



Increased flexibility and power-production from biomass through material development and corrosion prediction





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Goal

The overall goal of the project is to increase the efficiency and flexibility/predictability of power generation from biomass.

The scientific goals of the project:

- Determine the ***applicability*** and ***limitations of aluminium*** oxide forming materials for improved biomass conversion effect, as well as ***their comparison*** with ***existing materials***.
- Scale up ***lab-probe-fixed installation*** tests - predict impact of e.g. material and temperature on lifetime of key components. Implement ***thermodynamic-kinetic modelling*** of oxidation in complex environments.

Strategy

INCREASED POWER PRODUCTION FROM BIOMASS

Alumina forming materials – biomass environment

INCREASED FLEXIBILITY – BIOMASS POWER PRODUCTION

Scale up lab-probe-fixed installation – biomass environment

Strategy

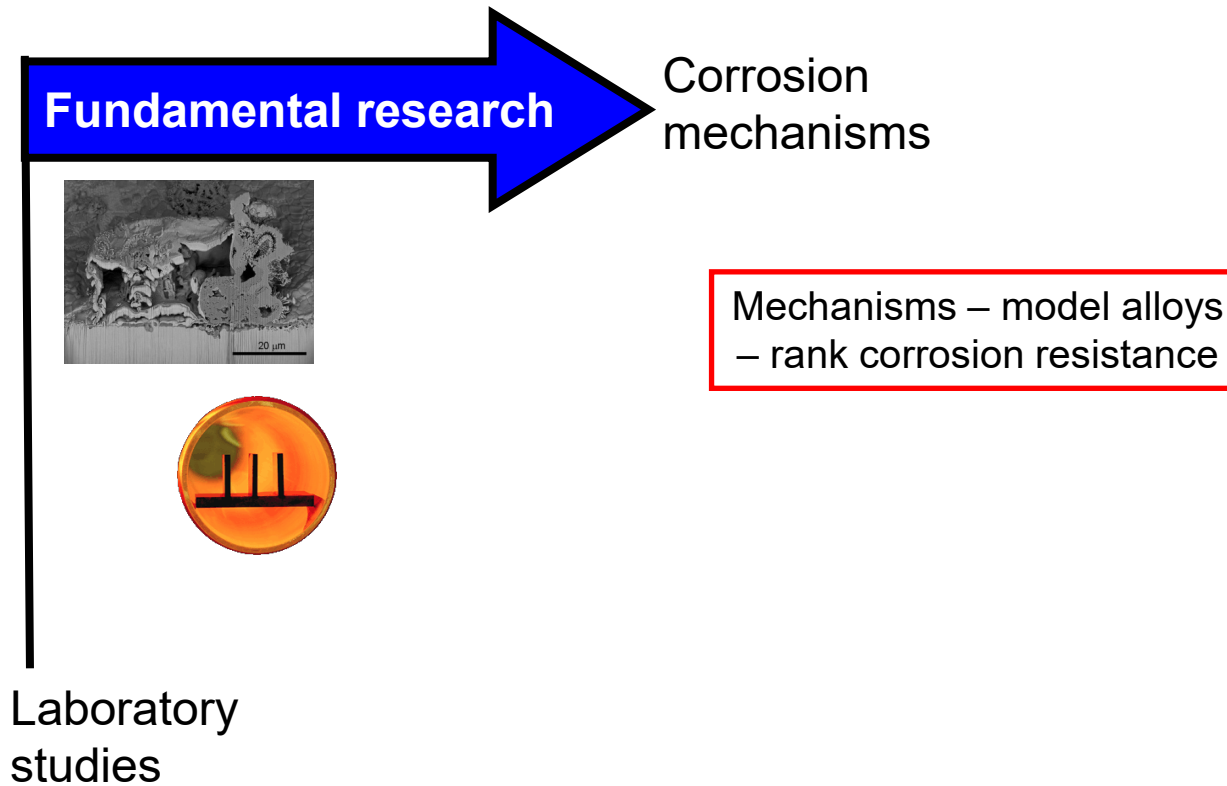
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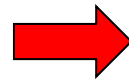
Research strategy – a two pronged approach



