STUCKY

Variable speed pump-turbines

Issues for hydraulic machinery

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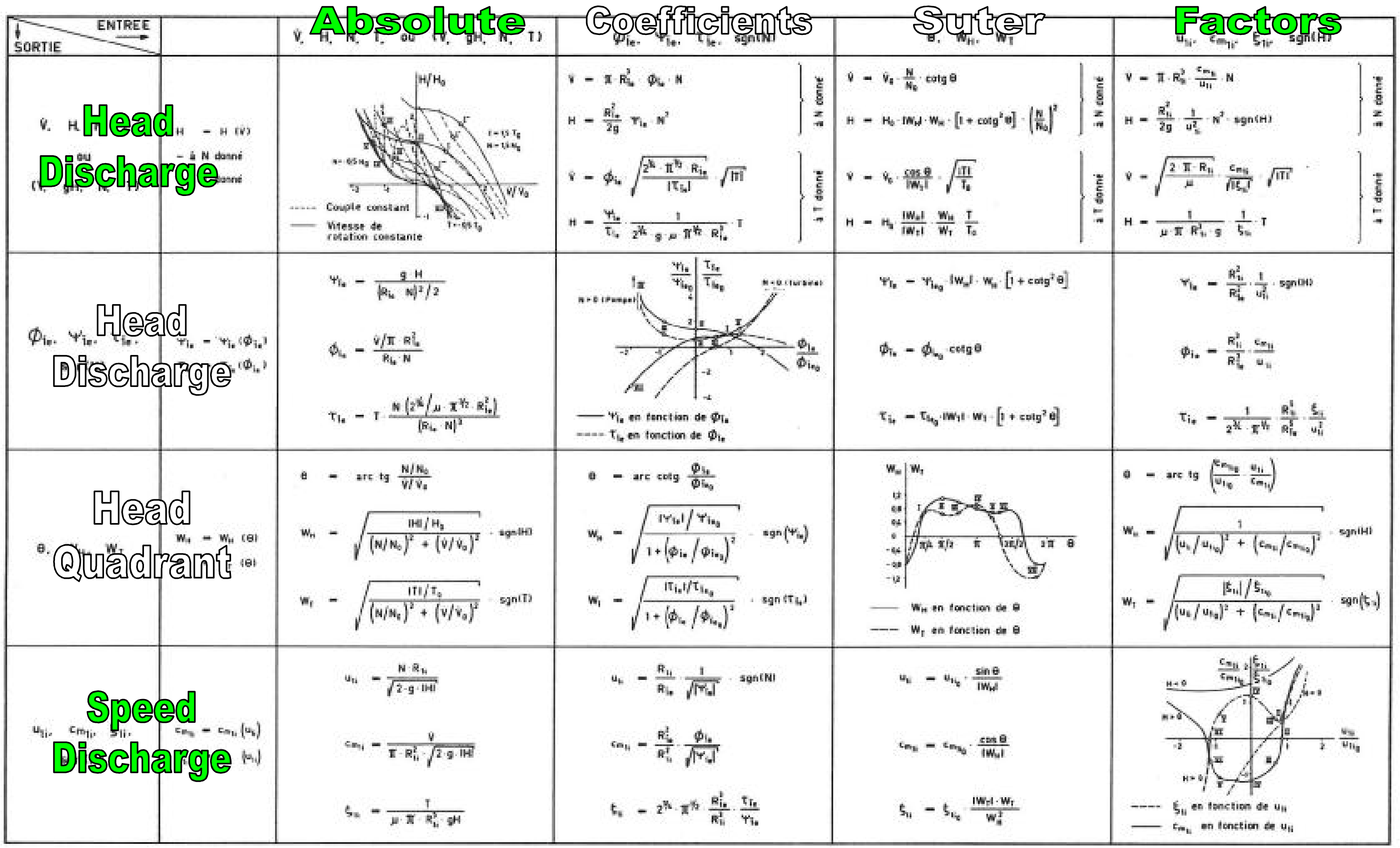
Variable speed pump-turbines – Issues for hydraulic machinery

