Mitigating Chloride Corrosion in WTE Superheater Tube Alloys

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Project Motivation

Chlorides Affect WTE Superheater (SH) Corrosion

MSW contains between 0.4-0.7 wt% chlorine. This fraction is liberated from waste during combustion in the form of HCl, Cl_2, and metal chlorides which can react with, deteriorate heat transfer surfaces.

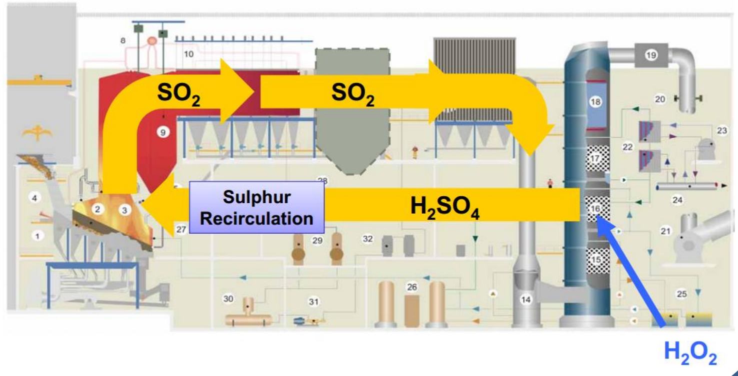
Chlorides have been largely attributed to the corrosion observed in WTE superheater tubes.

WTERT-US survey: Boiler maintenance costs WTE plants on average *$4 per short ton combusted*[1] or ~6% of gate fee

Some Potential Solutions to Reduce Cl Corrosion

- Design boilers, SH tubes with alloys, overlays, or coatings with Cl resistant materials
- Investigate sorbents to capture Cl compounds
- Additives which modify tube deposits to more corrosion resistant (e.g. sulfur- containing additives)

Novel approach for reducing Cl corrosion via SO_2 recirculation, by Gotaverken Miljo[2]
[WTERT 2012 presentation]



Corrosion Testing

Current Research Questions

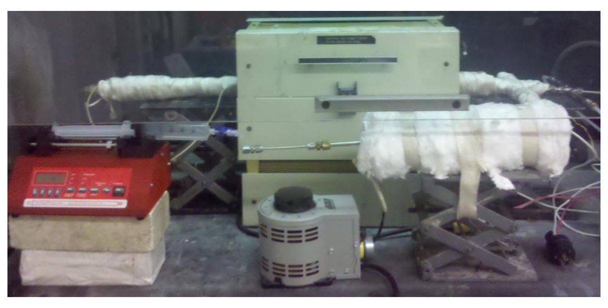
- ✓ How are SH tube alloys affected by chloride deposits? What are the probable corrosion mechanisms?
- ✓ What types of alloys provide protection against high temperature corrosion of chlorides?
- ✓ What is the effect of the SO_2/HCl ratio on alloys under chloride deposits?
- ✓ What is/are the most cost effective approaches to mitigating Cl corrosion in WTE boilers?

