LAB 8 – ENERGY LOSSES IN BENDS AND FITTINGS

LEARNING OUTCOMES

1. Demonstrate the minor energy losses due to different types of pipe fittings
2. Compute the minor loss coefficient for different types of bends and fittings

In this experiment, we will use the Energy losses in bends and fittings apparatus (shown in Figure 1) connected to the Armfield Hydraulic Bench to measure the head loss across different types of pipe fittings such as the bends, expansion and contractions. a variable area meter and an orifice plate. These pipe fittings are installed in a series configuration.

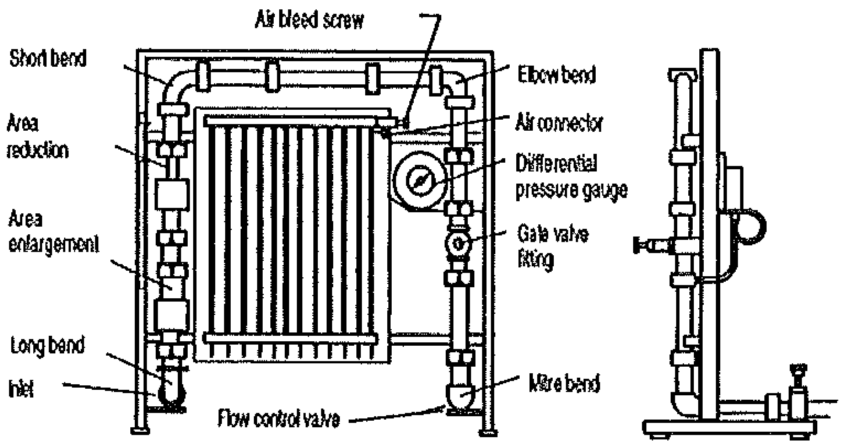

Figure 1. Schematic diagram of the energy losses apparatus

EXPERIMENTAL PROCEDURE

1. Ensure that the equipment is horizontal and start the pump
2. At a fixed flow rate, record all manometer heights and the variable area meter reading
3. Measure the flow rate using a stopwatch and collecting the water in a volumetric tank
4. Repeat the process for four different flowrates
5. Switch off the pump and close the main valve.

THEORY AND DATA ANALYSIS

The following fittings are connected in series configuration: long bend, area enlargement, area contraction, short bend, elbow bend, valve fitting and mitre bend.

Bends

Water traveling through a bend experiences centrifugal effect which varies depending on its specific distance from the center of curvature. This unbalanced condition creates secondary flow, a double spiral flow that continues for some distance after the bend. This secondary flow accounts for the energy losses in bends. The head loss (h_b) produced by a bend can be represented by the following equation

$$h_b = K_b \frac{V^2}{2g} \tag{1}$$

Where K_b is the loss coefficient of the bend, V is the velocity and g is the gravitational constant.

Sudden Expansions and Contractions

Sudden expansions and contractions are encountered in pipe networks. These sudden changes in pipe diameter are also sources of energy losses. This loss is due to the turbulence that is produced after the expansion or contraction is encountered. The losses due to expansions are generally greater than the losses caused by a contraction. The head loss (h_c) due to a sudden contraction can be described by the following equation:

$$h_c = K_c \frac{V_2^2}{2g} \tag{2}$$

Where K_c is the loss coefficient, and V_2 is the velocity after the contraction. The head loss due to a sudden expansion (h_x) can be expressed as:

$$h_x = \frac{(V_1 - V_2)^2}{2g} \tag{3}$$

Where h_x is the head loss due to sudden expansion, V_1 is the velocity of the water before the expansion and V_2 is the velocity of the water after the expansion.

Friction Factor

The friction factor (f) for pipe depends on the type of flow regime, which can be determined by the Reynolds number (Re). The Reynolds number is given by

$$\mathrm{Re} = \frac{\rho V D}{\mu} \tag{4}$$

Where ρ is the density of water, V is the velocity of the water, D is the diameter of the pipe and μ is the viscosity of the fluid. For laminar flow (Re <2000), the friction factor can be obtained using the Poiseulle formula

$$f = \frac{64}{Re} \tag{5}$$

For turbulent flow in a smooth pipe, a well-known curve fit to experimental data is given by

$$f = 0.316Re^{-0.25} \tag{6}$$

The resulting friction factor can be used to compute the head loss using the equation

$$\Delta h = \frac{fLV^2}{2gD_c} \quad (7)$$

TL;DR

	Parameter	Equation
1	Experimental Flowrate (Q)	$\frac{Volume}{Time}$
2	Velocity	Q/A
3	Head loss (Δh)	Manometer readings
4	Loss coefficient	Eq. 1, 2 and 3

DELIVERABLES

One team lab report containing the following

1. Letter of Transmittal (example: http://users.rowan.edu/~jagadish/resources/LoT_Example.pdf)
2. Materials and Methods
   a. In paragraph format explain what materials you used
   b. Explain the procedure for collecting data in your own words in paragraph format
   c. Explain the method for analyzing the data collected in lab. Retype all the equations, screenshotting is not permitted. Use subscripts and superscript where necessary
3. Results and Discussion
   a. In a table, reports the velocity, velocity head, Reynolds number and loss coefficient for each fitting for all trials
   b. What is the friction factor?
   c. Show a figure between Δh and $V^2/(2g)$ for each fitting
   d. Discuss your results
      i. Comment on the flow regime, loss coefficients.
      ii. What is the difference between minor and major losses?
   e. All calculations must be included in appendix and should not be presented here
4. Conclusions
   a. Briefly summarize your results and explain what you learned.
5. Appendix
   a. Show one sample calculation here