Steam Attemperation

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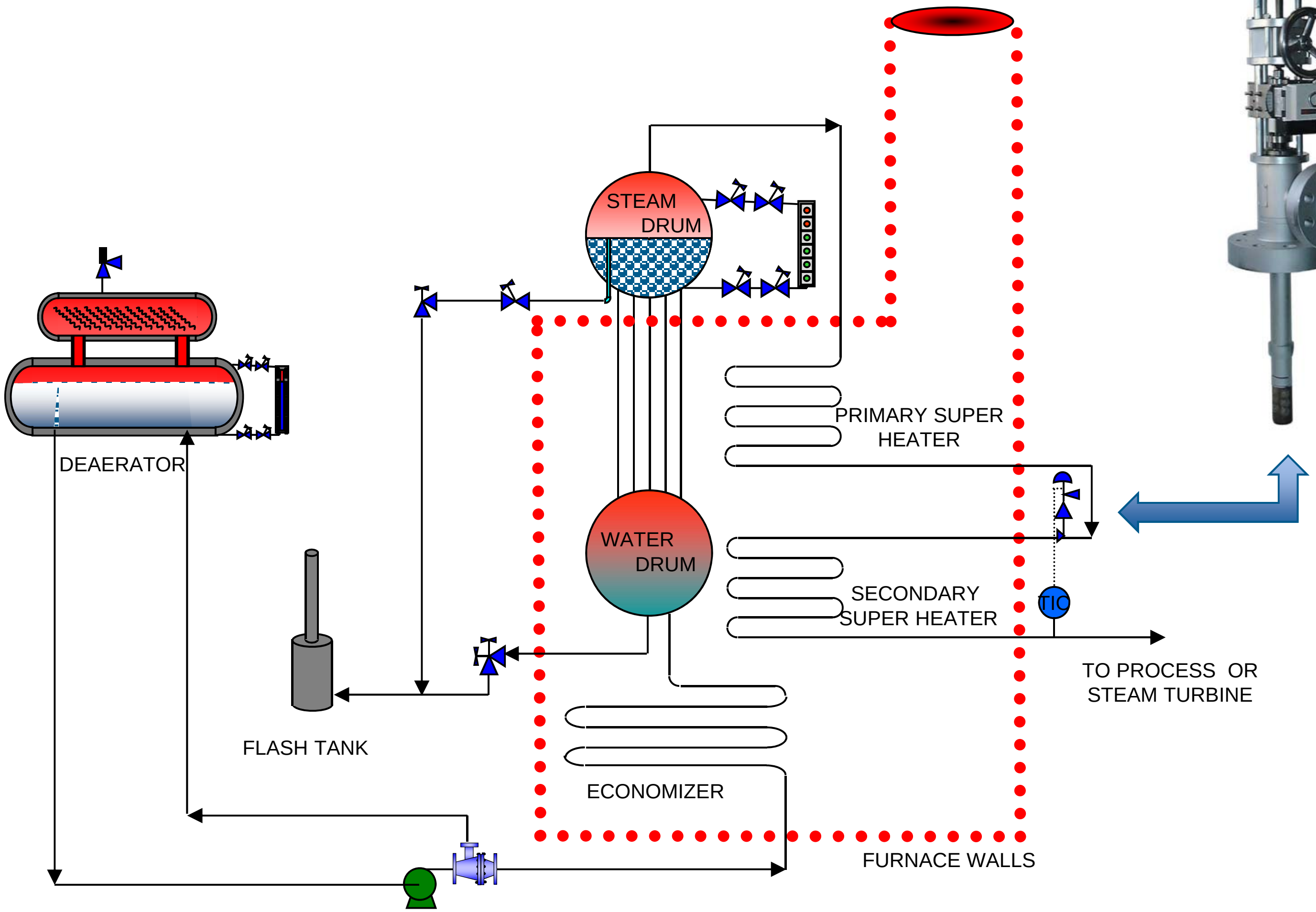
Steam Attemperation / Desuperheating

There are many different types of desuperheating systems. Each version has it's advantages and disadvantages. The primary goal in choosing a desuperheater is to insure rapid injection water evaporation while meeting the temperature control set point.

Parameters to consider:

- Controllability or Turndown
- Steam flow velocity
- Pipe Distances
- Droplet Size
- Nozzle type

The application (example):
Where to find the desuperheating control valve?



