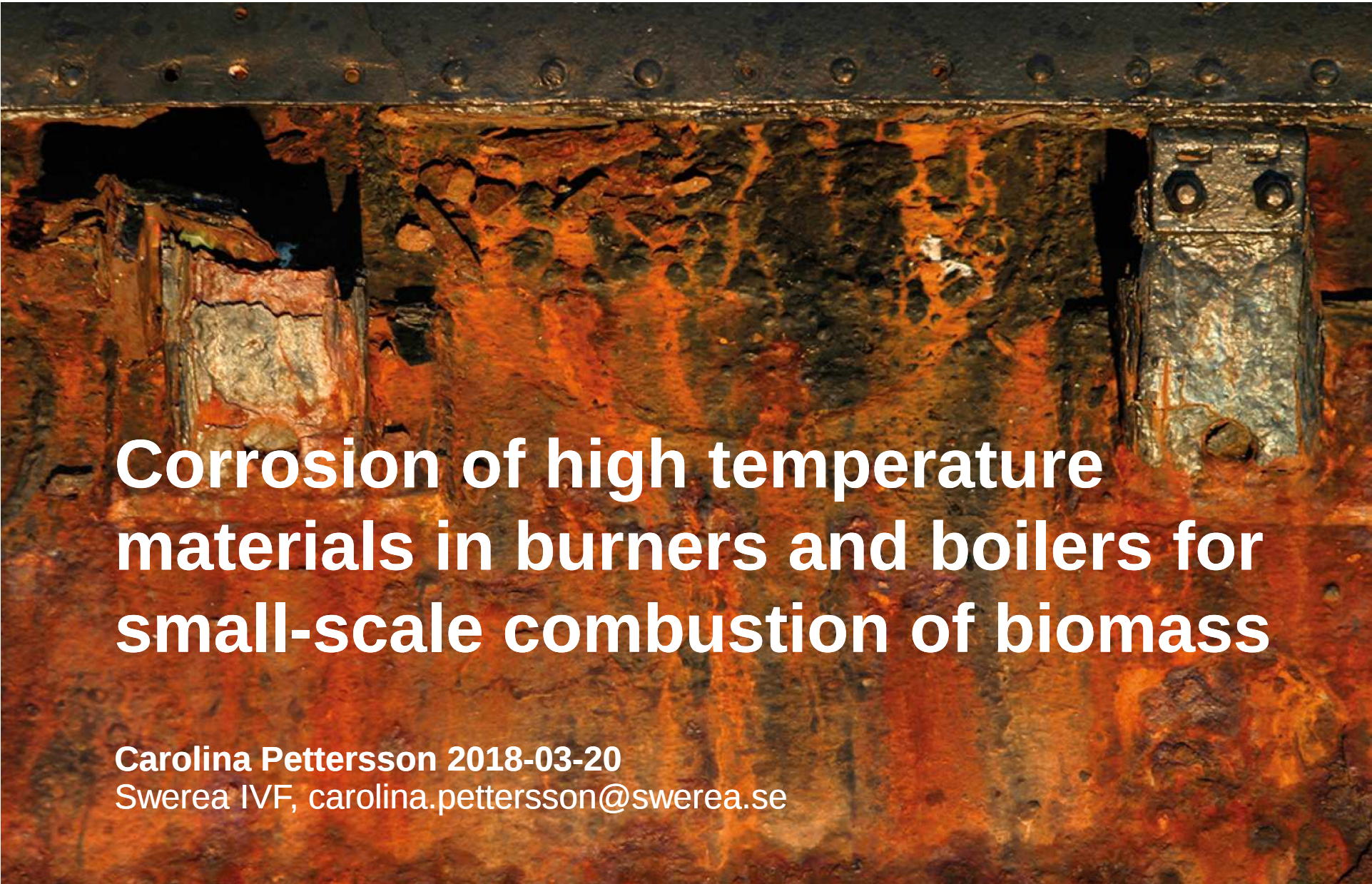




Corrosion of high temperature materials in burners and boilers for small-scale combustion of biomass

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Project members

- Janfire
- NIBE
- Sandvik Heating Technology
- Swerea IVF
- Chalmers



New in this period:

- Smålands stålgjuteri



Background

- In the combustion of bio-based fuels the critically exposed burner parts in small boilers are typically **uncooled** and are usually made of **FeCr or FeCrNi alloys**
- These materials can suffer attack from the **ashes** because of the formation of **alkali chromate**
- The reaction depletes the protective oxide in chromia, leading to accelerated corrosion
- This ultimately results in failure of the boiler unit and/or is limiting the service life of critical burner components

