SRF Use in a CHP-plant at Anjalankoski/FI

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REcovered Fuels COMbined with BIOmass

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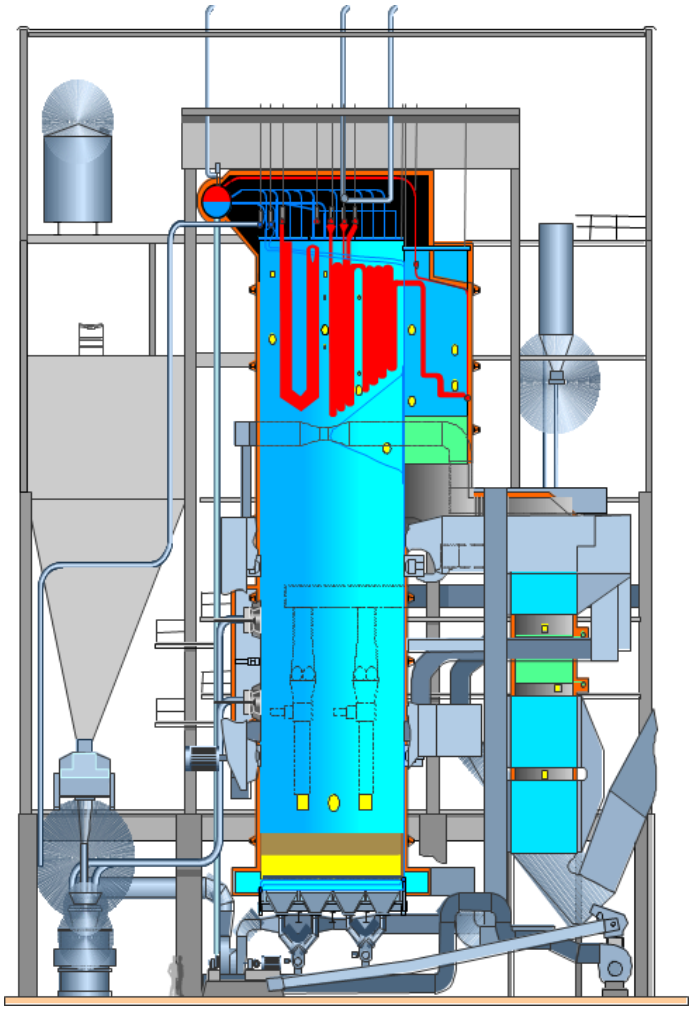
K2 Boiler

- **1971 Pulverised fuel boiler with grate for combustion**
  - Coal and bark
- **1995 Retrofit to BFB**
  - Bark and sludge
- **1996 Start of SRF co-incineration**
  - SRF, bark, sludge, forest residues
- **2006 Co-incineration permit**
- Increasing SRF share up to 60%
- **2008 K2 opti (modification project)**
  - Bed retrofit capacity 100 MW → 170 MW
  - SRF capacity 70 kt/a → 135 kt/a
- **K2 Steam parameters: 490°C, 80 bar**



Situation: Recombio Start

- K2 opti modification 2008
  - SRF use max. 135 000 t/a, SRF 60% / Bio 40%
    - 2007 70 000 t/a
  - Operational steam level up to 35-40 kg/s
    - 2007 23 kg/s

- Operations 2009-2010
  - PCDD/F emission over permit level
  - Superheater and boiler wall corrosion speed up
  - Boiler fouling problems increased
  - K2 availability < 85 %

