The Effect of fuel ash composition on Corrosion potential in Biomass-fired boilers

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Background

- Increase in usage of biofuels power generation systems due to pollution concerns.
- Decrease in boiler efficiency due to high moisture content of biofuels as well as unmanageable ash deposition problems and subsequent corrosion issues.

Objective

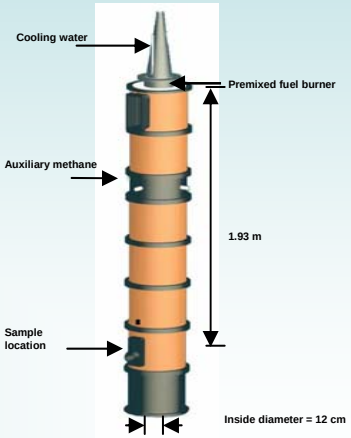
- To investigate the influence of fuel chemistry on chloride deposition on heat transfer surfaces in biomass-fired systems.

Operating conditions

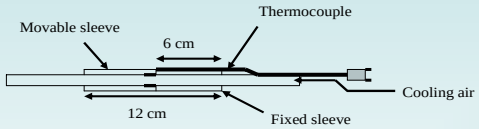
- Sampling section temperature - 800-900 °C.
- Sampling period = 30 minutes.
- Deposit collection probe surface temperature = 450-550 °C.
- 4-5% Oxygen in exhaust stream.

Experimental Set-up

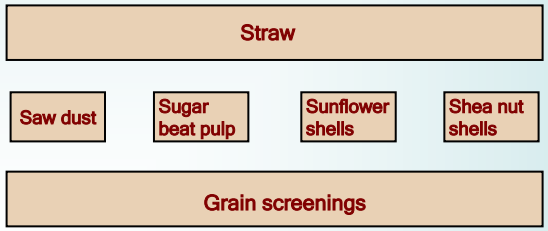
Reactor design (Multi-fuel Flow Reactor)



Probe Designs



Fuel matrix



Fuel analysis (Ultimate)

% w/w	Straw	Saw dust	Grain screenings	Sunflower shells	Shea nut shells
Moisture	11.0	11.0	12.5	10.1	17.0
C	43.9	44.9	44.7	47.6	43.6
H	5.9	5.8	6.1	6.0	5.0
O	38.7	38.1	34.7	35.4	32.0
N	0.5	0.2	2.0	0.9	2.4
Sum	100.0	100.0	100.0	100.0	100.0

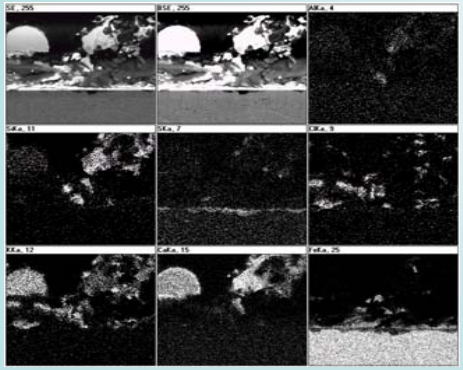
Fuel Ash analysis

% w/w	Straw	Sawdust	Grain screenings	Sunflower shells	Shea Nut shells
SiO_2	52	6.4	34.4	1.1	6.6
Al_2O_3	0.6	2.9	2.2	0.5	1.7
Fe_2O_3	1.1	0.9	2.6	0.9	2.4
CaO	9.2	45.3	15.8	16	6.4
MgO	1.8	9.8	3.9	13.1	7.9
Na_2O	0.3	3.2	1.9	< 0.2	0.4
K_2O	21.9	20.6	19.2	45.1	53.3
SO_3	4	2.8	5.1	11.7	10.4
P_2O_5	3.2	2.6	11.6	10.1	9.3
Cl	5.6	0.2	2.8	1.2	1.4
Other	0.3	5.3	0.5	0.3	0.2
Sum	100	100	100	100	100

Corrosion potential of biofuels

Under particular temperature and pressure conditions, alkali chlorides-metal surface interactions are found to be favored in the case of some biofuels.

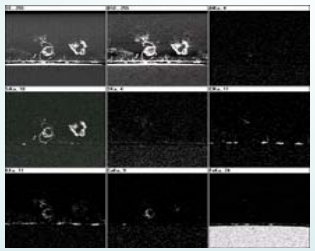
Grain screenings – Magnification 1000 X



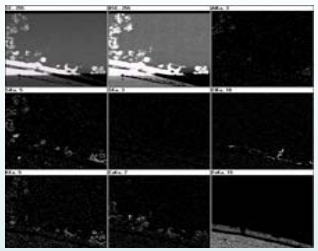
Results and Discussion

Effect of fuel mixing on ash chemistry

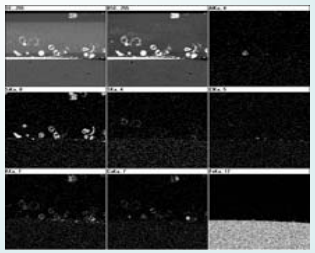
The interactions between ash compounds in a fuel blend demonstrate feasibility to reduce corrosion potential as the fuels blends produce lower levels of alkali chlorides deposition as compared to the pure fuel.



Straw (100%) - Magnification 200 X



Saw dust (100%) - Magnification 200 X

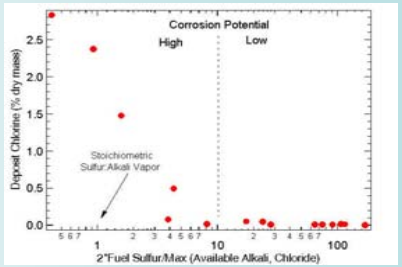


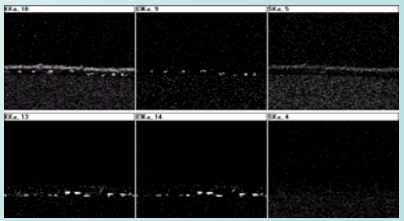
Straw – Saw dust (50%-50%) - Magnification 200 X

Effect of fuel sulfur on ash deposit chemistry

The experimental data confirms the hypothesis that alkali chlorides react with gaseous sulfur heterogeneously to form alkali sulfates, consistent with the previous thermodynamic equilibrium calculations.

Figure imported from Report on "Ash deposition and corrosion mechanisms", by Baxter L.L., Sandia National Lab.





K, Cl and S maps obtained from SEM analysis of 100% Sunflower shells (top) and 100% Straw (bottom) combustion tests. Magnification – 200 X

Conclusions – The biofuels exhibit high corrosion potential due to its high alkali and chlorine content. However, small amount fuel sulfur can control chloride deposition on the surface through heterogeneous sulfation of chlorides, in a thermochemically controlled manner. Such requirements can be accomplished by blending different fuels with appropriate selection.

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