Collaboration with HTC1a

Strategy – model alloys

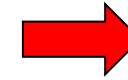
Tailor made model alloys



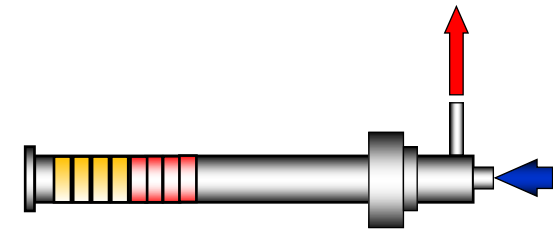
Ranking model alloys



Lab – collaboration
with **HTC1a**

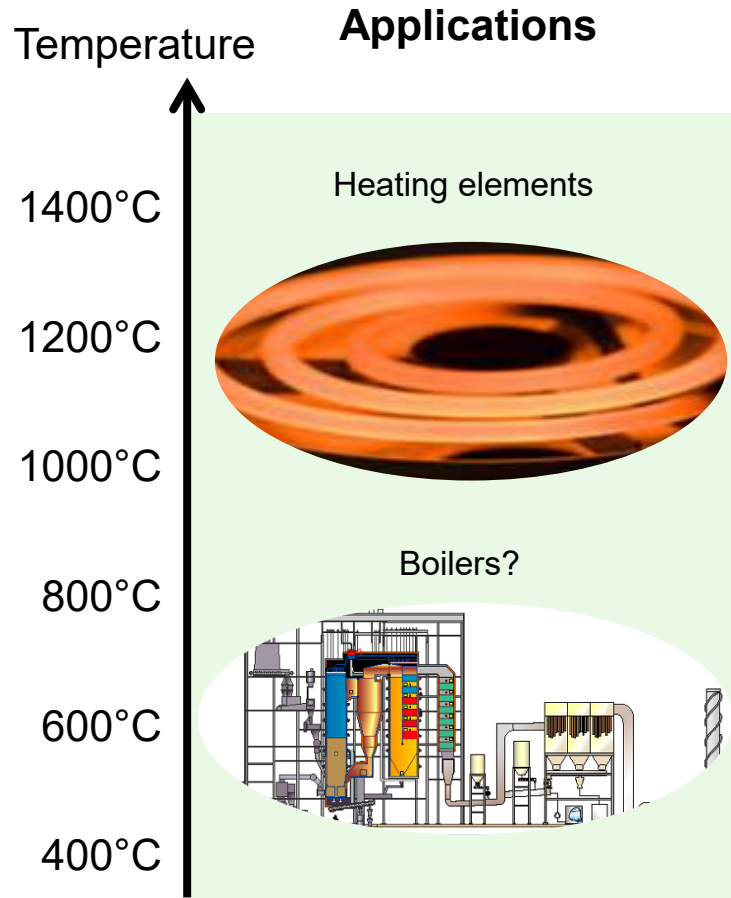


Most promising model alloys



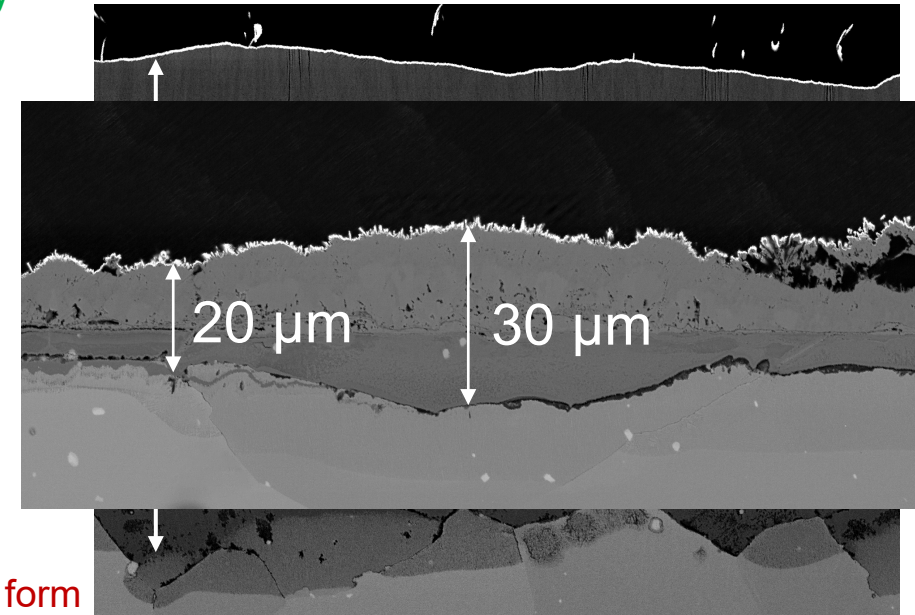
Corrosion tests in
the boiler

Challenges with FeCrAl alloys



An α -alumina scale forms at temperatures above ~900 °C that protects the alloy

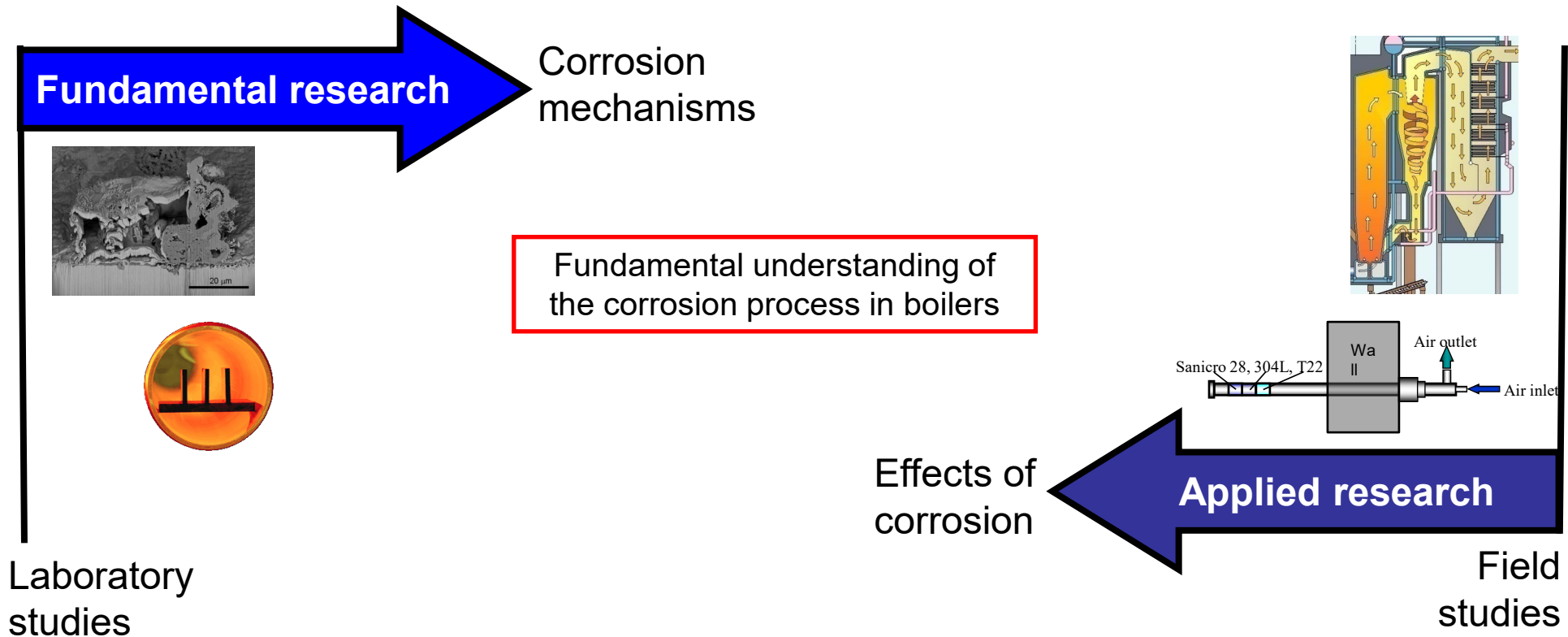
Secondary protection



At lower Temperatures

- Metastable forms of alumina may form
- Not as protective as α -alumina

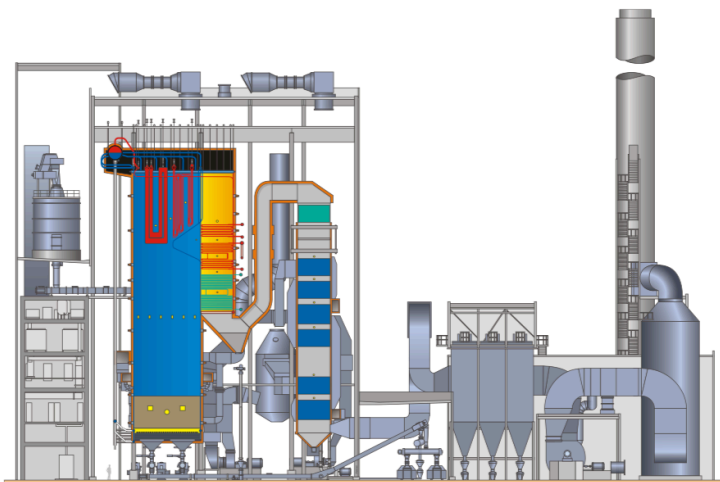
