Advanced utilisation options for biomass gasification fly ash

ICC Berlin - International Congress Center,
10 May 2007 Berlin, Germany

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1. Introduction

- Fly ash (FA) quality may limit biomass gasification
- FA from the gasification of biomass differs considerable from conventional combustion ash
  - unburned carbon is much higher, typically 10–60% w.w.
  - Relatively high chlorine and heavy metals in case of waste gasification
- These make the management of gasification fly ash a challenging task (difficult recycling or utilisation)

1. Introduction

- An increase in carbon conversion results in higher:
  - Efficiency
    - direct positive influence on power production efficiency
  - Utilisation potential
    - facilitate the development of sustainable economical methods for ash management
- BFB gasification needs to optimise operation to improve ash quality (reduce carbon content in ash)

2. Fly ash generation

- Pilot pant
  - 150 kW_{th} BFB pilot plant at the University of Seville
- Fuel
  - Orujillo: by-product from the olive oil industry: 3 Mt/yr HV of 18 MJ/kg)
- Bed material
  - ofite (also trials with limestone)
- Location
  - Fly ash (bottom ash simpler)

Test facility

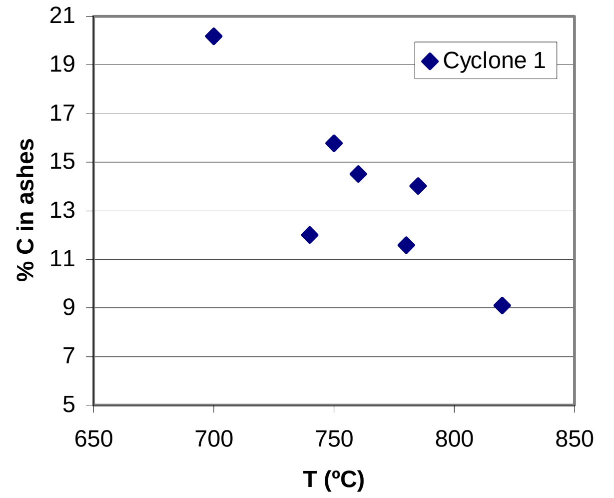
Technical and operating data of pilot plant facility

Inside bed diameter	0.15 m
Bed height	1.7 m
Inside freeboard diameter	0.25 m
Freeboard height	2.5 m
Fluidisation velocity	0.8 – 1.4 m/s
Bed material	Ofite, limestone
Fuel	Orujillo, MBM
Fuel feed rate	6 – 35 kg/h
Gasification agent	Air
Operating temperature	700 – 850ºC
Operating pressure	Atmospheric
Fluidisation regime	Bubbling
Maximum thermal capacity	150 kW_{th}

3. Ash characterisation

Basic ash characterisation

– Physical analysis: density and PSD
– Elemental and ultimate analysis



Test	T bed (ºC)	ER	%C Overflow	%C Cyclone 1	%C Cyclone 2
1	700	0.17	37.54	20.18	22.08
2	740	0.20	20.77	12.00	15.24
3	750	0.22	37.44	15.78	18.08
4	760	0.23	29.85	14.51	19.51
5	785	0.24	19.85	14.03	15.86
6	780	0.29	8.24	11.58	9.66
7	820	0.31	5.33	9.09	12.04

