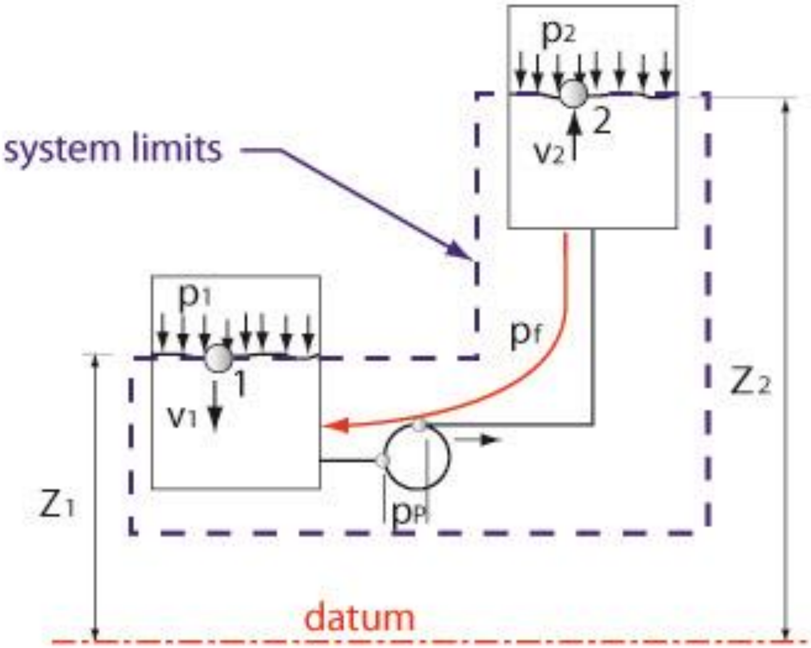
Universal system



Z_1 & Z_2 : suction and dischage tank level elevation

H_1 & H_2 : inlet and oulet pressure head

p_1 & p_2 : inlet and oulet pressure

v_1 & v_2 : inlet and oulet velocity

$\frac{v_1^2}{2g}$ & $\frac{v_2^2}{2g}$: inlet and outlet velocity head

h_f : friction head loss in the system

p_f : friction pressure loss in the system

h_P : pump total head

p_P : pump pressure difference

mg : mass times acc. due to gravity (weight)

V : volume

Note: the datum or reference plane can be any convenient surface or line in the plant

Energy balance for the universal system

energy IN — energy OUT

$$p_P V + mg Z_1 + p_1 V + \frac{1}{2} m v_1^2 = p_f V + mg Z_2 + p_2 V + \frac{1}{2} m v_2^2$$ — pV is energy

divide my mg

$$\frac{p_P V}{mg} + Z_1 + \frac{p_1 V}{mg} + \frac{v_1^2}{2g} = \frac{p_f V}{mg} + Z_2 + \frac{p_2 V}{mg} + \frac{v_2^2}{2g}$$ — $\frac{p_P V}{mg} = \frac{p_P}{\frac{mg}{V}} = \frac{p_P}{\gamma} = h_P$ units are in feet or head

$$h_P + Z_1 + H_1 + \frac{v_1^2}{2g} = h_f + Z_2 + H_2 + \frac{v_2^2}{2g}$$

Specific energy (head) $\frac{\text{energy}}{\text{unit weight}}$ balance

Pressure to head relationship

$p = \gamma Z$ in Imperial units $p\ (\text{psi}) = \frac{Z\ (\text{ft})}{2.31}$ for water

γ is the density of the liquid

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