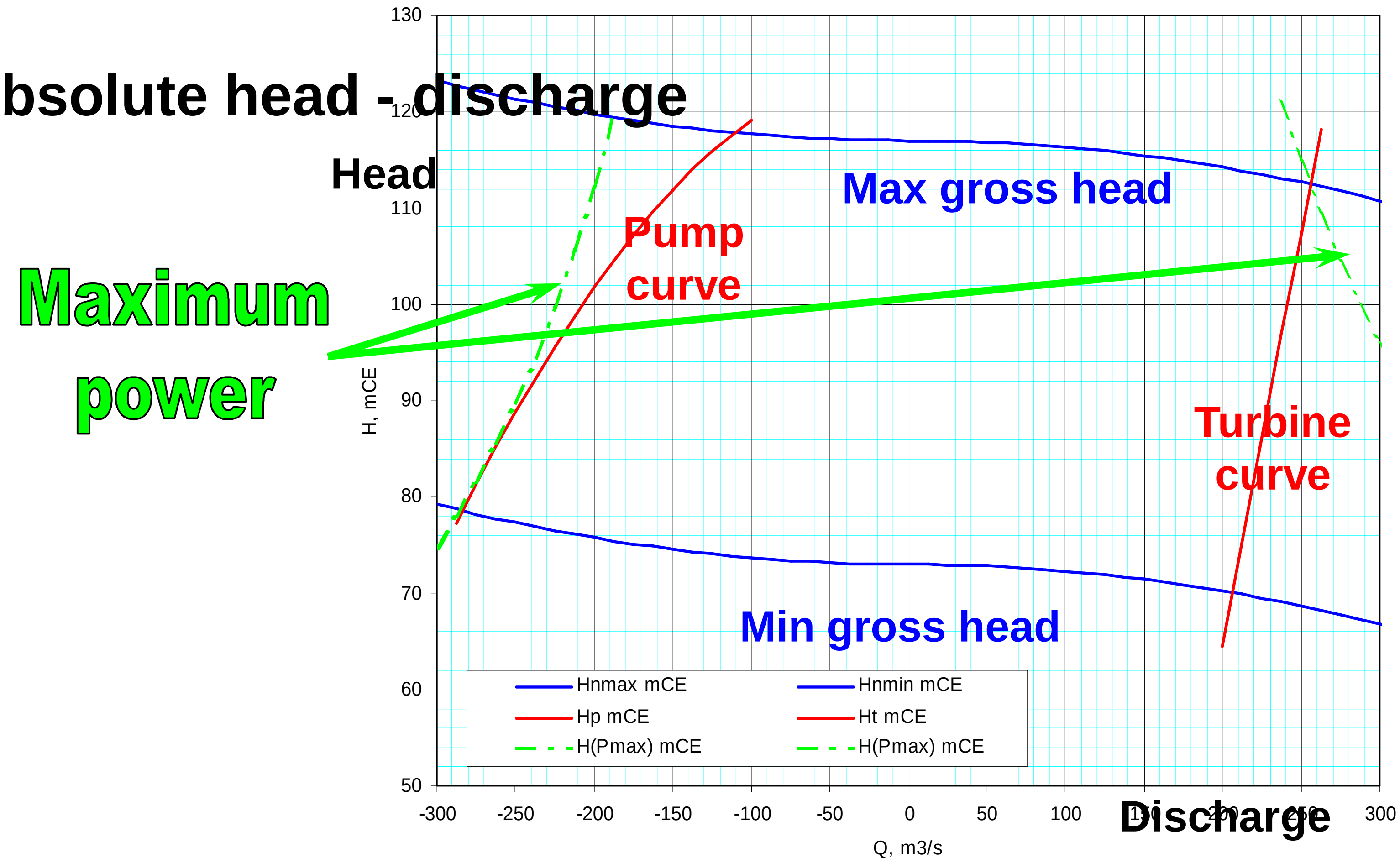
- Machine and system curves
- Power governing in pump mode
- Turbine best-efficiency head
- Pump mode cavitation at low head
- Pump start stability at high head
- Turbine mode stability

