High Temperature Corrosion of WTE Boiler Materials

Timothy Sharobem[1], Marco J. Castaldi [2], Paul F. Duby[1]

1. Department of Earth and Environmental Engineering, Columbia University, New York, NY

2. Department of Chemical Engineering, City College of New York (CUNY), New York, NY

Motivation

Boiler corrosion greatly impacts plant operation by limiting energy recovery and increasing operational costs and plant downtime.

Typical factors in boiler corrosion

- temperature
- temperature fluctuations in the boiler
- concentration of chlorine (Cl), sulfur (S) in combustion feed
- condensation of salts, originating from flue gas, along tubes

Waste-to-energy (WTE) boilers generally have higher corrosion than fossil fuel boilers due to higher Cl content in MSW

	MSW	Bituminous Coal
Total Cl wt.%	~0.5	~0.05
HCl in flue gas, ppm	~250	~30

Corrosion research involves evaluating and understanding the performance of different materials in typical operation environments

Current study: understanding trends in SO_2:HCl on corrosion of steels in superheater conditions.

Previous studies conducted by *Götaverken Miljö AB* and *KIT*[1] as well as at *Battelle*[2] have shown that boiler corrosion has decreased in the presence of greater SO_2:HCl ratios.

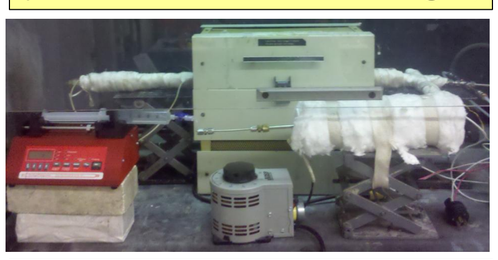
Experimental Methods

Approach: Isothermal testing of boilers materials coupons under synthetic WTE flue gas compositions

Methodology

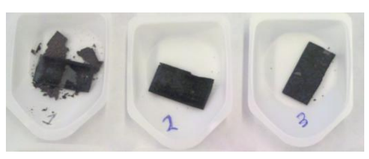
1. Coupon cleaning & mass measurement (ASTM G1-03)

2. Furnace testing (under simulated WTE flue gas)



3. Metal and deposit characterization (SEM/EDS)

4. Mass loss corrosion rate measurements (ASTM G1-03)



$$(mpy) = \frac{3.45*10^6 * W}{A* t* D}$$

W: mass loss, g A: area, cm^2
t: time, hrs D: density
mpy = 0.001" per year

Materials and testing conditions

Steel	Fe	Cr	Ni	C	Si	Mn	Mo	Al	Others
SA178A (carbon steel)	99.19	0.02	0.054	0.07	0.06	0.47	0.01	0.11	0.017
NSSER (stainless steel)	63.76	17.3	13.1	0.04	2.5	0.8	2.5		

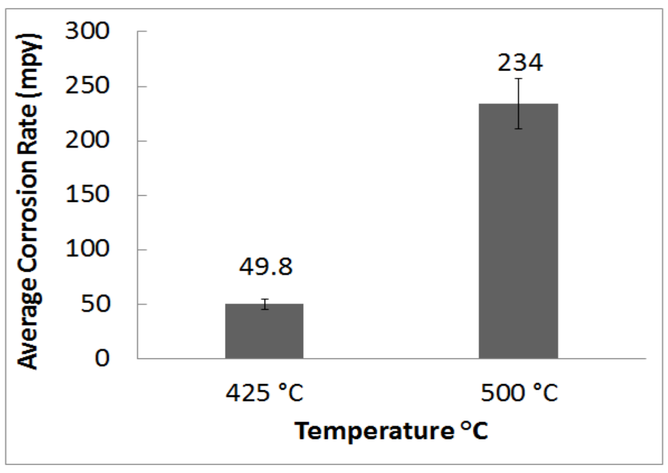
Elements listed are in wt%[3]; "Others" for SA178A : S, Ti, V, Ca, and N

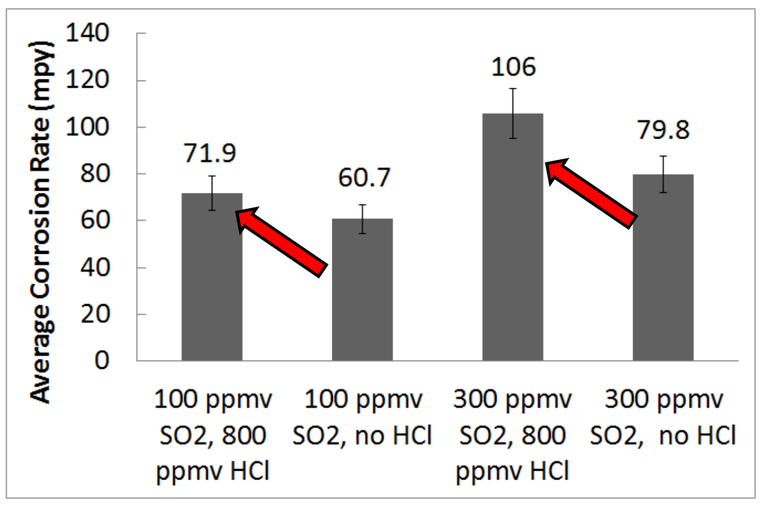
Experimental Conditions	
Isothermal temperature	425-700°C
Exposure time	0-100 hrs
Total Flowrate	500 cm^3*min^{-1} (STP)
Simulated Gas Compositions	
O_2	8%
CO_2	12%
H_2O	15%
HCl	0-800 ppmv
SO_2	0-1200 ppmv
N_2	balance