→ 2010: SRF use 75 000 t/a, SRF 50%, Bio 50%, steam production ≈ 30 kg/s

→ Recombio project

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Recombio Actions 1/2

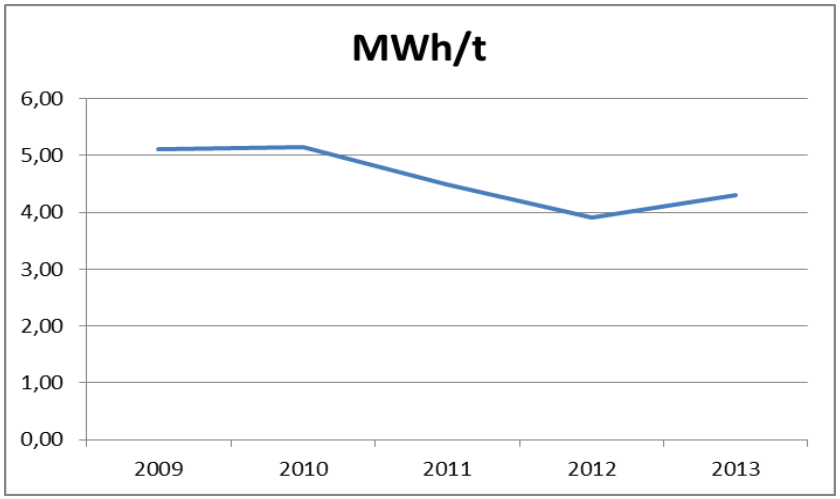
- Material probe test 2011 (superheaters)
  - Target: increase steam temperature 500 → 525°C
    - Examine alkaline chloride high temperature corrosion
- Material test 2012- (furnace wall)
  - Target: better corrosion endurance
    - Alloy 625 type overlay welded, AISI 309 overlay welded, AISI 310 overlay welded
    - 2-4 years follow up
- Vast measurements 2010-2013:
  - Emission: especially PCDD/F
  - Life-cycle: especially boiler tubes and superheaters

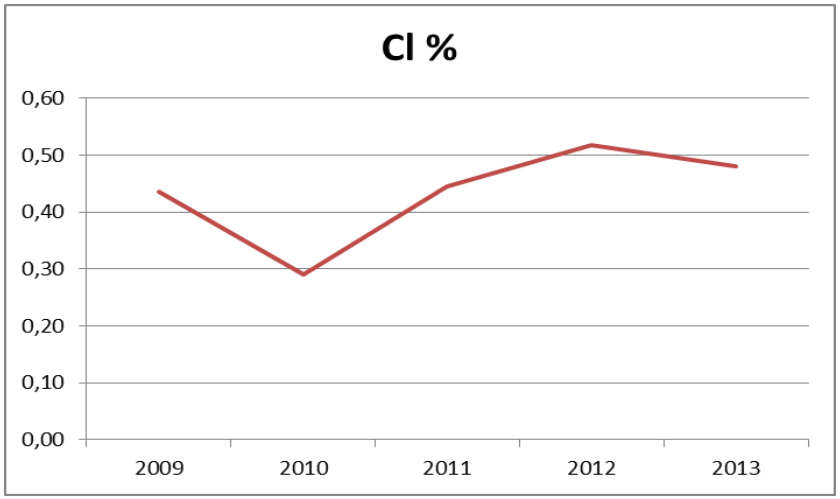
Recombio Actions 2/2

- SRF Quality Management System development (QMS)
  - Organised sample collection → analyses
- Recombio demonstration campaign 02/2012
  - Main partners: VTT and Metso
- Sulphur feeding system installation 01/2013
  - Metso Corrored analyzer
    - S/Cl ratio in flue gas → S feeding adjustment
  - PCDD/F control and corrosion endurance

SRF Purchasing and Quality

- K2 SRF use:
  - 2009 100 000 t
  - 2010 75 000 t
  - 2011 70 000 t
  - 2012 85 000 t
- SRF price development:
  - 2009 0 €/t → 2012 5-9 €/t
  - Increased consumption in Finland, transportation costs increased
- SRF quality
  - 7 suppliers
  - Chlorine content main problem
    - Development hasn't been totally satisfying on average level
    - Positive start for 2013
  - Other parameters:
    - Moisture 15-30 %
    - Ash 8-12 %