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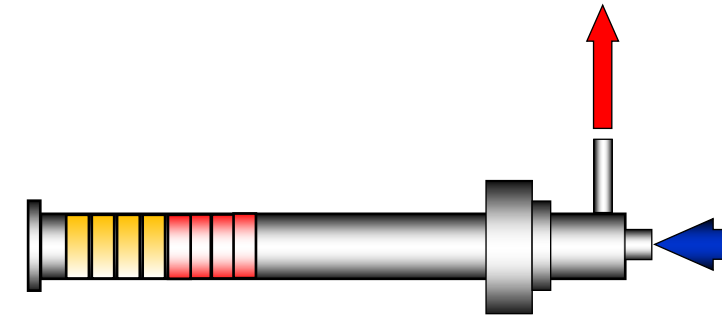
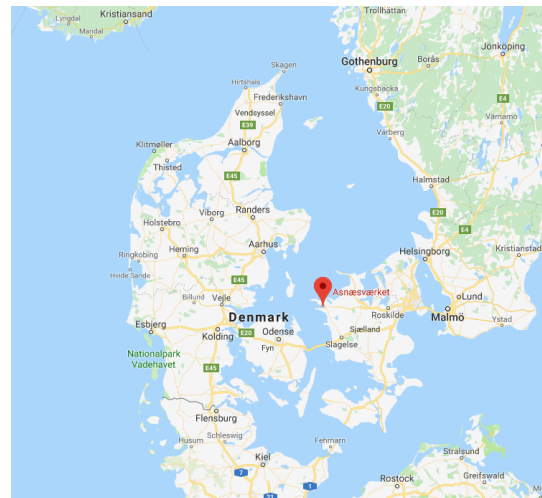
***Collaboration with HTC1a
Teamwork 2***

Strategy – model alloys

- Characterize the deposit at different positions/temperatures
- Expose the most promising model alloys (probe rings in the boiler – 168h/2000h)
 - Best primary AND secondary protection!
- Compare oxidation resistance with existing materials

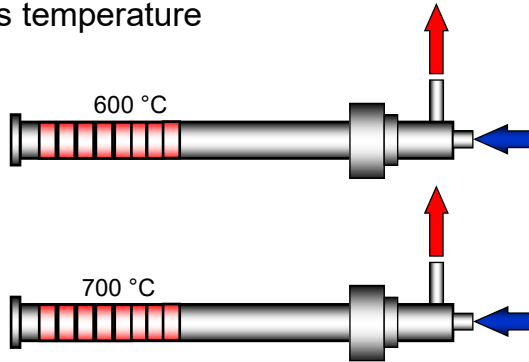


Side view illustration of ASV6Bio



Field exposure - Skærbæk

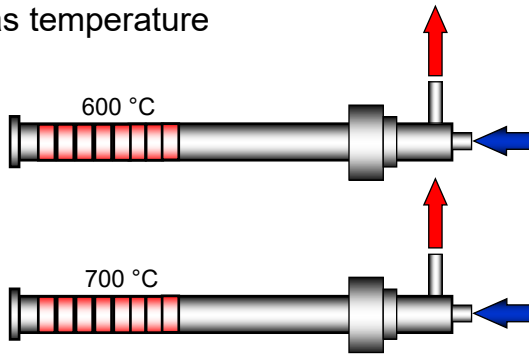
Lower fluegas temperature



Materials – 168h

- 347H
- 310
- Sanicro 25
- 347H with thermally sprayed with $\text{Fe}_{12.4}\text{Cr}_{3.7}\text{Al}_{1.3}\text{Si}$

