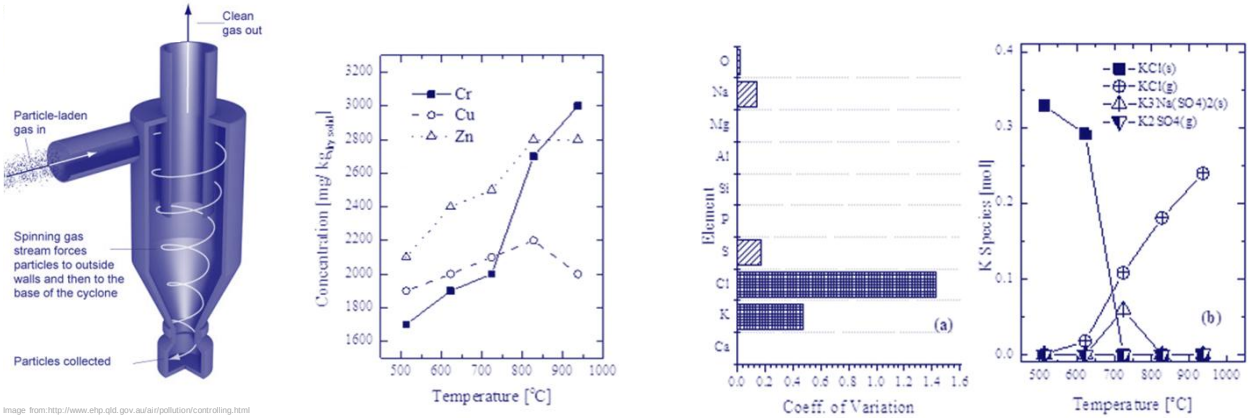
Business from technology



Hot Ash Treatment: Preliminary Experimental Results and Thermodynamic Insights

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FINNISH-SWEDISH FLAME DAYS 2013

Jyväskylän Paviljonki, Jyväskylä Finland

17th-18th April, 2013

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Background

- Waste and biomass co-firing has been in constant development to meet energy demand, independence and environmental requirements.

- Biomass : carbon neutral energy source

  Waste: alternative energy source/sanitary disposal

- Several issues in co-firing are still being resolved, one of which is…

- ASH DISPOSAL or UTILIZATION
  - Huge material resource
  - Country specific legislations
  - Uses: Earth construction applications, forest fertilizers
  - Challenges: Heavy metal content, variability in chemical and physical properties

- A *cleaner ash* is desirable.

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About this study

- Examine the concentration of seven elements (Zn, Cu, Ar, Ni, Pb, and Sb) as the cyclone temperature in a BFB test reactor is varied.

Features of the reactor

- 20 kW BFB test reactor at VTT.
- With electric heaters for stabilization are in place.
- Natural sand with d_p = 0.1-0.6 as bed material.
- $\bar{u}_{gas}$ = 0.5 cm/s sufficient to transport particles smaller than 100 μm to the cylcone.

