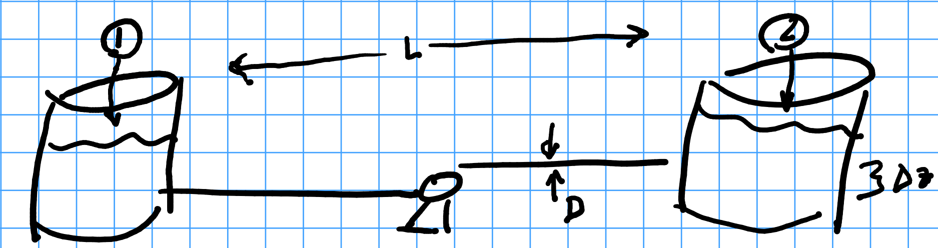
Lecture 33 - Example (Pumps)



$\Delta z = 4\,m$

$D = 1\,m$ (ID)

$L = 200\,m$

hydraulically smooth

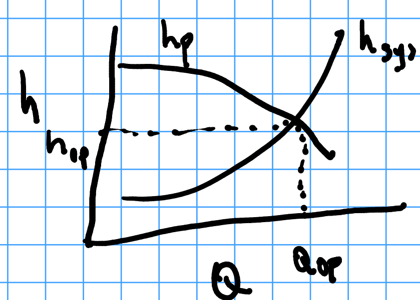
$h_p = h_{max} - BQ^2$ $\quad h_{max} = 13\,m$

$h_p = A - BQ^n$ $\quad B = 0.05\ \frac{m}{Lpm^2}$ $\quad Lpm = \frac{Liter}{min}$

*Assume
- constant $f = 0.002$
- no minor losses

$$\underbrace{\frac{\Delta P}{\rho g} + \frac{\Delta v^2}{2g} + g\Delta z}_{\Delta H} = \underbrace{\frac{W_m}{wg}}_{h_p} - \underbrace{\frac{E_v}{wg}}_{h_L}$$

(Eng. Bernoulli Eq)



$$\Delta H = h_p - h_L \Rightarrow h_p = \underbrace{\Delta H + h_L}_{h_{sys}}$$

$$\Delta H = \frac{\Delta P}{\rho g} + \frac{\Delta v^2}{2g} + \Delta z$$

$\left.\begin{matrix} P_1 = P_{atm} \\ P_2 = P_{atm} \end{matrix}\right\} \Delta P \to 0$ $\quad \left.\begin{matrix} v_1 \approx 0 \\ v_2 \approx 0 \end{matrix}\right\} \Delta v^2 \to 0$ $\quad \Delta z = 4\,m$

$$h_L = \frac{v^2}{2g}\left(\frac{4Lf}{D} + \underbrace{\sum_i k_i}_{0 \text{ for this prob}}\right)$$

if minor losses, add here (e.g. contractions, elbows)

$$h_{sys} = \Delta z + \frac{v^2}{2g}\left(\frac{4Lf}{D}\right) \qquad Q = v \cdot A = \frac{\pi D^2}{4} v \qquad v = \frac{4Q}{\pi D^2}$$

$$= \Delta z + \frac{1}{2g}\left(\frac{4Q}{\pi D^2}\right)^2 \cdot \frac{4Lf}{D} = \Delta z + \frac{16}{2g}\frac{Q^2}{\pi^2 D^4} \cdot \frac{4Lf}{D}$$

$h_{sys} = \Delta z + \frac{32}{\pi^2} \frac{Lf}{gD^5} Q^2$ ← I could put nums in now.

const ← · if not const → $f = f(Re)$, $Re \leftarrow Q$

$h_{sys} = h_p \Rightarrow h_{max} - BQ^2 = \Delta z + \frac{32}{\pi^2}\frac{Lf}{gD^5} Q^2$

$\phi(Q) = 0$ ← Newton's method.

$h_{max} - \Delta z = \left(B + \frac{32}{\pi^2}\frac{Lf}{gD^5}\right) Q^2$

$Q_{op} = \left(\frac{h_{max} - \Delta z}{B + \frac{32}{\pi^2}\frac{Lf}{gD^5}}\right)^{1/2} = 7.03 \text{ Lpm}$

$h_{op} = 10.53 \text{ m}$