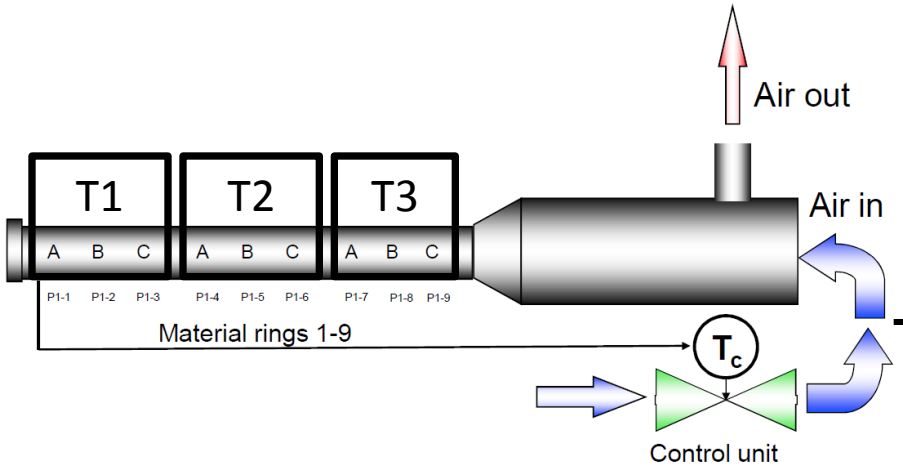


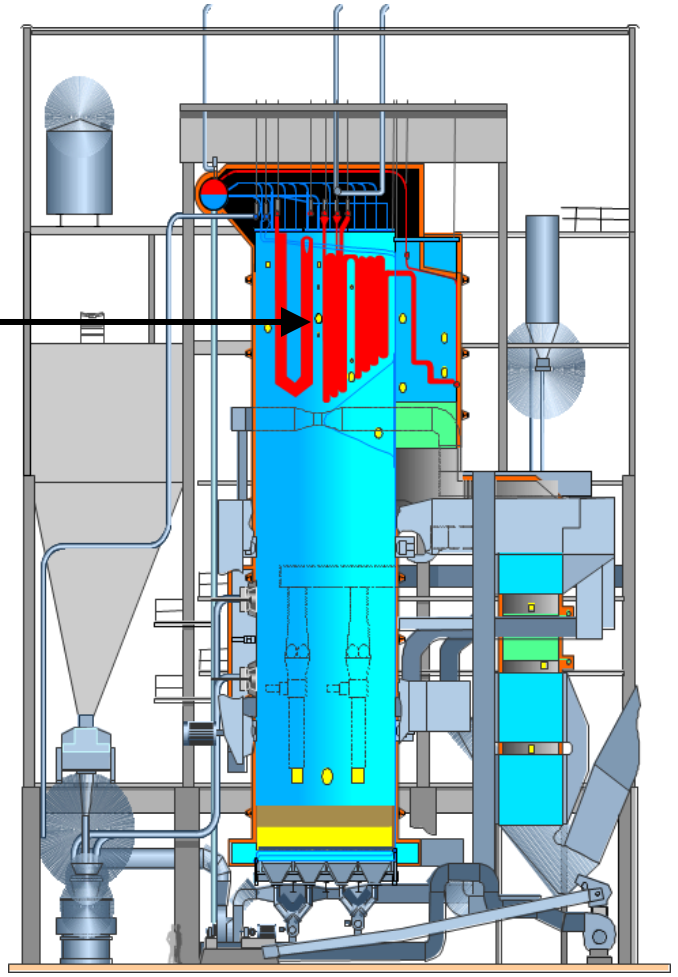


Demonstration in Anjalankoski K2 BFB boiler

Mitigating high temperature corrosion

Superheater Corrosion Material Probe Tests





- Target: increase steam temperature 500 → 525°C
- Exposure time 3000 hours

Materials:

A: 13CrMo4-5

B: TP310HCbN

C: Alloy 625 type overlay welded

Material temperatures:

T1: 460 °C

T2: 510 °C

T3: 560 °C

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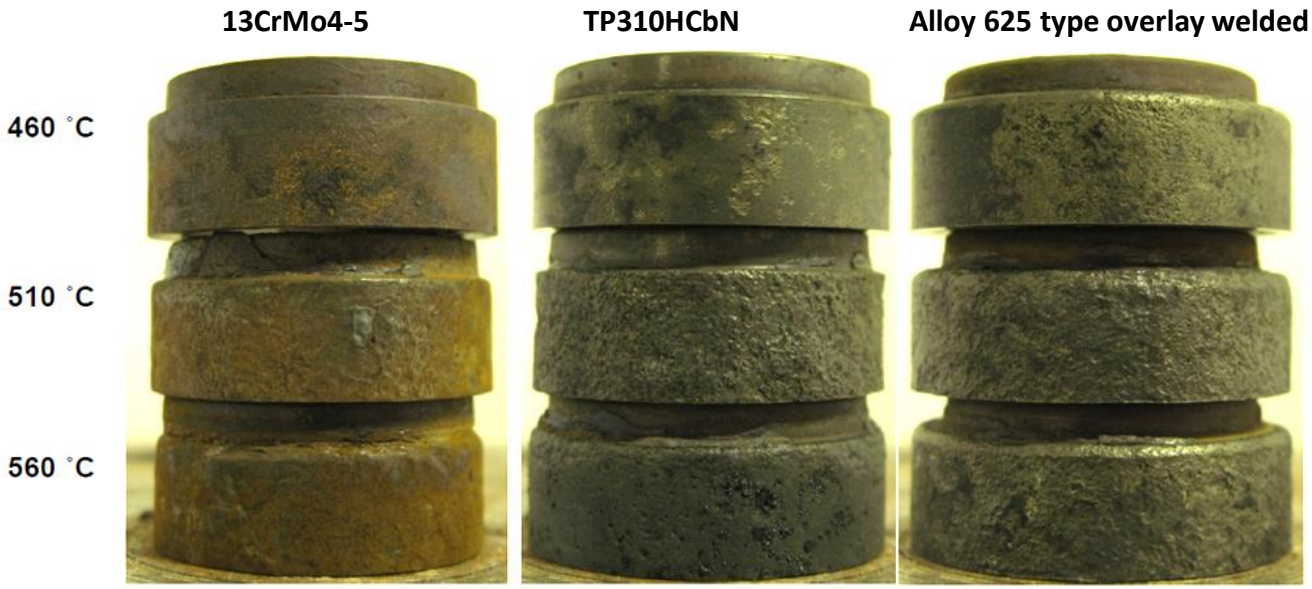
Results
Sample Rings



- Signs of corrosion detected in all samples
- Especially KCl found – alkali chloride induced corrosion
- High corrosion rates for 13CrMo4-5 and TP310HCbN at 510 °C and 560 °C. At 460 °C more local/pitting type of corrosion.
- For alloy 625 type overlay welded more local/pitting type of corrosion; lengthens the lifetime, but is not safe from corrosion either

Metso Corrosion Management

CorroStop Additives

- The Metso CorroStop consists of two fuel additives (liquid and solid) and an injection system that feeds the additive directly into the boiler.
- CorroStop™ – liquid solution
  - Aluminiumsulphate $Al_2(SO_4)_3$ or Ferric sulphate $Fe_2(SO_4)_3$
  - 15-30 % liquid solutions
  - Spraying through nozzles before superheaters
  - pH ~1 – HSE
- CorroStop+™ – elementary sulphur
  - Sulphur content > 95 %
  - 0,5 – 3,2 mm granulates
  - Addition to fuel feeding screws

Controlling of alkalichloride induced high temperature corrosion

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Metso Corrosion Management

CorroStop Additives

Measures and remedies

- The sulphate eliminates alkali chlorides in the gas phase and attaches to superheater surfaces forming a protective coat and neutralize the effects of alkalichloride in the process
- Sulphate decomposes at high temperature:

$$Fe_2(SO_4)_3 \Rightarrow 2\,Fe^{3+} + 3\,SO_4^{2-}$$

- Alkali chloride reacts with sulphur trioxide or dioxide

$$2MCl_{(g,c)} + SO_{3(g)} + H_2O_{(g)} \Rightarrow M_2SO_{4\,(g,c)} + 2\,HCl_{(g)}$$

$$2MCl_{(g,c)} + SO_{2(g)} + \tfrac{1}{2}\,O_{2\,(g)} + H_2O_{(g)} \Rightarrow M_2SO_{4\,(g,c)} + 2\,HCl_{(g)}$$

where M is Na or K

Slow down corrosion of superheaters

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Metso Corrosion Management

Corrored Analyzer

The Metso Corrored consists of the online analyzer unit and the sampling device. Hot flue gas sampling is followed by analyzer using proofed titration technology.