Trends in the market and technology

- Operating temperatures and pressures increase:
  - Steam temperatures up to 650ºC/ 1200ºF
  - Water pressure > 200 bar / 2900 PSI
- Thermal Cycling of power plants increases (several times/day)
- “Fast starting” combined cycle power plants in less than 30 minutes connected to the grid.
- Shorter start-up times increase Turn-Down ratio as cooling water flow increases.
- Material stresses rise with new steam conditions and quick load changes.
- The market is looking at new materials and construction methods.

Desuperheater product requirements

Due to increasing temperatures, more cycling and shorter startup times of HRSG boilers, product requirements increase:

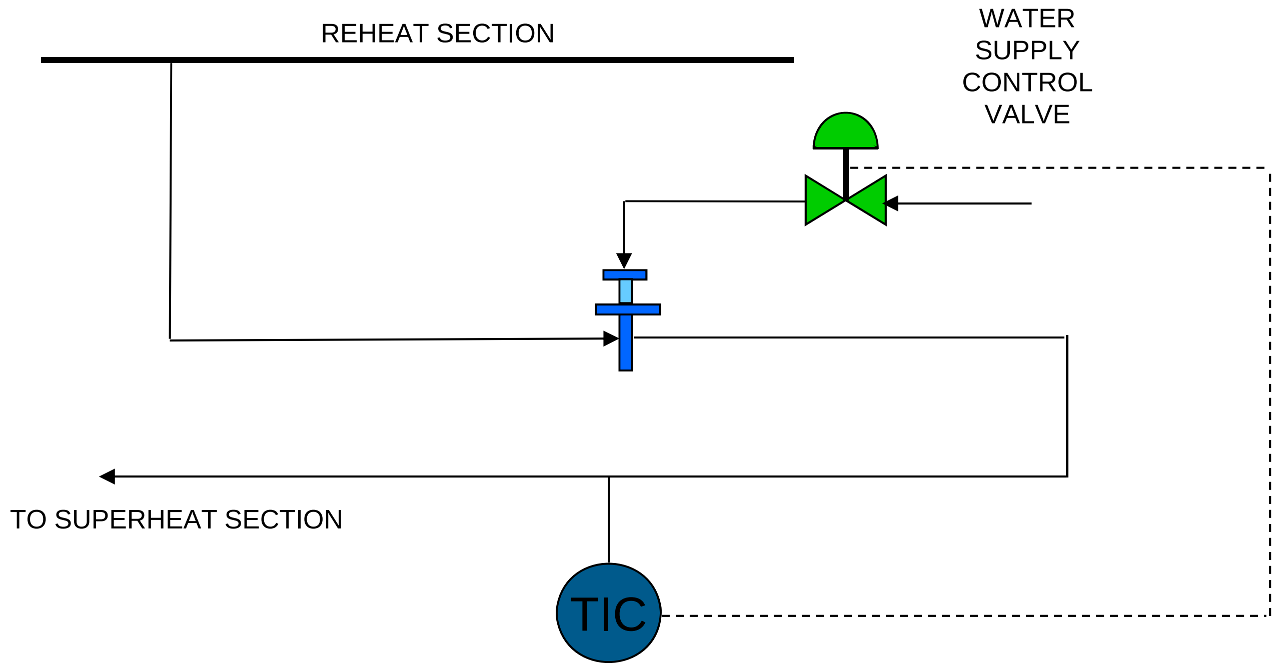
- Minimize evaporation length to provide maximum design flexibility and fast startup.
- Optimize temperature distribution in the steam flow for accurate and fast temperature readings/control.
- Maximize turn down ratio to handle both fast startup as normal cases.
- Maximize thermal cycling life time to decrease failure and maintenance costs if the material becomes highly stressed.
- Minimize pipe wall stresses/ water impingement to prevent costly pipe repairs (Thermal fatigue).

Pipe Run Distances vs Evaporation length

To have an idea of distances (rule of thumb):

- 3 to 5 meter of straight run down stream to the first elbow
- 10 to 15 meter of continuous run to the TIC insertion point.

In practice; both distances need to be as short as possible.



Research topic:

Mathematical model for prediction of evaporation length of water injection into steam.

