New Materials and Oxygen Carrier Aided for improved competitiveness of FB plants using renewable fuels

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e·on

stockholm exergi

Sumitomo SHI FW

SANDVIK

KANTHAL®
Part of Sandvik Group

MH Engineering

Energiforsk

AVANCEZ 1829
CHALMERS

Overall aim

Improve economy of power plants and CHPs:

Use of renewable fuels => Increase competitiveness vs fossil fuels.

Target two problem areas in FBC boilers:

Water wall corrosion.
Loop seal superheater corrosion/erosion.

Project plan

Decrease the overall cost of water walls and/or loop seal superheaters:

Improving the corrosion resistance of materials.

Mitigating the corrosion/erosion at the loop seal position (change of bed materials or optimized design).

Investigate the performance of materials:

Newly developed and commercial steels/alloys.

Thermal spray coatings and overlay weldings.

Increase the corrosion knowledge:

Material degradation mechanisms.

Environmental parameters at the loop seal position.

Roles

E.ON Värme Sverige AB

Stockholm Exergi AB

Responsible for boiler operation, fuel & gas analysis and collecting other operational data.

Kanthal AB

Sandvik Materials Technology AB

Providing materials, including newly developed model alloys.

MH Engineering AB

Providing coating materials.

Sumitomo SHI FW Energia OY

Responsible for sample installations, corrosion probe exposures and some corrosion evaluations/analyses.

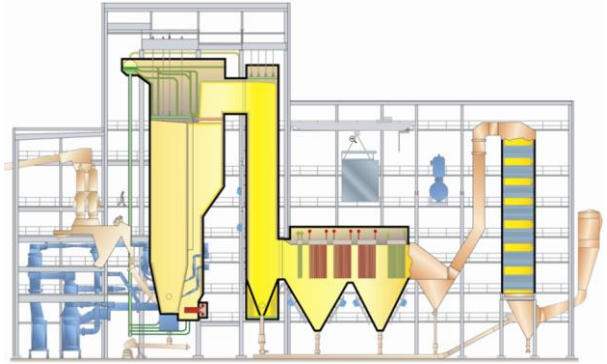
Energiforsk AB

Responsible for results dissemination, collaboration and continuous knowledge exchange between the academia and the industry stakeholders. Drafting the project agreement.

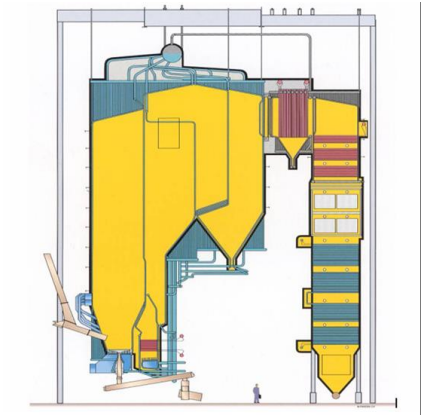
Chalmers University of Technology

Project leader. Responsible for short term corrosion testing, corrosion evaluation and analysis.

Project plan



Eon – Händelö
P15 Waste-fired boiler



Stockholm Exergi - Högdalen
P6 Paper-, Wood- and Plastics-fired boiler

WP1

Water walls corrosion

WP0

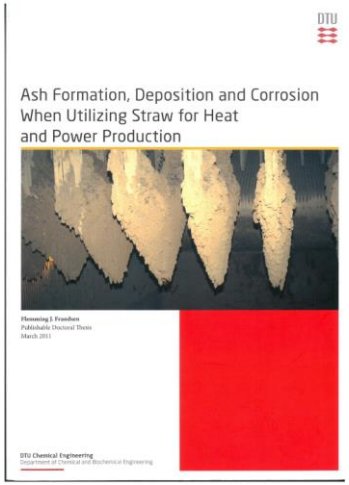
Planning/Methodology development

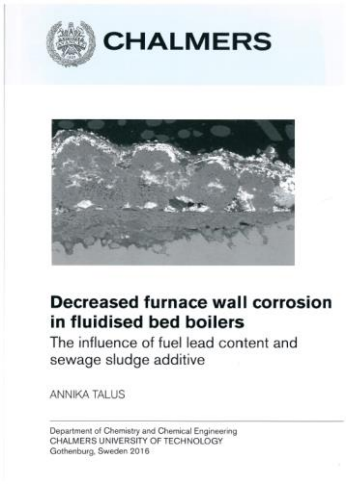
WP2

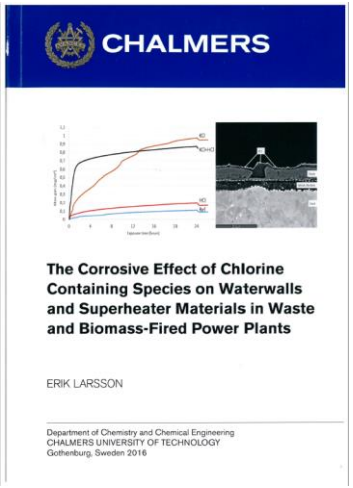
Loop seal corrosion/erosion

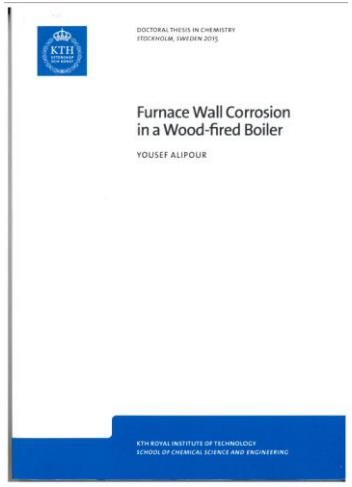
WP0

Literature review



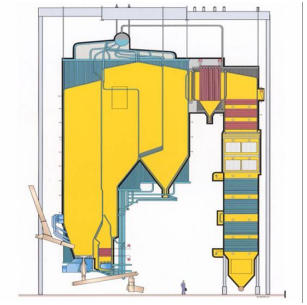






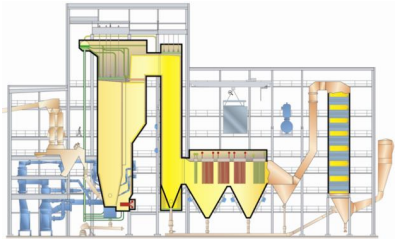
WP1 – Water walls

Högdalen P6



- *A test section of the water wall in the furnace chamber will be installed.*
- *The aim is to test commercially available materials as well as newly developed alloys and coatings.*
- *The current material installed today is overlay welding of Inconel625.*

Händelö P15



- *A section of the empty pass has been coated by means of metal spray (HVOF).*
- *The corrosion results of this test section will be compared to water walls overlay welded with Alloy625.*