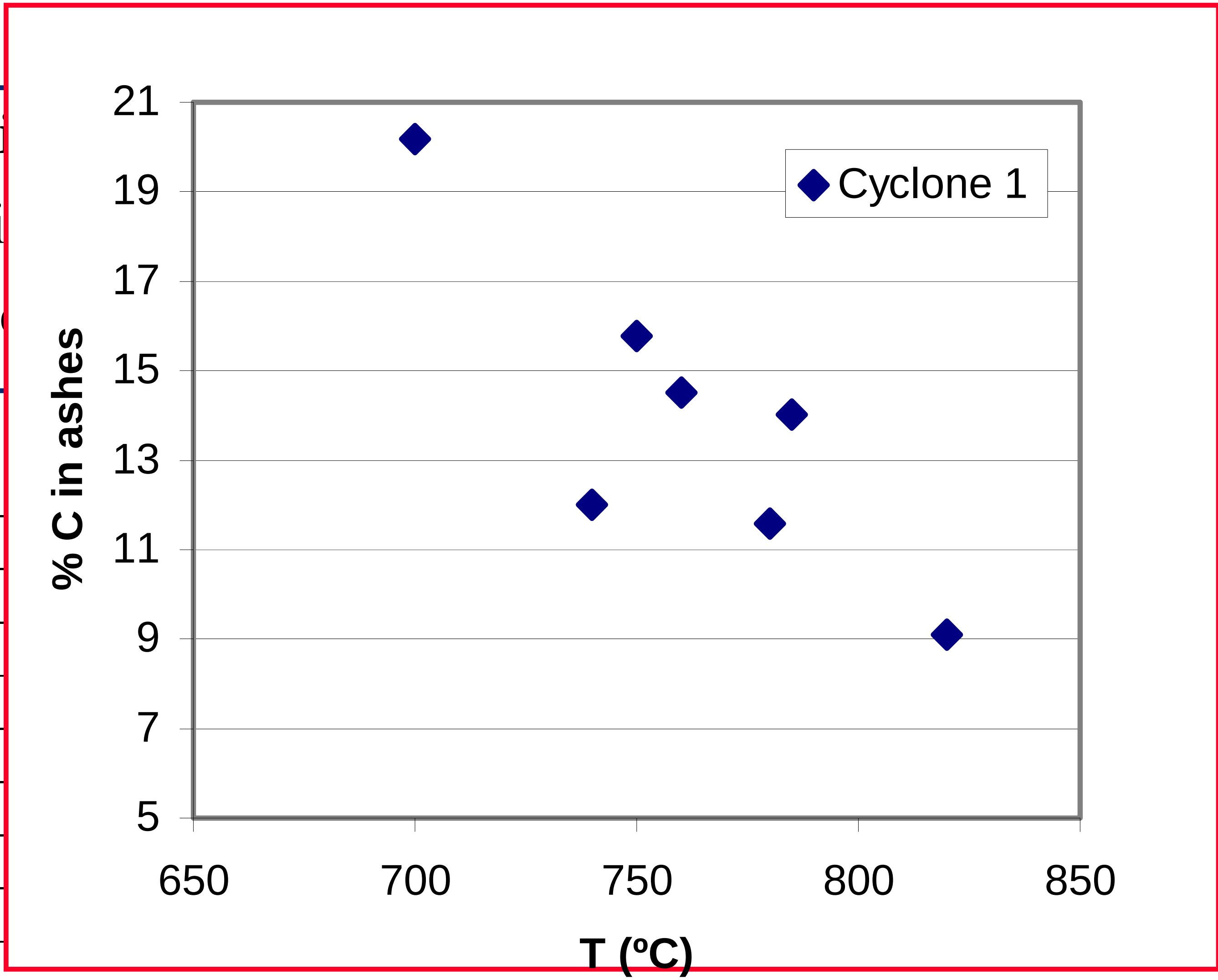
5. Ash characterisation

Basi

– Physi

– Elem

Test	yclone 2
1	.08
2	.24
3	.08
4	.51
5	.86
6	.66
7	.04



Detailed characterisation of ashes

- Further characterisation (necessary for the screening of existing utilisation options)
  - Trace elements (ASTM D-3683)
  - Ashes leachability
    - DIN 38414
    - TCLP (USEPA 1311)
    - Compliance batch leaching test EN 12457/1-4
    - Up-flow percolation test EN 14405 (Column test)
  - Analysis of Eluates (metals)
  - Thermal analysis (TGA, DSC, DTA)
  - Other: PAH, and specific for a given route being tested

4. Screening methods for fly-ash utilisation

1. **Use as fuel**:
   - co-firing in coal/biomass-fired power plants;
   - firing in a dedicated boiler
   - replacement fuel in smelters/incinerators
   - firing in cement kiln
2. **Use in construction**:
   - Fine applications: cement replacement in concrete
   - Less stringent applications:
     - soil stabilization
     - road base
     - structural fill (filler in asphalt, asphalt-like products)
3. **Use in agriculture**: directly as fertilizer or as soil improver.