Evaporation length is influenced by:

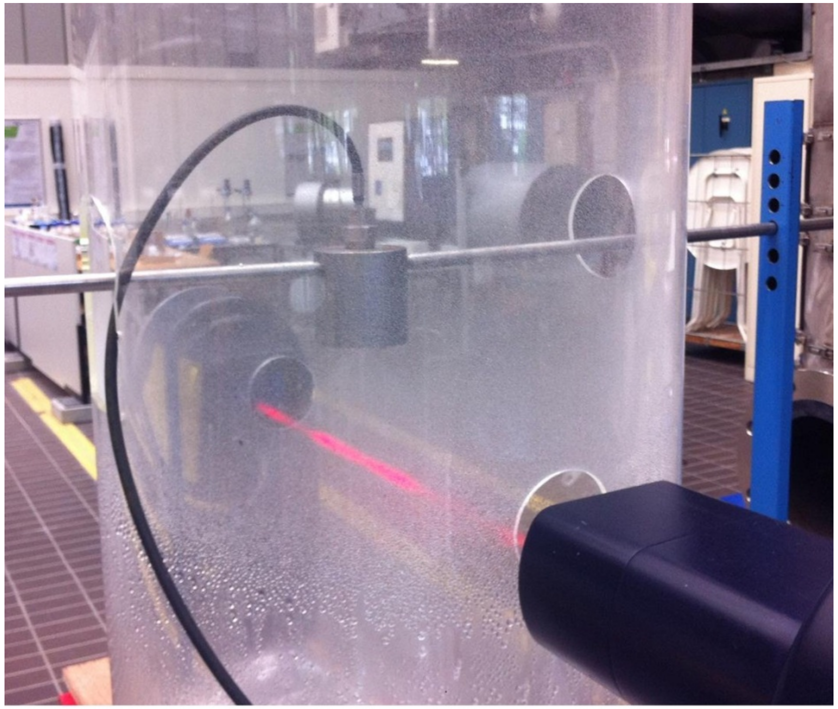
- Primary atomization
  - forming of droplets caused by the geometry and technology of the applied nozzle.
- Secondary atomization
  - Split up of larger droplets into smaller ones caused by drag forces of gas flow on the droplet.
- Droplet distribution
  - More equal droplet distribution inside the steam, the contact between hot steam and cold droplet is better guaranteed and evaporation time of each droplet is shortened.

Primary Atomization - Measurements on Pressure Swirl Nozzles

Master thesis study – University of Eindhoven, Netherlands

Measurement techniques

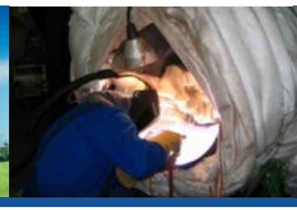
- Fraunhoffer Diffraction Theory (Malvern Spraytec)
    - *droplet size (Sauter Mean Diameter)*
    - *droplet distribution*
- Laser Doppler Anemometry (LDA)
    - *sheet velocity measurement*



Measurement range:

- *Fluid:*	Water
- *Pressure difference over nozzle*	5 – 80 bar
- *Volume flow*	0.5 – 9 LPM
- *Temperature range*	5 – 85°C




Results on Pressure Swirl Nozzles

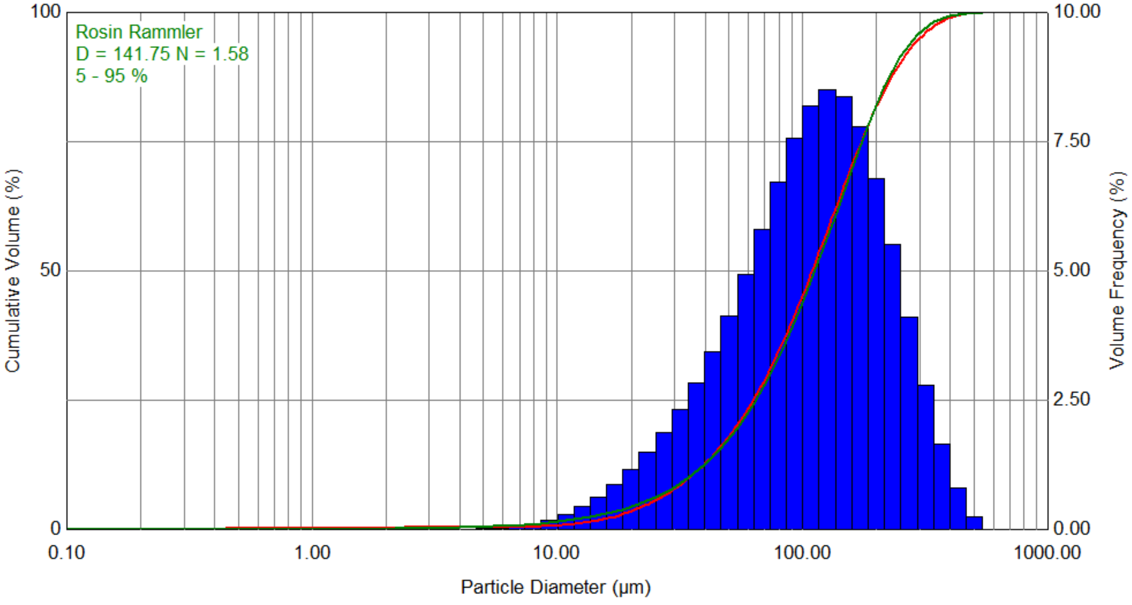
Mathematical model

Input :

