0.0.1 Pipe model V2

Surface resistance:

$$R_f = f_m \cdot \frac{8 \cdot L \cdot \rho}{\pi^2 \cdot D^5} \tag{1}$$

Form resistance

$$R_f = k_f \cdot \frac{8 \cdot \rho}{\pi^2 \cdot D^4} \tag{2}$$

$$\lambda(\dot{q}) = (R_f + R_m) \cdot |q| \cdot q \tag{3}$$

0.0.2 Valve model

The relationship between pressure difference and flow is the same for all flows and pressure differences:

$$\frac{\Delta p_1}{q_1^2} = \frac{\Delta p_2}{q_2^2} \tag{4}$$

Isolating one flow:

$$q_1 = q_2 \cdot \sqrt{\frac{\Delta p_1}{\Delta p_2}} \tag{5}$$

There will be a flow q_2 where the pressure drop (Δp_2) will be equal to one and thus:

$$q_1 = q_2 \cdot \sqrt{\Delta p_1} \tag{6}$$

Writing this up more generally:

$$q = k_v(OD) \cdot \sqrt{\Delta p} \tag{7}$$

Isolating the pressure difference:

$$\Delta p_{valve} = \frac{1}{k_v(OD)} \cdot q^2 <> \Delta p_{valve} = \frac{1}{k_v(OD)} \cdot |q| \cdot q \tag{8}$$

$h_v(OD)$ Constant dependent on valve opening degree (OD)

0.0.3 Tank model

The pressure in the bottom of the tank is proportional to the level of the tank:

$$P_{v4} \propto h_{tank} \tag{9}$$

h_{tank} is the level in the tank [m]

The following is true if the tank cross-sectional area (A) is constant

$$\dot{V}_\tau = d_\tau \tag{10}$$

As such the follow is true

$$\dot{V}_\tau \propto h_{tank} \propto d_\tau \tag{11}$$

And thus

$$\dot{p}_{v4} \propto d_t \tag{12}$$

Which leads us to

$$\dot{p}_{v4} = -\tau \cdot d_t \tag{13}$$

0.0.4 Pump model

The full pump model:

$$\Delta p_{pump} = \alpha(q, a) = a_2 \cdot q^2 - a_1 \cdot q - a_0 \cdot q \cdot \omega^2 \tag{14}$$

$a_0 - a_2$ are constants obtained from measurements of the pump

We disregard the ??? and thus end up with:

$$\Delta p_{pump} = \alpha(q, a) = a_2 \cdot q^2 - a_0 \cdot q \cdot \omega^2 \tag{15}$$