FlexGEN

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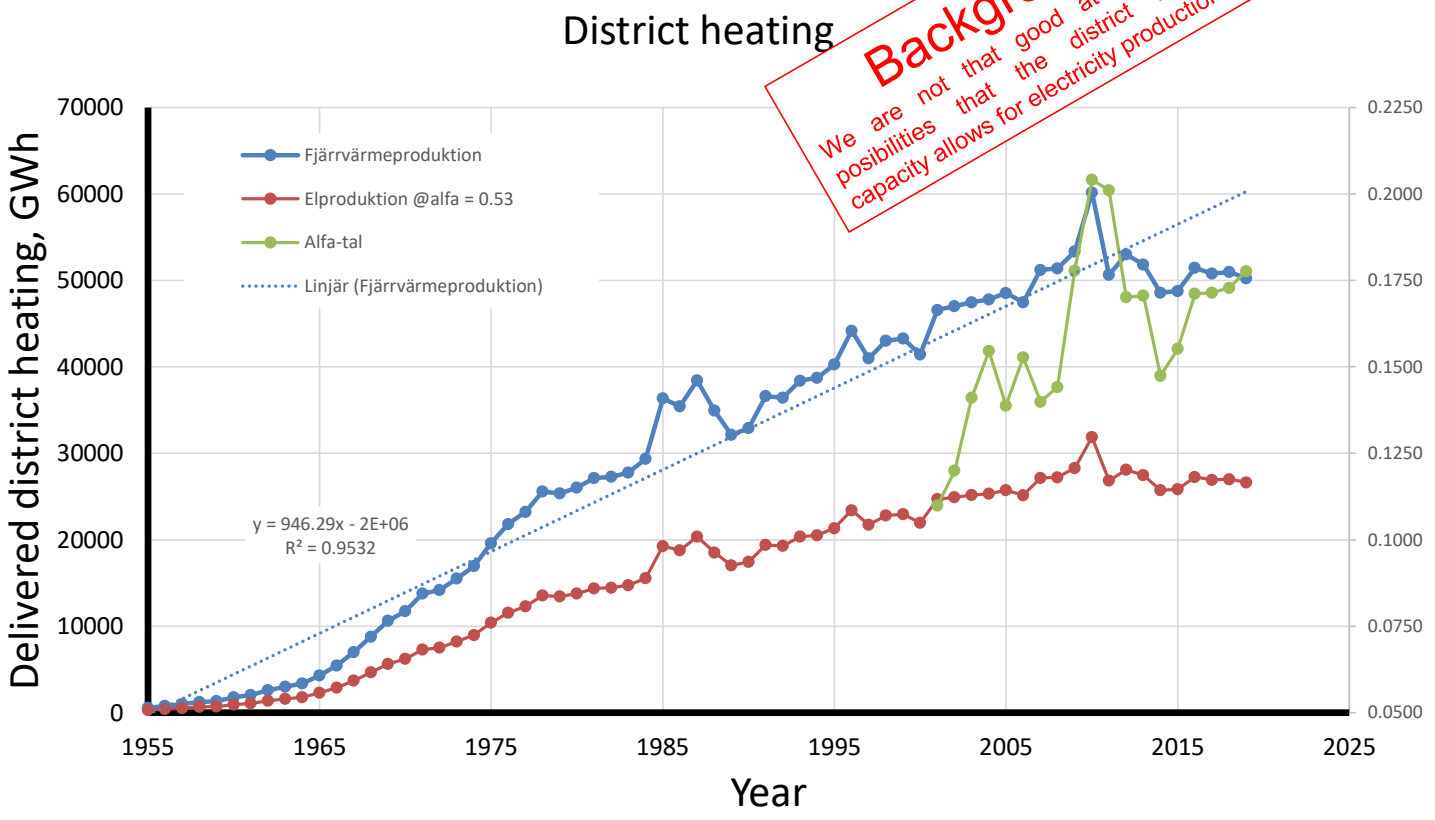
KME, 2023-03-06

