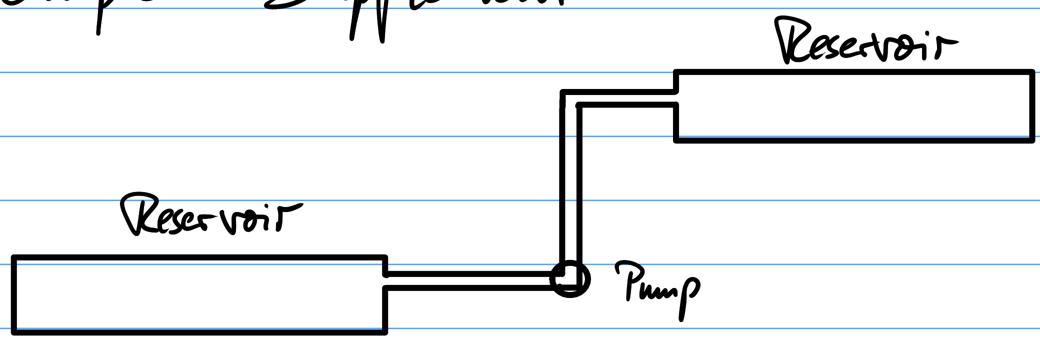
Chap 5: Supplement



Typical questions:

What is the required volume flow rate?
What losses happen at my pipe network?

Learn about:

What is an operation point for such a plant?

Chap 5, Supplement (Cont'd)

Recap: Bernoulli Eq

$$\frac{V_1^2}{2g} + \frac{p_1}{\rho g} + z_1 = \frac{V_2^2}{2g} + \frac{p_2}{\rho g} + z_2 + \underbrace{\Delta h_L}_{} \quad (1)$$

Sum of all losses along the streamline

„Verlusthöhe"

„head loss"

Pressure loss due to friction

$$\Delta p_L = \lambda \frac{L}{D} \frac{\rho}{2} V^2 \Rightarrow \boxed{\Delta h_L = \frac{\Delta p_L}{\rho g} = \lambda \frac{L}{D} \frac{V^2}{2g}}$$

Pressure loss due to sudden expansion

$$\Delta p_L = \underset{\text{zeta}}{\zeta} \frac{\rho}{2} V^2, \quad \zeta = \left(1 - \frac{A_1}{A_2}\right)^2 \Rightarrow \boxed{\Delta h_L = \frac{\Delta p_L}{\rho g} = \underset{\text{zeta}}{\zeta} \frac{V^2}{2g}}$$

ch. 5, p. 58

Pressure loss due to a constriction

$$\Delta p_L = \underset{\text{zeta}}{\zeta} \frac{\rho}{2} V^2 \quad \zeta = \left(\frac{1-\psi}{\psi}\right)^2 \Rightarrow \boxed{\Delta h_L = \frac{\Delta p_L}{\rho g} = \underset{\text{zeta}}{\zeta} \frac{V^2}{2g}}$$