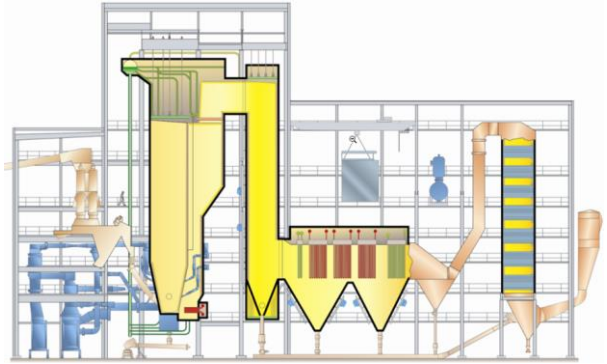
Furnace Wall Corrosion Tests

Sumitomo SHI FW

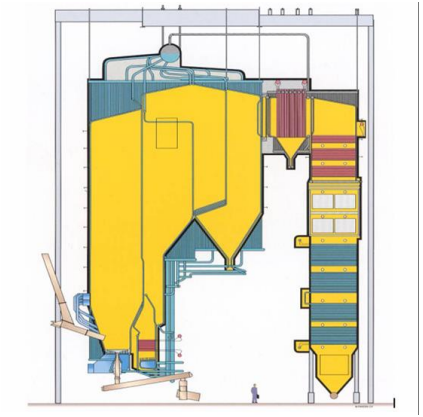
Testing Method

- Wall corrosion probes for testing different material candidates
  - Probes (L = 60 mm or longer) are machined from different rod materials.
  - Installation of the probes can be done during boiler operation.
  - Each probe includes own thermocouple to verify material temperature.
  - Probe temperature can be increased by using insulation between probe and fin.

Project plan



Eon – Händelö
P15 Waste-fired boiler



Stockholm Exergi - Högdalen
P6 Paper-, Wood- and Plastics-fired boiler

WP1

Water walls corrosion

WP0

Planning/Methodology development

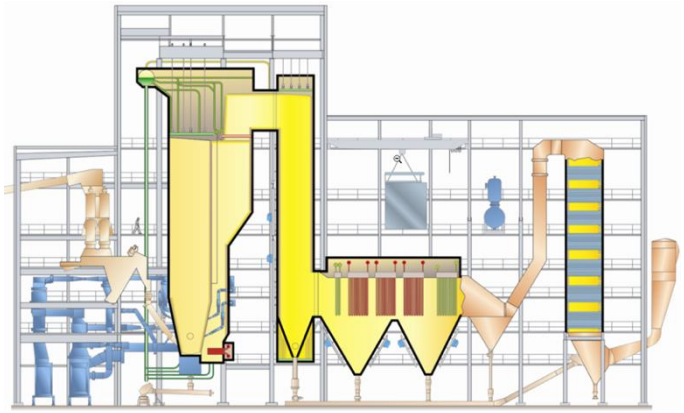
WP2

Loop seal corrosion/erosion

Summary and material loss of bulk materials

12 months exposure Händelö – March 2019-March 2020

Händelö

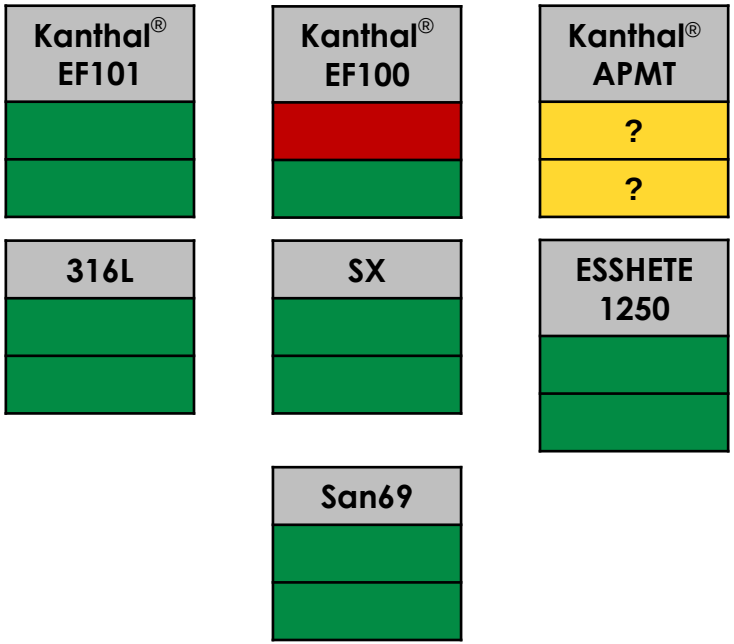


Eon – Händelö
P15 Waste-fired boiler

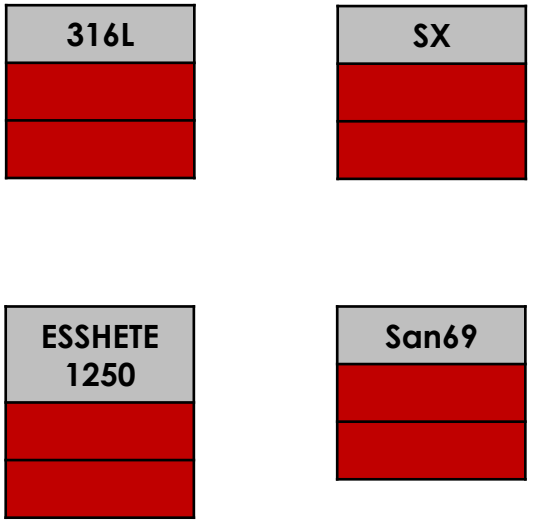
Materials
Kanthal® EF101
Kanthal® EF100
Kanthal® APMT
316L
SX
Esshete1250
San69

Summary 12 months

Superheater 2



Superheater 3



Material loss of bulk materials

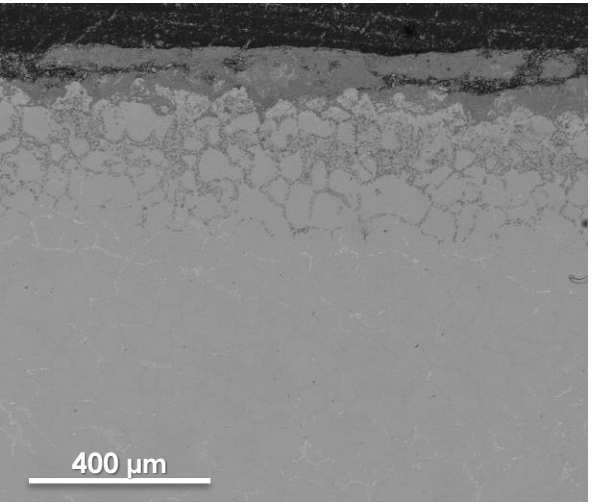
Kanthal® EF101 U
Kanthal® EF100 D
~~Kanthal® APMT U~~
316L U
SX U
Esshete1250 U
San69 U