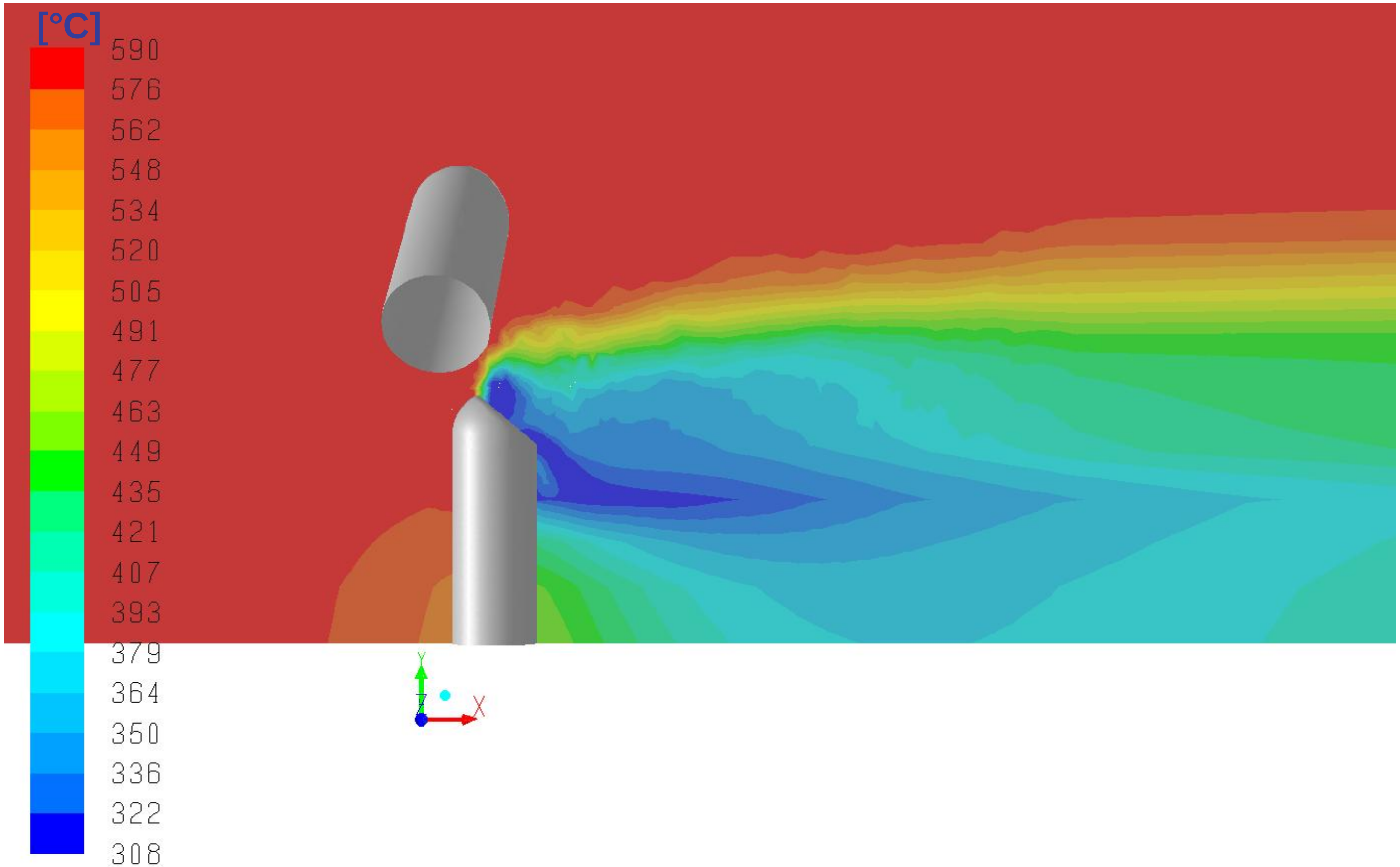
- **Nozzle Geometry:**
    - *Orifice diameter*
    - *Swirl diameter*
    - *Inlet area*
- **Pressure difference**