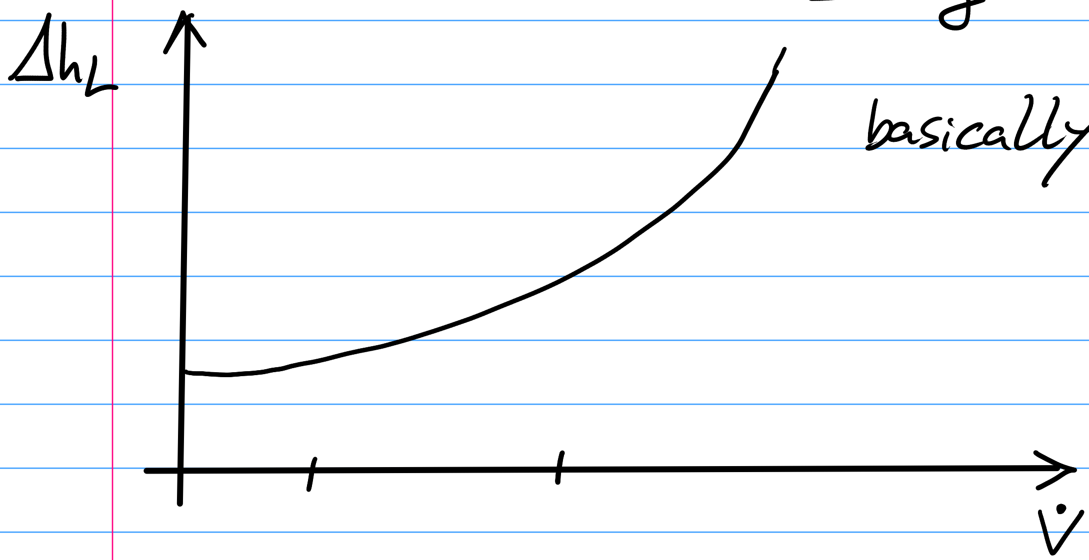
$$\psi = \frac{A_2}{A'}$$

ch. 5, p. 60

Chap 5, Supplement (cont'd)

$$\frac{1}{2g}\left(V_1^2 - V_2^2\right) + \frac{1}{\rho g}\left(p_1 - p_2\right) + z_1 - z_2 = \underbrace{\sum \Delta h_L}_{\text{Sum of all individual losses of all sorts of equipment}}$$

$$\ldots = \sum \zeta \cdot \frac{V^2}{2g}$$



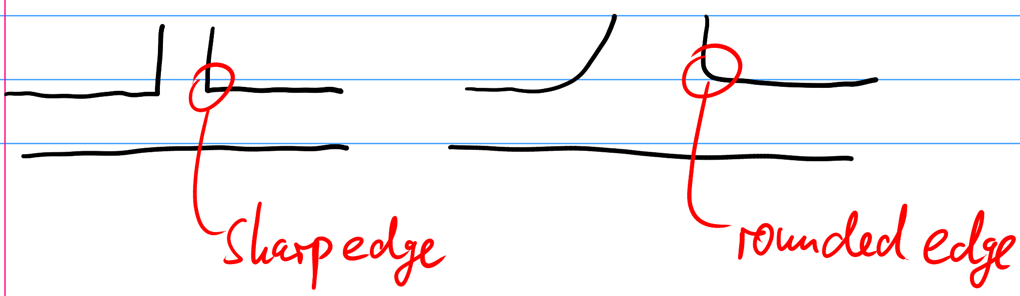
basically a parabola

$\dot{V}$ ~ characteristic for average velocities

Systemkennlinie

system characteristic

⇒ That is a lot of work to compute!



All details in pipe system matter!

Chap 5 Supplement (cont'd)