Higher fluegas temperature

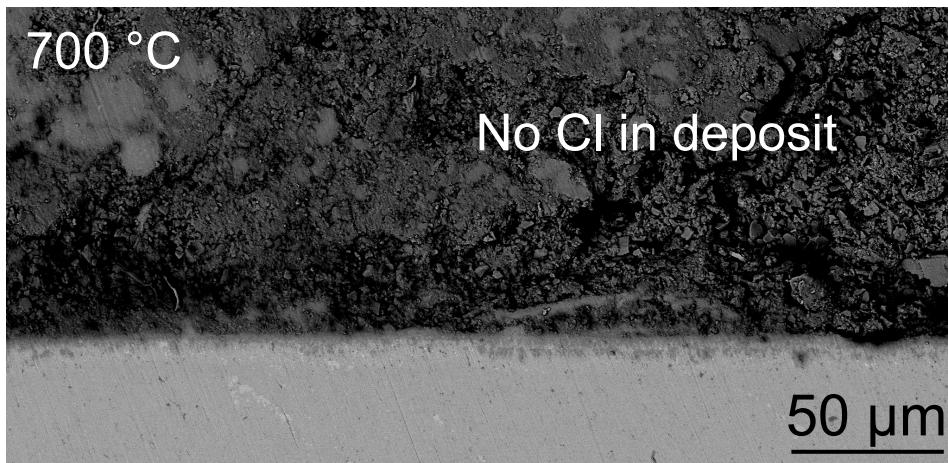
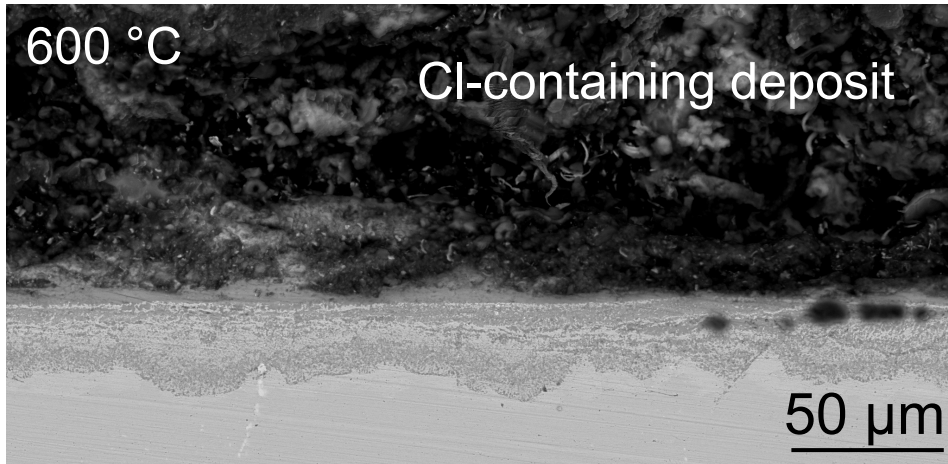


- $\text{Fe}_{12.4}\text{Cr}_{3.7}\text{Al}_{1.3}\text{Si}$
- $\text{Fe}_{10}\text{Cr}_4\text{Al}_0\text{Si}$
- $\text{Fe}_{10}\text{Cr}_4\text{Al}_1\text{Si}$
- $\text{Fe}_{10}\text{Cr}_3\text{Al}_2\text{Si}$

Material temperature

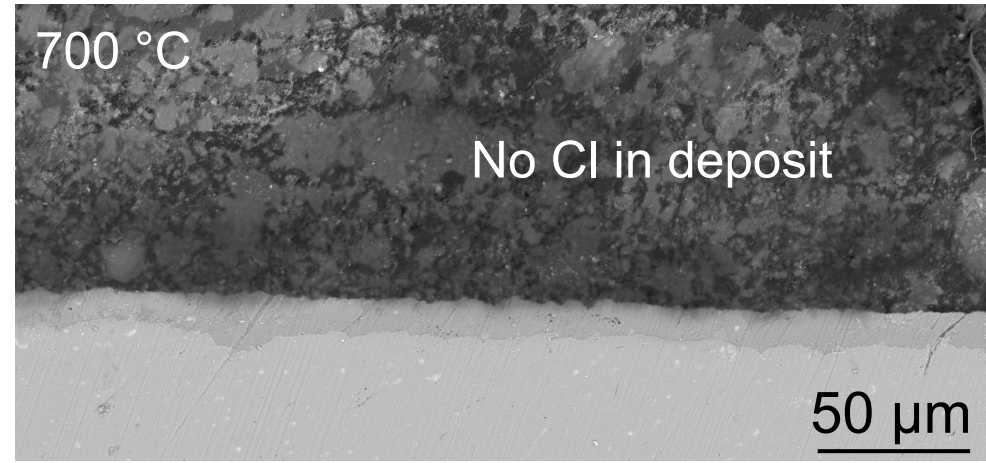
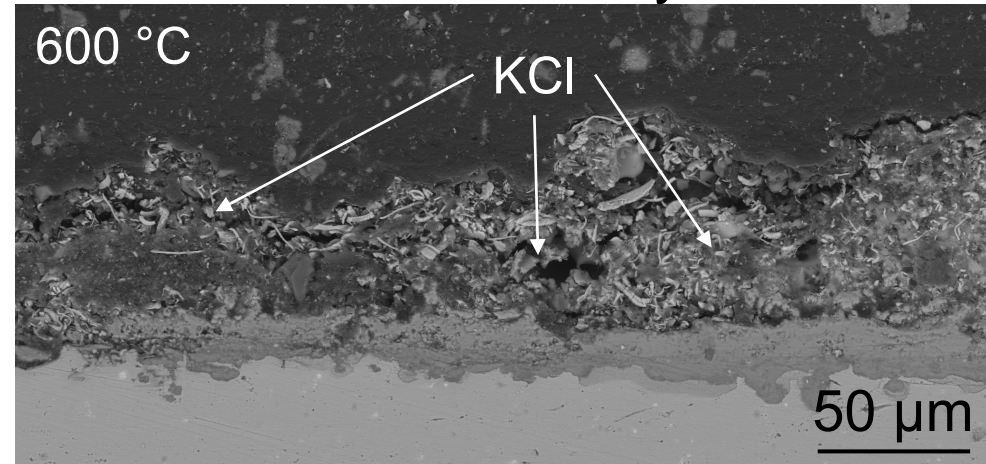
Influence on corrosion attack

