Pump @model

The most general Pump model is given as a function of the mass flowrate on the intake $p_{\rm in}$ and discharge pressure $p_{\rm out}$:

(1) $$\dot m = M(p_{\rm out}, p_{\rm in})$$

It's often presented in terms of intake volumetric flowrate:

(2) $$q = q_{in} = \frac{\dot m}{\rho(p_{in})} = \frac{M(p_{\rm out}, p_{\rm in})}{\rho(p_{in})}$$

where

$\rho(p)$	fluid density as a function of fluid pressure p

The electrical power consumption $W = \frac{dE}{dt}$ is given by:

(3) $$W = \eta(q) \cdot q \cdot (p_{\rm out} - p_{\rm in})$$

where

η	pump efficiency

In most practical cases the pump model (2) depends on the difference between intake and discharge pressure $p_{\rm out} - p_{\rm in}$ and called Pump Characteristic Curve (see **Fig. 1**):

(4) $$q = q(p_{\rm out} - p_{\rm in})$$

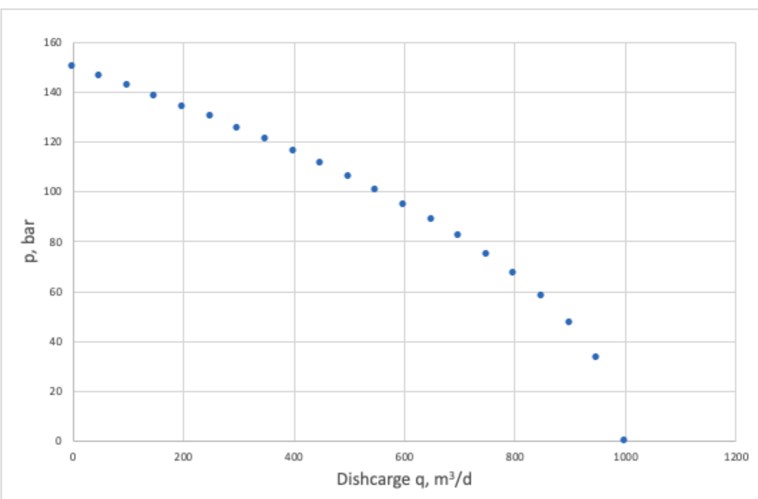

Fig. 1. Example of Pump Characteristic Curve.

A popular pump proxy model is given by the quadratic equation with 3 inputs ($\{q_{rfmax}, \delta p_{\rm max}, k_f\}$):

(5) $$q = \frac{q_{\rm max}}{2 \cdot k_f} \cdot \left[-1 + k_f + \sqrt{(1+k_f)^2 - 4 \cdot k_f \cdot (p_{\rm out} - p_{\rm in})/\delta p_{\rm max}}\right]$$	(6) $$p_{\rm out} = p_{\rm in} + \delta p_{\rm max} \cdot \left[1 + (k_f - 1) \cdot \frac{q}{q_{\rm max}} - k_f \cdot \left(\frac{q}{q_{\rm max}}\right.\right.$$

(7) $$\eta(q) = 4\,\eta_{\rm max} \cdot q/q_{\rm max} \cdot (1 - q/q_{\rm max})$$

where

$\delta p_{\max}$	maximum pressure gain that pump can exert over the input pressure $p_{\rm in}$
$q_{\max}$	maximum flowrate that pump can produce
$k_f \in [0, 1]$	total hydraulic pump friction (dimensionless)
η	pump efficiency
$\eta_{\max}$	maximum pump efficiency

Real pumps have non-constant $k_f = k_f(q)$ friction coefficient which often modelled as a 3rd order polynomial and the overall real-pump model taking 6-inputs.

Many pumps can be normally adjusted by the variation of the working frequency which affects the maximum pump flowrate and maximum pressure gain as:

(8) $q_{\max} = q^*_{\max} \cdot \frac{f}{f^*}$	(9) $\delta p_{\max} = \delta p^*_{\max} \cdot \left(\frac{f}{f^*} \right)^2$

where

$q_{\max}$	maximum intake flowrate at the working frequency f	$\delta p_{\max}$	maximum pressure gain at the working frequency f	f	adjusted working frequency
$q^*_{\max}$	maximum intake flowrate at the nominal frequency f^*	$\delta p^*_{\max}$	maximum pressure gain at the nominal frequency f^*	f^*	nominal frequency

See also

Natural Science / Engineering / Device / Pump

Physics / Fluid Dynamics / Pipe Flow Dynamics / Pipe Flow Simulation (PFS)

References