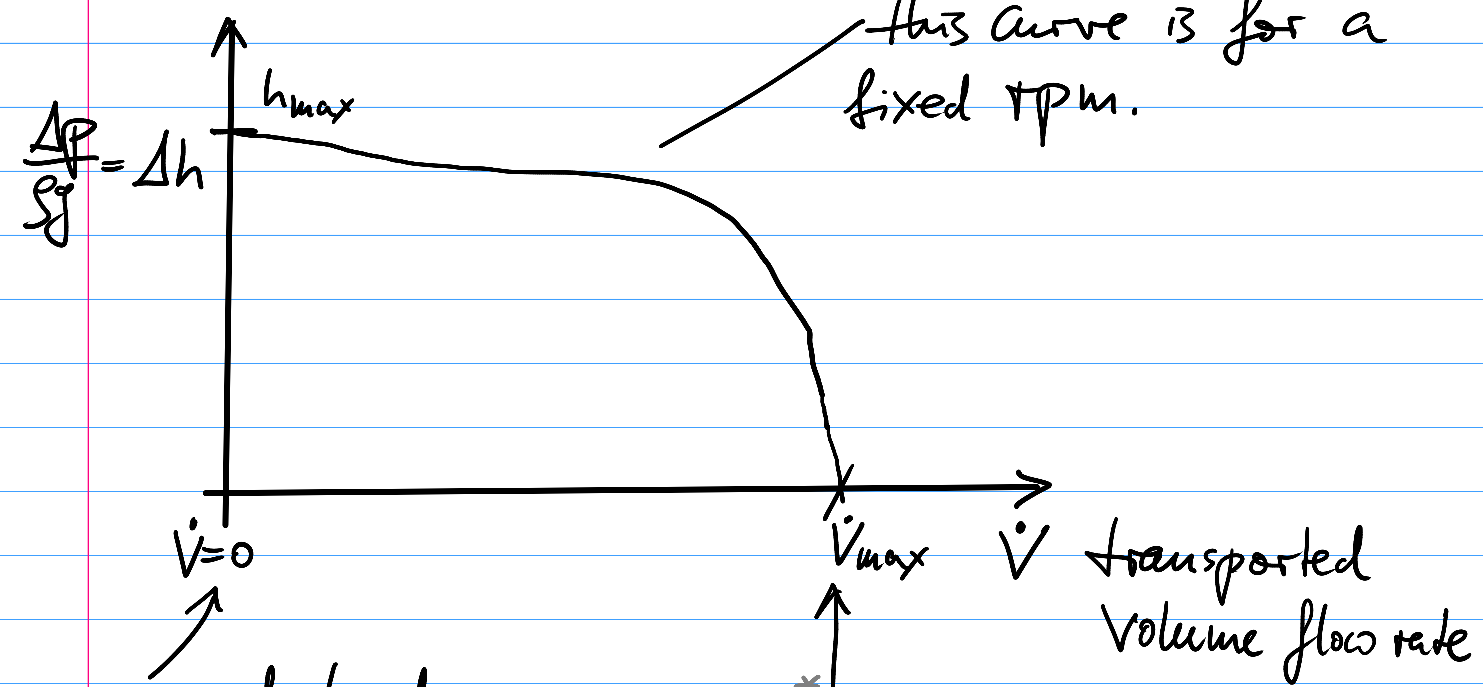
Pumps required to provide the volume flow rate. Potentially many pumps, potentially spread over the entire system.

To operate pumps (economically) efficiently, pumps should meet the requirements.

Our example of radial pumps is just one special single case.

Typically pumps behave like this characteristic:

this curve is for a fixed rpm.



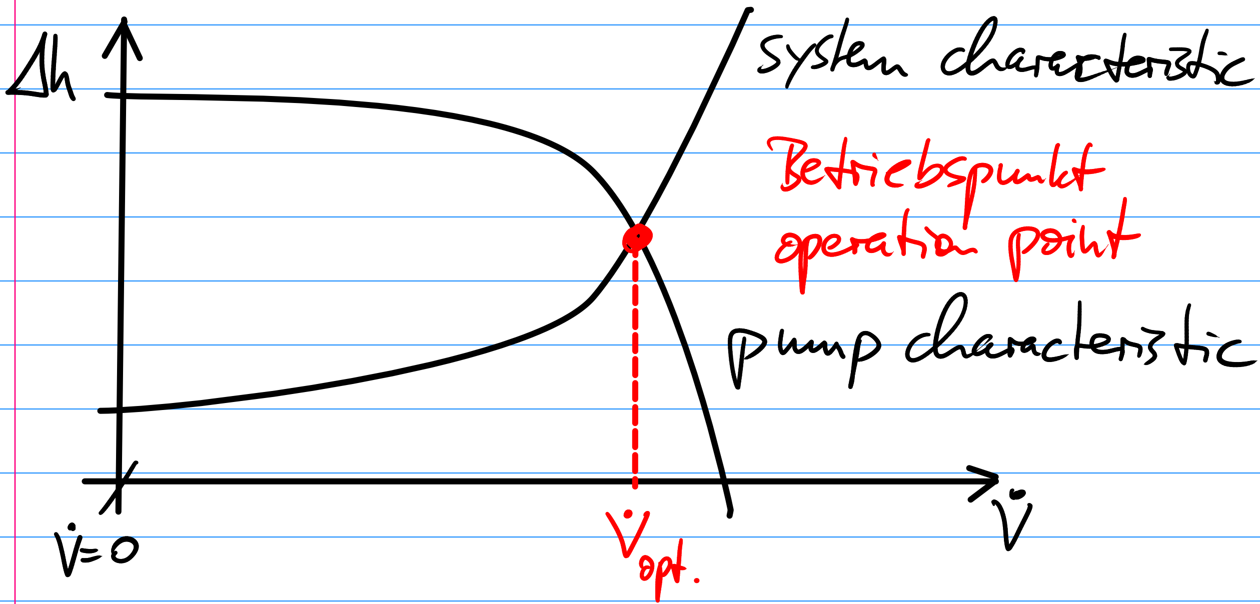
Pipe end closed
$\Rightarrow$ maximum pressure

