Energiforsk

DTU

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

Ørsted

KANTHAL®
Part of Sandvik Group

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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

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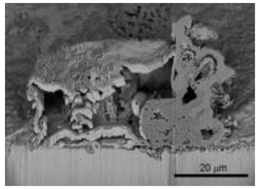
Research strategy – a two pronged approach

Fundamental research

Corrosion mechanisms



Mechanisms – model alloys
– rank corrosion resistance

Laboratory studies

Collaboration with HTC1a

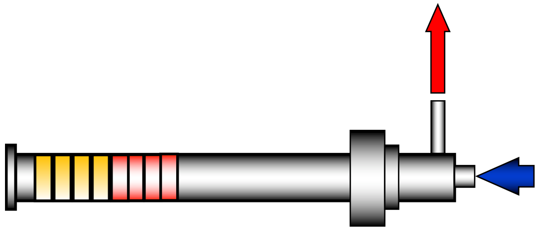
Strategy – model alloys

Tailor made model alloys

Ranking model alloys

Lab – collaboration with **HTC1a**

Most promising model alloys



Corrosion tests in the boiler

Challenges with FeCrAl alloys

Temperature

Applications

1400°C

1200°C

1000°C

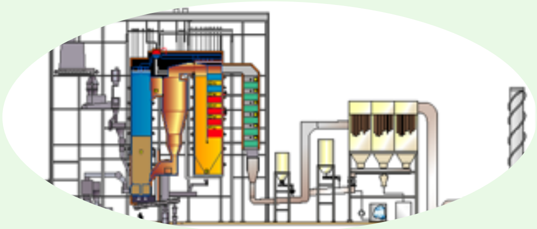
800°C

600°C

400°C

Heating elements

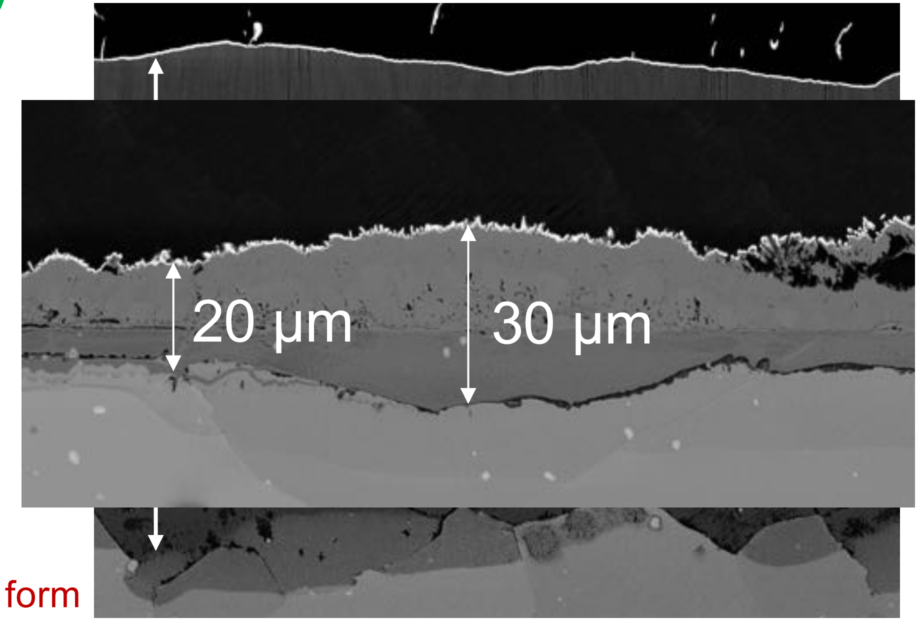
Boilers?



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

Primary protection

Secondary protection



At lower Temperatures

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

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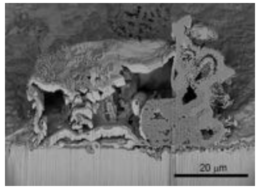
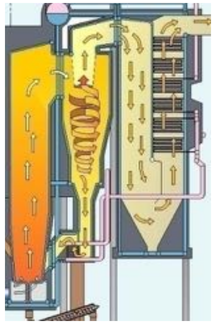
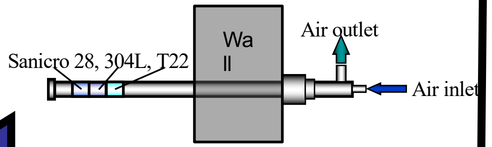