Activities previous 4 year period

<i>Year</i>	<i>Activity</i>
2014	Planning and production of materials to be investigated
2015	Cyclic lab exposures (Kanthal) 850°C Analysis of exposed materials at Swerea IVF
2016	Cyclic lab exposures (Kanthal) 600°C Analysis of exposed materials at Swerea IVF Field exposures ~800°C (Janfire) Analysis of exposed materials at Swerea IVF
2017	Cyclic lab exposures with elevated Cl-content at 600°C Analysis of exposed materials at Swerea IVF (sample preparation) and Kanthal (microscopy) Cyclic and continuous “box with ash” exposures Initial exposure and analysis at Kanthal Field exposures initiated at Janfire boiler

Experimental work

- Exposures in lab and in field
 - Cyclic ranking tests
 - Testing of model alloys
 - Exposures with ash on the surface
- Analysis of the corrosion products and oxide scale in SEM
 - Top view and cross sections
 - Chemical analysis with EDS
- Measurement of the oxide scale in OM

Lab testing: ranking test, thermal cycling

- Performed at Kanthal site in Hallstahammar
- Cycling, 1 hour hold time at high temperature, 30 minutes at RT
- 850°C and 600°C
- Reference wood pellets ash (Janfire) was manually placed on the samples.
Ash was replaced each 10th cycle in order to maintain its corrosiveness.



Samples, general appearance

At start



After 60 cycles



Production of model alloys

- Performed at Kanthal site in Hallstahammar
- Coupons were prepared from reference and model alloys



Lab scale vacuum melting and hot rolling

Field test: ranking test, thermal cycling

- Performed by Janfire and exposed at commercial installation (laundry)
- 6 samples are welded on a sheet of 304 which was welded on to the wall of a 600 kW burner
- Operating temperature ~800°C
- Exposure time ~1200h (daytime)



Field exposure test set-up

Samples

Example of results from lab exposures

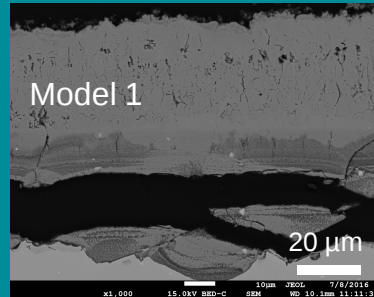
- The influence of Si to FeCrAl alloys with different Cr-content
- Model alloys with potential for alumina protection
- Exposure temp: 600°C
- No. of cycles: 100

No.	Material	Fe	Cr	Al	Si
1	model	bal.	5	4	
3	model	bal.	5	4	2
6	model	bal.	10	4	
7	model	bal.	10	4	2
15	model	bal.	21	3	2
FeCrAl	Kanthal AF	bal.	21	5	

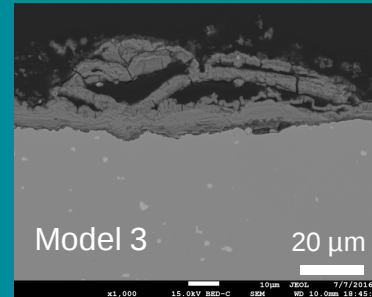
The role of 2 wt% Si addition

5 wt% Cr

Without Si



With Si

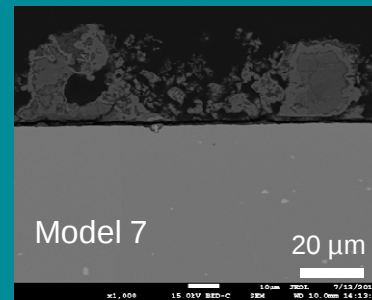
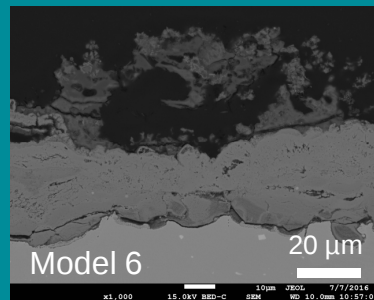


Oxide scale thickness

1: 50-80 µm

3: 2-30 µm

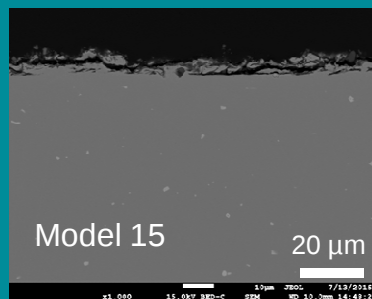
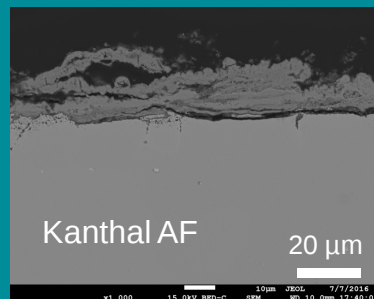
10 wt% Cr