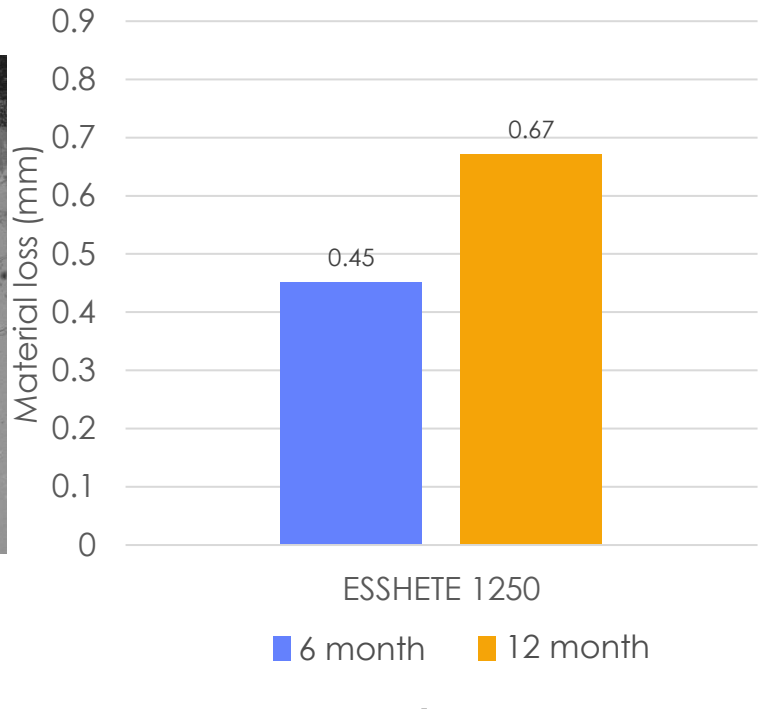
Superheater 2

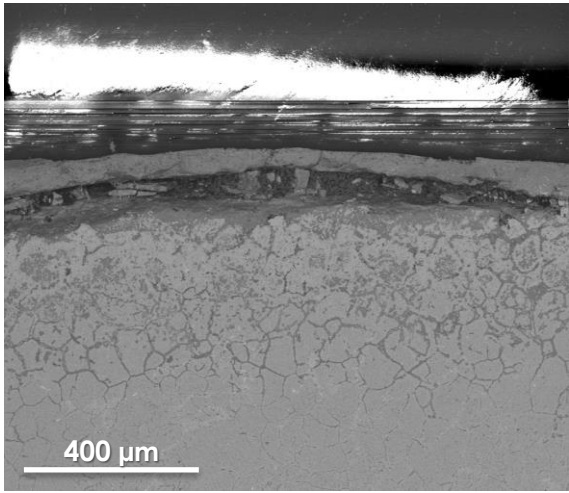
12 months

March 2019-2020

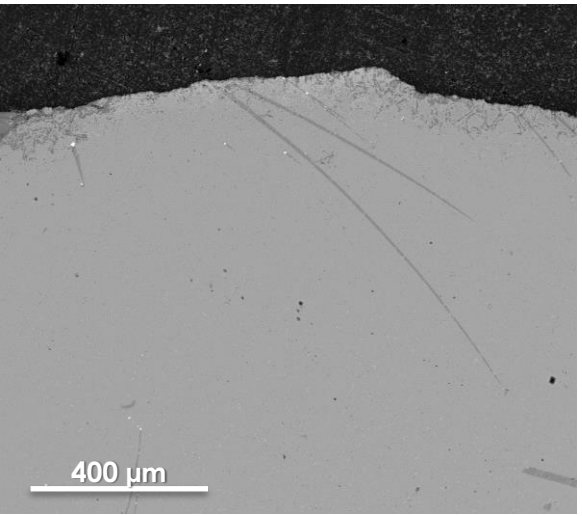
ESSHETE 1250

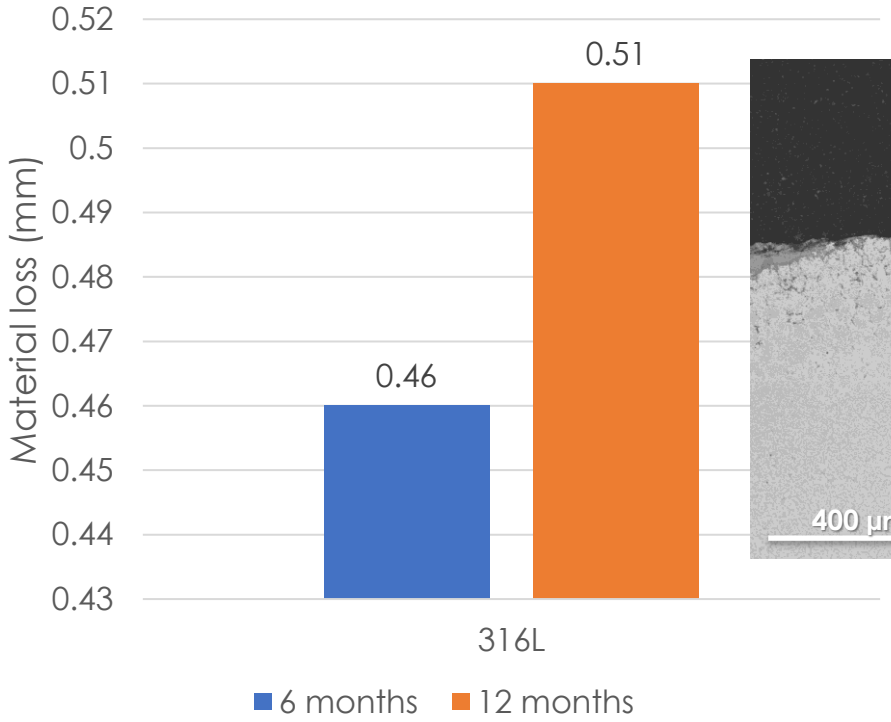


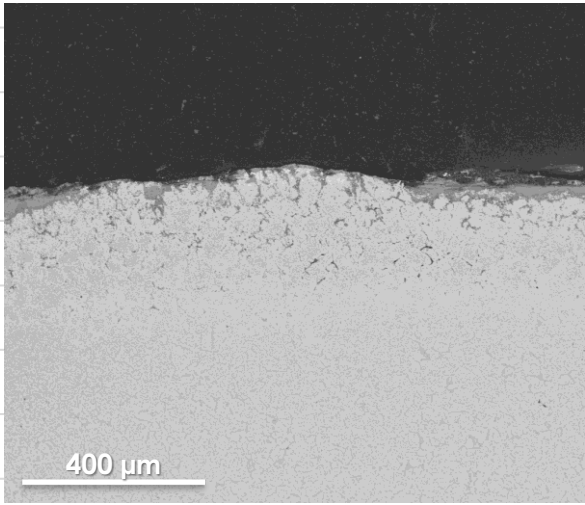




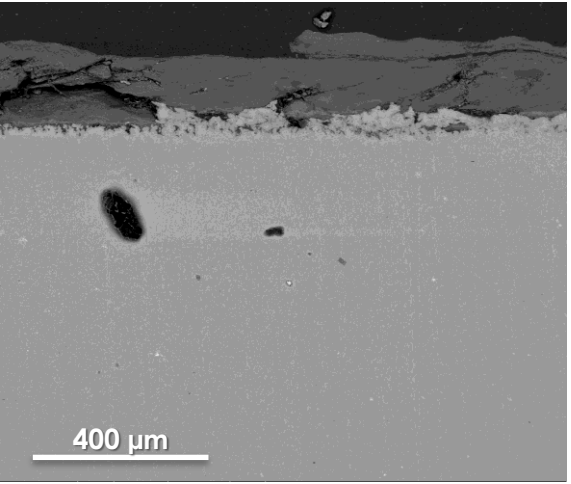
316L

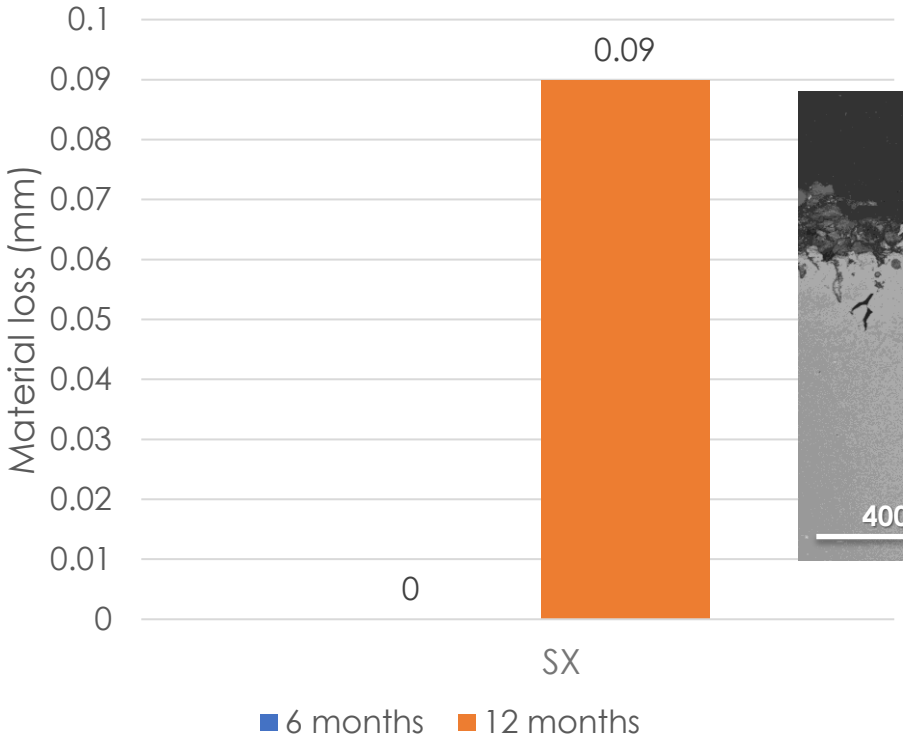

400 µm