Machine curves



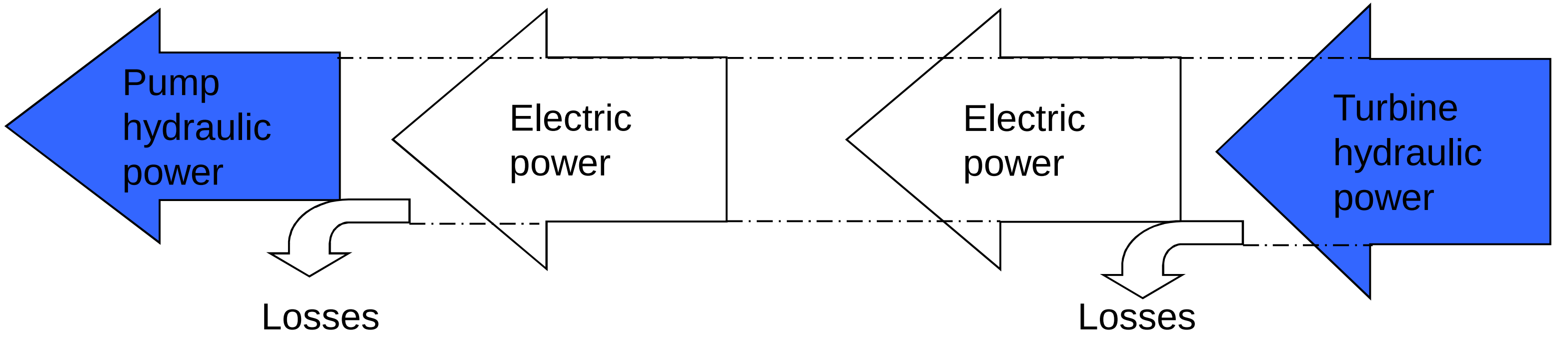
Machine and system curves

- **Absolute head - discharge**



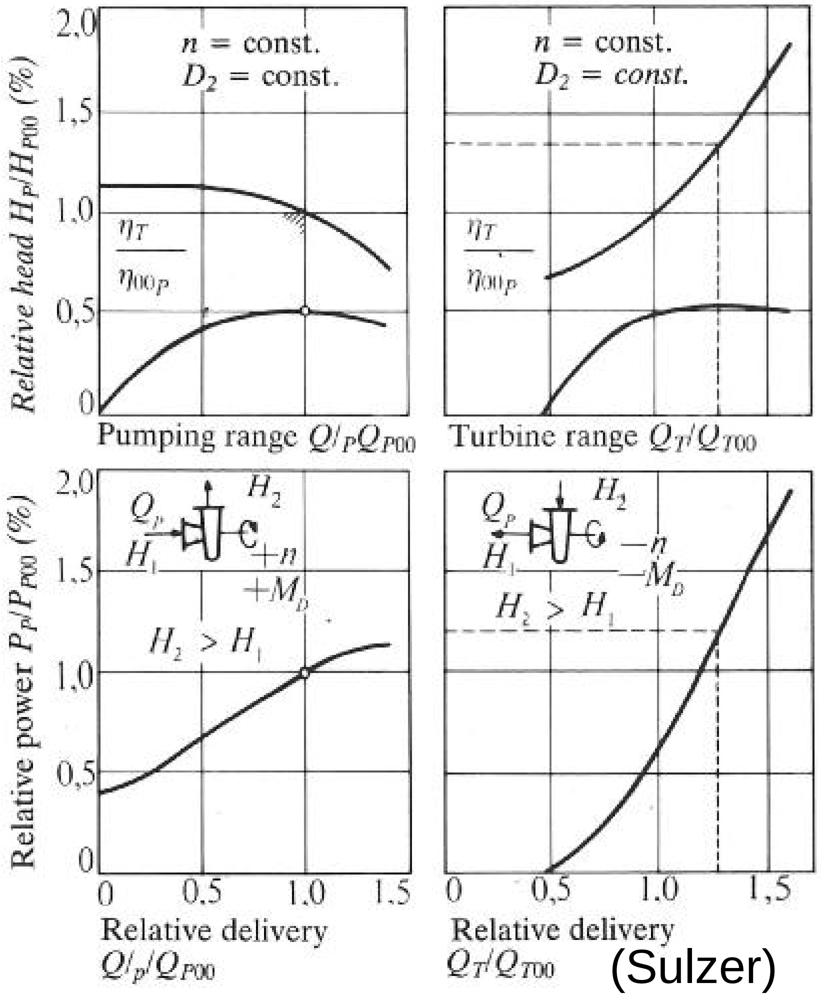
Machine and system curves

- **Maximum power in pump and turbine modes**



Machine and system curves

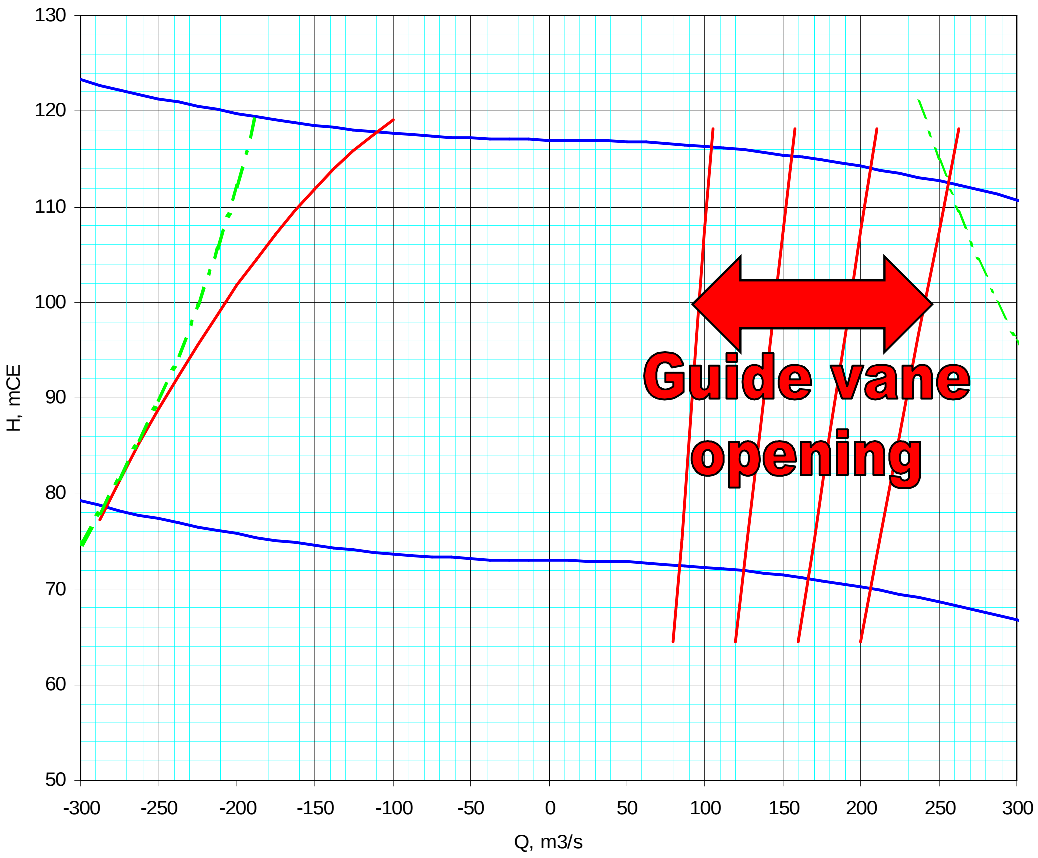
- **Maximum power is at high discharge**
  - **⇒Maximum pump power is at lowest head**



(Sulzer)