Laboratory studies

Fundamental understanding of the corrosion process in boilers





Applied research

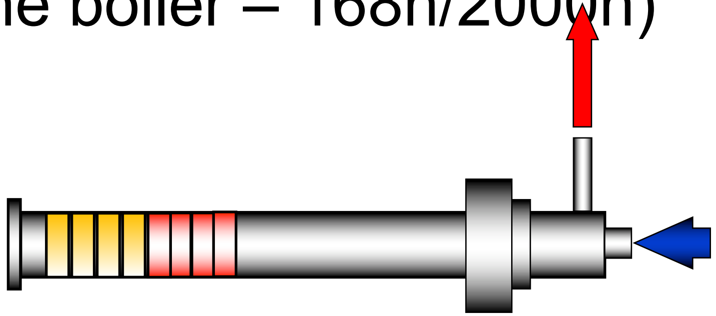
Effects of corrosion

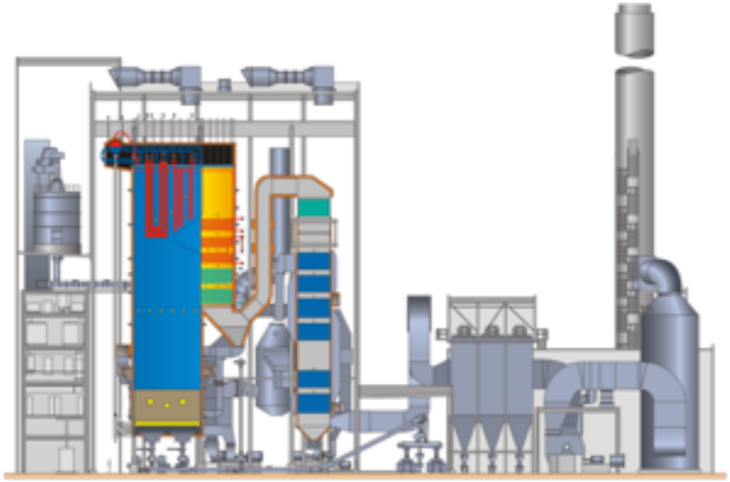
Field studies

Collaboration with HTC1a
Teamwork 2

Strategy – model alloys

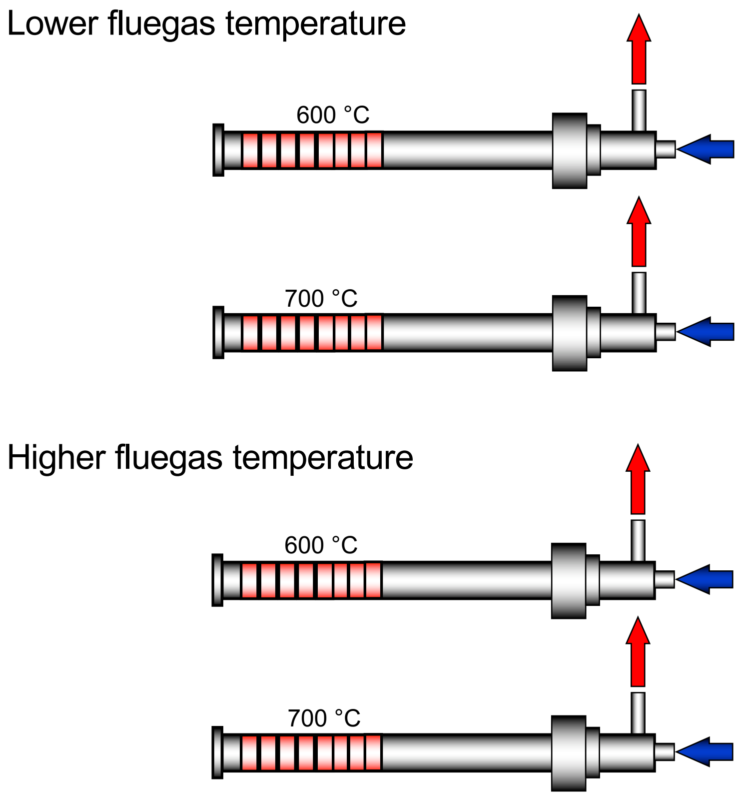
- Characterize the deposit at different positions/temperatures
- Expose the most promising model alloys (probe rings in the boiler – 168h/2000h)
  - Best primary AND secondary protection!
- Compare oxidation resistance with existing materials





Side view illustration of ASV6Bio

Strategy – model alloys



Materials – 168h

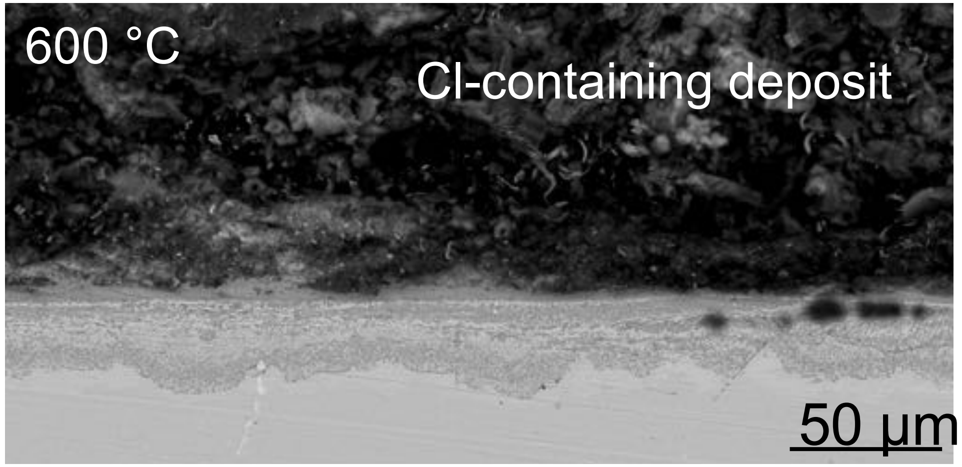
- 347H
- 310
- Sanicro 25
- 347H with thermally sprayed with Fe12.4Cr3.7Al1.3Si