no* opposing pressure
$\Rightarrow$ maximum flow rate

*very small

Chap 5 Supplement (cont'd)

⇒ Match characteristics



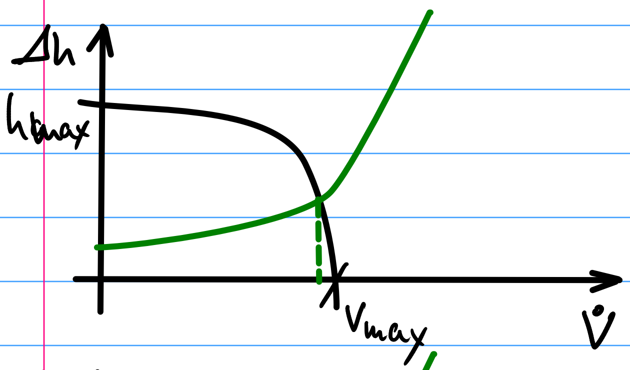
↳ That should better be the volume flow rate required from the plant.

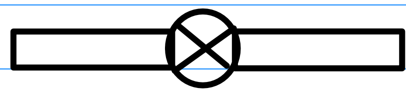
⇒ Choose the right pump! That is the task!

⇒ What to look for?
How to go about it?

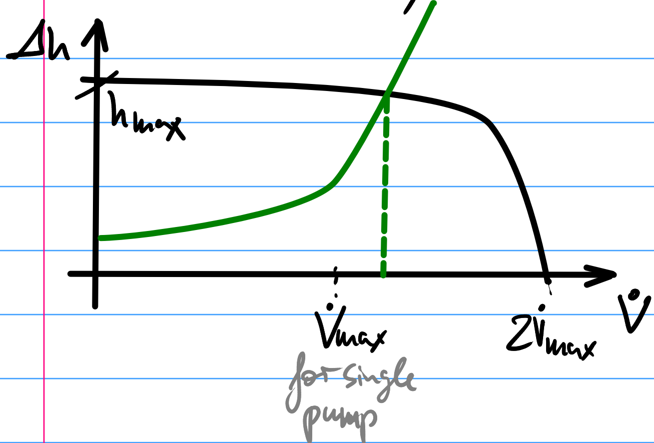
Chap 5 Supplement (Cont'd)

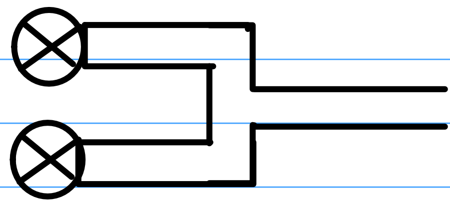
pump characteristics (yes, plural)





