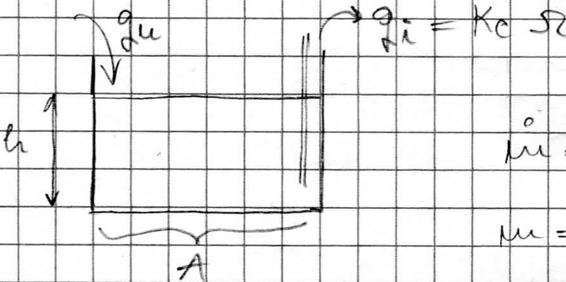
SPREMNICI ENERGIJE

(1)



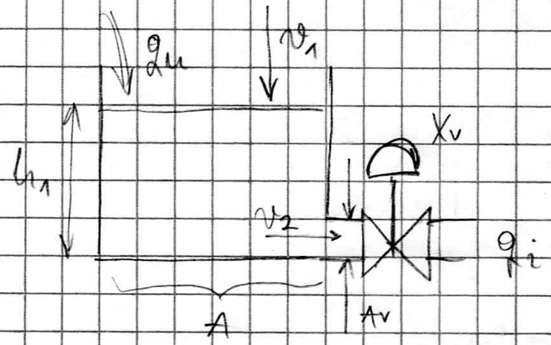
$\dot m = q_u - q_i$

$m = \rho V = \rho A h$

$\frac{d}{dt}\rho A h = q_u - q_i$

$\dot h = \frac{1}{\rho A} q_u - \frac{K_c}{\rho A}\Omega$

(2)



Toricellijev zakon:

$A v_1 = A v_2$

Bernullijeva jednadžba:

$\cancel{p_0} + \rho g h_1 + \frac{1}{2}\rho \cancel{v_1^2} = \cancel{p_0} + \cancel{\rho g h_2} + \frac{1}{2}\rho v_2^2$

$A >> A_v \Rightarrow v_2 >> v_1 \Rightarrow v_1 \approx 0$

$\dot m = q_u - q_i$

$\rho A \dot h = q_u - q_i$

$v_2 = \sqrt{2gh_1} = \sqrt{2gh}$

$q_i = \rho A_v \cdot \sqrt{2gh}$

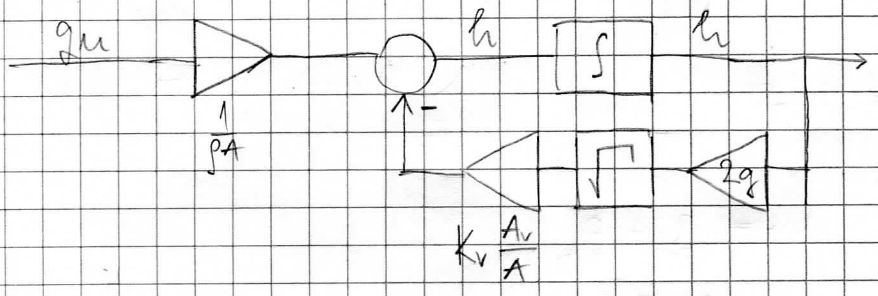
$\rho A \dot h = q_u - \rho A_v \sqrt{2gh}$

$\dot h = \frac{1}{\rho A} \cdot q_u - \frac{A_v}{A}\sqrt{2gh}$

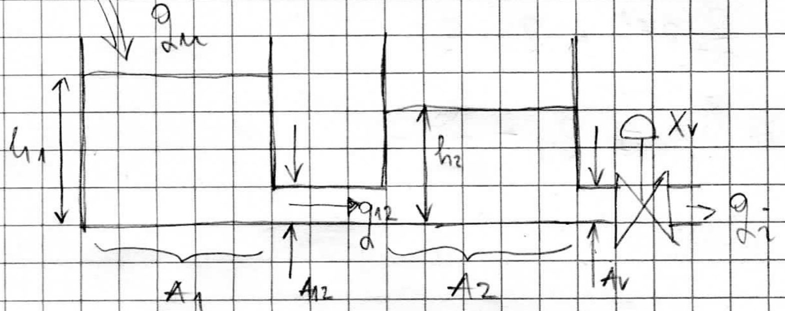
BEZ VENTILA

S VENTILOM: $q_i = K_v \rho A_v \sqrt{2gh}$

$K_v = [0, 1] \rightarrow$ KONSTANTA VENTILA



③



a) $\dot{m}_1 = q_u - q_{12}$

$m_1 = \rho V_1 = \rho A_1 h_1$

$\rho A_1 \dot{h}_1 = q_u - q_{12}$

$$\cancel{p_0} + \underbrace{\rho g (h_1 - h_2)}_{\text{1. POSUDA}} + \cancel{\tfrac{1}{2}\rho v_1^2}^{\,0} = \cancel{p_0} + \underbrace{\cancel{\rho g h_{12}}}_{\text{MEĐUCIJEV}}^{\,0} + \tfrac{1}{2}\rho v_1^2$$

$$v_{12} = \sqrt{2g(h_1 - h_2)}$$

$$q_{12} = \rho A_{12} \sqrt{2g(h_1 - h_2)} \rightarrow \text{VRIJEDI SAMO ZA } h_1 > h_2$$