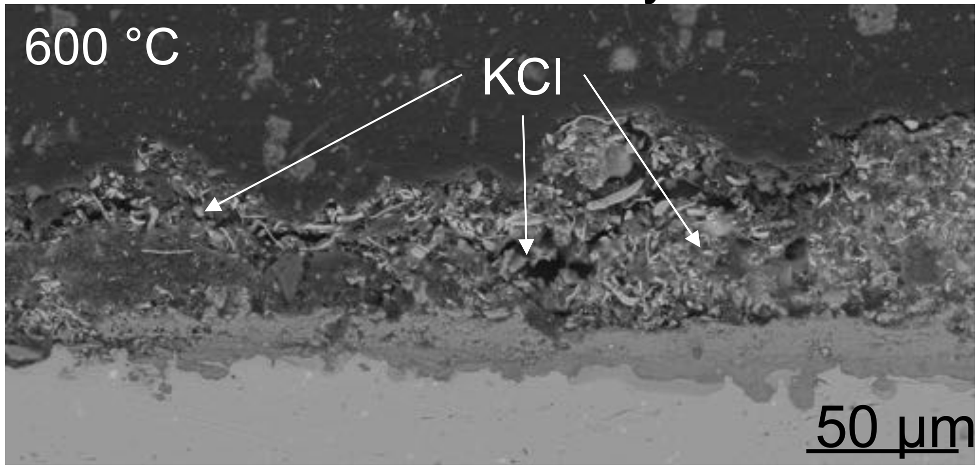
- Fe12.4Cr3.7Al1.3Si
- Fe10Cr4Al0Si
- Fe10Cr4Al1Si
- Fe10Cr3Al2Si