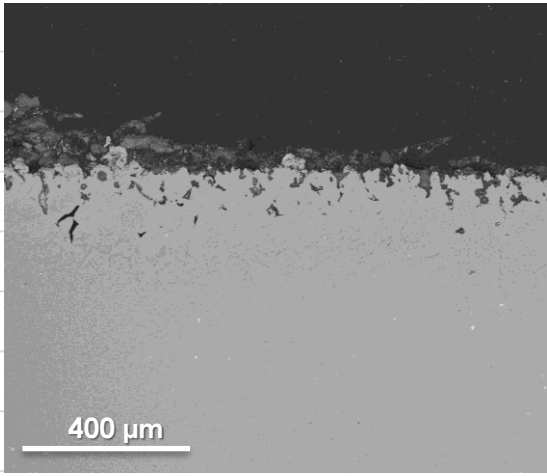

0.52
0.51
0.5
0.49
0.48
0.47
0.46
0.45
0.44
0.43
Material loss (mm)
0.46
0.51
316L
6 months
12 months


400 µm

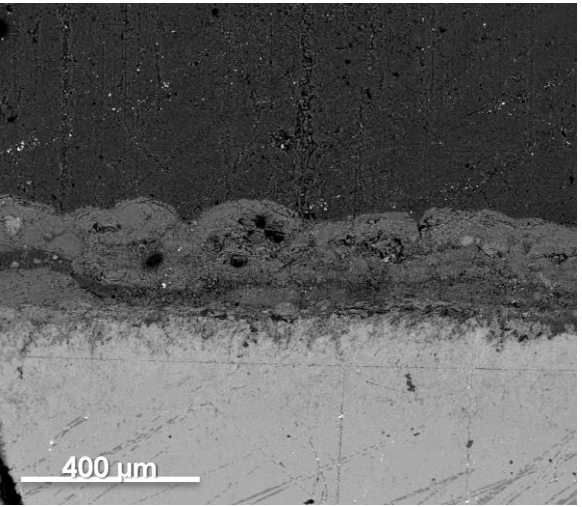
SX

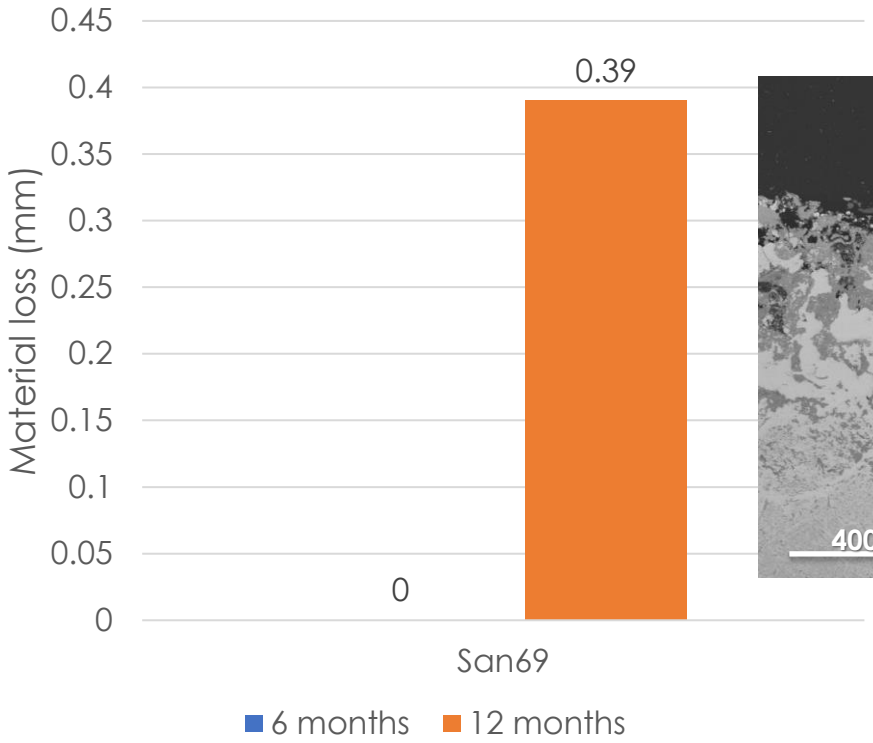

400 µm

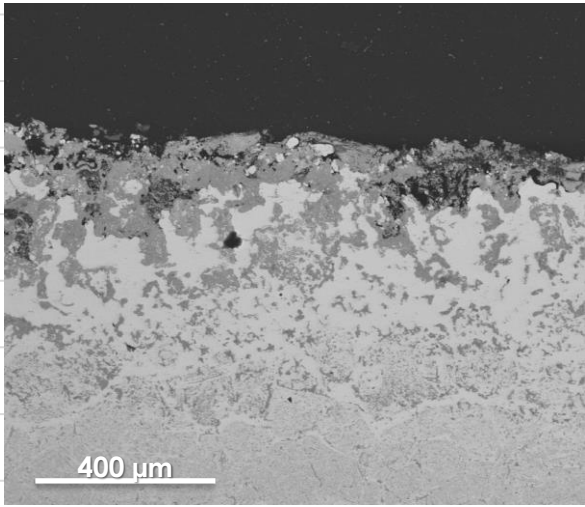

0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
Material loss (mm)
0.09
0
SX
6 months
12 months