Combined heat and power - Sweden

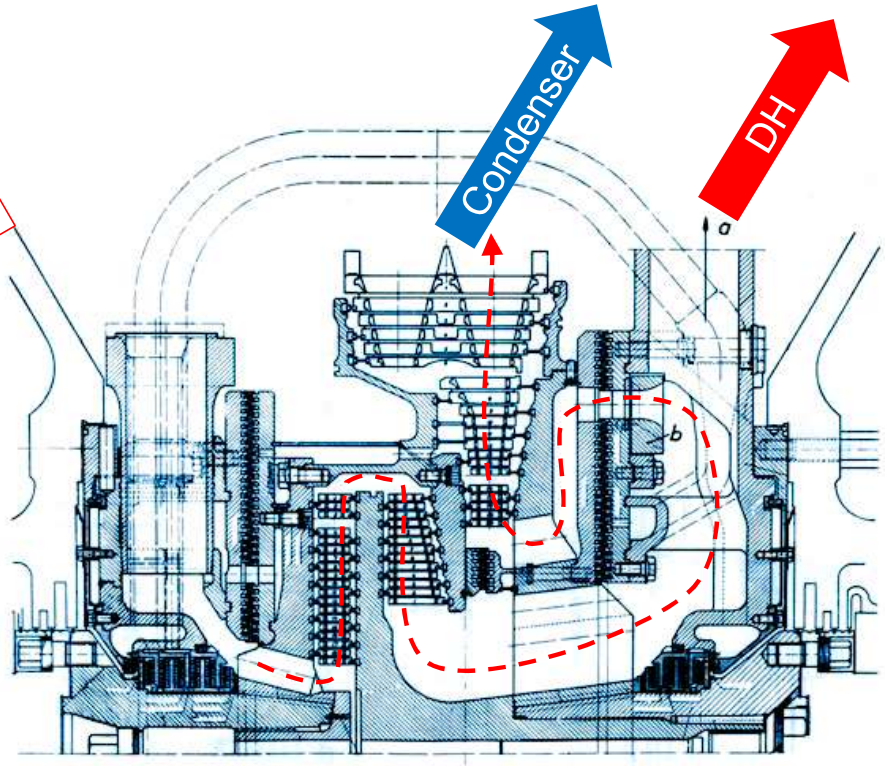


Background

We are not that good at using the posibilities that the district heating capacity allows for electricity production

The first DH-turbine – Karlstad 1950

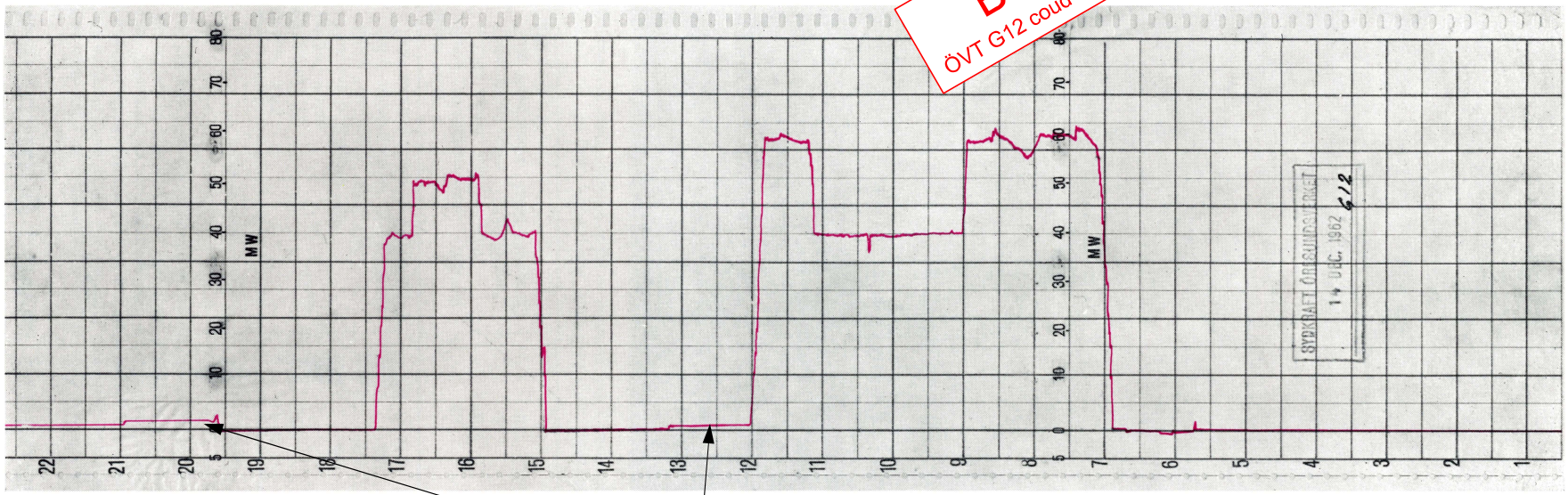
Background
Even the first steam turbine for district heating in Sweden had a condensation tail!