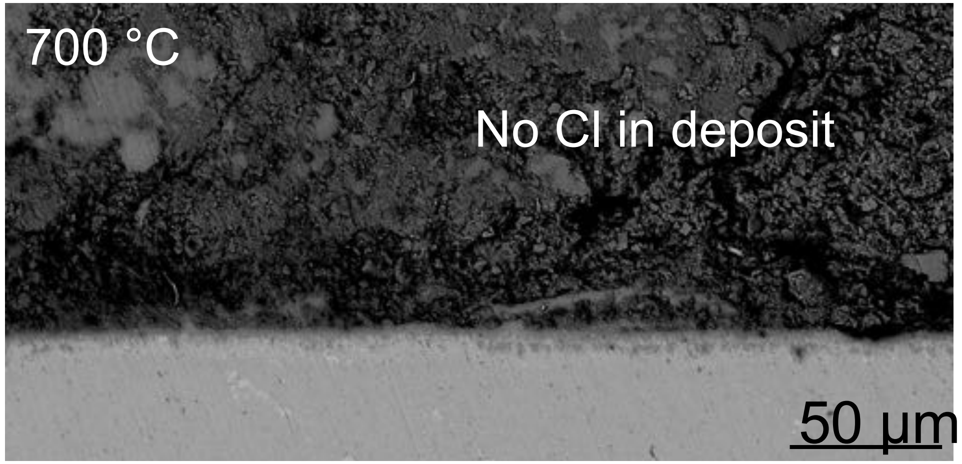
Material temperature

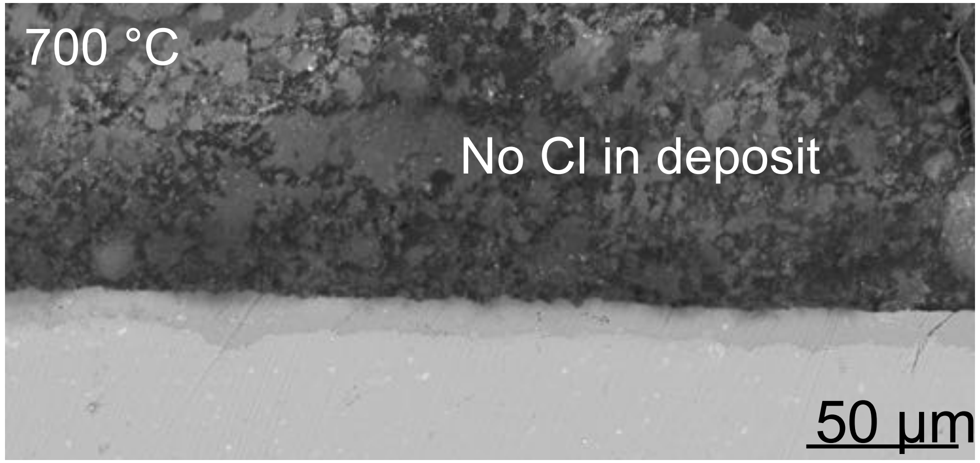
Influence on corrosion attack

Stainless steel | **FeCrAl** alloys









Low flue gas temperature

Sanicro 25 | **Fe10Cr4Al0Si**

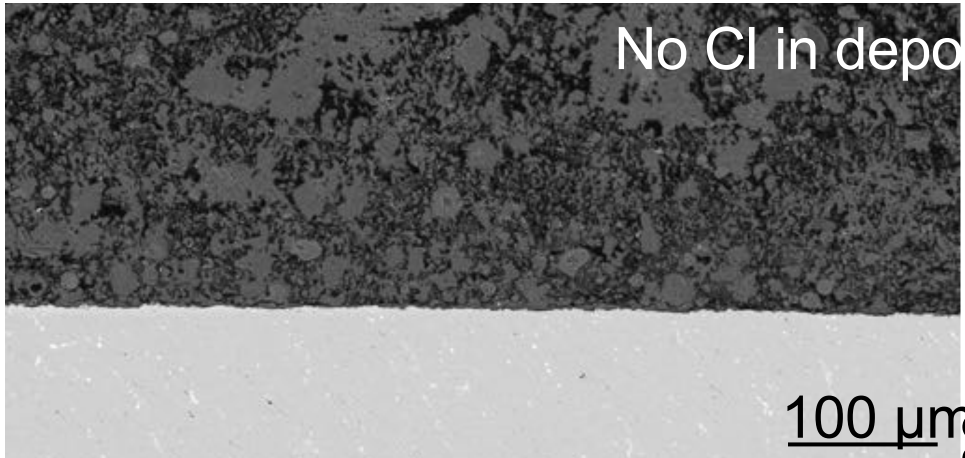
Alloy composition (Si-effect)

