Innovative solutions for the combustion of unsuitable biomass resources by mixing

23rd European Biomass Conference and exhibition, Vienna 2015

Context

Biomass mixing could be used to improve the combustion properties of resources which are currently not suitable for combustion.

We focused on determining and understanding which interactions between inorganic species can occur during biomass combustion.

We thus highlighted compounds and mechanisms that can be used to mitigate the technical and environmental issues .

PIEDNOIR Brice*, COMMANDRÉ Jean-Michel, BENOIST Anthony, VAITILINGOM Gilles
French Agricultural Research Centre for Development (CIRAD)
TA B-114/16, 73 Avenue Jean-François Breton
34398 Montpellier Cedex 5
*brice.piednoir@cirad.fr

Chemicals associated with some issues occurring during biomass combustion

Slagging

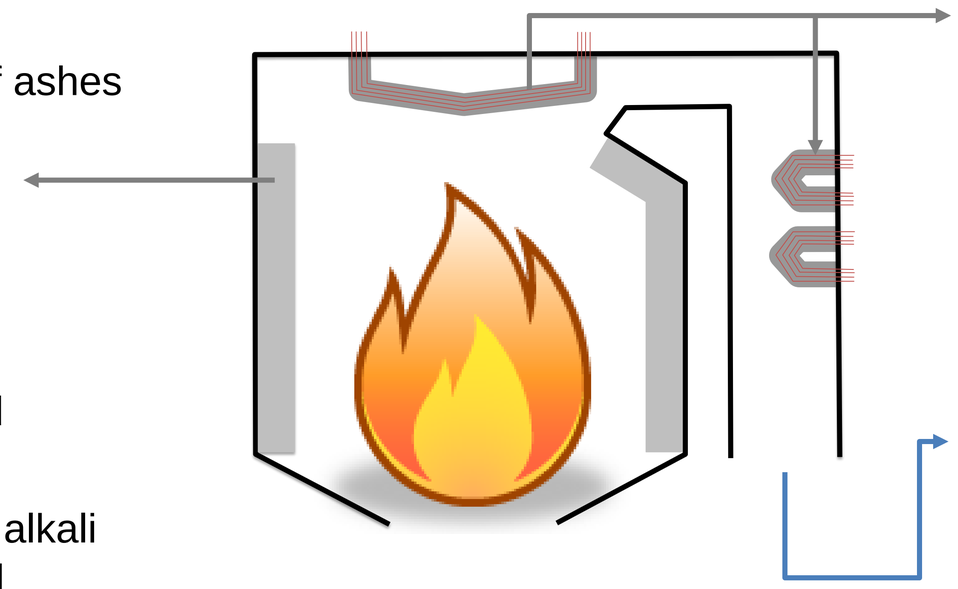
Partial melting and sintering of ashes

Main chemicals involved :
K, Na, Si, S, P

Corrosion

Active oxidation by chlorinated species: HCl, Cl_2

Aggravated by the sulfation of alkali deposits: SO_2 , SO_3, KCl, KOH



Fouling

Ash deposits in the convective sections

Condensation of KCl, K_2SO_4

Ash particles impaction : alkali (K, Na) silicates

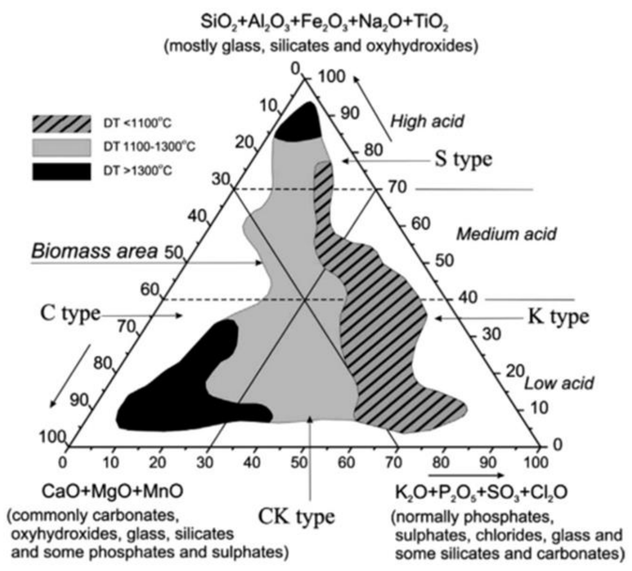
Atmospheric emissions

NOx, N_2O, SOx, PCB (Cl),

Particulate matter

Potential mitigation strategies by blending biomass resources

Increased ash fusion temperatures



Areas of low, medium and high initial deformation (DT) ash fusion temperatures for 55 varieties of biomass. Vassilev et al. (2014)