4.2 MW power production

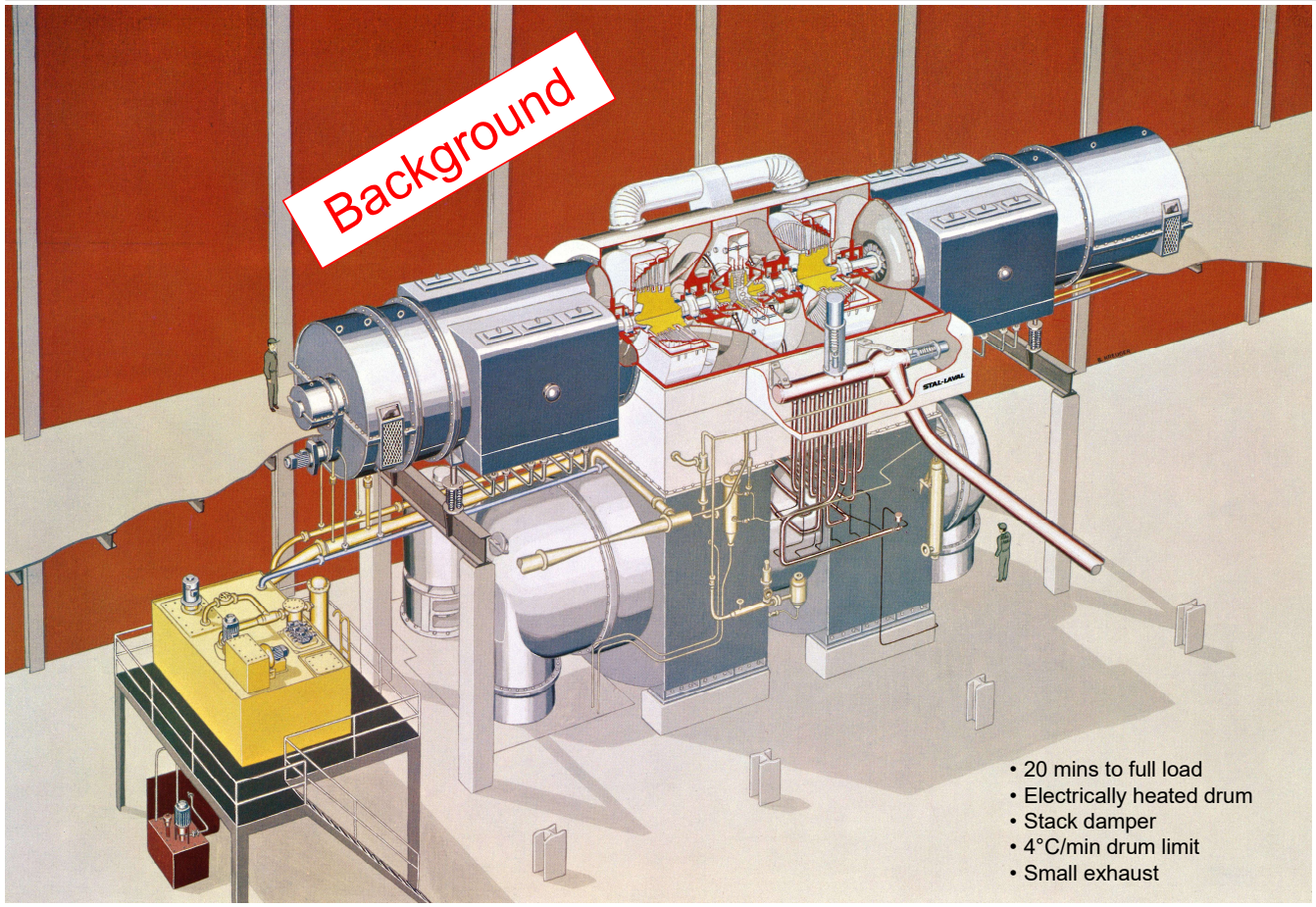
Möller-system with controlled extraction for DH