Experimental Approach

1. Coupon Cutting and Cleaning

Coupons cut from SH alloys, 3.2 cm² area

2. Furnace Tests

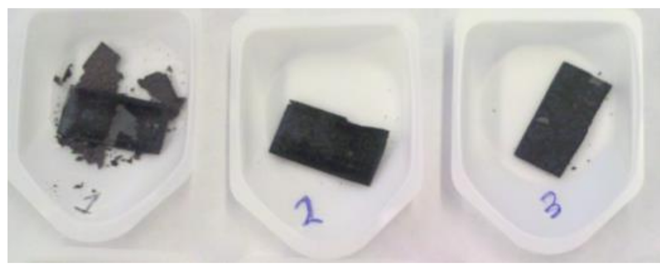


Isothermal testing, under synthetic WTE flue gas

3. Coupon, Deposit Characterization

XRD, SEM-EDS

4. Corrosion Rate Assessment



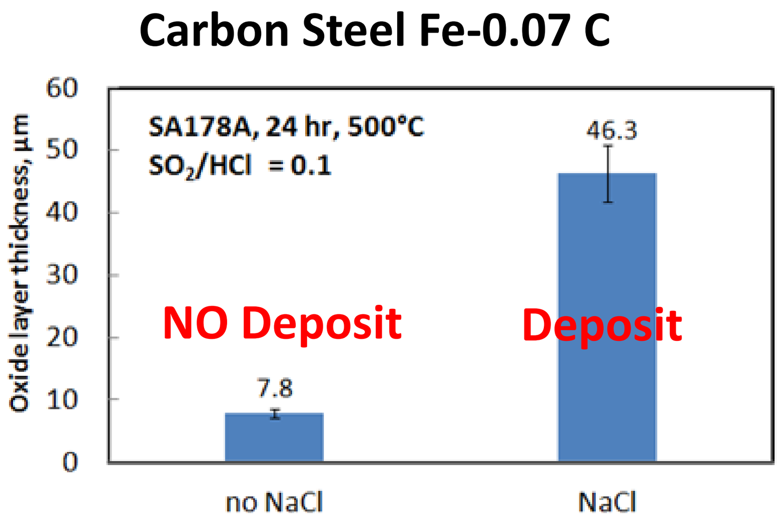
Rate calculated from mass loss, in accordance with ASTM method G1-03

Testing Conditions Metal temperatures: 450-550°C (842-1022°F); Gas Composition: 8% O_2; 12% CO_2; 15% H_2O; 800 ppmv HCl; SO_2 80-800 ppmv; N_2 balance, 500 SCCM, Deposit NaCl chosen as chloride surrogate, deposit on coupon of 4.0 mg/cm² ± 10%

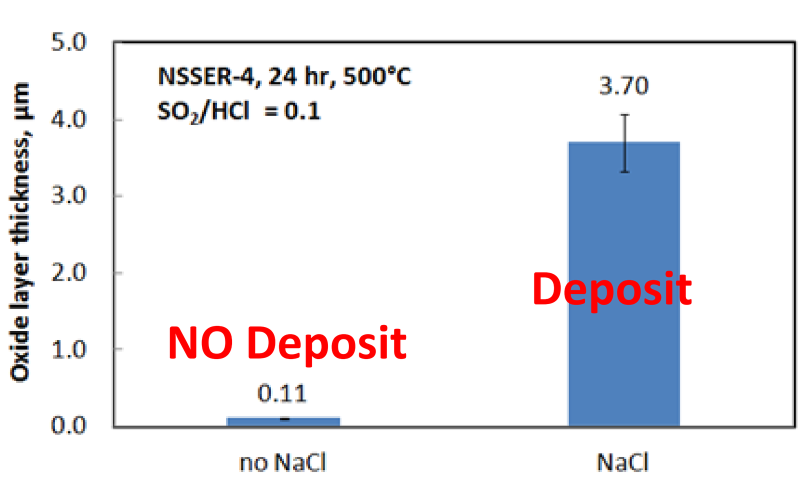
Results and Discussion

Effect of Chloride Deposit

Carbon Steel Fe-0.07 C



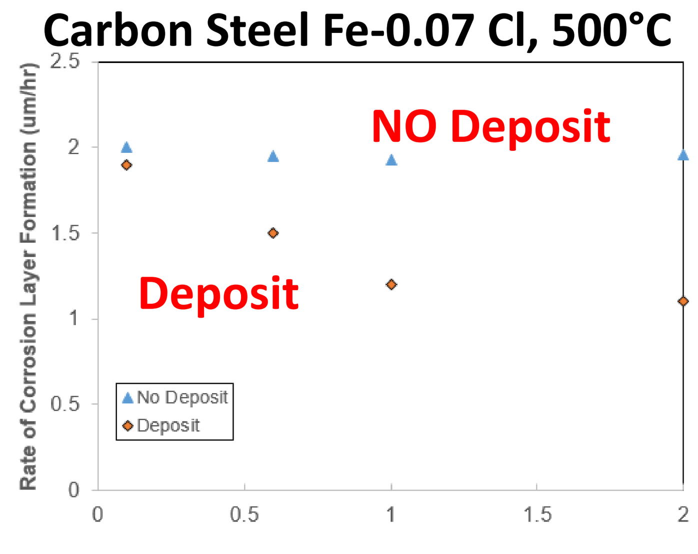
Stainless Steel Fe-17.3Cr-13.1Ni



NaCl layer ***significantly*** accelerate corrosion layer formed unto c-steel, stainless steel over 24 hours by about an order of magnitude at 500 °C (932 F)

