Hydraulics - 06.03.2011
Exercise - 1

Q1. Three pipes are connected in series between two reservoirs with a difference in level of 12m. The friction factors, lengths and pipe diameters are given below. Determine the flow rate neglecting minor losses.

<table>
<thead>
<tr>
<th>Pipe</th>
<th>L(m)</th>
<th>D(cm)</th>
<th>f</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>600</td>
<td>25</td>
<td>0.021</td>
</tr>
<tr>
<td>2</td>
<td>800</td>
<td>30</td>
<td>0.019</td>
</tr>
<tr>
<td>3</td>
<td>400</td>
<td>35</td>
<td>0.024</td>
</tr>
</tbody>
</table>

\[ h_f = f \frac{L \ V^2}{D \ 2g} \quad \text{and inserting} \quad V = \frac{4Q}{\pi D^2} : \]

\[ h_f = 8f \ \frac{L \ Q^2}{D^5 \ g\pi^2} \]
Exercise - 1

\[ h_f = f \frac{L V^2}{D 2g} \]  and inserting \( V = \frac{4Q}{\pi D^2} \):

\[ h_f = 8f \frac{L Q^2}{D^5 g \pi^2} \]

\[ \sum hL = \frac{8f_1 L_1 Q^2}{\pi^2 g D_1} + \frac{8f_2 L_2 Q^2}{\pi^2 g D_2} + \frac{8f_3 L_3 Q^2}{\pi^2 g D_3} \]

\[ 12 = \frac{8f_1 L_1 Q^2}{\pi^2 g D_1} + \frac{8f_2 L_2 Q^2}{\pi^2 g D_2} + \frac{8f_3 L_3 Q^2}{\pi^2 g D_3} \]

\[ Q = 0.2 m^3 / sec \]
Exercise - 2

Q2. Assume that the same three pipes of previous example are now in parallel with the same total loss of 20.3 m. Compute the total rate $Q$(m3/hr), neglecting the minor losses. Use equivalent pipe concept. $\varepsilon = 0.2$ mm.

a) Assume eq. Pipe length of 200m.
b) Assume eq. Pipe diameter 0.06m

<table>
<thead>
<tr>
<th>Pipe</th>
<th>L(m)</th>
<th>D(cm)</th>
<th>$\varepsilon$ (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>8</td>
<td>0.2</td>
</tr>
<tr>
<td>2</td>
<td>150</td>
<td>6</td>
<td>0.2</td>
</tr>
<tr>
<td>3</td>
<td>80</td>
<td>4</td>
<td>0.2</td>
</tr>
</tbody>
</table>

The fluid is water ($\rho = 1000$ kg/m3, $\nu = 1.02 \times 10^{-6}$ m2/s).
Exercise - 2

\[ h_{L(A-B)} = f \cdot \frac{L}{D} \cdot \frac{V^2}{2g} \]

\[ Q = \sqrt{\frac{h_L g \pi^2 D^5}{8 fL}} \]

a)

\[ \sqrt{\frac{D_{eq}^5}{L_{eq}}} = \sum_{i=1}^{n} \sqrt{\frac{D_i^5}{L_i}} = \sqrt{\frac{D_1^5}{L_1}} + \sqrt{\frac{D_2^5}{L_2}} + \sqrt{\frac{D_3^5}{L_3}} \]

\[ \sqrt{\frac{D_{eq}^5}{200}} = \sqrt{\frac{0.08^5}{100}} + \sqrt{\frac{0.06^5}{150}} + \sqrt{\frac{0.04^5}{80}} \]

\[ D_{eq} \approx 0.09m \]
Exercise - 2

\[ h_{L(A-B)} = f \cdot \frac{L}{D} \cdot \frac{V^2}{2g} \]

\[ 20.3 = f \cdot \frac{200}{D_{eq}} \cdot \frac{V^2}{19.62} \]

\[ D_{eq} = 0.09m \]

\[ 20.3 = f \cdot \frac{200}{0.09} \cdot \frac{V^2}{19.62} \rightarrow 0.1791 = f \cdot V^2 \]
Exercise - 2

Assume \( f = 0.02 \)

\[
20.3 = f \cdot \frac{200}{0.09} \cdot \frac{V^2}{19.62} \rightarrow 0.1791 = f \cdot V^2
\]

\[
0.1791 = f \cdot V^2 \rightarrow f = 0.02 \rightarrow V = 2.99 \text{ m/ sec}
\]

\[
\text{Re} = 2.6 \times 10^5
\]

\[
\text{Re} = 2.6 \times 10^5; \frac{\varepsilon}{D_{eq}} = 0.0002 / 0.09 = 0.002
\]

\[
f = 0.024
\]
Exercise - 2

Recalculating \( f = 0.024; \)  \( V = 2.73 \text{ m/sec}; \)  \( \text{Re} = 2.4 \times 10^5 \) OK!

Discharge \( Q = 0.00286 \text{ m}^3 / \text{sec} \)