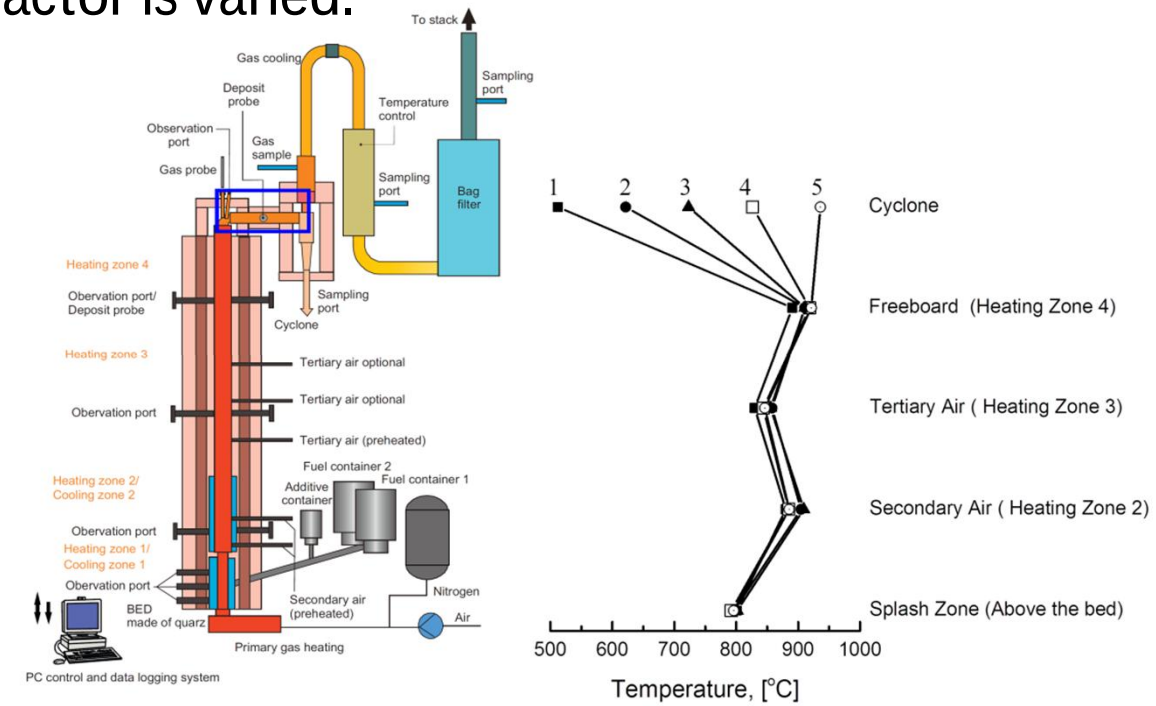

Figure 1. Schematic diagram of the Bubbling Fluidized Bed setup at VTT and the temperature during the experimental runs.

- Temperature of the cyclone for different test runs.

Test Run	1	2	3	4	5
Cyclone Temp., [°C]	512	622	724	827	937

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About this study

- Fuel blend of RDF, bark, and chromated copper arsenate impregnated wood (CCA) at 28/70/2 mass portion was burnt.

- Mean fuel feeding rate was 51.6 g/min and combustion air feeding rate 11.16 mol/min (+ 1.24 mol/min N_2 via the fuel feeding line) corresponding to an air/fuel ratio of 1.33.

Ultimate analysis of the RDF-Bark-CCA wood mixture.

Component	Unit	Conc.
C	m% d.s.	52.5
H		6.2
N		0.4
O[calc]		37.9
Si	mg/kg d.s.	5222
Al		2512
Fe		633
Ti		503
Ca		12300
Mg		1023
P		450
Na		560
K		2000
S		1400
Cl		2700

Component	Unit	Conc.
As	mg/kg d.s.	32
Cd		0.3
Co		0.7
Cr		50
Cu		56
Hg		0.07
Mn		380
Ni		2.2
Pb		45
Sb		13
Tl		0.1
V		1.3
Zn		190
H_2O	m%a.r.	28.1
Calorific Value	MJ/kg d.s.	20.21

- Elemental analysis of the ash follows the SFS/EN 13656 standard.

- Thermodynamic modeling implemented in FactSage 6.3 at P= 1bar and with 319 ideal gas species and 421 pure solid species. In addition salt (FTSalt) and oxide (FTOxide) solid solution species were also included.

