Synergy Effects on Co-Firing Sewage Sludge with Biomass or Waste on the Presence of Alkali Chlorides in a CFB-Boiler

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Combustion of clean stem wood in the Chalmers Boiler



Foto: Jan-Olof Yxell, Chalmers Combustion of "Dirty" Biomass:

- Forest residues
- Straw
- Salix
- Residues from bio-ethanol plants?
- Residues from biodiesel plants
- Refuse derived fuel (RDF) Leads to:

Alkali Chlorides!

• A key specie for severe fouling and corrosion on superheaters in bio- and waste fuel combustion



...and agglomerates in the particle seal of the boiler



Zeolites in nonphosphorus detergents

Zeolites in municipal sewage sludge

15-30% zeolites



Under 5 % Anjontensider (natnumilkylsurfat) polykarboxylater, enzymer (profees, envylas).

INNEHÄLLER: Natriumkarbonst, natriumsulfat, natnumdisilikat. CMC (karboxylmetylcellulosa), PVP (polyvinylporrotidon), siikon.

pH: Ca 10,5 i brukslösning (alkalsk). FÖRVARING: Torrt och i sormal rumstemperatur.

FÖRPACKNING: Sorteras som papper. KUNDKONTAKT: 020-71 10 10/www.coop.ss

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MILJÖ

leads to



The Research Boiler



	Sewage	Straw	Wood	Wood
	sludge	pellets	pellets	chips
Proximate analysis				
Water (wt-%, raw)	73.7	11.3	7.7	42.4
Ash (wt-%, dry)	49.9	6.9	0.3	0.6
Combustibles (wt-%, dry)	50.1	93.1	99.7	99.4
Volatiles (wt-%, daf)	95.2	80.7	81.6	83.4
Ultimate analysis (wt-%, daf)				
С	52.3	49.1	50.3	49.9
Н	7.7	6.3	6.2	6.2
0	30.9	43.4	43.4	43.8
S	2.36	0.12	0.01	0.02
Ν	6.68	0.73	0.05	0.15
CI	0.12	0.36		0.01
Ash analysis (g/kg dry ash)				
К	15		92	120
Na	9.4	9.0	4.8	4.9
Al	79	6.5	7.7	3.7
Si	160	300	43	18
Fe	160	2.1	18	2.0
Са	48	52	210	230
Mg	11	10	31	36
Р	59	14	12	17
Ti	4.9	0.4	0.3	0.2
Ва		0.4	4.0	0.9
Lower heating value (MJ/kg)				
Hu, daf	20.29	18.42	18.89	18.63
Hu, raw		14.93	17.19	9.61

daf= dry and ash free, raw= as received

Derating	Load, MW th	5.7
peraims	Bed temp, °C (bottom)	851
onditions:	Bed temp, °C (top)	872
	temp. combustion chamber,	
	after exit duct, °C	821
	temp. flue gas, after	
	bag house filter, °C	153
	Pressure drop, furnace, kPa	6.8
	Addition of hydrated lime:	
	Ca/S molar ratio	9.7
	Ca/(S+0,5Cl) molar ratio	7.1
	Excess air ratio	1.21
	primary air flow/	
	total air flow, %	60
	fluidising velocity	
	at top, m/s	4.6

C

Influence of available alkali and chlorine – Immediate response!



Influence of sulphur supply – Immediate response!



- Start of straw pellets
- Start of sulphur granules
- Increase in flow of sulphur granules
- 7. Stop of addition of sulphur granules
 - Stop of the supply of straw pellets



Formation of alkali chlorides

(up-stream the convection pass)



- 1. Pure wood pellets
- 2. Start of straw pellets
- 3. Start of PVC
- 4. Start sewage sludge

5. Start of hydrated lime ahead of bag filter

Formation of alkali chlorides

(up-stream the convection pass)



Sulphation of potassium chloride $2KCI+SO_2+0.5O_2+H_2O \rightarrow K_2SO_4+2HCI$

Ash effect? Which one? Further evidence of the benefits of municipal sewage sludge:

- SEM EDX analysis of deposit rings
- SEM-EDX analysis of fly ashes
- Thermodynamic equilibrium calculations
- Low-pressure impactor measurements
- Analysis of impactor samples
- SEM-EDX analysis of bed material samples

Deposits formation



SEM-EDX, Sludge case, fly ash



wt-%	Al_2O_3	SiO_2	K ₂ O	P_2O_5	CaO	Fe_2O_3
Spot 1	17	65	14	2	1	0
Spot 2	19	33	4	20	7	14

XRD: Fe₂O₃, CaSO₄,NaAlSi₃O₈, KAlSi₃O₈

SEM-EDX, Sludge case, fly ash

Elemental maps using SEM EDX in the test MSS



Elemental composition recalculated as oxides

	Total	1	2	3	4	5	6	7	8	9
AI_2O_3	10	24 (24)17	13	30	14	2	1 (5
CaO	8	7	9)10	13	3	8	26	3 (10
CI	0	0	0	0	0	0	0	0	1 (13
Fe ₂ O ₃	4	5 (8) 1	17	2	29	1	0	1
K₂O	5	9	11	4	15	9	7	3	1 (17
MgO	2	2	2	1	1	2	2	2	1	1
Na₂O	1	2	1	1	1	3	1	0	0 (6
P_2O_5	5	13	10) 3	5	8	10	9	3	1
SO_3	2	0	0	0	0	1	1	1	1 (14
SiO ₃	62	37	34	62	34	42	29	55	88 (32

 K_2SO_4 , $Ca_9MgK(PO_4)_7$, $KCa_9Fe(PO_4)_7$ and $KAlSiO_8$ were identified in the ash by means of XRD. $KAlSi_2O_6$ and $KAlSi_3O_8$ were predicted by thermodynamic equilibrium calculations.

Impactor measurements in the convection pass



Impactor measurements in the convection pass, elements

Mole conc. dn/dlog(Dp) (mol/m_n³)



Reference test (RT) wood and straw pellets

Municipal sewage sludge (MSS) and wood+ straw pellets





0

Ρ





quartz sand

EM-EDX

ed with

of





Layers of K, Si and Ca





SEMMIId



Si

Ca









Al

Fe

Conclusions:

- Pure wood results in low concentrations of (KCl+NaCl) in the flue gas if there is a lack of chlorine.
- Straw feeding increases the amount of available alkali and chlorine and the concentration of KCl+NaCl increases.
- Excess of chlorine drastically increases the formation of KCl+NaCl.

Conclusions:



Acknowledgements

- Swedish Energy Administration (main funding of all activities)
- EU project "CoPower"
- Vattenfall Research and Development (for the free use and support of the alkali monitor)
- SEP, Scandinavian Energy Project
- University College of Borås
- SP Technical Research Institute of Sweden
- Akademiska Hus AB for the operating and maintenance of the research boiler
- The research staff at the research boiler for carry out the tests