Output :

- **Discharge coefficient (Mass flow)**
- **Sheet thickness**
- **Sauter Mean Diameter**
- **Droplet distribution**
- **Droplet velocity**

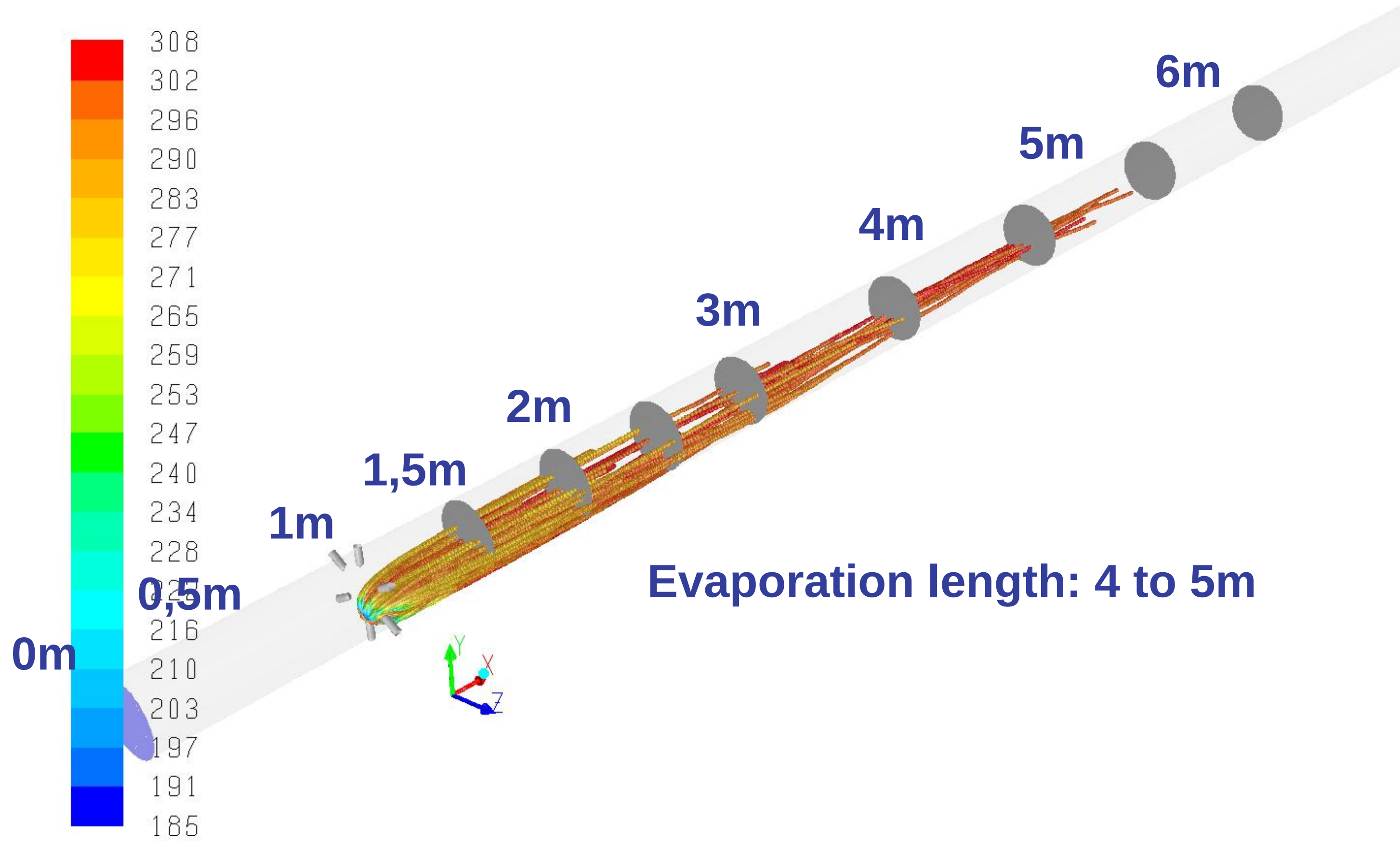


Results of primary atomisation investigation are used for CFD analysis.



Model without turbulence

Evaporation of water droplets into steam



Discrete Particle Model without coalascence or break-up.

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Research interests related to MP1106:

- Droplet breakup
- Droplet coalescence
- Multi-phase flow
- Validation of models in life steam environment

Thank you for your attention