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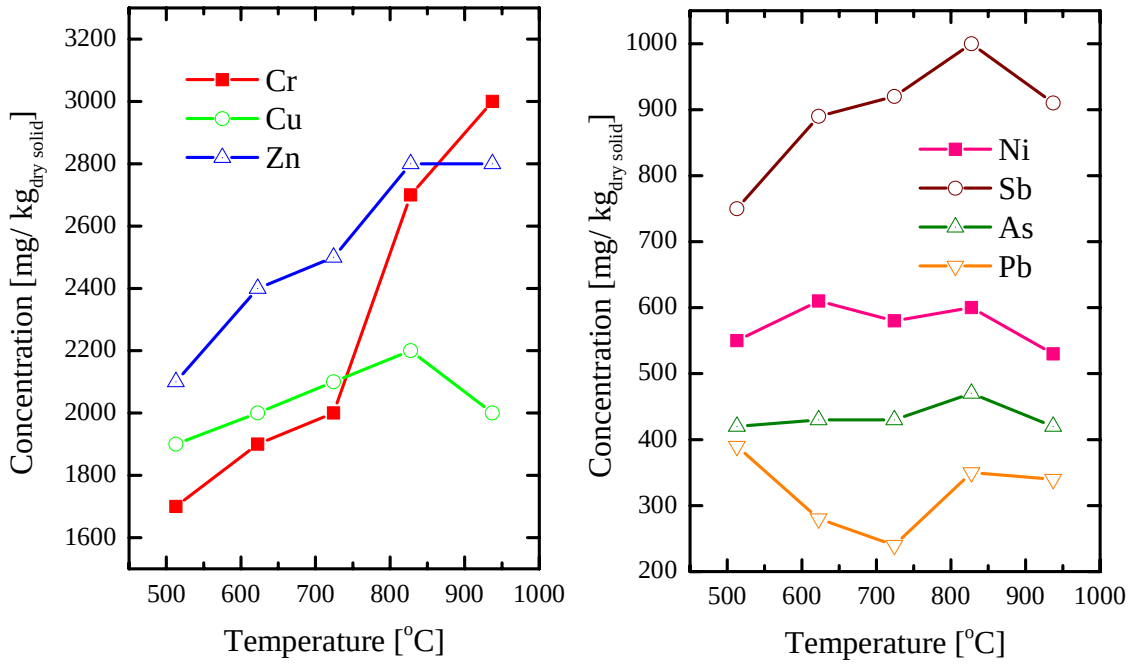
Experimental Results

- Elements can be classified into two categories based on their dependency with the cyclone temperature.



Trace element concentration profile for the cyclone fly ashes collected.

Class I (elements showing clear dependency with $T_{cyclone}$)	
Chromium	Copper
Antimony	Zinc
Lead	

Class II (elements without clear dependency with $T_{cyclone}$)	
Arsenic	Nickel

- Class 1 , in general, exhibited increasing concentration with $T_{cyclone}$, with Pb showing some special behavior.

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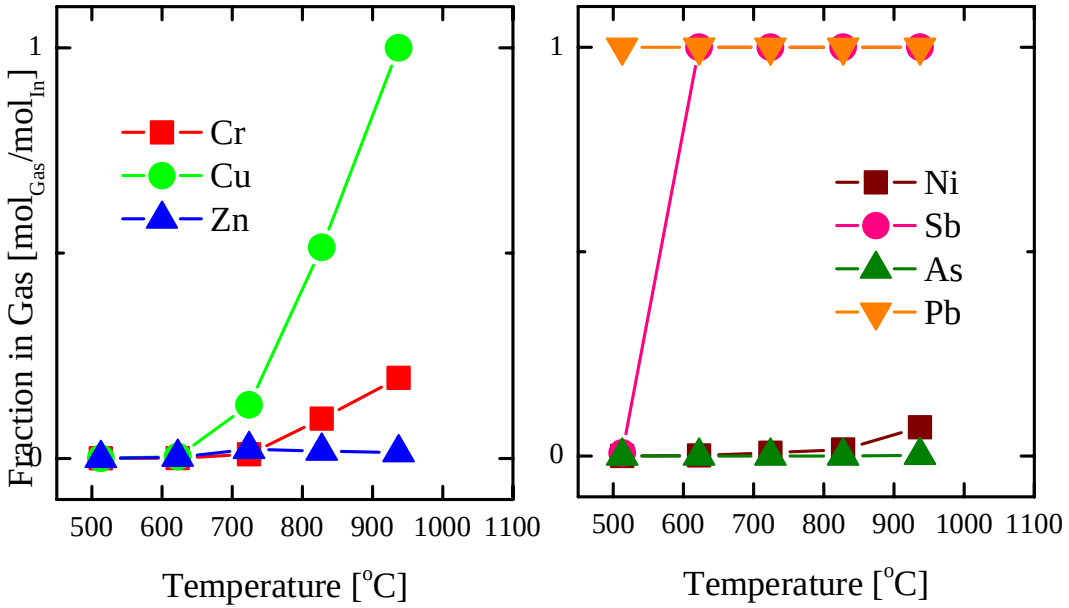
Thermodynamic Insights

