HYDRAULICS
MINOR (LOCAL) HEAD LOSSES EXPERIMENT

BACKGROUND

Energy losses in pipe flows are the result of friction between the fluid and the pipe walls and internal friction between the fluid particles. Minor (local) head losses occur at any location in a pipe system where streamlines are not straight, such as at pipe junctions, bends, valves, contractions, expansions, and reservoir inlets and outlets. In this experiment, minor (local) head losses through a pipe section that has several bends, transitions, and fittings will be measured.

PURPOSE

To determine the head loss coefficient (K) for the flow through a range of pipe fittings including bends, a contraction and an expansion.

APPARATURES

The apparatus for the experiment of minor (local) head losses consists of:

- One Sudden Expansion (between 5-6)
- One Sudden Contraction (between 7-8)
- Three Elbows (between 1-2: sharp edged elbow; between 3-4: short elbow; between 9-10: long elbow)
- Points 1-2-3-4-5-6-7-8-9-10 show the location of the piezometer (manometer) tubes located in the experimental setup (see Figure 1). The piezometer heads are read from the piezometer (manometer) board on the apparatus.

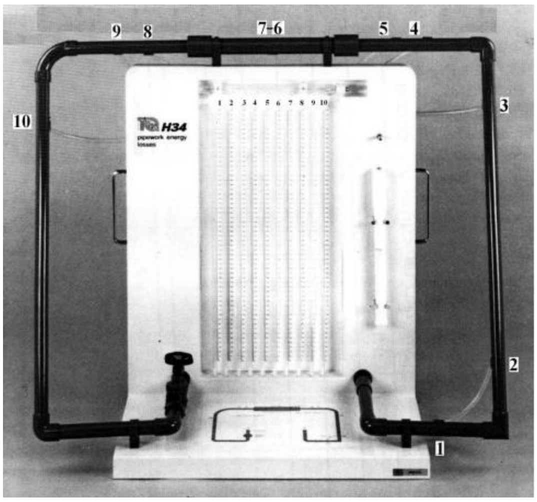

Figure1: Minor (local) head losses experimental apparatus

THEORY

The energy balance between two points in a pipe can be described by the Bernoulli equation, given by;

$$\frac{p_1}{\gamma}+z_1+\frac{V_1^2}{2g}=\frac{p_2}{\gamma}+z_2+\frac{V_2^2}{2g}+H_L$$

where; P_i is the static pressure (in Pa or kN/m^2) at point i, g is the specific weight of the fluid (in kN/m^3), z_i is the elevation (in meters) of point i, V_i is the fluid velocity (in m/s) at point i, g is the gravitational constant (in m/s^2), and H_L is the head loss (in meters).

The term P_i/γ is referred to as the static head; z_i is the elevation head; and $V_i^2/2g$ is the velocity (or dynamic) head. The summation of the static head and the elevation head, P_i/γ + z_i, is referred to as the piezometric head. <u>The piezometric head is what is measured with the piezometer (manometer) board on the apparatus for this experiment.</u>

The energy loss which occurs in a pipe fitting (so-called minor head loss) is commonly expressed in terms of a head loss (H, meters) in the form of;

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

where; K is the the loss coefficient, and V is the mean velocity of flow into the fitting,

<u>***For the expansion and contraction, V used in the formula is the velocity of the fluid in the smaller-diameter pipe.*</u>

Because of the complexity of flow in many fittings, K is usually determined by experiment. For the pipe fitting experiment, the head loss is calculated from two manometer readings, obtained before and after each fitting, and K is then determined as;

$$K = \Delta H / \left(\frac{V^2}{2g}\right)$$

To eliminate the effect of this area change on the measured head losses, this value should be added to the head loss readings for the expansion and the contraction. <u>Note that (ΔH) will be positive for the expansion and will be negative for the contraction.</u>

PROCEDURE

Adjust the flow from the bench control valve, and at a given flow rate, take the readings from all of the manometers after the levels are fixed. In order to determine the volume flowrate, you should carry out a timed volume collection using the volumetric tank. This is achieved by closing the ball valve and measuring (with a stopwatch) time taken to accumulate a known volume of fluid in the tank, which is read from the sight glass. You should collect fluid for at least one minute to minimize timing errors. Repeat this procedure to give a total of at least three sets of measurements.

DATA & RESULTS

The following dimensions from the equipment are used in the appropriate calculations;

- Internal diameter and area of pipework:

D_1 = 22.5mm; $A_1 = 3.97\text{x}10^{-4}\text{m}^2$

- Internal diameter and area of pipework at expansion outlet and contraction inlet:

D_2 = 29.6mm; $A_1 = 6.88\text{x}10^{-4}\text{m}^2$

Velocities for measured flowrate Q(lt/sec) at section area $A_1(\text{m}^2)$ and $A_2(\text{m}^2)$ are given below;

$$V_1 = \frac{10^{-3} \cdot Q}{A_1} \text{ (m/sec)} \qquad V_2 = \frac{10^{-3} \cdot Q}{A_2} \text{ (m/sec)}$$

Datas should noted in Table 1 read from the manometer heights to calculate, the head losses for each parts (contraction, expansion and elbows).

K: minor head loss coefficient for each part can be found from the graph which is drawn for total minor head losses in each part (ΔH) with respect to the velocity heads ($\frac{V^2}{2g}$). K value is determined from the slope of this line.

Table 1 Total head losses -in millimeter- from the piezometer readings

Experiment	Accumulated water in the bench (l)	Time (sec)	Q (l/sec)	V_1 (m/sec)	V_2 (m/sec)	$\frac{V_1^2}{2g}$ (mm)	$\frac{V_2^2}{2g}$ (mm)	Sharp Edged Elbow **1-2**	Long Elbow **3-4**	Expansion **5-6**	Contraction **7-8**	Short Elbow **9-10**
1												
2												
3												