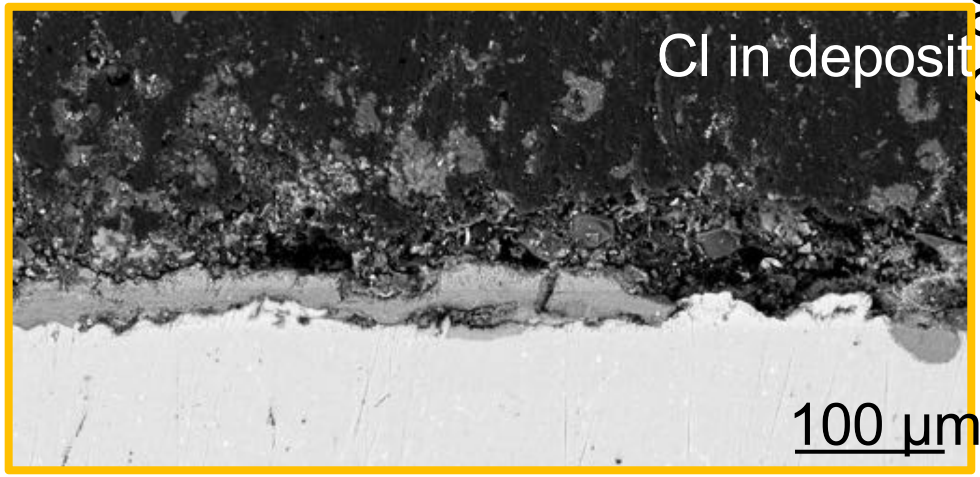
Influence on corrosion resistance

<u>Without Si</u> — Majority of the sample **<u>With Si</u>**

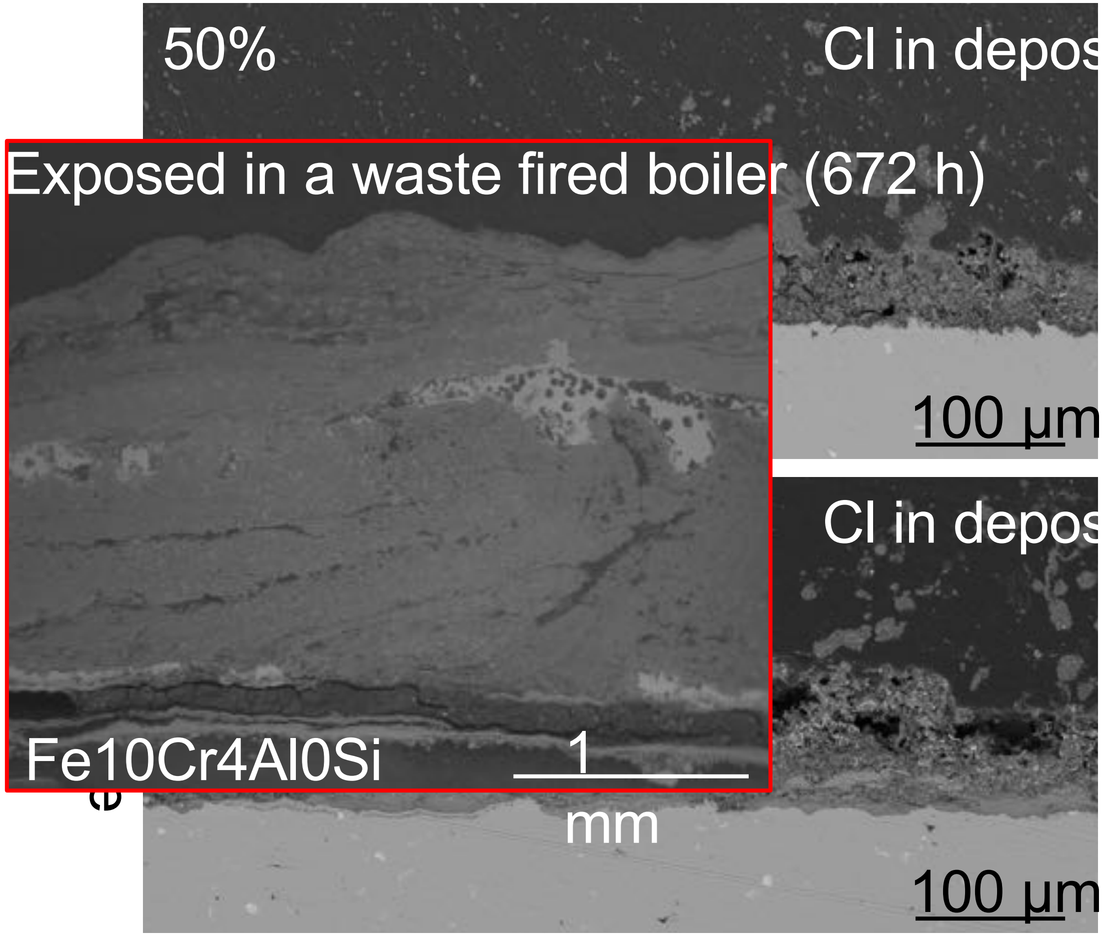
Fe10Cr4Al0Si

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**
- **Coated A197** showed **great corrosion resistance**
  - No oxide formation detected
  - Minimal material loss

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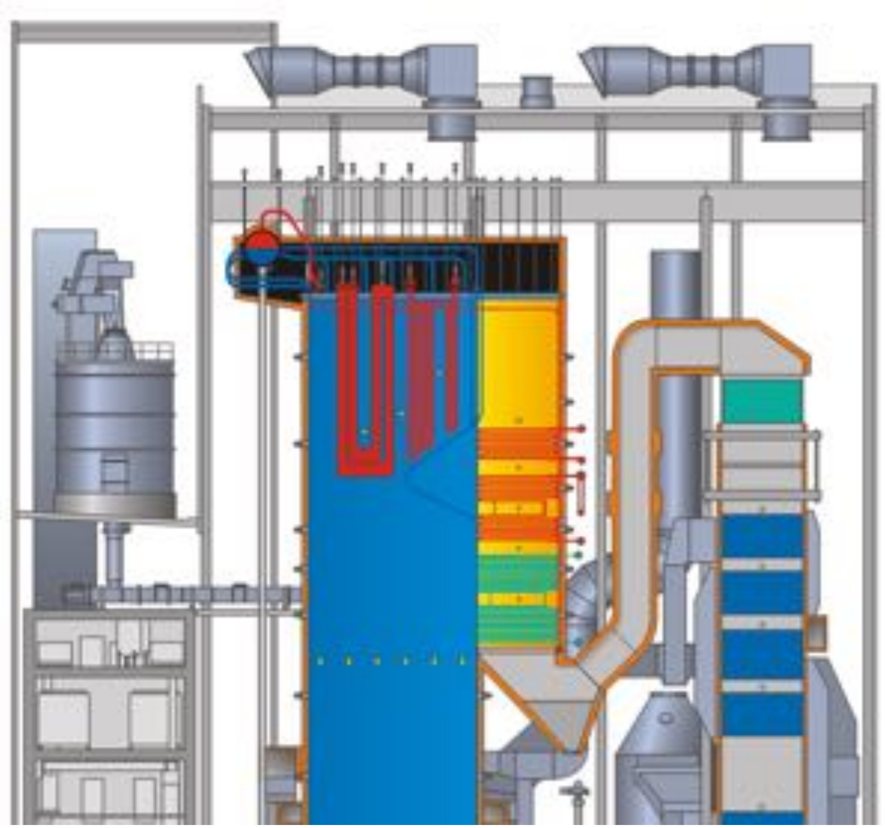
New boiler - Superheater test tube installations

