FLUID MECHANICS FOR MECHANICAL ENGINEERING (ME 208F)

Section C:
Flow Through Pipes- I

Energy Losses due to friction

- When a liquid flows through a pipeline, shear stresses develop between the liquid and the pipe wall.
- This shear stress is a result of friction, and its magnitude is dependent upon the properties of the fluid, the speed at which it is moving, the internal roughness of the pipe, the length and diameter of pipe.
- **Friction loss**, also known as **major loss**, is a primary cause of energy loss in a pipeline system.

Friction Losses in Laminar flow

- In laminar flow, the fluid seems to flow as several layers, one on another. Because of the viscosity of the fluid, a shear stress is created between the layers of fluid.
- Energy is lost from the fluid to overcome the frictional forces produced by the shear stress.
- Energy loss is usually represented by the drop of pressure in the direction of flow.
- Therefore, the frictional head loss, h_f, can be written in terms of pressure drop along the pipeline, as follows:

$$h_f = \frac{\Delta P}{\rho g}$$

Substituting the Hagen-Poiseuille equation and applying the continuity equation, Q = VA, to the above resulted into the following expression:

$$h_f = \frac{32 \mu L V}{\rho g D^2} = \frac{64}{Re} \frac{L}{D} \frac{V^2}{2g}$$

Friction Losses in Turbulent flow

- In turbulent flow, the friction head loss can be calculated by considering the pressure losses along the pipelines.
- In a horizontal pipe of diameter D carrying a steady flow there will be a pressure drop in a length L of the pipe.
- Equating the frictional resistance to the difference in pressure forces, and manipulating resulted into the following expression:

$$h_f = \lambda \frac{L}{D} \frac{V^2}{2g}$$

This equation is known as **Darcy-Weisbach (D-W)** equation, in which λ is the friction factor. It should be noted that λ is dimensionless, and the value is not constant

- Blasius (1913) was the first to propose an accurate empirical relation for the friction factor in turbulent flow in smooth pipes, namely

$$\lambda = 0.316/Re^{0.25}$$

Thus, the calculation of losses in turbulent pipe flow is dependent on the use of empirical results and the most common reference source is the Moody diagram. A Moody diagram is a logarithmic plot of λ vs. Re for a range of k/D. A typical Moody diagram is shown in Figure 6.9.

Minor Losses

- In addition to head loss due to friction, there are always other head losses due to pipe expansions and contractions, bends, valves, and other pipe fittings. These losses are usually known as **minor losses (h_{Lm})**.

- In case of a long pipeline, the minor losses maybe negligible compared to the friction losses, however, in the case of short pipelines, their contribution may be significant.

Sudden Contraction

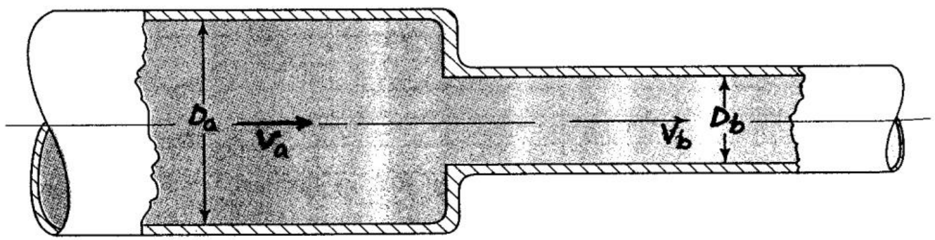
The energy loss due to a sudden contraction can be calculated using the following;

$$h_{Lm} = K_C \frac{V_b^2}{2g}$$

The K_C is the coefficient of contraction and the values depends on the ratio of the pipe diameter (D_b/D_a) as shown below.

D_b/D_a	0.0	0.2	0.4	0.6	0.8	1.0
K	0.5	0.49	0.42	0.27	0.20	0.0

Values of K_C vs. D_b/D_a



Flow at sudden contraction