OPĆENIT SLUČAJ: $q_{12} = \underbrace{\mathrm{sgn}}_{\text{SIGNUM}}(h_1 - h_2)\sqrt{2g\underbrace{|h_1 - h_2|}_{\text{APSOLUTNO}}}$

$$\rho A \dot{h}_1 = q_u - A_{12}\rho\sqrt{2g(h_1 - h_2)}$$

b) $\dot{m}_2 = q_{12} - q_i$

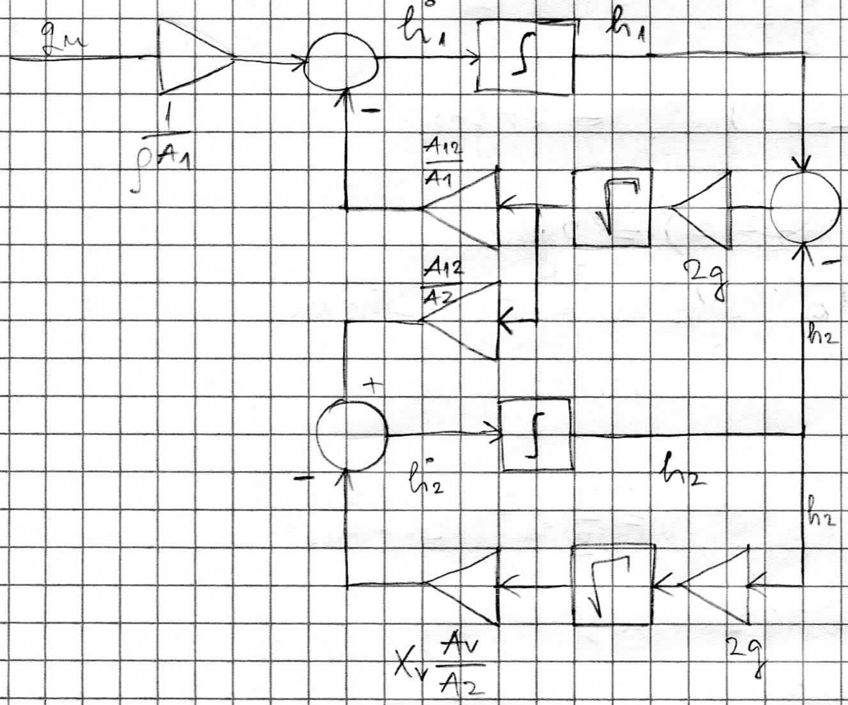
$q_i = X_v \rho A_v \sqrt{2g h_2}$ (KAO I PRETHODNI ZAD.)

$$\dot{m}_2 = \rho A_2 \dot{h}_2 = \rho A_{12}\sqrt{2g(h_1 - h_2)} - X_v \rho A_v \sqrt{2g h_2}$$

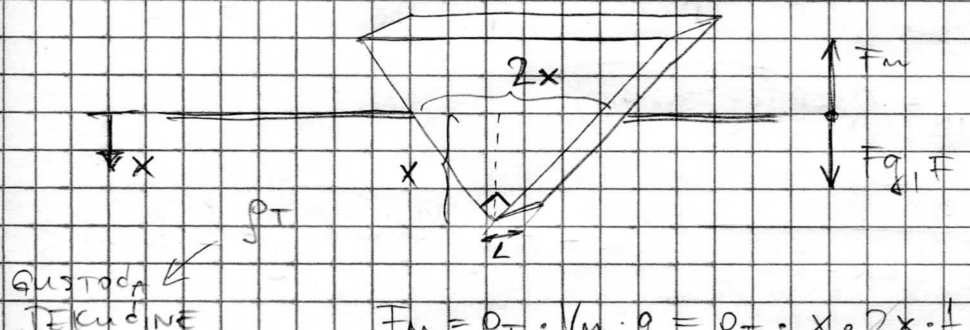
$$\dot{h}_1 = \frac{1}{\rho A_1} q_u - \frac{A_{12}}{A_1}\sqrt{2g(h_1-h_2)}$$

$$\dot{h}_2 = \frac{A_{12}}{A_2}\sqrt{2g(h_1-h_2)} - x_v \frac{A_v}{A_2}\sqrt{2gh_2}$$

uz $h_1 > h_2$



(4) U tekućini je uronjeno tijelo mase M kao na slici.
Pronađi po kojem se zakonu tijelo giba u x-smjeru



