The steps in calculating the head loss in a pipe
Steps in Finding the Head Loss in Pipes

In order to find losses in a pipe, the following steps must be followed:

1. Determine whether the flow is laminar or turbulent by checking the value of the Reynolds's number $N_R$.
   - If $N_R < 2000$, then the flow is laminar.
   - If $N_R > 4000$, then the flow is turbulent. For values in between 2000 and 4000, it is not decisive.

2. $N_R = \frac{\nu D P}{\mu} = \frac{\nu D}{\mu} = \frac{\nu D}{\nu}$
   - Evaluate the Reynolds's number.

3. For both types of flow, the head loss is
   
   $$H_L = f \left( \frac{L}{D} \right) \cdot \frac{V^2}{2g}$$

   where
   - $H_L$ is the head loss in [m]
   - $f$ is the frictional factor (dimensionless)
L is the length of the pipe in [m]
D is the diameter of the pipe in [m]
v is the fluid speed in [m/s]
g is the acceleration due to gravity [m/s²]

4. If flow is laminar then

\[ f = \frac{64}{\text{Re}} \]

Friction Factor

\[ \text{Re} = \frac{64}{\text{Re}} \left( \frac{1}{D} \right) \left( \frac{v^2}{g} \right) \]

5. If flow is turbulent, then we must find the relative roughness:

Relative Roughness \( \frac{E}{D} \)

This is then applied with \( \text{Re} \) to the Moody Diagram to find the friction factor \( f \).
Example 4-5 (Esposito, Fe)

\[ L = \]

\[ V = 50 \text{ cm/s} = \frac{50}{100} \text{ m/s} = 0.5 \text{ m/s} \]

\[ L = 10 \text{ m} \]

\[ = 0.5 \left( \frac{\text{cm}^2}{\text{m}} \right) \left( \frac{1 \text{ m}}{100 \text{ cm}} \right)^2 \]

\[ = 0.5 \times 10^{-4} \text{ m}^2/\text{s} \]

Diameter = 1 inch = 25.4 mm = 0.0254 m

1. \[ v = 10 \text{ ft/s} = 3.048 \text{ m/s} \]
2. \[ v = 40 \text{ ft/s} = 12.192 \text{ m/s} \]

First \[ N_R = \frac{vD}{v} = \frac{(3.048)(0.0254)}{0.5 \times 10^{-4}} \]

\[ = 1548.4 \Rightarrow \text{ laminar flow} \]

\[ N_R = \frac{(12.192)(0.0254)}{0.5 \times 10^{-4}} \]

\[ = 6193.536 \Rightarrow \text{ turbulent flow} \]
Commercial steel pipe:

\[ \text{roughness} = 0.046 \text{ mm} = 0.046 \times 10^{-3} \text{ m} \]

\[ \text{roughness factor} = \frac{0.046 \times 10^{-3}}{0.0254} = 0.0018 \]

using the Moody Diagram, with \( N_R = 6193 \)

and \( \frac{E}{D} = 0.0018 \) → \( f = 0.036 \)

For laminar flow \( f = \frac{64}{D} = 0.04/33 \)

\( \frac{1548.4}{1} \)

**turbulent flow**. \( f = 0.036 \)

\[ H_L = (0.04/33) \cdot \left( \frac{10}{0.0254} \right) \cdot \left( \frac{3.048}{(2)(981)} \right)^2 = 7.7 \text{ m} \]

\[ H_L \text{ / turbulent} = (0.036) \cdot \left( \frac{10}{0.0254} \right) \cdot \left( \frac{12.192}{(2)(981)} \right)^2 \]

\[ = 107.4 \text{ m} \]

(14 times the loss in head)!!!

Alternatively, \( f \) for turbulent flow can be found:

\[ \frac{1}{f^2} = -2.69 \left( \frac{E}{D} \right) + 2.51 \text{ (for } N_R V_f) \]
Figure 4-10. The Moody diagram. (Reprinted from Introduction to Fluid Mechanics by J. E. John and W. L. Haberman, Prentice Hall, Englewood Cliffs, NJ, 1988.)