Experiment No.3 : Sudden Expansion and Contraction

Object:

To determine minor loss coefficients for sudden expansion and contraction in a circular pipe.

Theory:

The flow in a piping system may be required to pass through a variety of fittings and abrupt changes in area. Additional head losses are encountered primarily as a result of flow separation which is termed as minor losses. The minor loss is of following types:

1. Pipe entrance or exit
2. Sudden / Gradual expansion or contraction
3. Bends or elbows
4. Valves

The minor head loss may be expressed as

$$h_m = K\frac{\overline{V}^2}{2} \tag{3.1}$$

The constant 'K' is different for different type of minor loss. Further, h_m is the head loss and $\overline{V}$ is the average velocity.

If the entrance is from a finite reservoir, it is termed as a *sudden contraction (sc)* between two sizes of pipe. If the exit is to a finite-sized pipe, it is termed as a *sudden expansion (se).* For circular pipes, minor loss coefficients for sudden expansion and contraction are shown in figure 1. It can be seen that the loss coefficients are based on the velocity head in smaller pipes. The theoretical estimation for K_{se}, using control volume analysis neglecting separation zones, is given by equation 3.2.

$$K_{se} = \frac{h_m}{\overline{V}^2/2g} = \left(1-\left(\frac{d}{D}\right)^2\right)^2 \tag{3.2}$$

For, sudden contraction because of adverse pressure gradient, flow separation downstream a pipe causes the main stream to contract through a minimum diameter (d_{min}) called a vena contracta. The empirical formula for K_{sc} is given in equation 3.3.

$$K_{se} \approx 0.42\left(1-\left(\frac{d}{D}\right)^2\right) \tag{3.3}$$

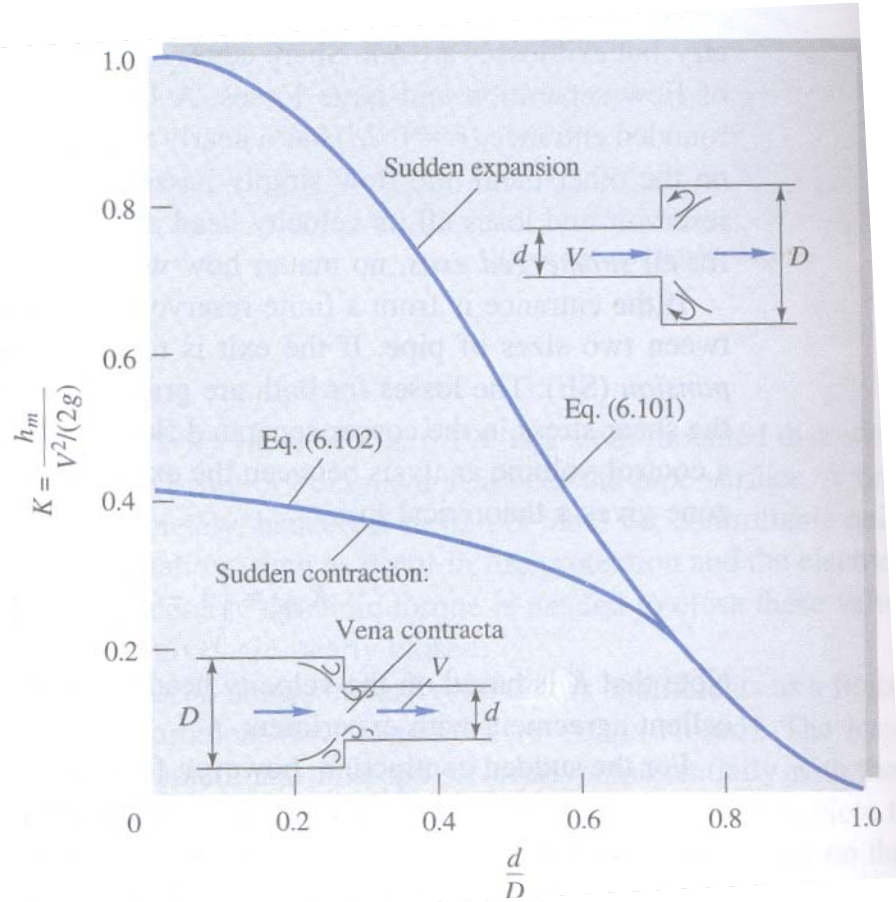

Figure 1 Sudden Expansion and Contraction losses along with expected flow patterns.

Given Data

1. **Tank Area (A)= 2ft × 2ft**
2. **Pipe Diameter before expansion/after contraction (d_1 or d_4) =2.54×10^{-2} m^2**
3. **Pipe Diameter after contraction/before expansion (d_2 or d_3) =5.08×10^{-2} m^2**
4. **Specific gravity of Manometric liquid (S_{me}) = 1.6**

Observations:

S.NO	Level of water Rise (h)	Time for collecting water	Sudden Expansion			Sudden Contraction		
			X_1	X_2	$\Delta p/\rho g$	X_1	X_2	$\Delta p/\rho g$

Graphs to be plotted

1. $h_{m\,se}$ vs $\overline{V}^2/2g$ and $h_{m\,sc}$ vs $\overline{V}^2/2g$ on one graph paper
2. log $h_{m\;se}$ vs $\log\overline{V}$ and determine the value of K_{se} and n graphically for $h_{m\,se} = K_{se}\overline{V}^n$
3. log $h_{m\;sc}$ vs $\log\overline{V}$ and determine the value of K_{sc} and n graphically for $h_{m\,sc} = K_{sc}\overline{V}^n$

Discussion

1. Discuss the physical significance of the experiment?
2. Show with the help of Buckingham Pi Theorem the dependence of K_{se} and K_{sc} on other factors.
3. Explain why K_{se} and K_{sc} are not equal.