6: 0-50 µm

7: 0-3 µm

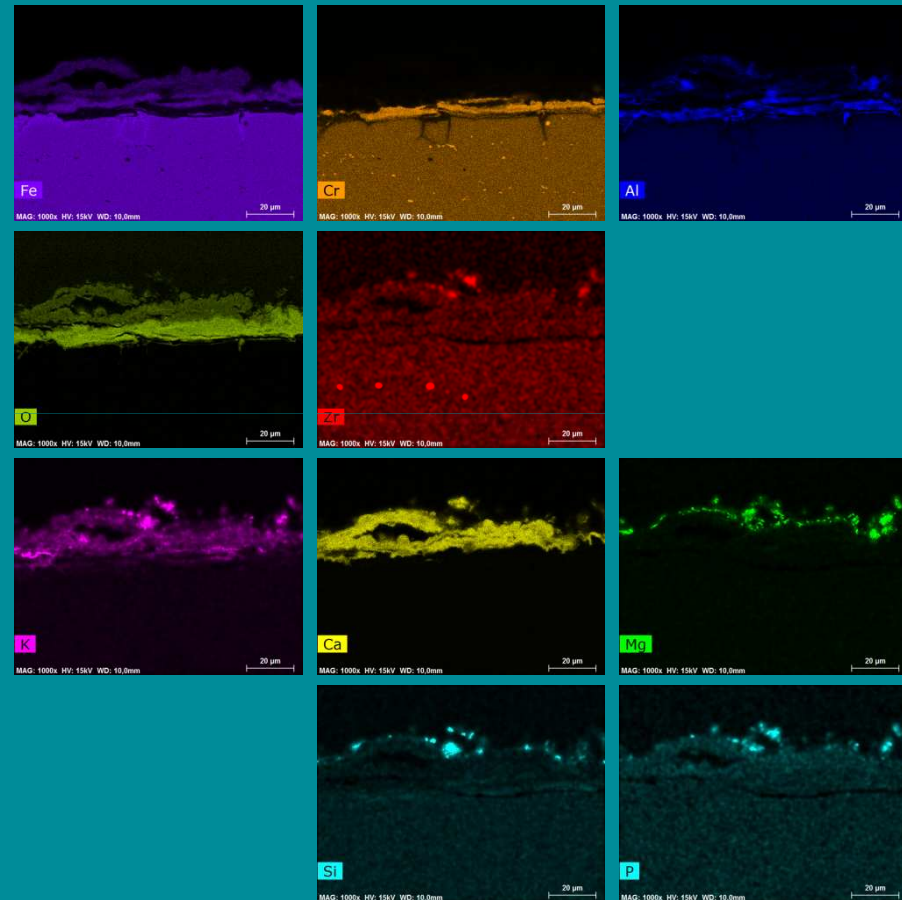
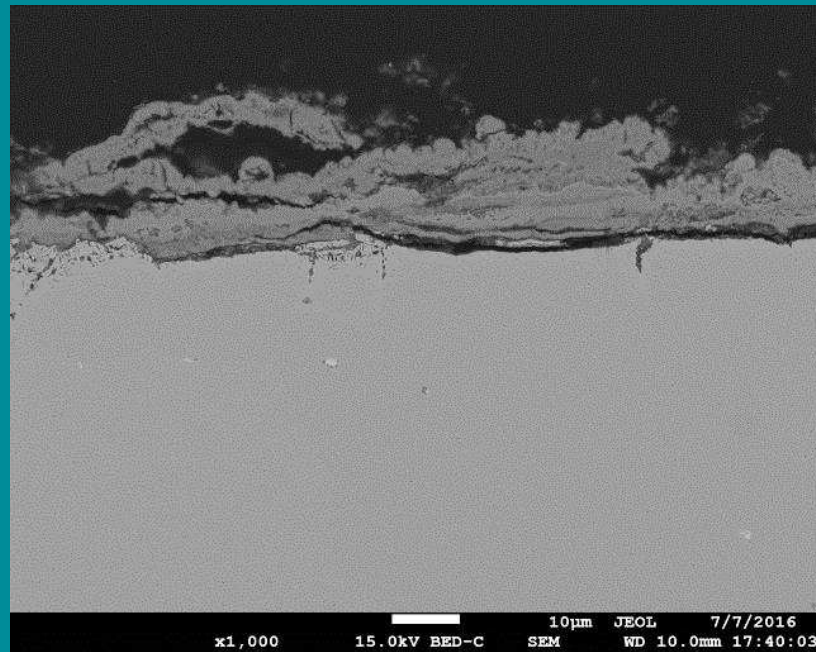
21 wt% Cr



AF: 1-30 µm

15: 2-10 µm

Kanthal AF (21Cr, 5Al): Cross section, centre, EDS-analysis



New type of experimental set-up



Some conclusions and continuous work

- Obtaining useful results from lab ranking test is possible
- Deposits in the field exposure differs from the ash used in lab testing
 - Shorter exposure times in field tests
 - Longer exposure time in laboratory scale
 - New method using an ash filled alumina box under evaluation.
Less labor intensive – allows comparison of several samples, several temperatures and several types of ash
- Model alloy system seems to have potential for further development
- → Further work to clarify the mechanisms is needed



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