Stainless steel



Sanicro 25

FeCrAl alloys



Fe10Cr4Al0Si

Low flue gas temperature

Alloy composition (Si-effect)

Influence on corrosion resistance

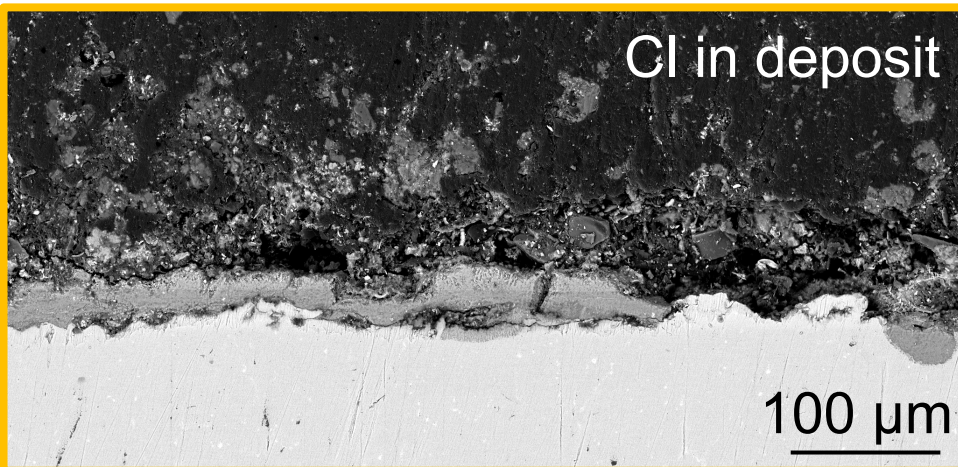
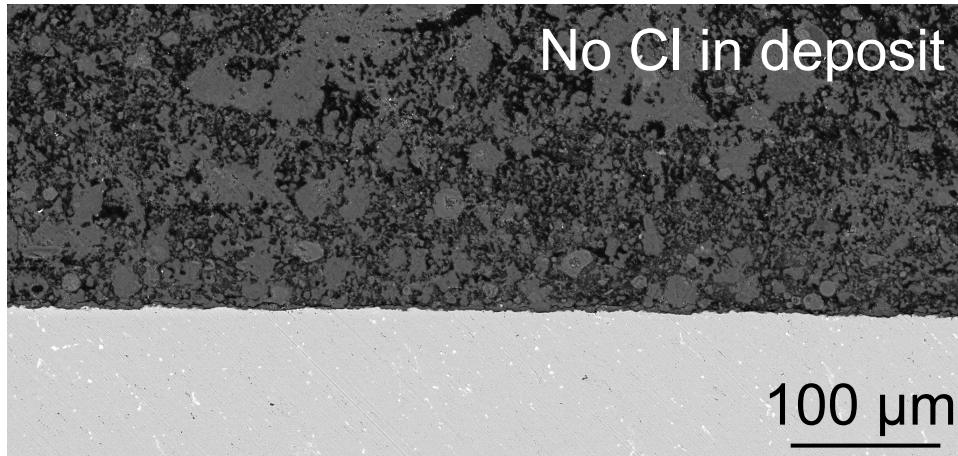
Without Si