- Volatilization of elements according to thermodynamic equilibrium calculations.



Fraction of elements (thermodynamically) expected to be in the gas phase at different temperature settings.

- Thermodynamic equilibrium expects Pb to be in the vapor phase at the studied temperature range, however it was found in the cyclone fly ash.
  - Limitation of thermodynamic model.
- Results for Cu and Cr suggests decreasing concentration vs. temperature due to volatilization.
  - In contrast with the experimentally measured.

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Thermodynamic Insights

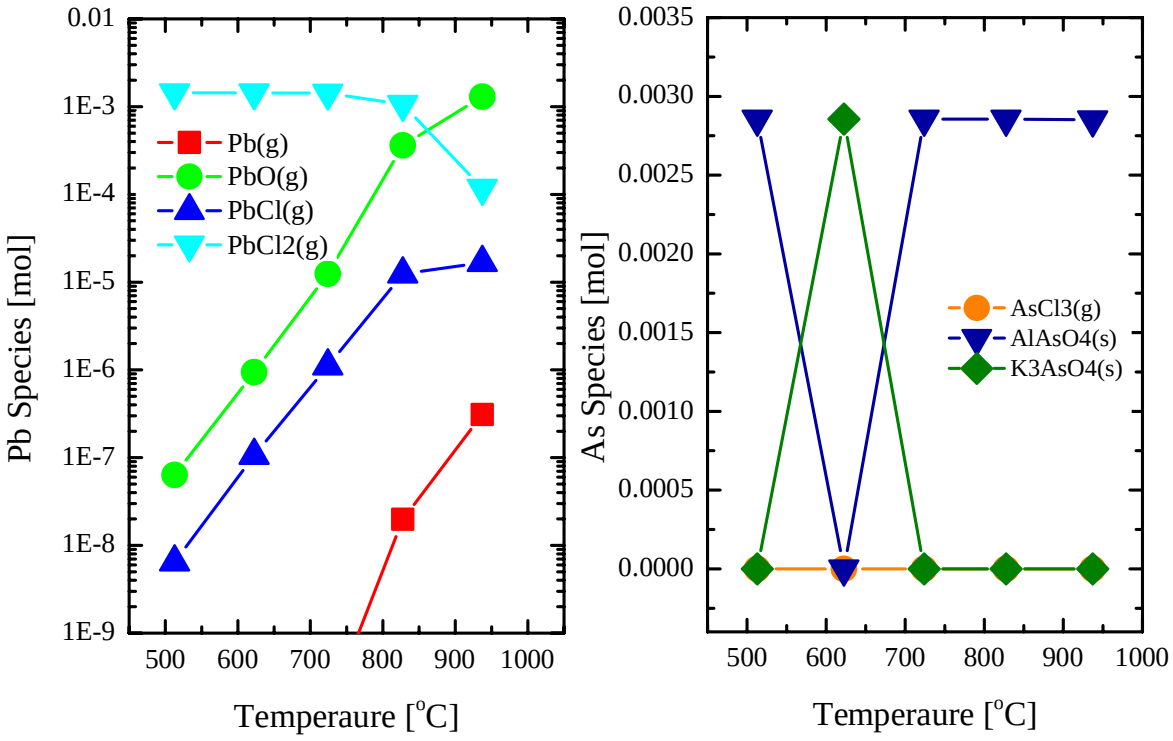
- Key speciation of Class 1 vs Class 2 elements.