Trends with the SO_2/HCl Ratio

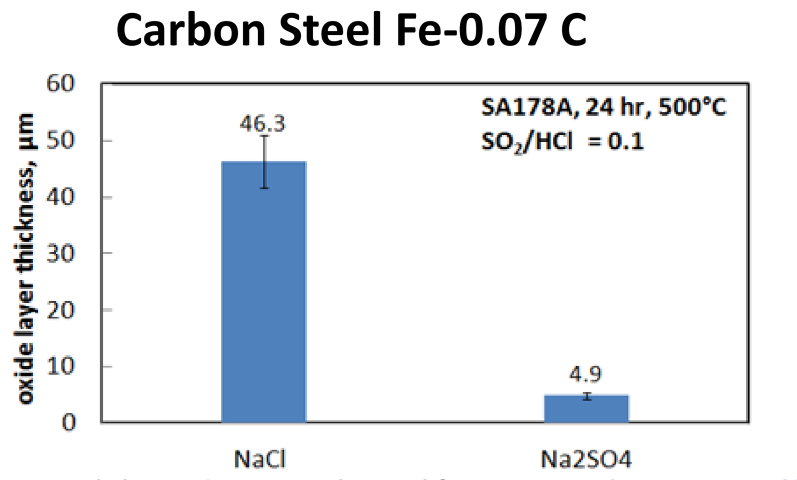
Carbon Steel Fe-0.07 Cl, 500°C



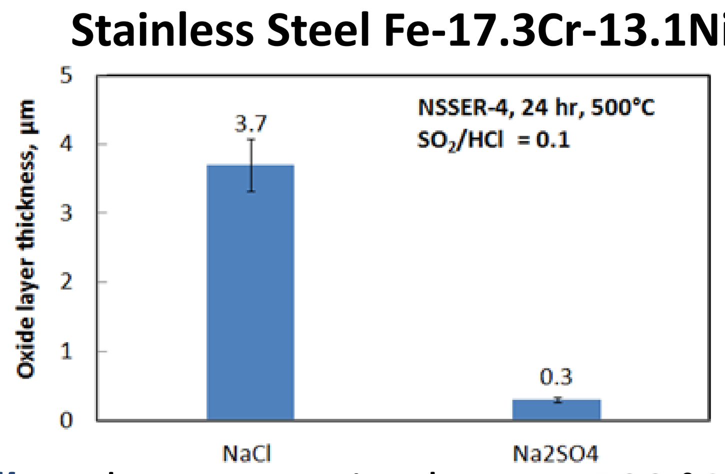
Increasing the SO_2/HCl to elevated levels above typical operation range of 0.1-0.3 range ***suppresses*** formation of corrosion for c-steel at 500 °C (932 F)

Potential Effect of Sulfating Chloride Deposits

Carbon Steel Fe-0.07 C

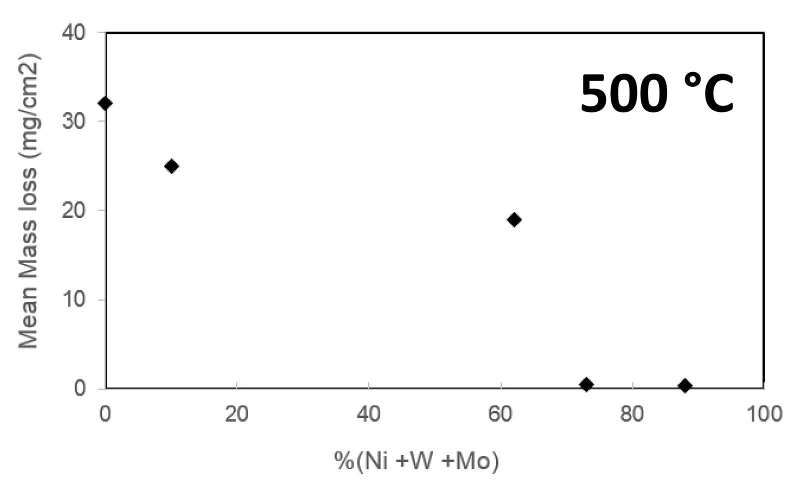


Stainless Steel Fe-17.3Cr-13.1Ni



Replacing chlorides with sulfates, ***substantially*** reduces corrosion layer at 500 °C (932 F)

Effect of Alloy Composition on Chloride Resistance



Increasing concentration of ***Ni+W+Mo*** has shown significant improvement on material loss under NaCl deposit

Conclusions

- Chloride deposits considerably accelerate alloy corrosion under superheater conditions versus sulfate deposits or under WTE flue gas alone
- Increasing the SO2/HCl ratio can suppress the accelerated corrosion due to chloride deposits for carbon and stainless steels
- Increasing the concentration of certain alloying elements, in particular Ni, W, Mo can achieve better SH chloride corrosion performance
- Future work will investigate economic impact of alloying choice versus additives

References
1. PhD Thesis, Shang-Hsiu Lee
2. Sven Andersson Presentation, WTERT 2012

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