ÖVT G12 (70 MW) – 1962

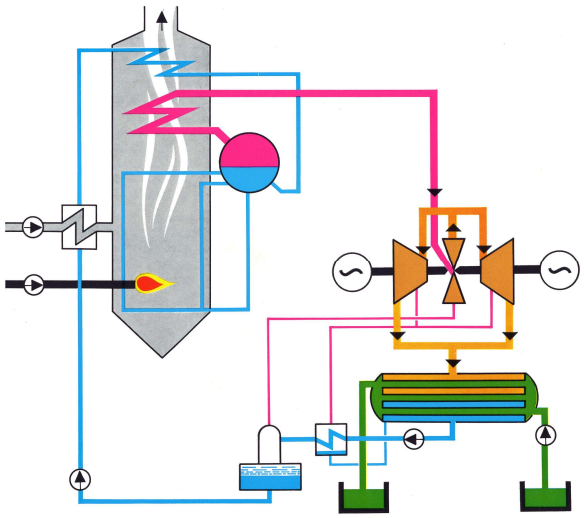


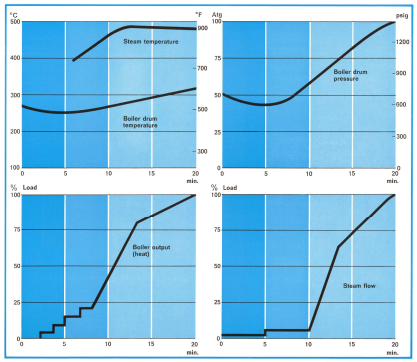
Synchronous condensation, $p_2 \geq 0.05 \cdot p_{2,100\%}$

Condensing unit – DURAX Peak Power 250 MW



- 20 mins to full load
- Electrically heated drum
- Stack damper
- 4°C/min drum limit
- Small exhaust



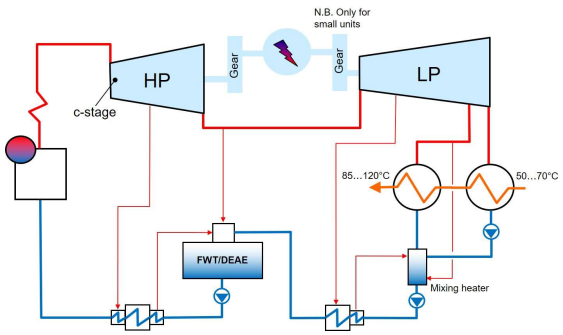


Courtesy to STAL

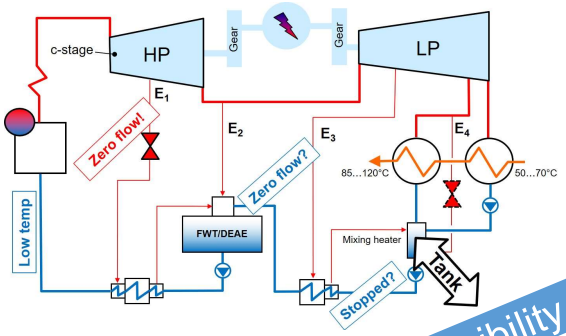
FlexGEN – a technology carrier for 2030

- Technology platform beyond 2030 – i.e. the next generation thermal
  - ✓ Flexible baseload – small and large scale
  - ✓ Biomass and integration of hydrogen
- Current plants
  - ✓ Address the power shortage
  - ✓ Enhanced flexibility