Results to Date

Effect of temperature and hydrogen chloride on SA178A

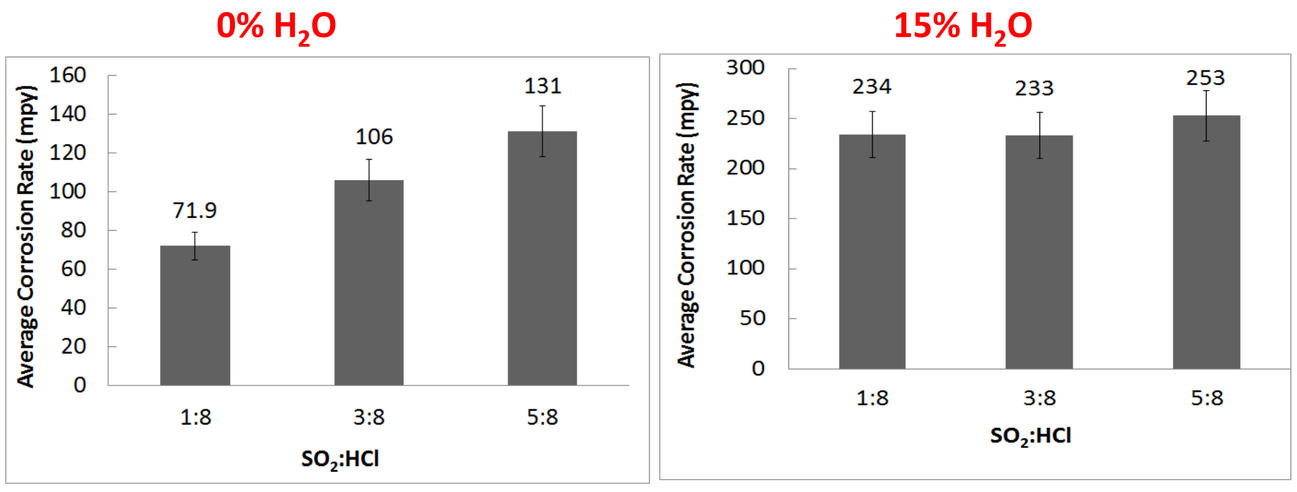
As expected, this carbon steel demonstrated very large wastage over 50 hrs in presence of 800 ppmv HCl. Effect was significantly reduced with temperature .





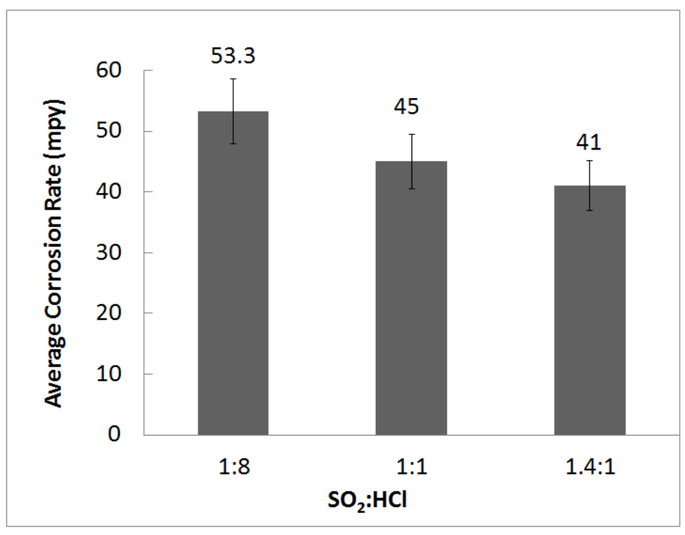
Dry gas (0%H_2O) tests on right observed the increased corrosion in presence of HCl. Deposits obtained under HCl were had more cracks, a possible indication of chlorine cycle behavior.

Effect of SO_2:HCl on carbon steel at 500°C



SA178A does not have a trend in corrosion rate with respect to SO_2: HCl between 1:8 to 5:8, where previous studies have shown moderate corrosion reduction. This suggests that gas phase reactions at 500°C in absence of metal salts will not reduce corrosion as SO_2 is increased.

Salts tests on NSSER



NaCl was coated (4 mg/cm^2) on NSSER and exposed to various SO_2:HCl ratios for 24 hrs at 500°C. Initial tests are more consistent with other literature suggesting possible formation of protective sulfates at these conditions.

Future Work

Future work will focus on the effect of SO_2:HCl on differing salt deposition as well as the effect of temperature on various superheater materials.

References

1. S. Andersson, J. Froitzheim, E. Larsson and J.Pettersson, "Sulphur recirculation for increased electricity production in MSWI" Proceedings: International Symposium on Energy from Biomass and Waste Venice, Italy; 8-11 November 2010.
2. Krause, H.H. "Hot corrosion in boilers burning municipal solid waste." Metal Handbook, Ninth edition, Vol. 13: Corrosion, ASM International, 1987, p. 997-998.
3. S.H. Lee, S.-H., *High Temperature Corrosion Phenomena in Waste-to-Energy boilers,* PhD thesis, Columbia University 2009.

The authors acknowledge WTERT at Columbia University for supporting this work.