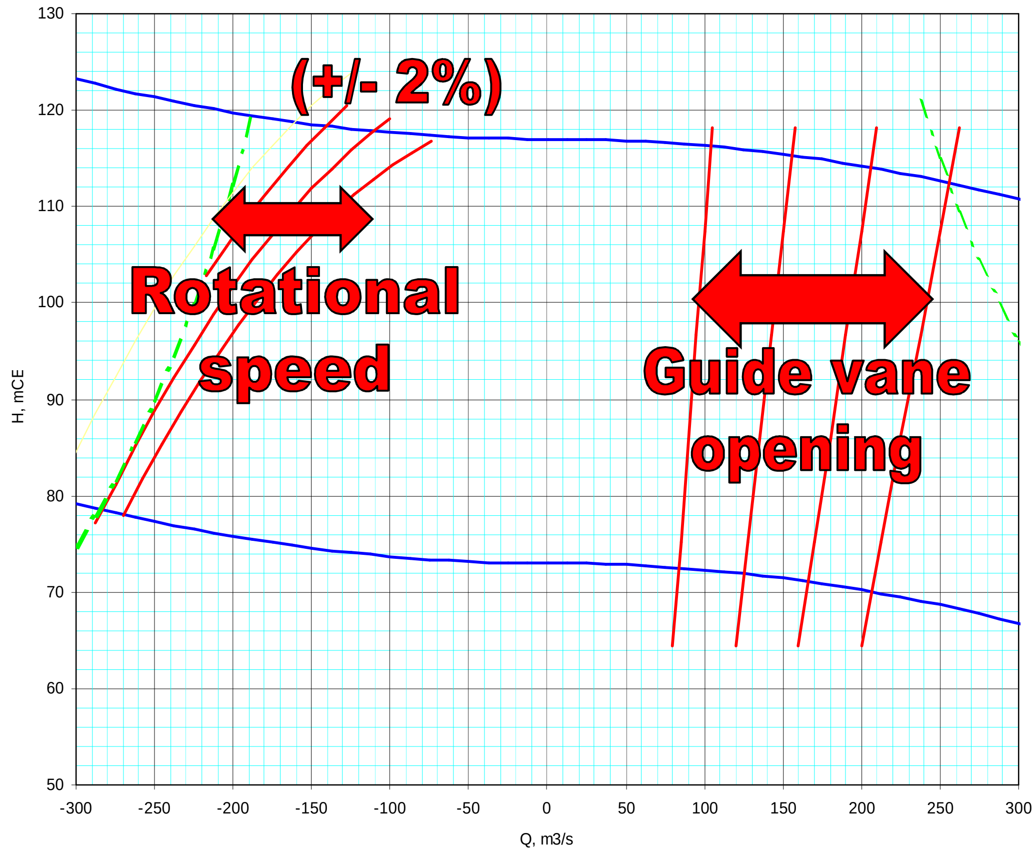
Power governing in pump mode

- **Constant speed: power governing in turbine mode only**



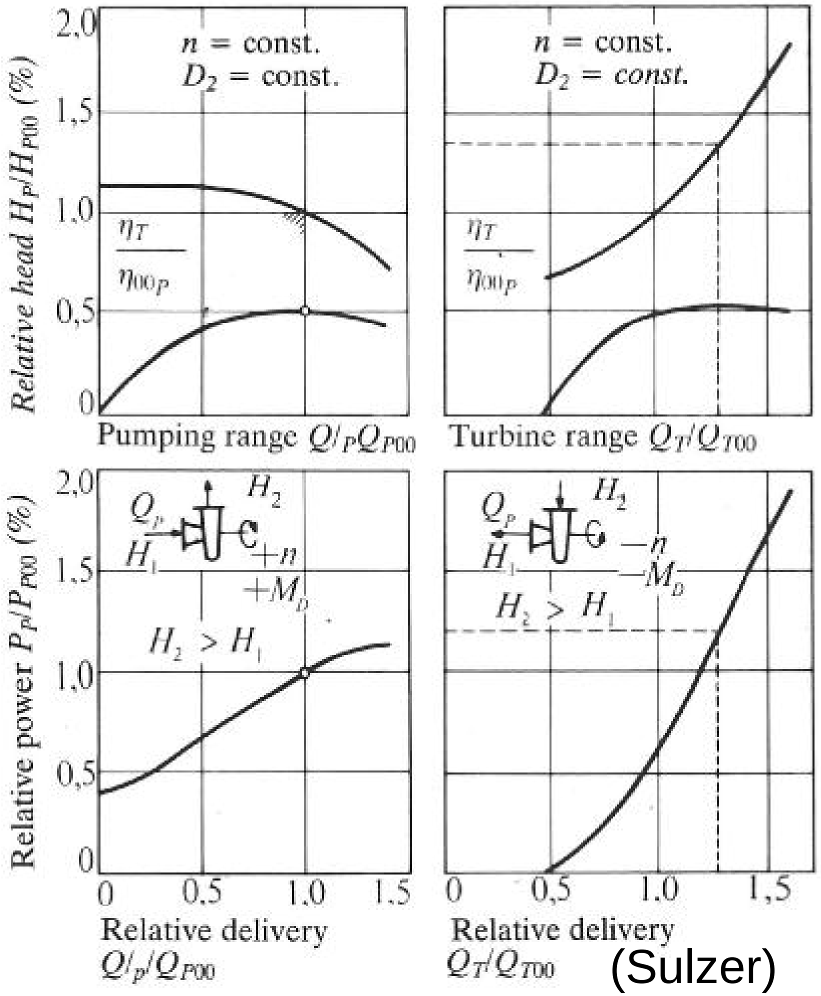
Power governing in pump mode