— Majority of the sample

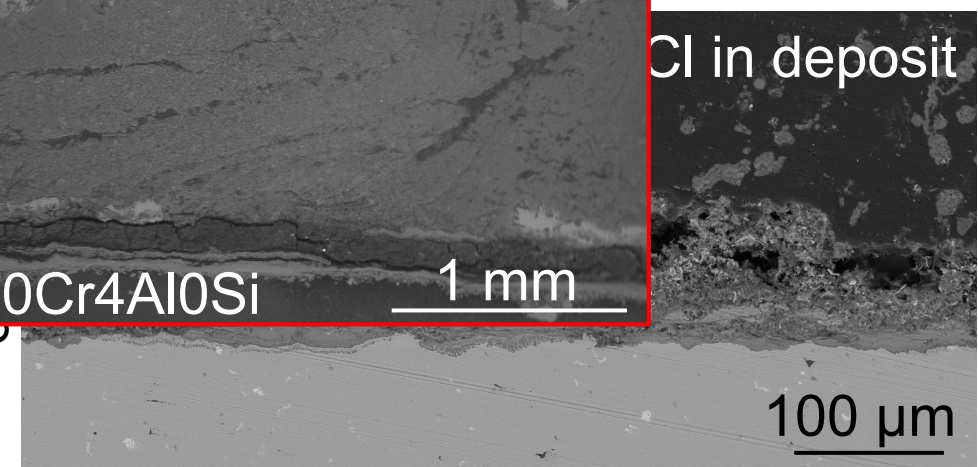
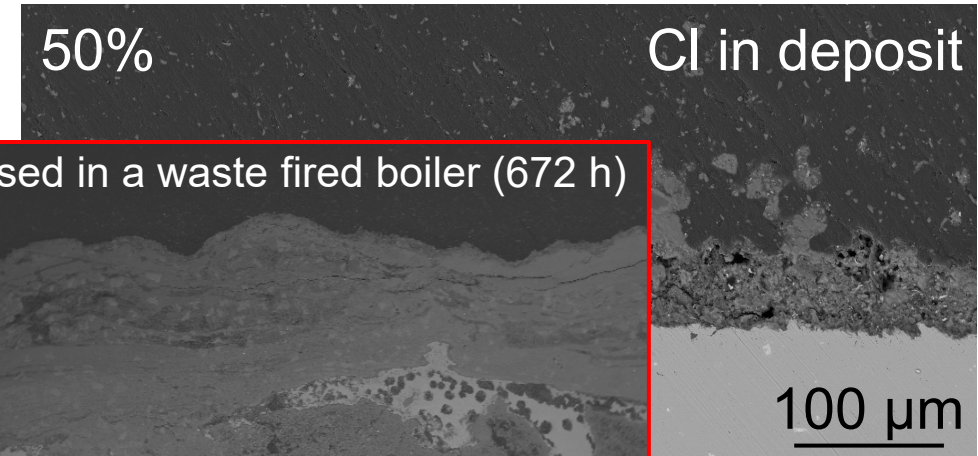
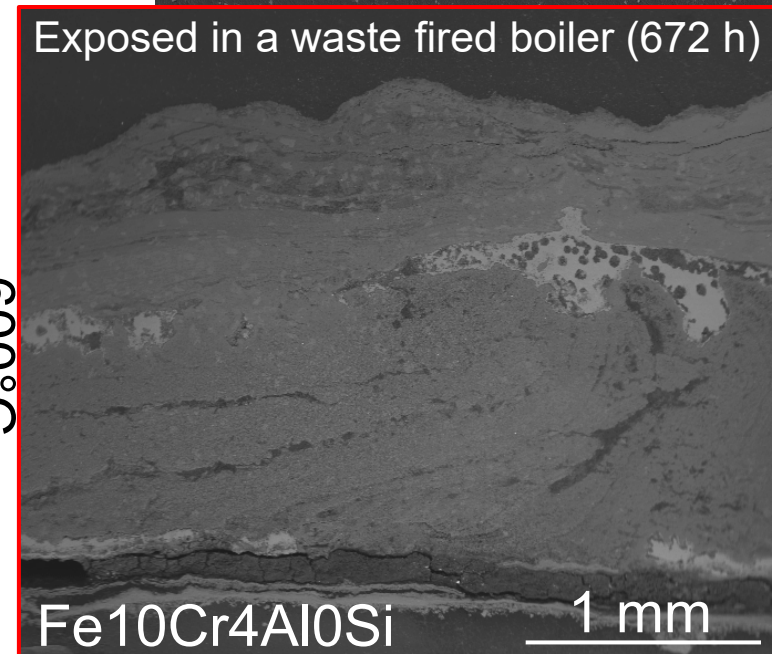
With Si

Fe10Cr4Al0Si

Fe12.5Cr3.4Al1.3Si



600°C



General remarks:

- The operating parameters of the boiler (fuel, temperature etc.) resulted in a **very mild environment**
 - Minor corrosion attack
 - IC analysis showed **very low Cl concentration** in all cases (<1 wt%)
- Longer exposures needed to achieve a better understanding of the influencing parameters

Material temperature:

- The **corrosion attack** was **slightly higher** at **600 °C**
- SEM analysis indicated **increased amount of Cl in deposit** at the **lower** material temperature (600 °C)
- **IC analysis** showed **very low Cl concentration** in deposit at **both material temperatures**

Flue gas temperature:

- **SEM and IC showed minor or no influence** of flue gas temperature on the **amount of Cl** in the deposit
- **No clear effect** of flue gas temperature on the **extent of corrosion attack**

Alloy composition:

- In average, the **FeCrAl alloys** (more highly alloyed) **behaved better** than the stainless steels
 - Were able to better **withstand presence of Cl**
- Indication of **improved corrosion behaviour** with **Si-addition**
- **Coating (FeCrAl)** showed **great corrosion resistance**
 - No oxide formation detected
 - Minimal material loss

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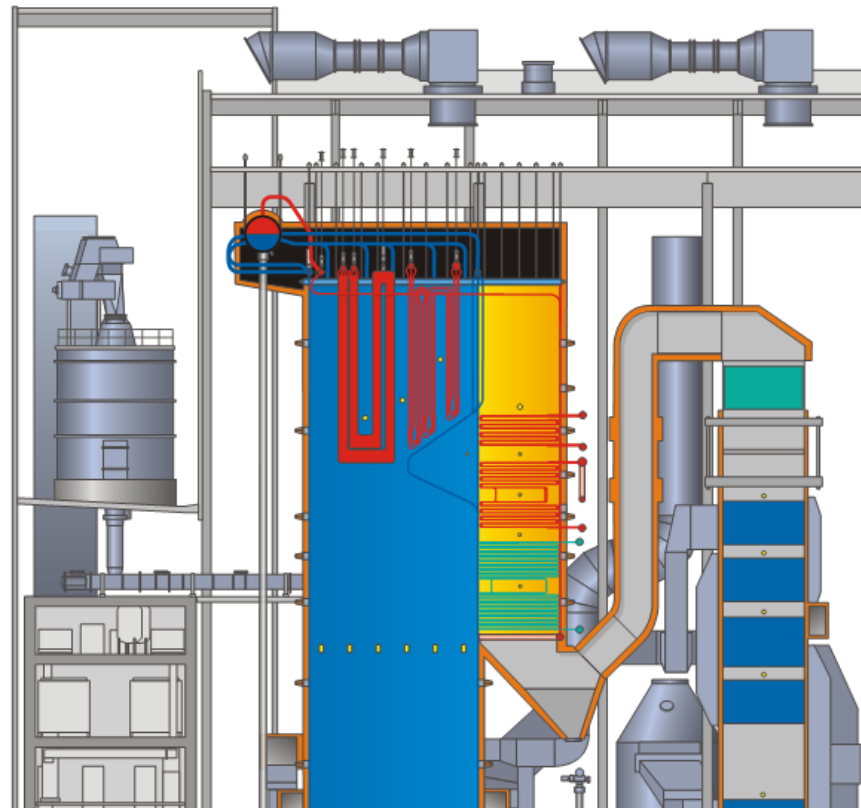
Scale up lab-probe-fixed installation – biomass environment