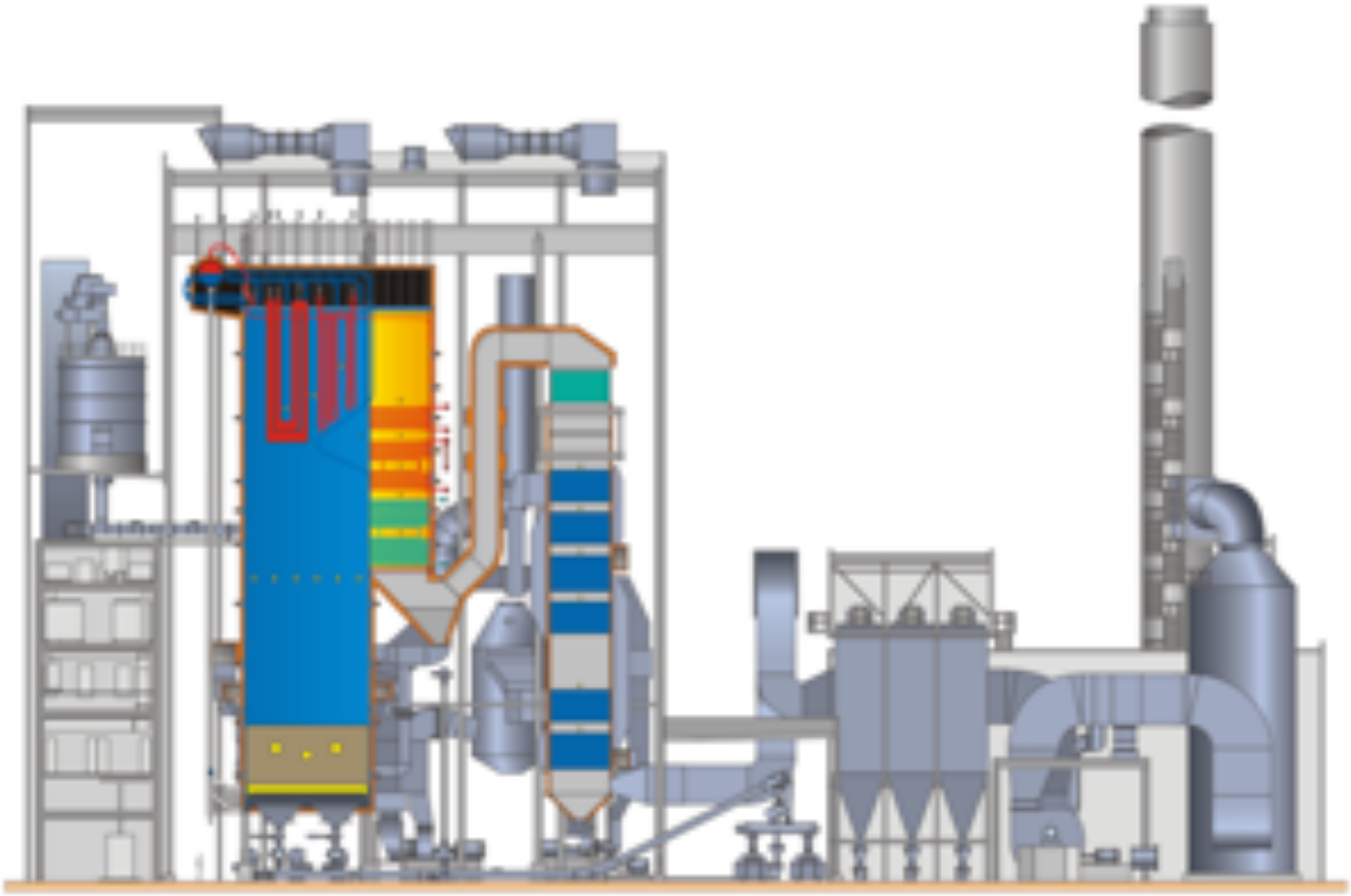
Ørsted

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

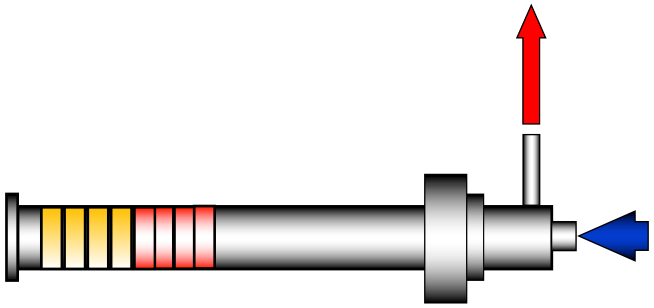


Valmet

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



Side view illustration of ASV6Bio



Samples of same material – probe 168h and 2000h

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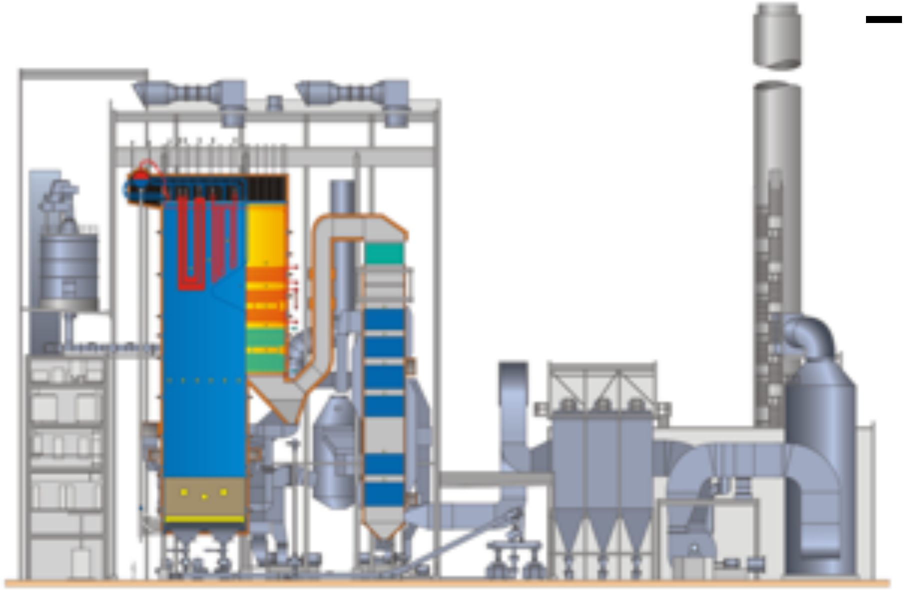