- **Variable speed: power governing in pump mode also**



Turbine best-efficiency head

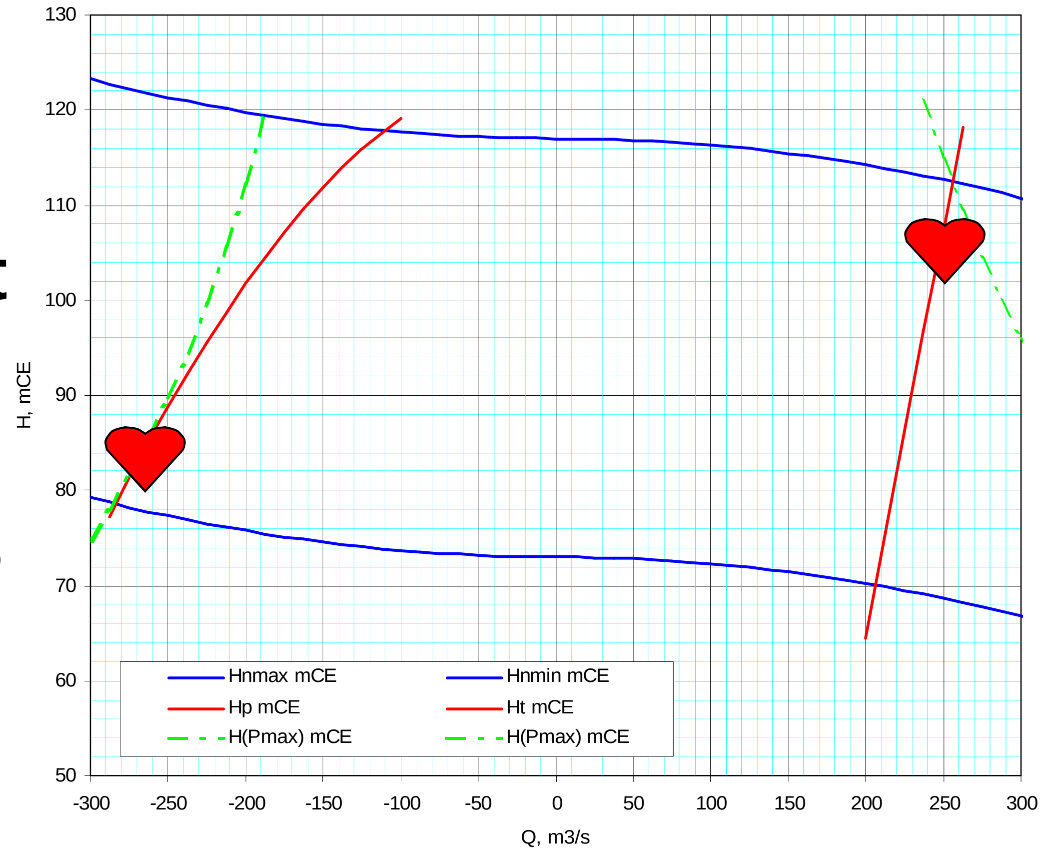
- **Turbine BEP at greater head than pump BEP**
  - **⟹Variable speed allows efficiency gain in turbine mode**