New boiler - Superheater test tube installations

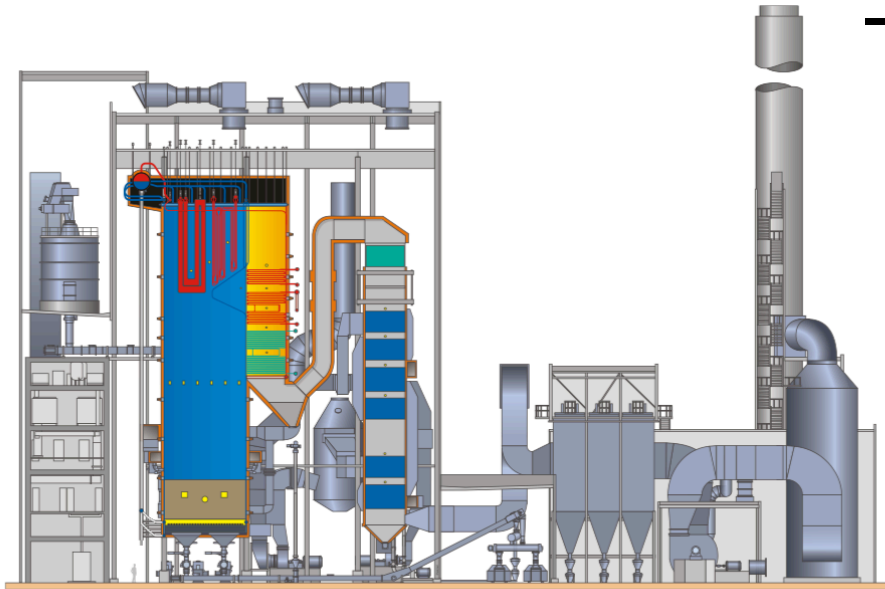


- Four test tube materials installed to the tertiary superheater
- Straight tubes, hottest part of the tertiary superheater

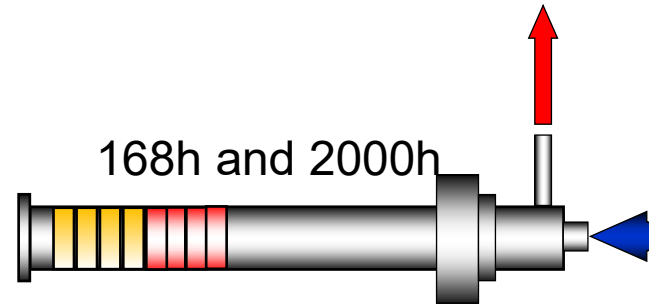
Material type	Grade	Tube size
347H	X7CrNiNb18-10	38,0 x 6,3 mm
347HFG	X8CrNi19-11	38,0 x 7,1 mm
310HCbN	SA-213 TP310HCbN	38,0 x 4,5 (min) mm
304HCu	KA-SUS304J1HTB	38,0 x 8,0 (min) mm



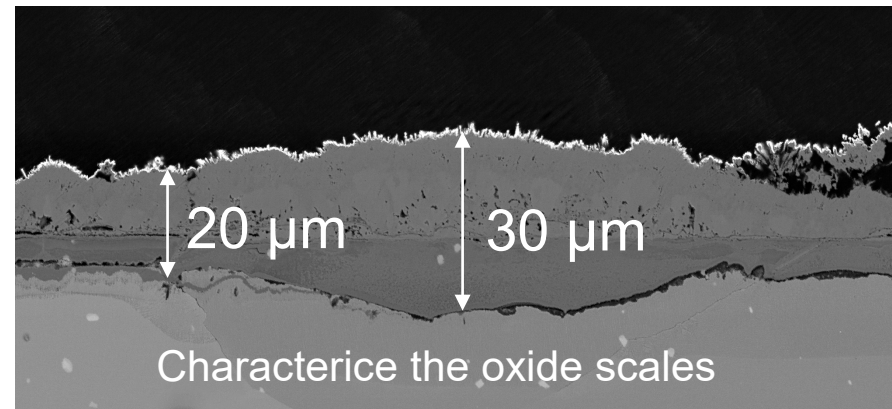
Characterize the oxide microstructure in lab/probe/fixed installed samples – modelling perspective