- Total chlorine concentration
- Effective sulphur concentration
- Calculates the flue gas S/Cl molar ratio
- Allows you to rely on “real data” instead of calculations and estimations

Providing

- Flue gas S/Cl molar ratio for corrosion risk and rate evaluation
- Fuel Cl content for fuel quality determination
- Information for fuel blend and additive control

Sensor

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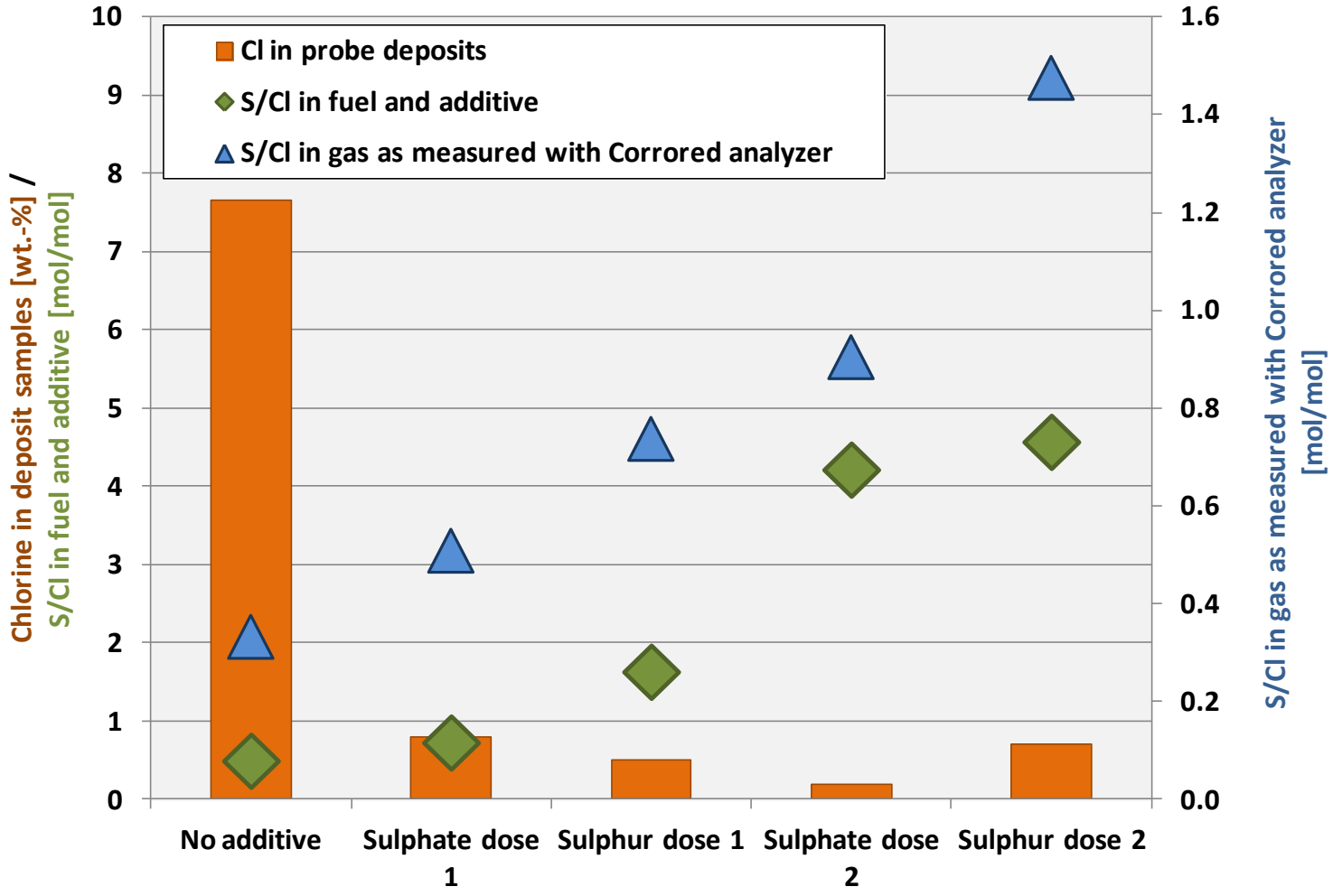
Additives Effect Anjalankoski BFB



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Recombio Results

- K2 availability 94-96%
- Adjustment of air system 2011
- New SRF purchasing contract model 2011/2012
  - Based on QMS-implementation and quality development (CEN/TC 343)
  - Intense correlation between price and quality
- Knowledge about different materials
  - Life-cycle cost calculations → investment plans in the future
- Sulphur feeding system 2013
  - Metso Corrored analyzer
- PCDD/F emission has decreased about 90% since 2009
  - Last measurement aprox. 0,1 ng/m3
    - Last improvement 0,3 → 0,1 with use of on sulphur feeding 2013
- Corrosion endurance development
  - Final effect still open → life cycle measurement → follow-up
  - Preliminary results seems promising → further development