of Water	Time	Flow Rate	Tube Height									
			1	2	3	4	5	6	7	8	9	10

Instructor's Signature

For Calculations:

Flow Rate (ft^3/s)	V_1 (ft/s)	$V_1^2/2g$ (ft)	V_2 (ft/s)	$V_2^2/2g$ (ft)	Measured Head Loss Δh (ft)					Total Head Loss ΔH (ft)	
					Mitre 1 - 2	Elbow 3 - 4	Enlargement 5 - 6	Contraction 7 - 8	Bend 9 - 10	Enlargement	Contraction