(Sulzer)

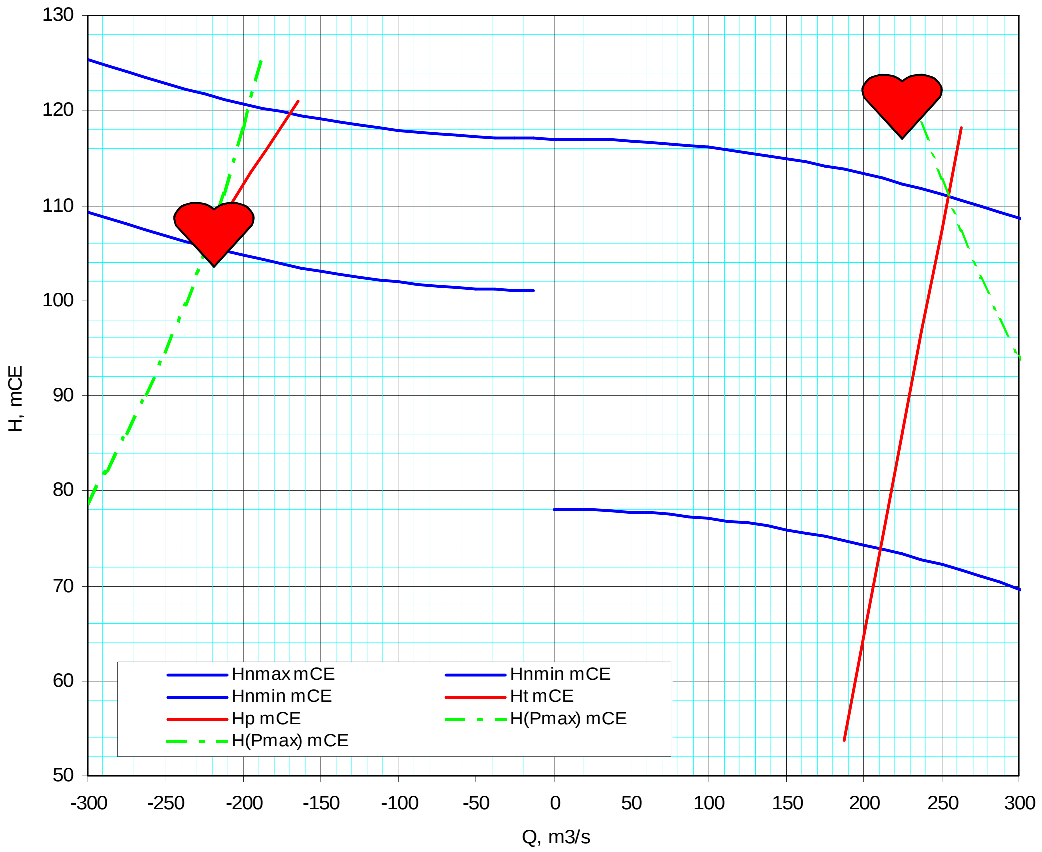
Pump mode cavitation at low head

- **BEP close to max discharge**
  - **⇒Reduced efficiency at high head**
  - **⇒High turbine BEP discharge**