400 µm

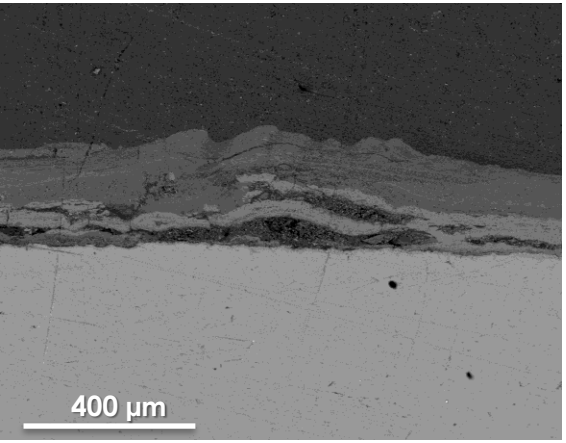
San69

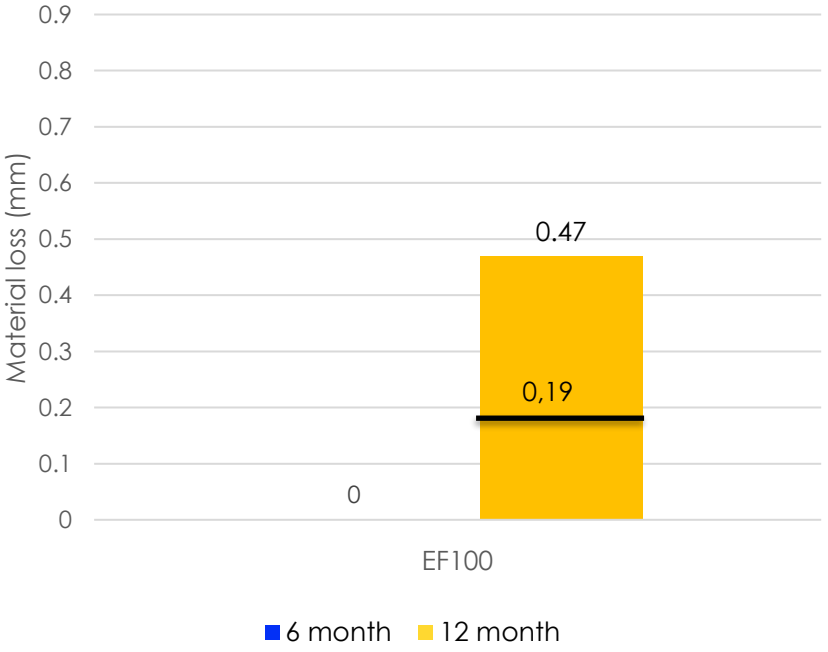

400 µm

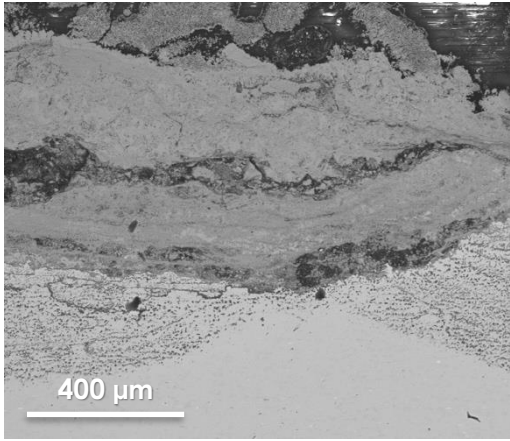

0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Material loss (mm)
0.39
0
San69
6 months
12 months