1994…2025

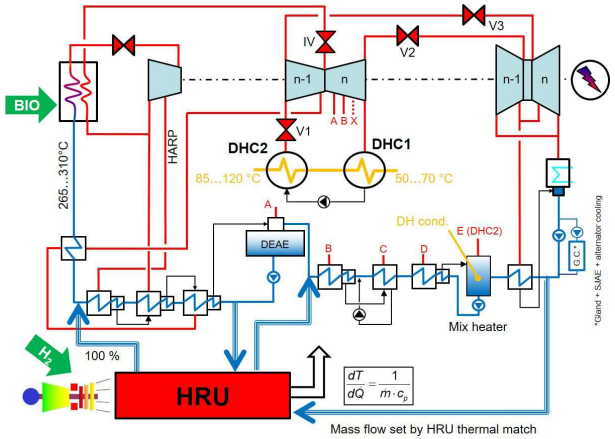


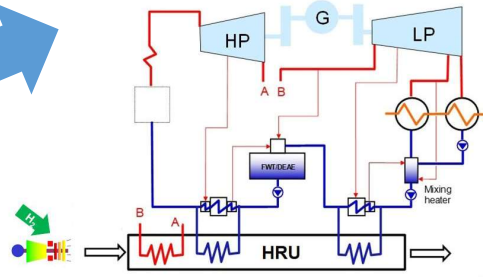
2025…2030



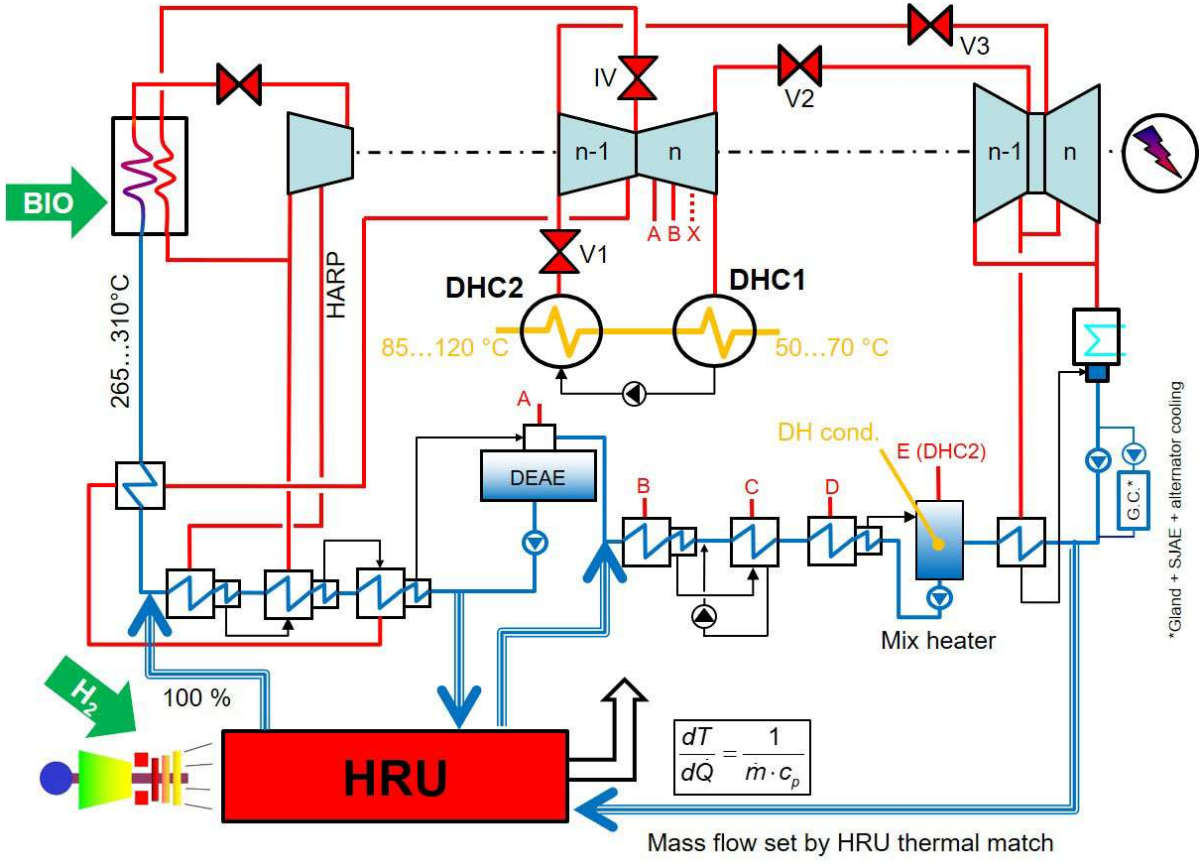
Efficiency + flexibility

2030…





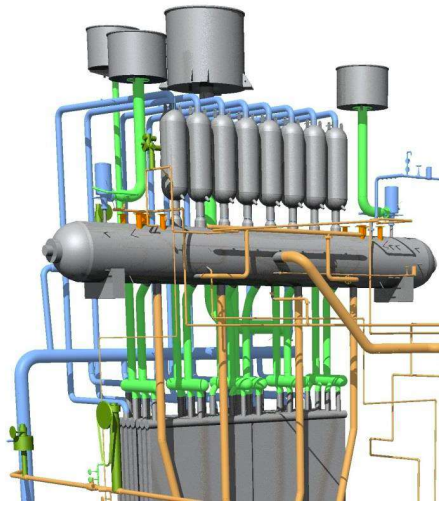
Flexible district heating plant – incl H_2