Side view illustration of ASV6Bio

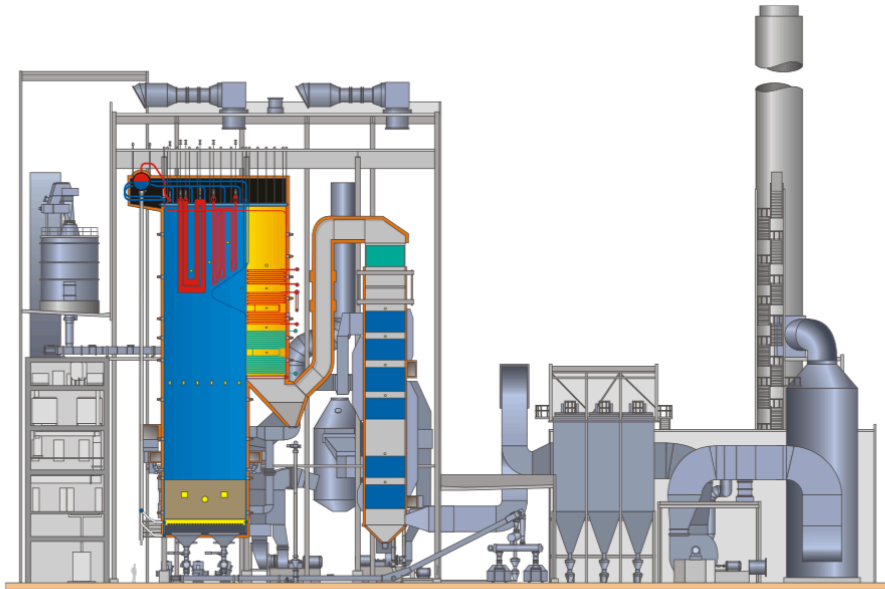


168h

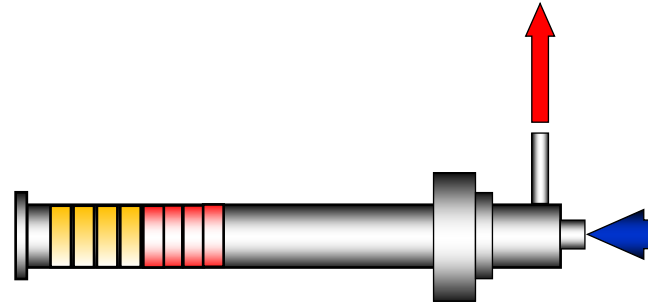


Characterize the oxide scales

Characterize the oxide microstructure – modelling perspective

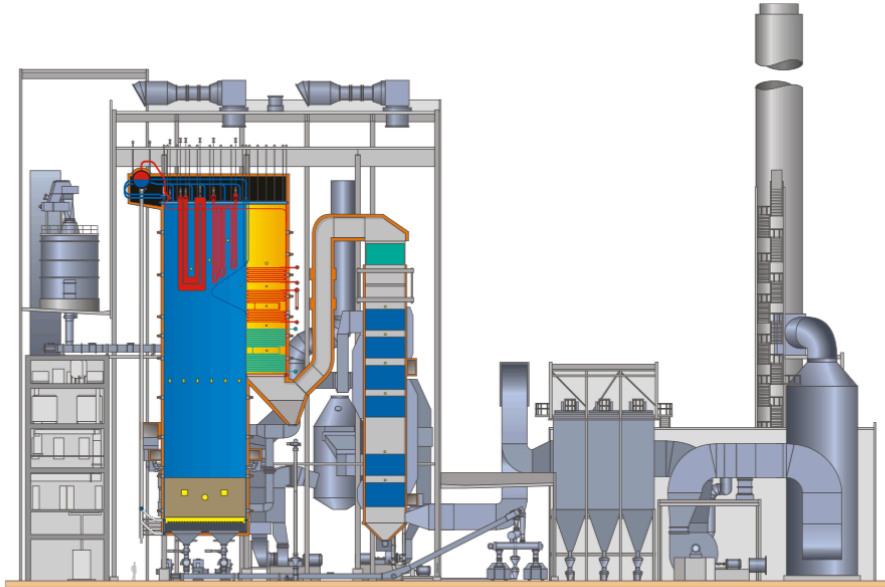


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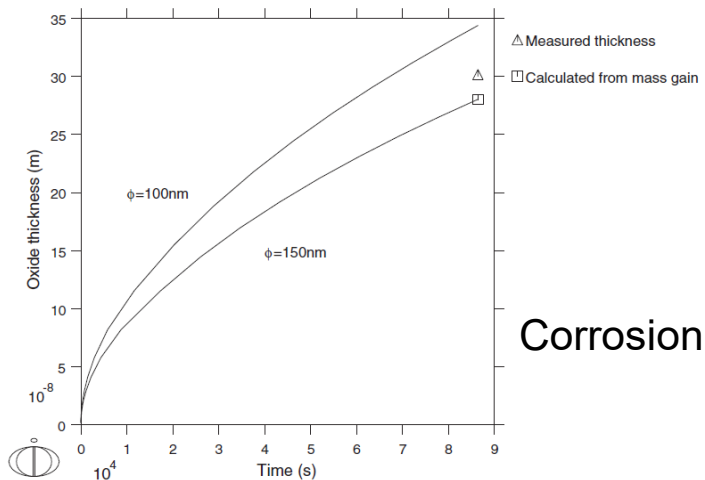
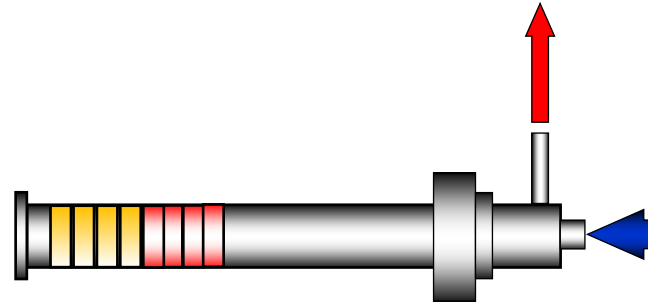


Model the oxide scales

Characterize the oxide microstructure – modelling perspective



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Corrosion rate – calculations up to 8000h performed

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