Lead

- Shift from PbCl2 as the dominant gas species to PbO as the temperature increases.

Arsenic

- Has remained solid within the temperature range under consideration.
- AlAsO4(s) and K3AsO4(s) were formed.



Speciation of Pb (an element classified as C1) and As (an element classified as C2).

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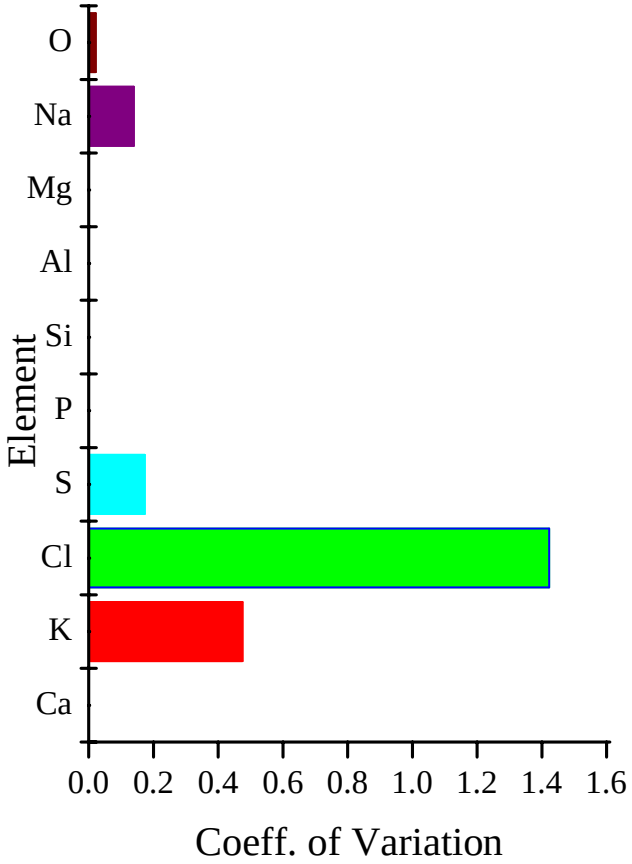
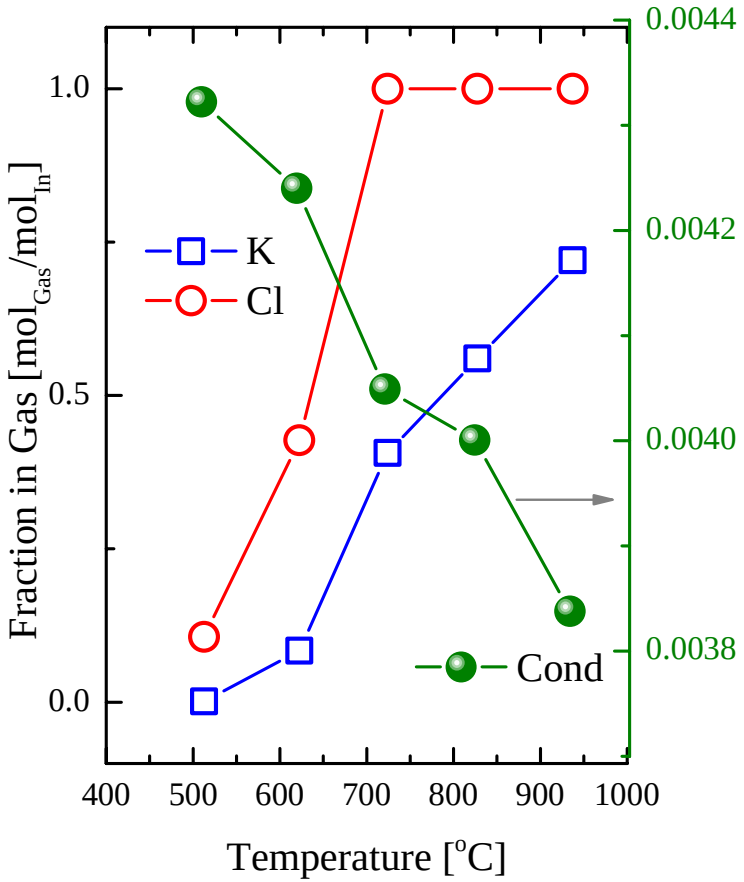
Thermodynamic Insights