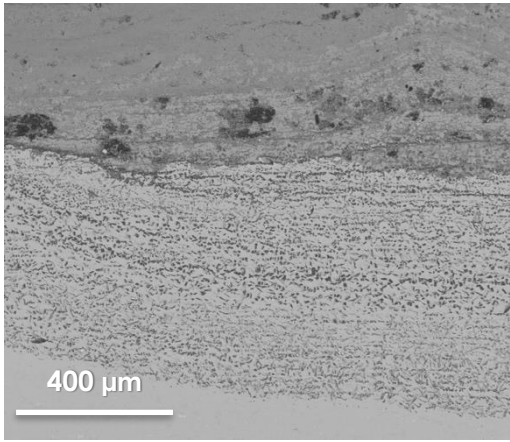

400 µm

Kanthal® EF100

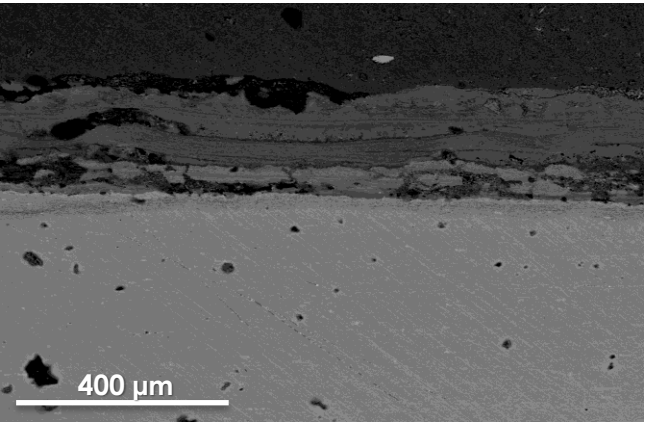


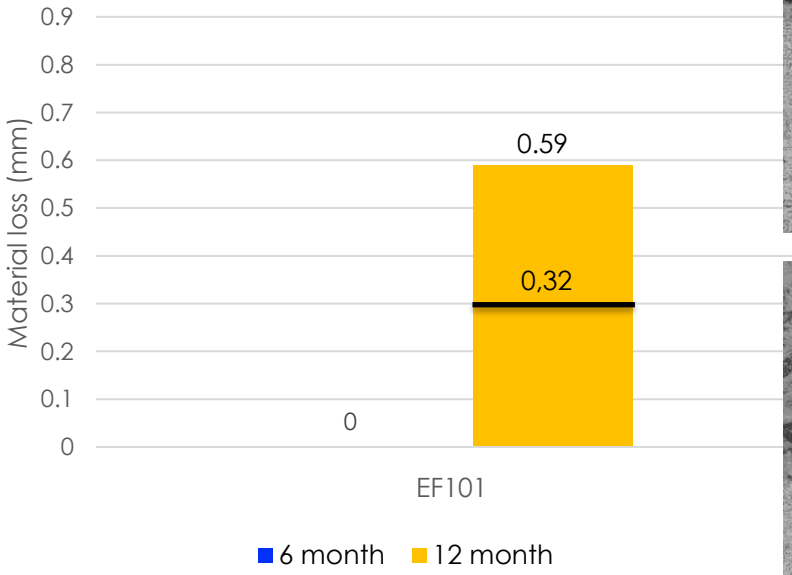


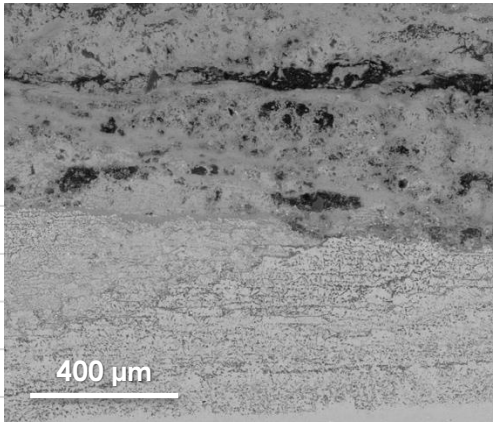


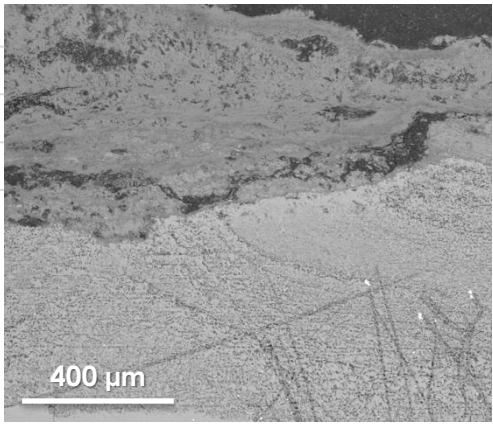


Kanthal® EF101



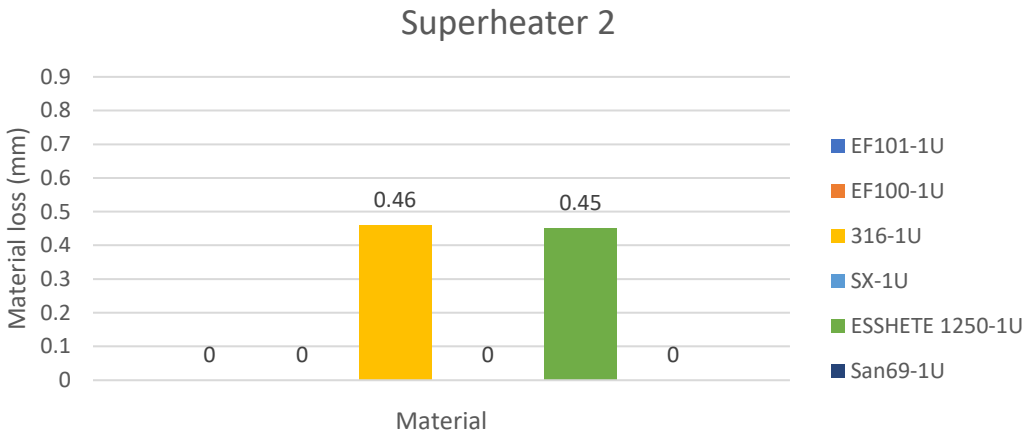




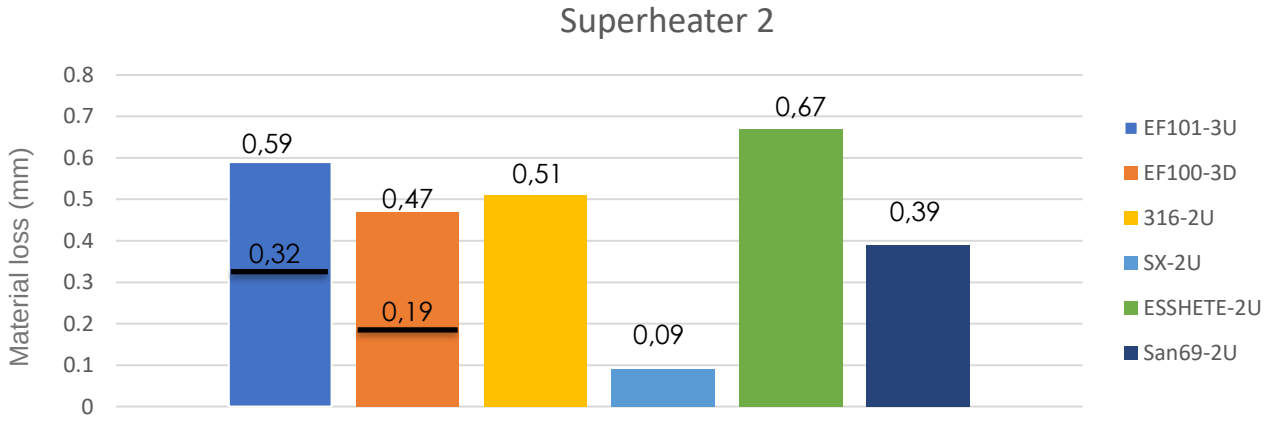


Superheater 2

6 months



12 months



Ongoing and Future work

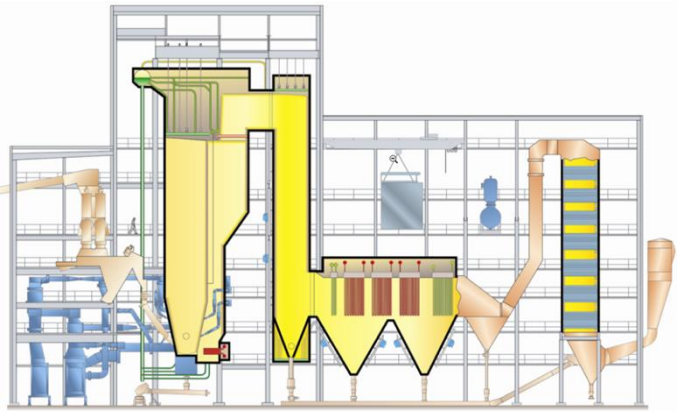
- **Perform SEM and material loss analysis on downward faced samples.**
- **Perform EDX analysis on samples.**