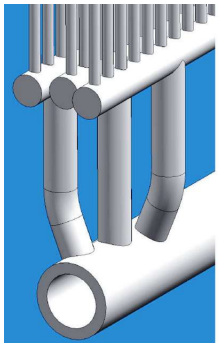


- Very Advanced steam data
  - ✓ 600…700°C
  - ✓ Chromium parts
  - ✓ Chlorides?
- Solid biomass
  - ✓ Storage
- Flexible
  - ✓ Two-shift capability
  - ✓ Condensate stop
  - ✓ RH-charge
  - ✓ Etc. etc.
- Hydrogen
  - ✓ Integration in heater train or as direct combustion in steam

Flexibility

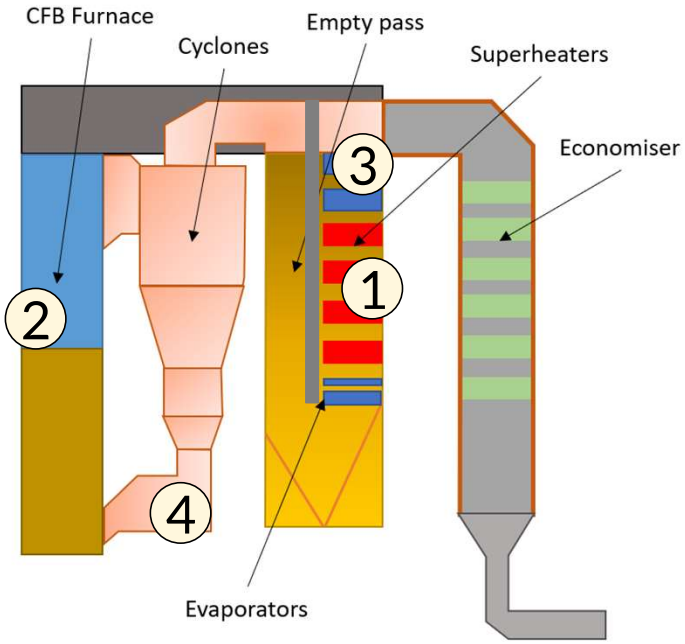
- Heat and power assets can be a part of:
  - ✓ Primary frequency control (FCR-x)
  - ✓ Secondary control (xFRR)
  - ✓ Contingency back-up
- A pile of wood chips is a formidable energy storage
  - ✓ 5…6 to fire up a CFB
  - ✓ 25…100 percent load range (agglomeration et al.)
  - ✓ The turbine can run in ventilation mode
- We need to decouple power from the heat!
- A GTCC can, regardless of size, start within 30 mins
  - ✓ 1,400 MW in 28 minutes!
  - ✓ Loads of knowledge to be carried into…
- Grid-code (RfG) requirements
  - ✓ Fault ride-through capability (house-load transfer)
  - ✓ Inertia vs. flexibility





FlexGen: WP3 Material perspective

Present challenges with biomass as fuel



Alkali chlorides (1) and (2) , molten species: (1), (2) and (3), local reducing conditions (2)

Fig. 2.2. Deposit formation on a superheater used in a grate fired boiler during combustion of waste wood.

Kassman, H. (2012). Strategies to reduce gaseous KCl and chlorine in deposits during combustion of biomass in fluidised bed boilers.