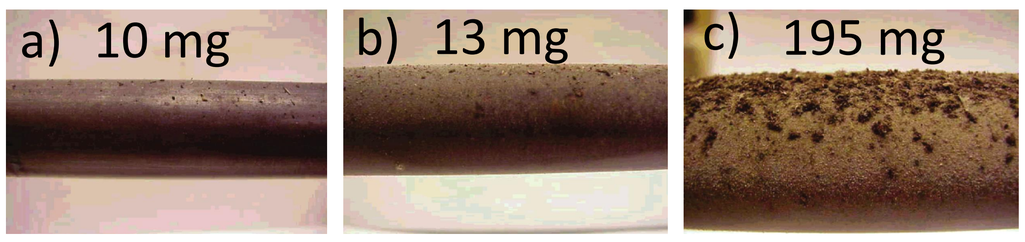
Decreased release of KCl

Alkali chlorides could be trapped by aluminium silicates

$Al_2O_3 \cdot 2SiO_2 + H_2O + 2\,KCl \rightarrow K_2O \cdot Al_2O_3 \cdot 2SiO_2 + 2\,HCl$

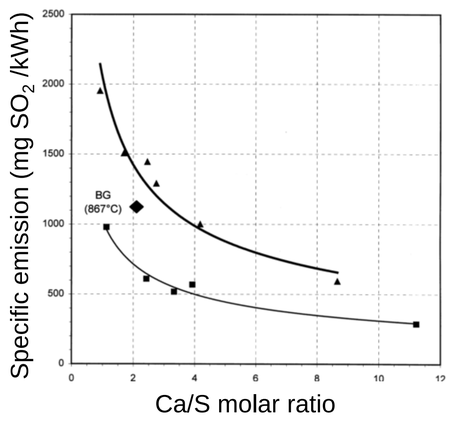
Aho & Silvennoinen (2004) prevented Cl-deposition when adding pulp sludge (enriched in aluminium silicate) to a mix of chicken litter and pine bark.

Abrasion by solid ash particles



Photographs of deposition probes used by Skryfvars et al. (2005) when studying the fouling behavior of rice husk and eucalyptus bark
a) 100% rice husk, b) 64% rice husk, 36% eucalyptus bark,
c) 100% eucalyptus bark

Sequestration of gas in the ashes



Desulphurisation reaction

$$CaCO_3 + SO_2 + \frac{1}{2}O_2 \rightarrow CaSO_4 + CO_2$$

Specific SO_2 emissions as a function of Ca/S molar ratio of blended fuel pellets (lignite, wood, lime) for 2 grate temperature (upper curve: 1000°C; lower curve: 800°C). Heschel et al. (1999)

ONGOING

We selected biomass resources based on their chemical composition: grape marc (N), olive cake (K), rice husk (Si), wheat straw (Cl), rape straw (S), pine bark (Ca). Combustion experiments will be led on blends of these resources. Influence of the molar ratio Ca/N on the NOx emissions is being studied.

REFERENCES

Aho, M., & Silvennoinen, J. (2004). Preventing chlorine deposition on heat transfer surfaces with aluminium–silicon rich biomass residue and additive. *Fuel*, *83*(10), 1299–1305.
Heschel, W., Rweyemamu, L., Scheibner, T., & Meyer, B. (1999). Abatement of emissions in small-scale combustors through utilisation of blended pellet fuels. *Fuel Processing Technology*, *61*(3), 223–242.
Khan, A. a., de Jong, W., Jansens, P. J., & Spliethoff, H. (2009). Biomass combustion in fluidized bed boilers: Potential problems and remedies. *Fuel Processing Technology*, *90*(1), 21–50.
Nielsen, H. P., Frandsen, F. J., Dam-Johansen, K., & Baxter, L. L. (2000). The implications of chlorine-associated corrosion on the operation of biomass-fired boilers. *Progress in Energy and Combustion Science*, *26*(3), 283–298.
Skrifvars, B. J., Yrjas, P., Laurén, T., Kinni, J., Tran, H., & Hupa, M. (2005). The fouling behavior of rice husk ash in fluidized-bed combustion. 2. Pilot-scale and full-scale measurements. *Energy and Fuels*, *19*(9), 1512–1519.
Vassilev, S. V., Baxter, D., & Vassileva, C. G. (2014). An overview of the behaviour of biomass during combustion: Part II. Ash fusion and ash formation mechanisms of biomass types. *Fuel*, *117*, 152–183.

© CIRAD, June 2015