SEM analysis of WOL samples

6-12 months exposure

Händelö

Händelö



Eon – Händelö
P15 Waste-fired boiler

Material temperature
~ 600°C
574-617°C

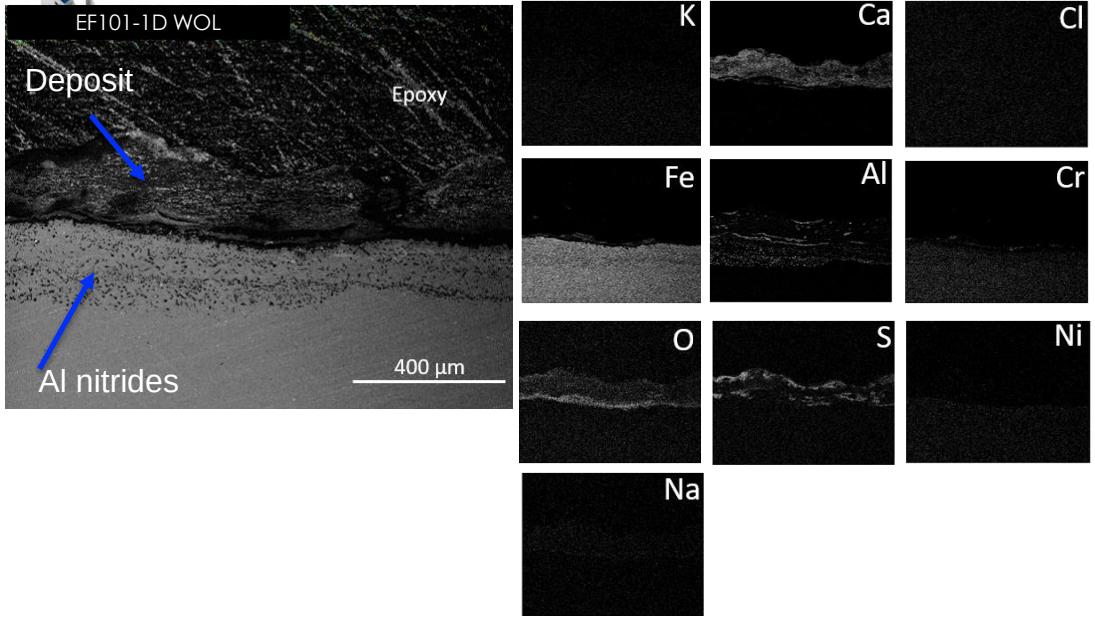
6-12 months

March-March 2019-2020

Materials	Position	Time
Kanthal® EF101-1D WOL	SH2	6month
Kanthal® EF100-1D WOL	SH2	6month
Kanthal® EF100-2D WOL	SH2	12month
Kanthal® APMT-1D WOL	SH2	6month
Inconel 625-6D WOL	SH3	6month

Kanthal® EF101-1D WOL

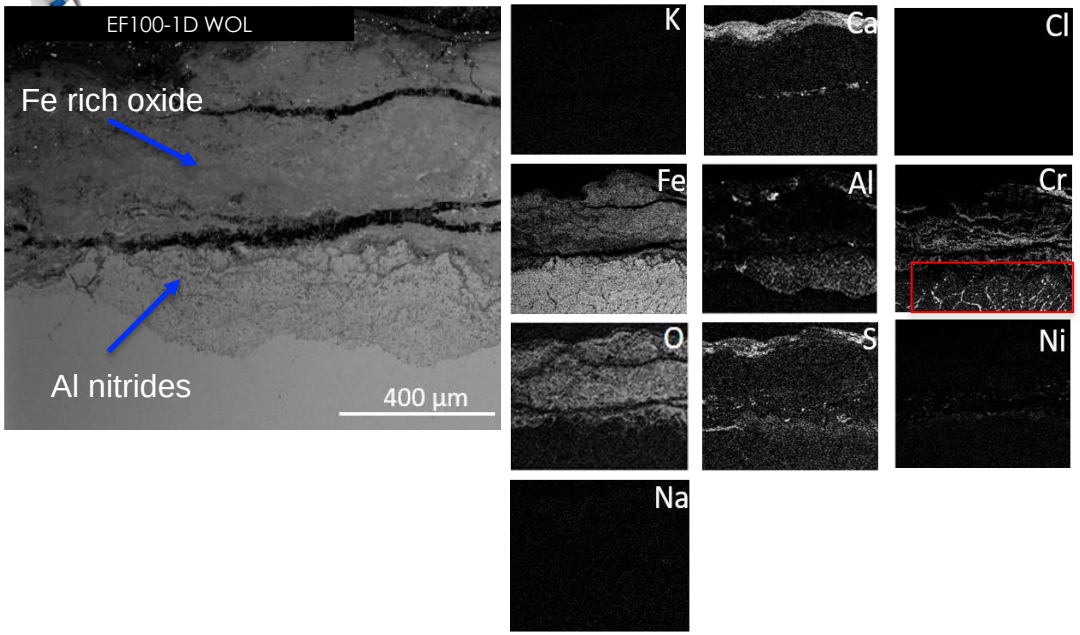
Materials	Position	Time
Kanthal® EF101-1D WOL	SH2	6month



- Internal oxidation (Al nitrides) ≈ 200µm
- Deposit thickness≈ 200µm
- Oxide thickness: ≈ 40µm
- Thin and adherent oxide

Kanthal® EF100-1D WOL

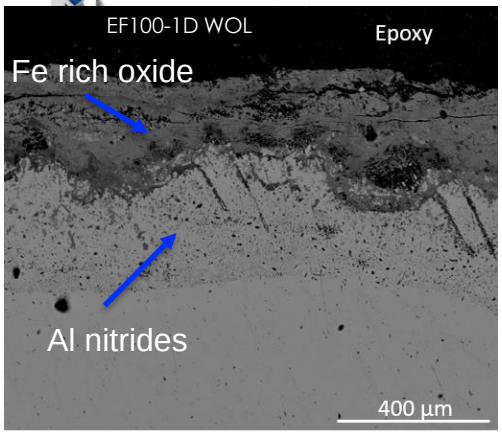
Materials	Position	Time
Kanthal® EF100-1D WOL	SH2	6month

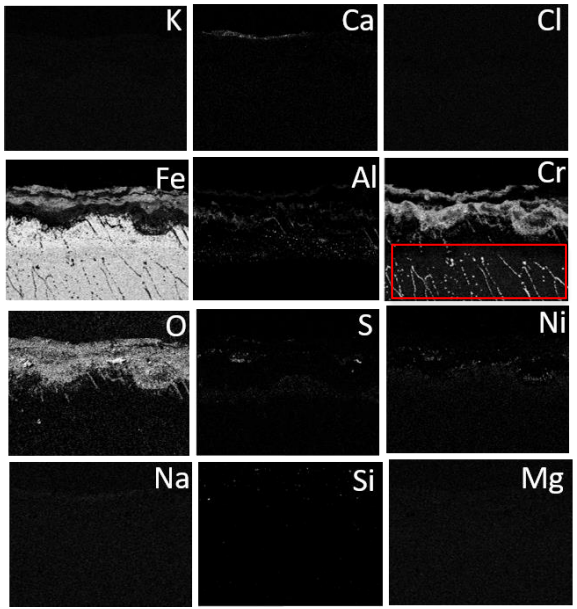


- Internal oxidation (Al nitrides) ≈ 230µm
- Deposit visible
- Cr enrichment in G.B
- Oxide thickness: ≈ 500µm

