Lecture 34 – More Pumps & Turbines – Example (NPSH, Parallel/Serial)

Ex 1: NPSH

$Q_{op} = 16.6$ L/min

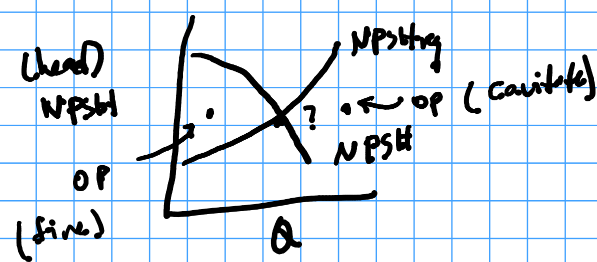
$h_{op} = 6.475$ m

$h_{in} = A - BQ^2$ $\quad A = 13\text{m}$ $\quad B = 0.021 \frac{\text{m}}{\text{Lpm}^2}$ $\quad P_v = 26.5$ kPa

Will the system cavitate?

$NPSH_{req} = 0.034 \frac{\text{m}}{\text{Lpm}^2} Q^2$

* $NPSH = NPSH_{req}$ $\quad NPSH > NPSH_{req}$ (no cavitate)



$$NPSH = h_{in} - \frac{P_v}{\rho g}$$

$$= A - BQ^2 - \frac{P_v}{\rho g} = 13\text{ m} - 0.021 \frac{\text{m}}{\text{Lpm}^2} Q^2 - \frac{26.5 \text{ kPa}}{10^3 \frac{\text{kg}}{\text{m}^3} \cdot 9.8 \text{ m/s}^2}$$

$$= 10.3\text{ m} - 0.021 \frac{\text{m}}{\text{Lpm}^2} Q^2$$

$$10.3\text{ m} - 0.021 \frac{\text{m}}{\text{Lpm}^2} Q^2 = 0.034 \frac{\text{m}}{\text{Lpm}^2} Q^2$$

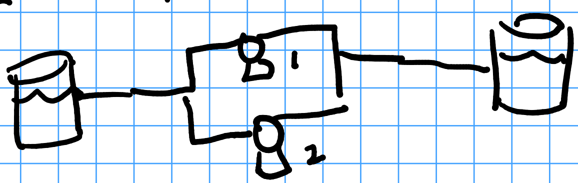
$$10.3\text{m} = 0.055 Q^2 \frac{\text{m}}{\text{Lpm}^2}$$

$$Q^2 = \frac{10.3}{0.055} \text{Lpm}^2 \Rightarrow \underline{\underline{Q = 13.7 \text{ Lpm}}}$$

maximum flow rate.

$\therefore$ System will cavitate

Ex2: Pumps in parallel.



$$h_{sys} = C + D\,Q_{tot}^2$$

$$h_{p_1} = A_1 - B_1 Q_1^2$$

$$h_{p_2} = A_2 - B_2 Q_2^2$$

Find the operating point

$$h_{sys} = h_{p,tot}$$

key principles (parallel)

(i) $Q_{tot} = Q_1 + Q_2$

(ii) $h_p = h_{p_1} = h_{p_2}$

serial is easier

$Q_{tot} = Q_1 = Q_2$

$h_{p_{tot}} = h_{p_1} + h_{p_2}$

h_{p_1}: invert

$$h_{p_1} - A_1 = -B_1 Q_1^2 \Rightarrow \frac{A_1 - h_{p_1}}{B_1} = Q_1^2 \qquad Q_1 = \sqrt{\frac{A_1 - h_{p_1}}{B_1}}$$

h_{p_2}: invert

same algebra $\Rightarrow$ $Q_2 = \sqrt{\dfrac{A_2 - h_{p_2}}{B_2}}$

like to ... ?

$$Q_{tot} = Q_1 + Q_2 = \sqrt{\frac{A_1 - h_p}{B_1}} + \sqrt{\frac{A_2 - h_p}{B_2}}. \qquad Q_{tot}(h_p) \to h_p(Q_{tot})$$

$$\boxed{Q_{tot}(h_p) = Q_{tot}(h_{sys})} \Rightarrow Q_{op} \Rightarrow h_{op}$$

h_{sys}: invert

$$h_{sys} = C + D Q_{tot}^2 \Rightarrow \frac{h_{sys} - C}{D} = Q_{tot}^2 \qquad Q_{tot}(h_{sys}) = \sqrt{\frac{h_{sys} - C}{D}}$$

$$\sqrt{\frac{h_{sys} - C}{D}} = \sqrt{\frac{A_1 - h_p}{B_1}} + \sqrt{\frac{A_2 - h_p}{B_2}}$$

$h_{sys} = h_p = h_{op}$

plug in after solve to get Q_{op}

use a computer

$$0 = -\sqrt{\frac{h_{op} - C}{D}} + \sqrt{\frac{A_1 - h_{op}}{B_1}} + \sqrt{\frac{A_2 - h_{op}}{B_2}} = \phi(h_{op})$$