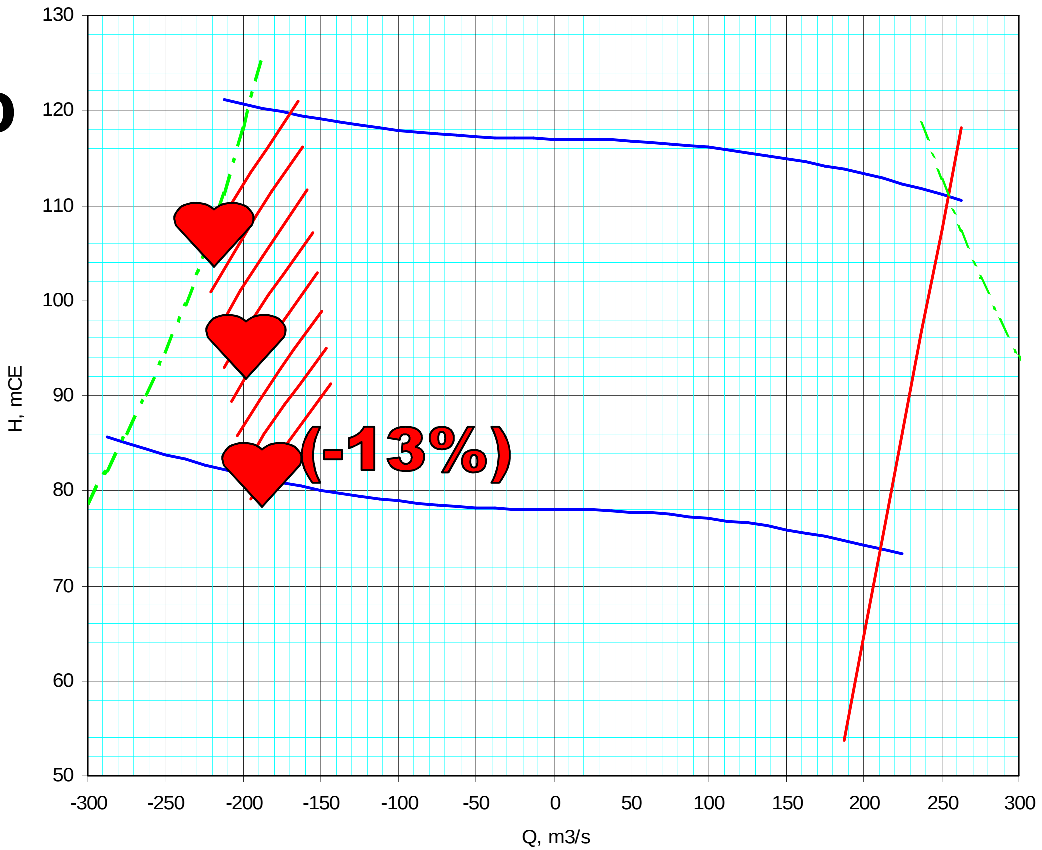
Pump mode cavitation at low head

- **Reduction of pump head range**
  - **⇒Plant operation restricted**
  - **⇒Turbine operation below BEP head**



