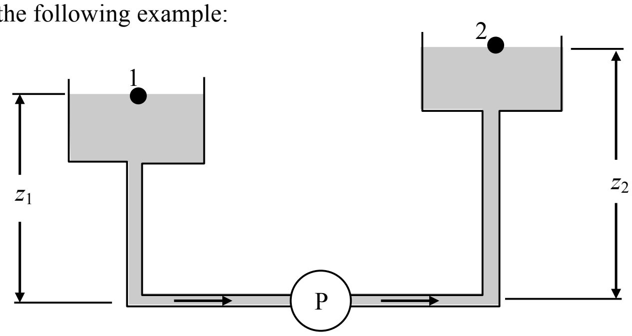
5. System Characteristic Curves and Pump Selection

How do we select a pump for a given system? Analyze the system to determine the shaft head required to give a specified volumetric flow rate. Compare this result to a given pump performance curve (*H*-*Q* curve) to determine if the pump operates efficiently at this *Q*. If so, then the choice of pump is appropriate.

Consider the following example:



Apply the EBE from 1 to 2:

$$\left(\frac{p}{\rho g}+\alpha\frac{\bar{V}^2}{2g}+z\right)_2=\left(\frac{p}{\rho g}+\alpha\frac{\bar{V}^2}{2g}+z\right)_1-H_{L12}+H_{S12} \quad (34)$$

where $p_1 = p_2 = p_{atm}$ and $V_1 = V_2 = 0$. Thus, the head required from the pump is:

$$H_{S12}=\left(z_2-z_1\right)+H_{L12} \quad (35)$$

Recall that:

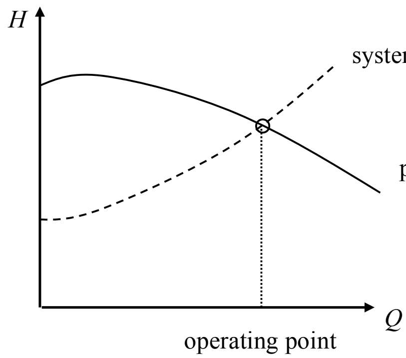
$$H_{L12}=\sum_i K_i\frac{\bar{V}_i^2}{2g}=\sum_i K_i\frac{Q_i^2}{2gA_i^2} \quad (36)$$

so that:

$$H_{S12}\approx\left(z_2-z_1\right)+CQ^2 \quad (37)$$

where C is a constant that incorporates the loss coefficients and area ratios, and an "≈" is used since the loss coefficients may depend on the flow velocities.

The conditions at which the system will operate will depend on the intersection of the system head curve with the pump performance curve as shown in the figure below.



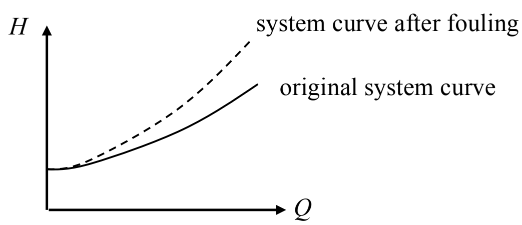
Notes:
1. Ideally we would want the operating point to occur near the BEP for the pump.

2. For laminar flow,

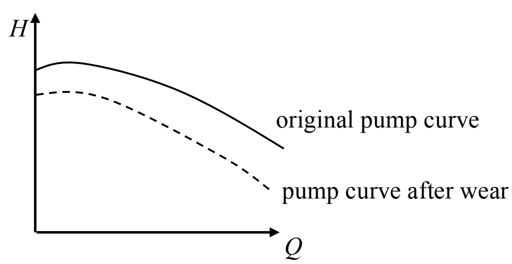
$$K_{\text{major}} = \frac{64}{\text{Re}}\left(\frac{L}{D}\right) = \frac{64\nu}{VD}\frac{L}{D} = \frac{c}{Q} \quad \text{where } c \text{ is a constant} \tag{38}$$

   $\Rightarrow H_L \sim Q$
   $\Rightarrow$ system curve is: $H_S = c_1 + c_2 Q$ (a line instead of a parabola!)

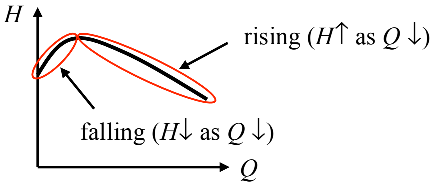
3. The system curve may change over time due to fouling of the pipes and other factors $\Rightarrow$ increased losses $\Rightarrow$ system curve becomes steeper



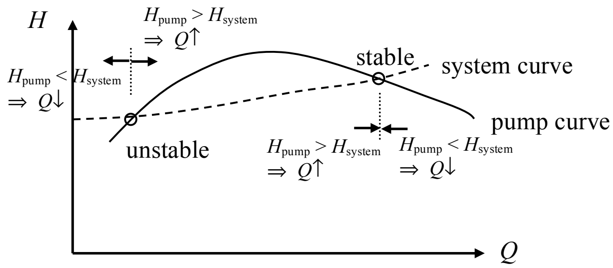
The pump curve may also change due to wear on the bearings, impeller, etc.



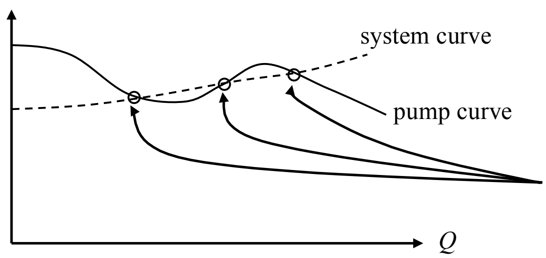
4. Stability issues become significant when the pump has a flat or falling (defined as a performance curve where $H \downarrow$ as $Q \downarrow$) performance curve.



Consider perturbations to the system from the operating point.

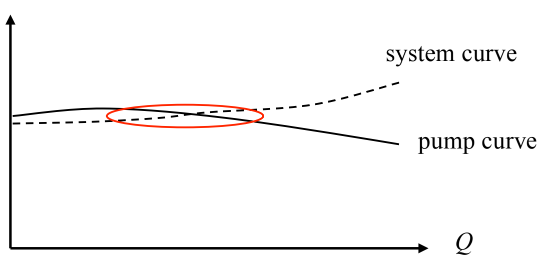


falling pump curve



For the system shown at the left there are three operation points! The system may oscillate between these points!

flat pump/system curves



For the system shown at the left, the system may drift over a wide range of Q!