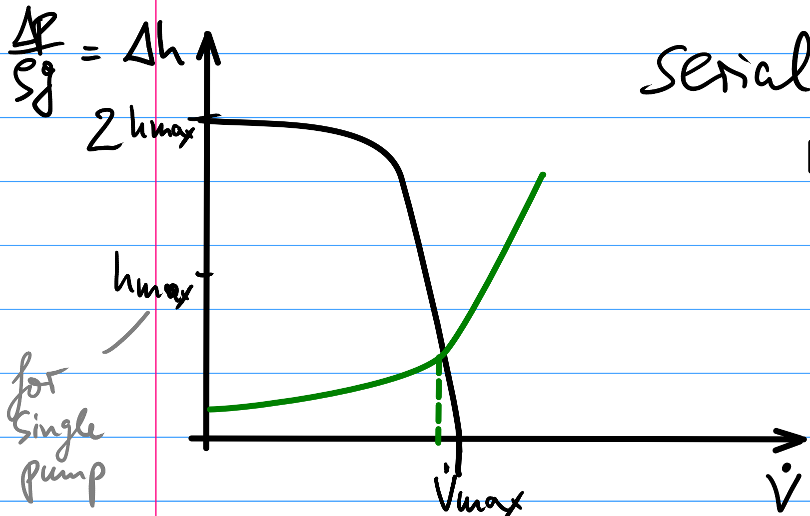
parallel operation

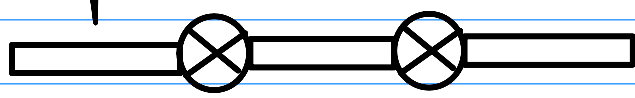




can transport double of the flow rate

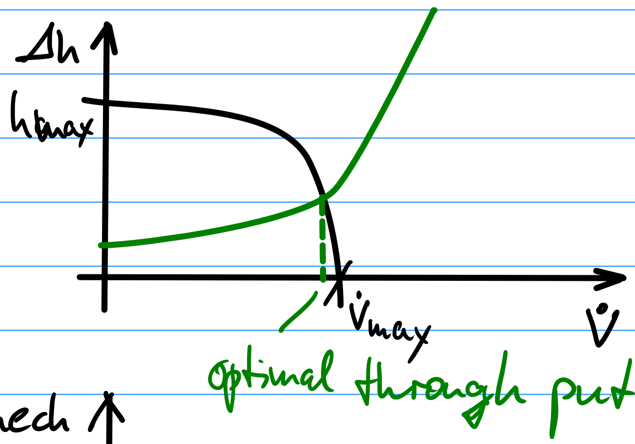
serial operation





pressures add up
$\Rightarrow$ doubling of the maximum pressure (or "head" for that matter)

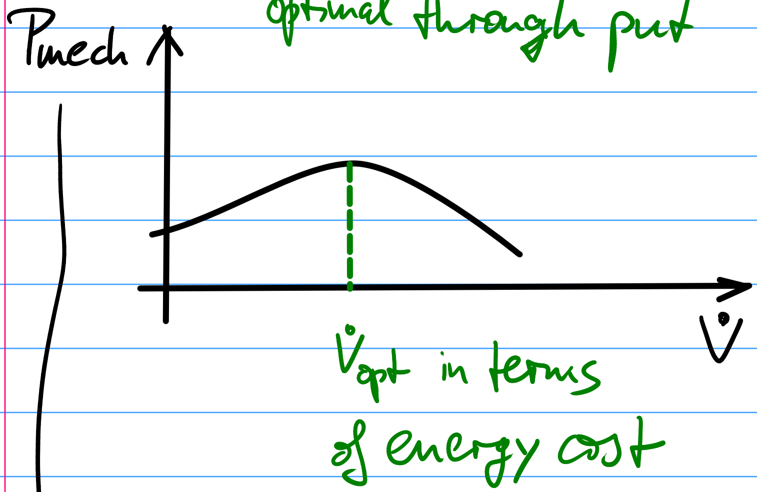
Chap 5 Supplement (Cont'd)



pump characteristic

system characteristic

This should match!



mechanical power delivered

Chap5 Supplement (Cont'd)

So far pump characteristic for
<u>fixed rotation</u> speed!

⇒ How do quantities change, if rotation speed changes?

⇒ Drehzahl n = rotations per minute

unit $\left[\frac{1}{s}\right]$

Volume flow rate $\dot{V}_2 = \dot{V}_1 \frac{n_2}{n_1}$

pressure $p_2 = p_1 \left(\frac{n_2}{n_1}\right)^2$

mech. power (for work) $P_{W,2} = P_{W,1} \left(\frac{n_2}{n_1}\right)^3$