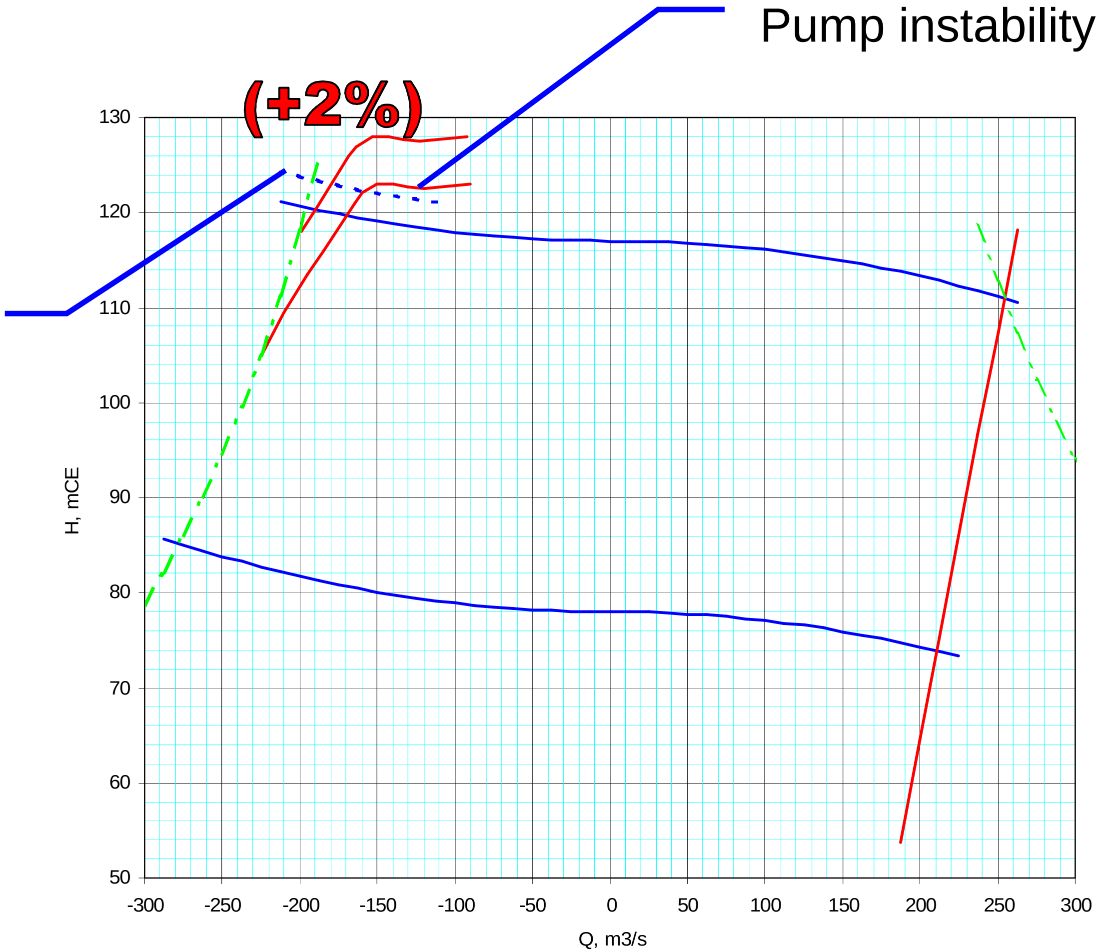
Pump mode cavitation at low head

- **Variable speed**
  - ⇒**Little or no restriction**
  - ⇒**Less submersion required at low speed**



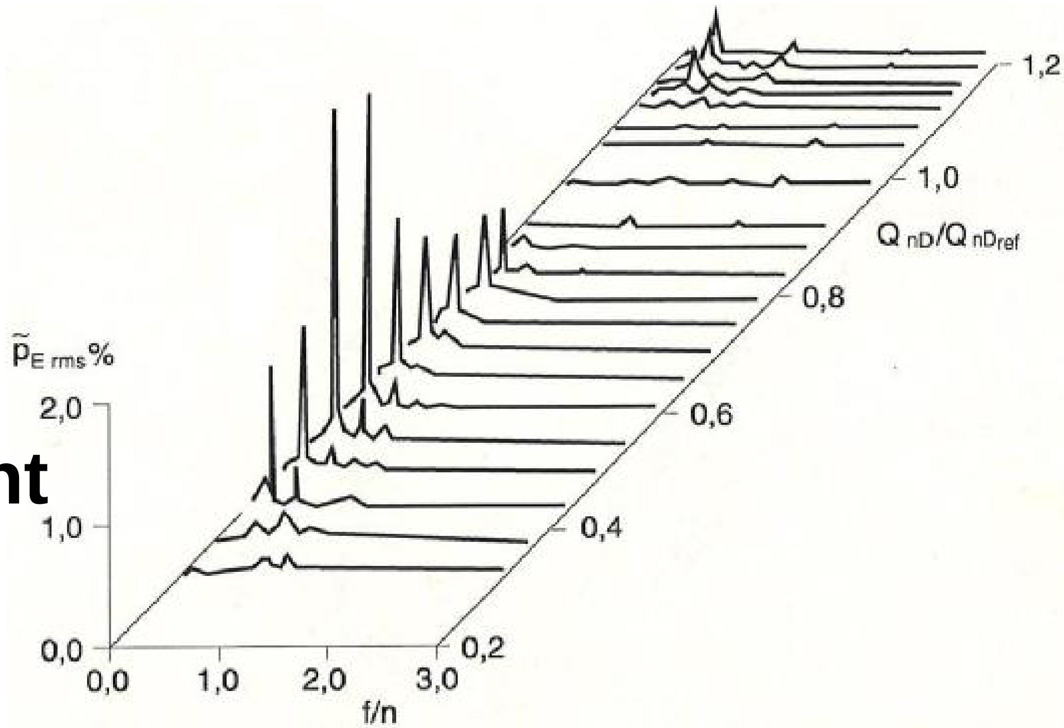
Pump start stability at high head

Transient head rise at pump start



Turbine mode stability

- **Hydraulic excitation frequencies are proportional to rotational speed**
  - **⇒Variable speed may help prevent system resonance**



Variable speed can:

- **Allow power governing in pump mode**
- **Improve efficiency in turbine mode**
- **Improve pump operation over large head range / reduce submersion**
- **Improve pump start stability at high head / reduce surge tank volume**
- **Help prevent hydraulic system resonance**

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Thank you for your attention