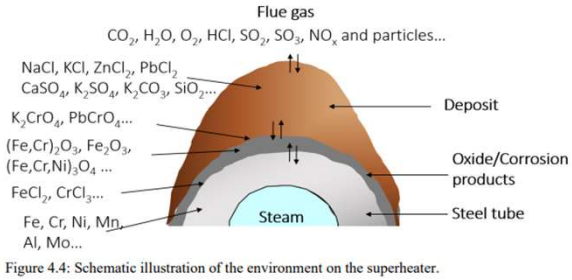
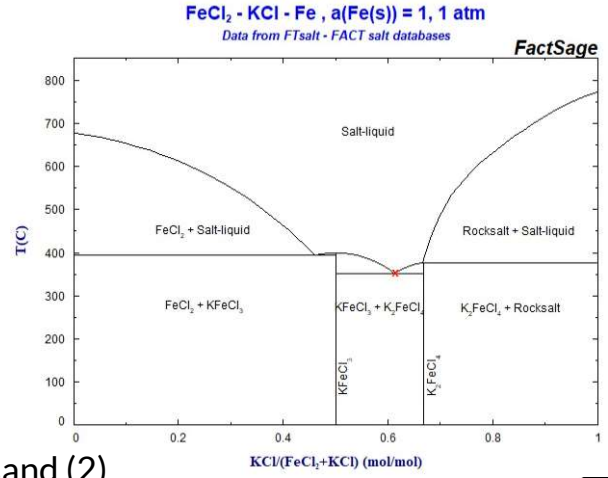


Figure 4.4: Schematic illustration of the environment on the superheater.

Larsson, E. (2017). The Corrosive Effect of Chlorine Containing Species on Waterwalls and Superheater Materials in Waste and Biomass-Fired Power Plants.

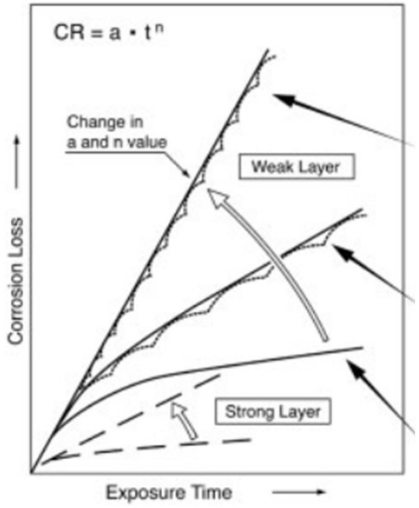
Salts	Melting point °C
$ZnCl_2$	318
$PbCl_2$	489
KCl	772
NaCl	801
$FeCl_2$	673

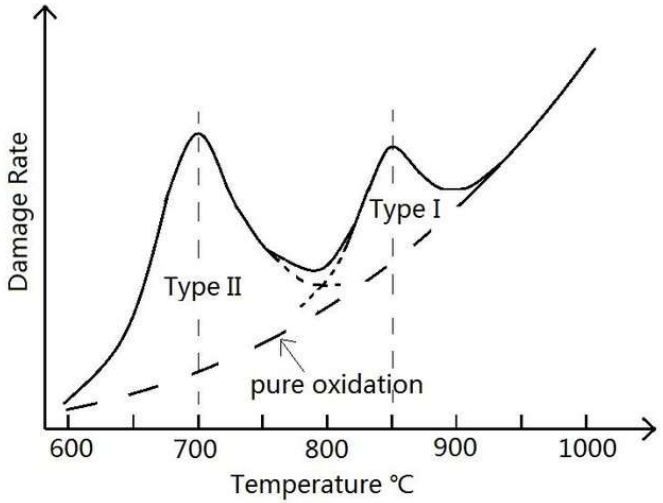


Erosion-corrosion from circulating sand (2)
Erosion-corrosion from bubbling sand (4)
Erosion-corrosion from soot blowers (1) and (3)

Future Challenges

- Effect of higher temperature:
  - Creep, molten species, hot corrosion (sulfur)
- Effect of fast startup/shutdown:
  - Fatigue, creep fatigue, thermal shock/mismatch, hydrated metallic chlorides (aqueous corrosion during shutdowns).
- Evaluation of materials in harsher conditions:
  - Laboratory studies can replicate up to a certain extent the real field conditions and its fluctuations.





Zhang, Pimin. (2019) Performance of MCrAlX coatings: Oxidation, Hot corrosion and Interdiffusion

Laboratory Exposures & Characterization methods

- Tube furnaces
  - Up to 1200°C
  - Isothermal and cyclic exposures.
  - Including gas mixtures, water vapor.
- Metallographic preparation and characterization techniques.