Kanthal® EF100-2D WOL

Materials	Position	Time
Kanthal® EF100-2D WOL	SH2	12month

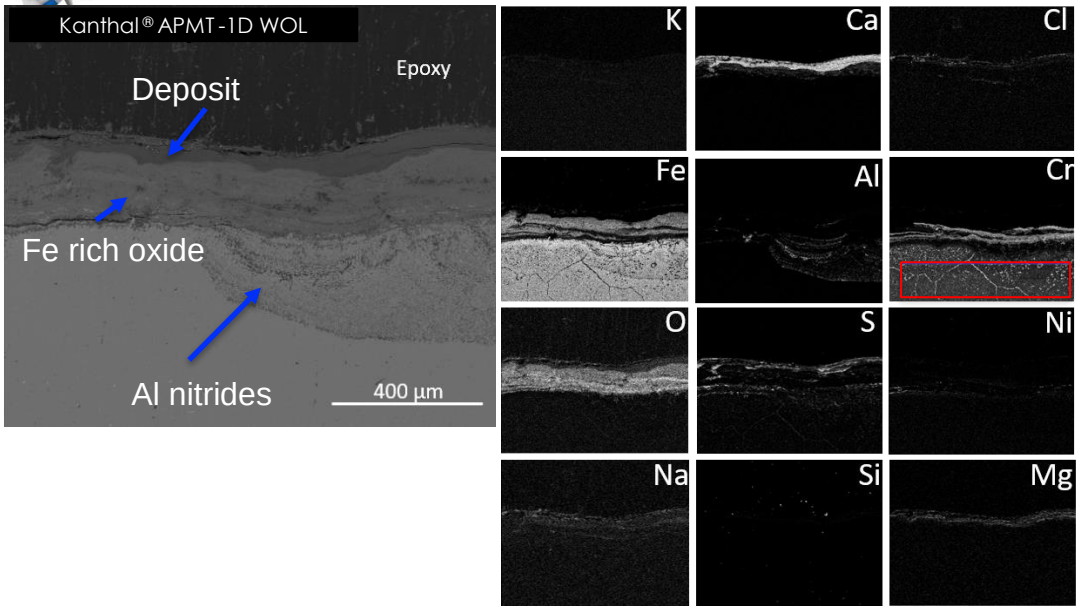




- Internal oxidation (Al nitrides) ≈ 280µm
- Cr enrichment in G.B
- Oxide thickness: ≈ 260 µm
- Poor adhesion of oxide

Kanthal® APMT-1D WOL

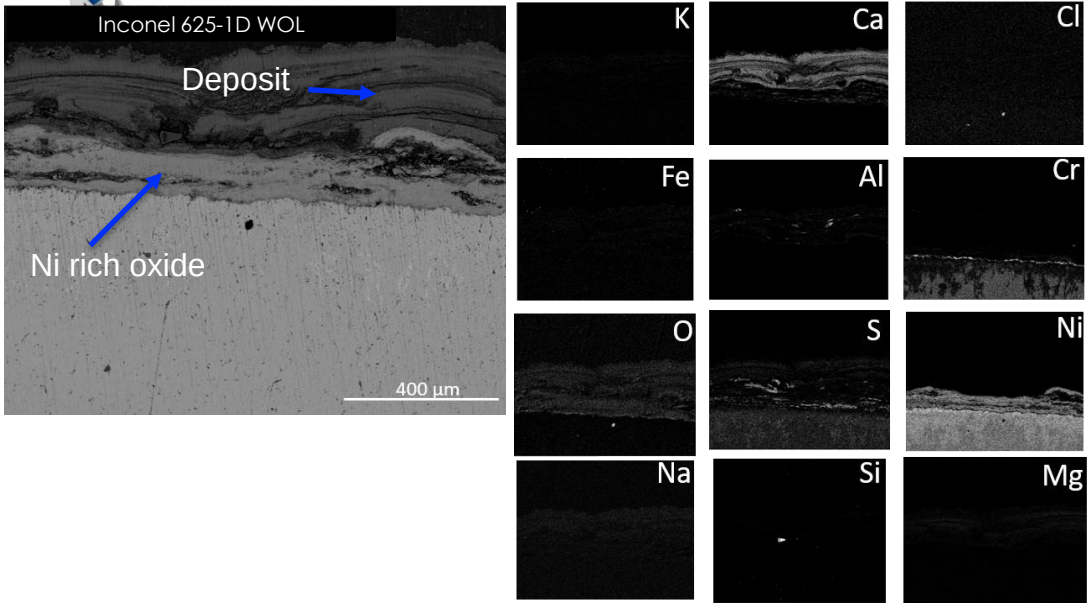
Materials	Position	Time
Kanthal® APMT-1D WOL	SH2	6month



- Internal oxidation (Al nitrides) ≈ 220µm
- Deposit visible
- Cr enrichment in G.B
- Oxide thickness: ≈ 260 µm
- Adherent oxide

Inconel 625-6D WOL

Materials	Position	Time
Inconel 625-6D	SH3	6month



- Ni rich oxide
- Deposit visible≈ 260µm
- Oxide thickness: ≈ 140µm

Summary SEM/EDX results- Händelö

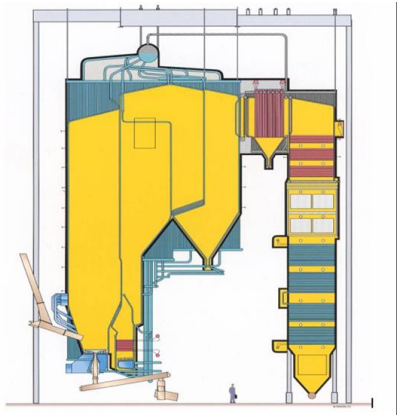
- Kanthal® EF101 WOL shows indication of formation of an adherent thin oxide layer after 6 month.
- Al-enriched zone was observed on Kanthal® EF100, Kanthal® EF101, and Kanthal® APMT WOL and is suggested to consist of Al-nitrides.
- Local Cr enrichment in G.B was observed for EF100 and Kanthal® APMT WOL sample.

Ongoing and future work Händelö WOL samples

- Ongoing SEM analysis of remaining samples from first and second recovered batch.

Ongoing work Högdalen WOL samples

- **Ongoing SEM analysis of remaining samples from first recovered batch (12 month of exposure).**



Stockholm Exergi - Högdalen
P6 Paper-, Wood- and Plastics-fired boiler

Higlights of upcoming events WP1 & WP2

WP1

Probe exposure in Högdalen P6 water walls (168h). Test will start November, earliest.

WP2

Summarize results från Händelö (batch 1, SH2) and submit an abstract for the fluidized bed conference (Gothenburg, 8-11 May, 2022).

Thank you for your attention!