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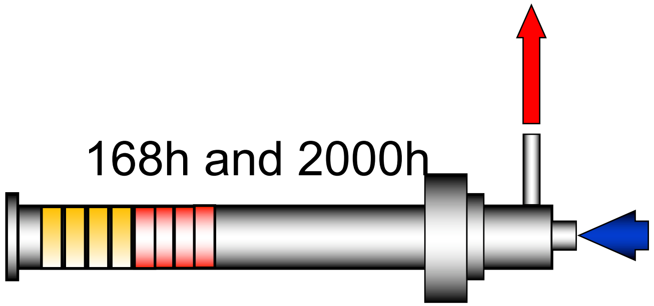
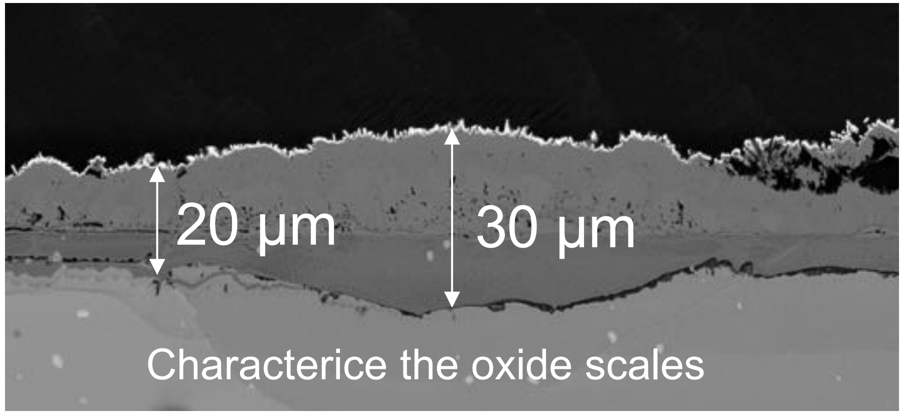
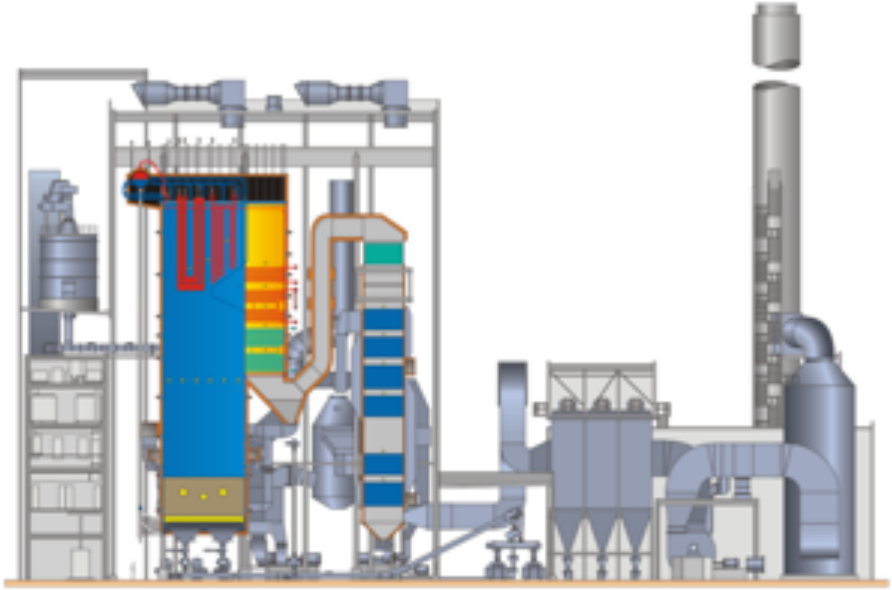


168h



Characterize the oxide microstructure – modelling perspective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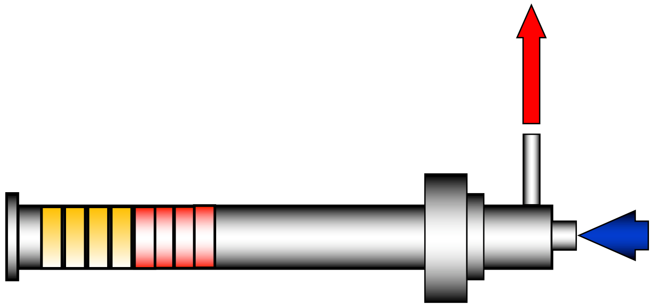