F = VANJSKA SILA

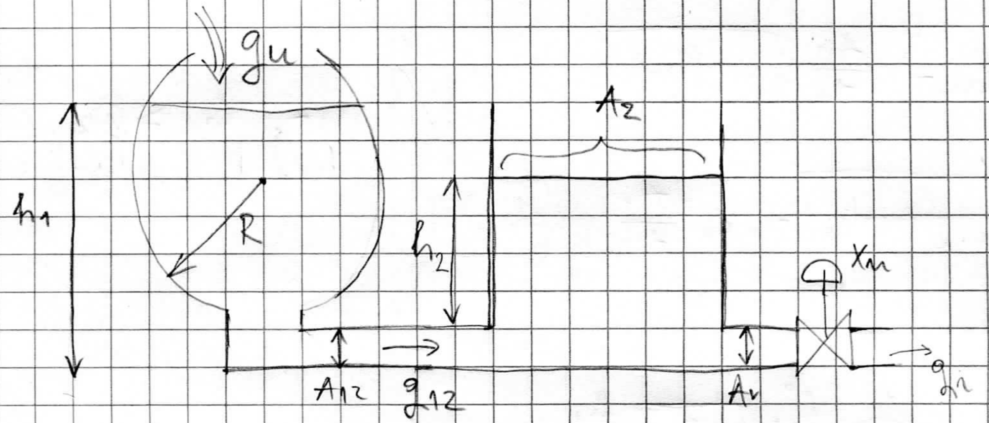
$$F_u = \rho_T \cdot V_u \cdot g = \rho_T \cdot x \cdot 2x \cdot \frac{1}{2} \cdot L \cdot g$$

$$Ma = \Sigma F$$

$$M\ddot{x} = Mg + F - \rho_T x^2 L g$$

$$\ddot{x} = g + \frac{F}{M} - \frac{\rho_T L g}{M} x^2 = f(x, F)$$

5



$$q_i = A_v \sqrt{\rho}\, \sqrt{2\Delta p}\; x_u \quad \leftarrow \text{ZADANO}$$

$$\Delta p = \rho g (h_2 - 0) = \rho g h_2$$

$$q_i = A_v \sqrt{\rho}\, \sqrt{2 g h_2}\; x_u = A_v \rho \sqrt{2 g h_2}\; x_u$$

$$\dot m_1 = q_u - q_{12}$$

STERA BEZ KAPICE: $V = \frac{\pi}{3} h^2 (3R - h)$

$$m_1 = \rho \frac{\pi}{3} h^2 (3R - h)$$

$$\frac{dm_1}{dt} = \rho \frac{\pi}{3} \left[2h \cdot \dot h (3R - h) + h^2 \cdot (-\dot h) \right]$$

$$= \rho \frac{\pi}{3} \left[6h\dot h R - 2h^2 \dot h - h^2 \dot h \right] = \rho \frac{\pi}{3} \left[(6hR - 3h^2)\dot h \right]$$

$$\cancel{p_0} + \rho g (h_1 - h_2) + \frac{1}{2} \cancel{\rho v_1^2}^{\,0} = \cancel{p_0} + \cancel{\rho g h_{12}} + \frac{1}{2} v_{12} \rho$$

$$q_{12} = A_{12} \rho \sqrt{2g(h_1 - h_2)}$$

$$\dot h = \frac{1}{\rho \frac{\pi}{3} (6hR - 3h^2)} \left[q_u - A_{12} \rho \sqrt{2g(h_1 - h_2)} \right] = f(h_1, h_2, q_u)$$

$$\dot m_2 = q_{12} - q_i$$

$$\rho A_2 \dot h_2 = A_{12} \rho \sqrt{2g(h_1 - h_2)} - A_v \rho \sqrt{2 g h_2}\; x_u$$

$$\dot h_2 = \frac{A_{12}}{A_2} \sqrt{2g(h_1 - h_2)} - \frac{A_v}{A_2} \sqrt{2 g h_2}\; x_u = f(h_1, h_2, x_u)$$

USTALJENO STANJE:

h_{10}, h_{20} } RAVNOTEŽNE VELIČINE

$\dot{h}_2 = 0$

$\Downarrow$

$$A_{12}\sqrt{2g(h_{10}-h_{20})} = A_v\sqrt{2gh_{20}}\; x_u$$

$$\left(\frac{A_{12}}{A_v x_u}\right)^2 (h_{10}-h_{20}) = h_{20}$$

$$h_{10} = h_{20}\left[\left(\frac{A_v x_u}{A_{12}}\right)^2 + 1\right]$$

Linearizacija mat. modela

① $y_s = f(u_s)$

taylor $\Rightarrow$ $y = f(u_0) + \frac{df}{dt}\Big|_{u_0}(u-u_0) + \cancel{\frac{1}{2!}\frac{d^2f}{dt^2}\Big|_{u_0}(u-u_0)^2} \dots$

$u - u_0 \approx 0$

$$y = \underbrace{f(u_0)}_{y_0} + \underbrace{\frac{df}{dt}\Big|_{u_0}}_{K}(u-u_0)$$

$y = y_0 + K(u-u_0)$ — AFINA

$y - y_0 = K(u-u_0)$

$\Delta y = K\Delta u$

- odrediti radnu točku
- derivirati

$y = y_0 + \Delta y$

$u = u_0 + \Delta u$