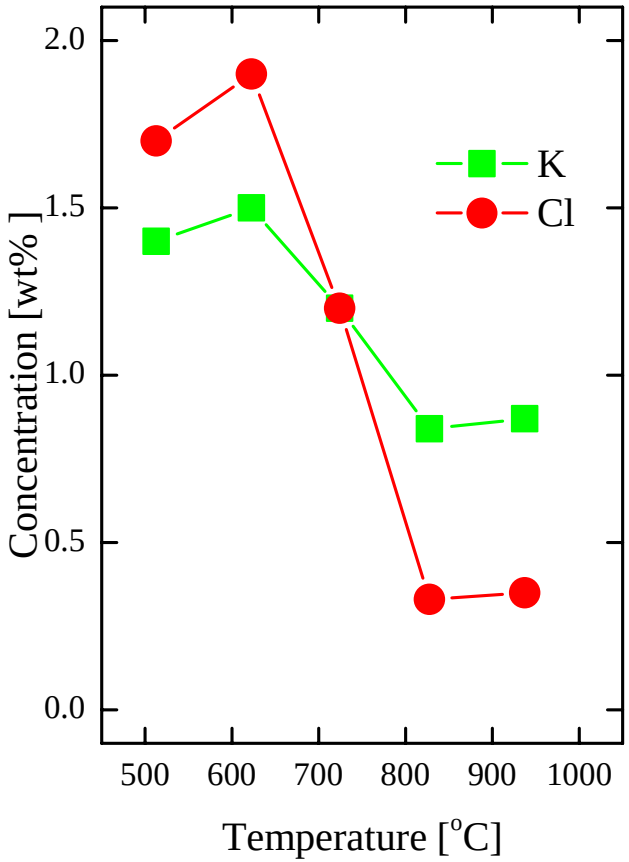
- A look at the minor ash forming elements.



K and Cl are elements having the largest variation at the temperature range under consideration.



K and Cl volatilize and significantly affect the amount of condensed formed.



Volatilization of K and Cl is supported by XRF measurements of the ash samples.

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In summary

- Thermodynamic models suggest that the trend in the concentrations of elements under class C1 can be explained by either or combination of the following reasons
  - Inability of the trace elements to vaporize.
    - ✓ kinetic and transport restriction
    - ✓ elements originally present as chlorides have probably lost Cl, which strongly weakened their volatilization as function of temperature leading to apparent increase in concentration
  - Loss of major ash forming elements due to volatilization.
    - ✓ Cl and K exists favorably in gaseous state as the temperature is increased.
- As for the elements in class C2, they remain in the solid phase thus their concentration did not vary significantly.

Acknowledgements

- We are thankful to VTT, and OSER project, Metso Power, Foster Wheeler, and the European Regional Development Fund for the resources shared to this study.

KESKI-SUOMEN LIITTO
Regional Council of Central Finland

European Union
European Regional Development Fund

Leverage from the EU 2007–2013

- Raili Taipale and Esa Kallio are acknowledged for providing key experimental data and information on the test parameters.

Thank you.
I am now ready for your questions.

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