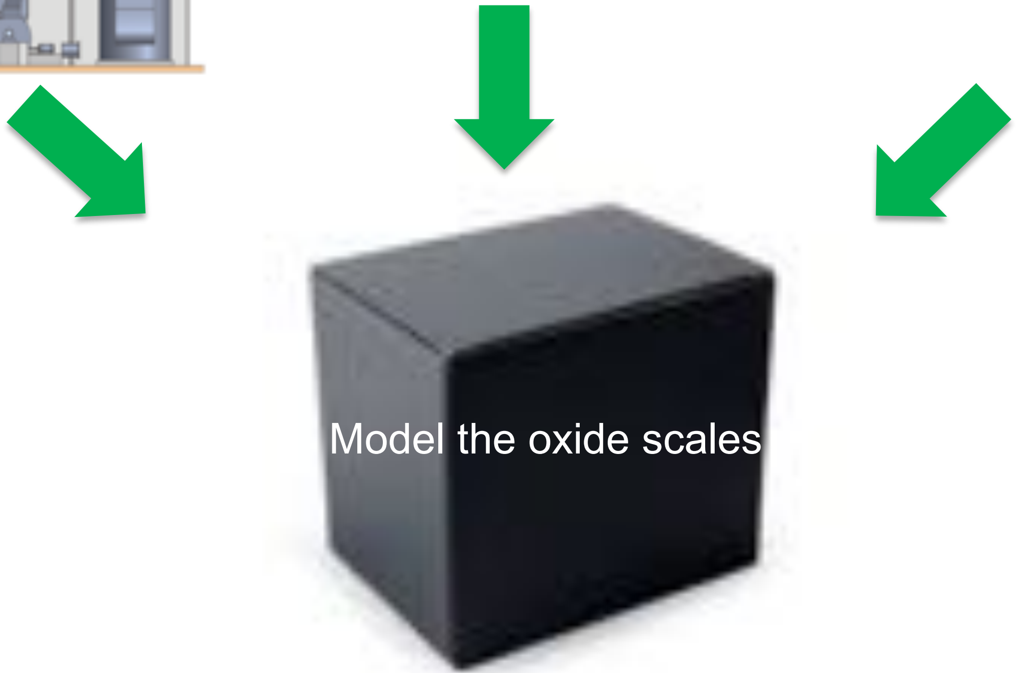

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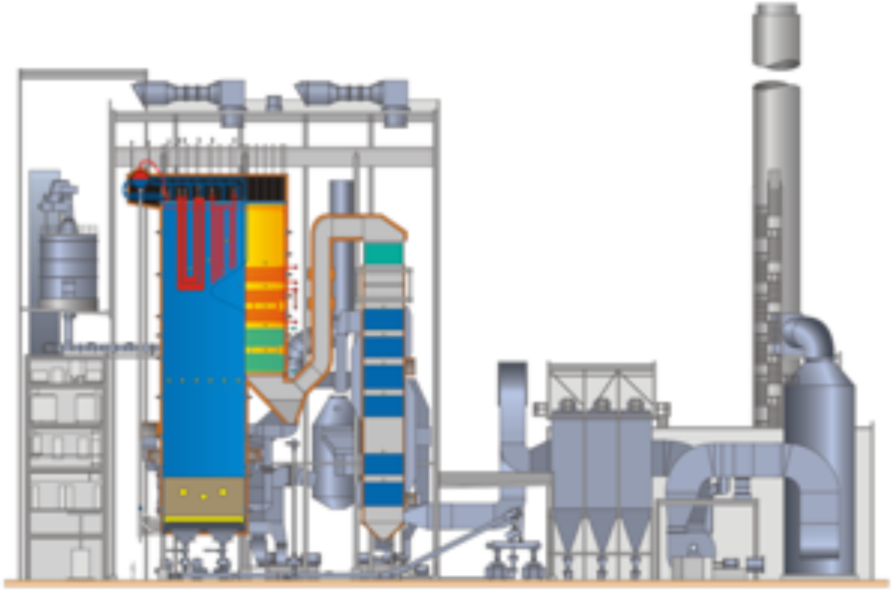

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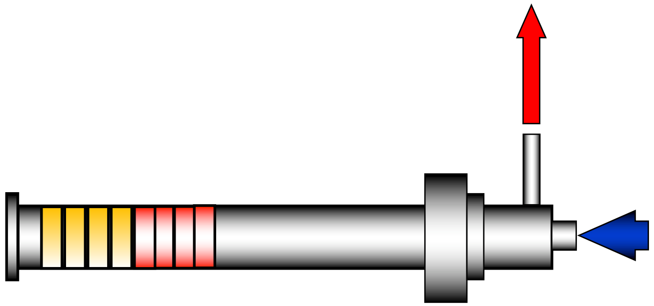

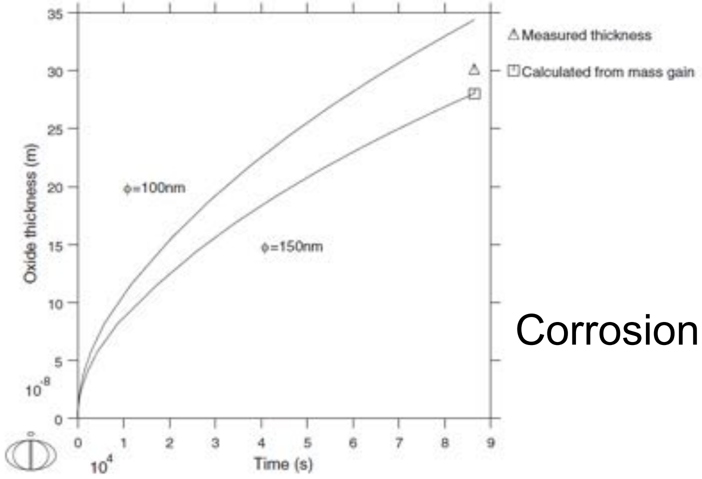

Corrosion rate – calculations up to 8000h performed

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