Conclusions from preliminary screening

1. Cl, alkali metals (K) and carbon content limit ash utilisation
2. Pretreatment necessary (washing and oxidation)
3. Economic methods for management without pretreatment are more attractive

– fuel in cement kilns

– Advanced utilisation

- Stabilisation/Solidification (S/S)
- lightweight wall boards
- bricks with special properties

5. Manufacturing of lightweight wallboards

Method of preparation:

- low-cost moulding and curing methods
- ash percentages up to 60%w/w
- gypsum and additives (vermiculite and fibre)

Main Results:

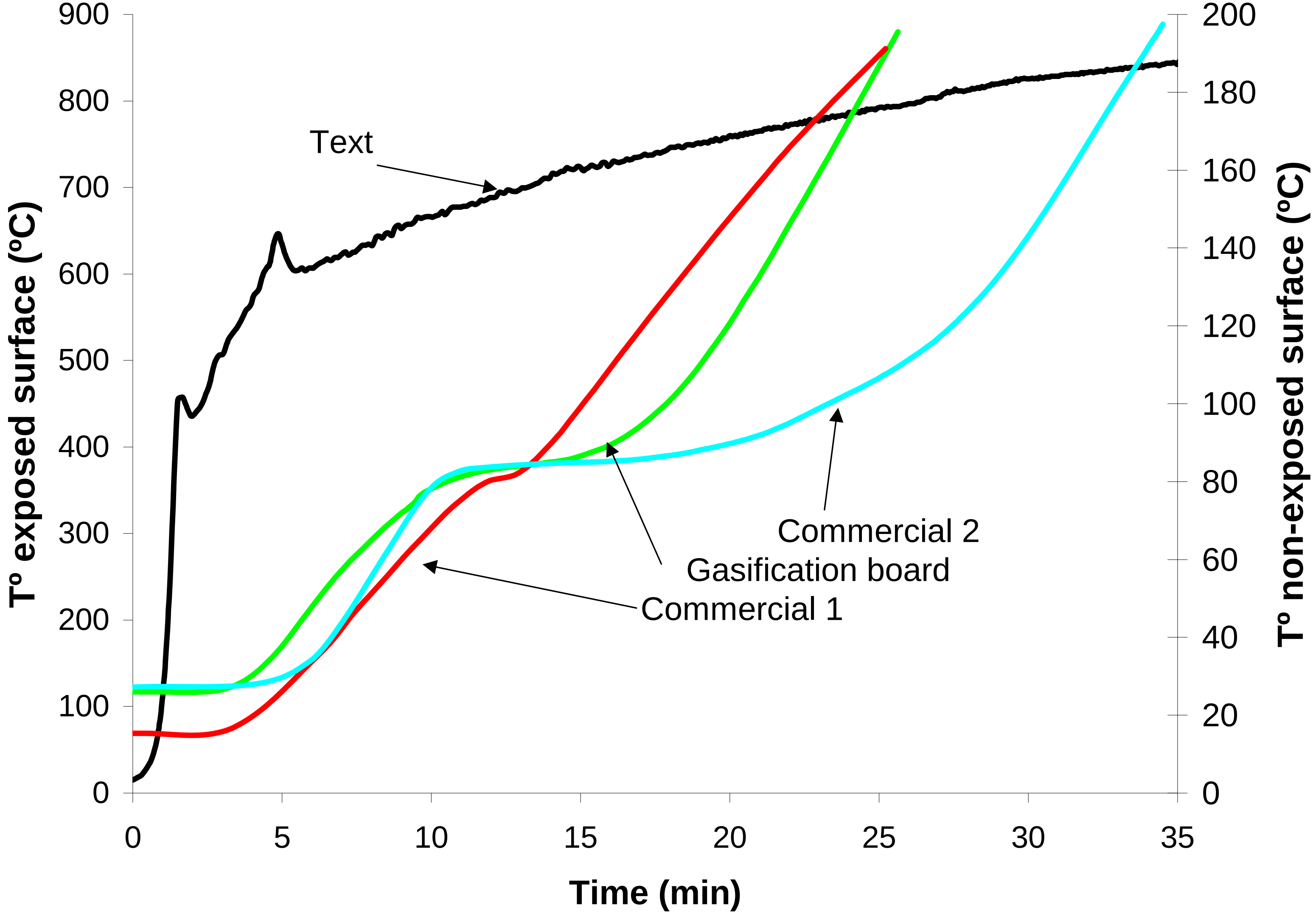
– Acceptable mechanical and properties

ρ (kg/m^3)	pH	A(%)	Rc (MPa)	S_H (Shore C)
652	9.95	67.4	0.43	28

– Good environmental behaviour (leaching)

– Further studies on optimisation of blends

Fire resistance test curves for various board



Leaching tests results (DIN: (µg/L))

Component	Limit	Orujillo gasification ash
Cd	100	<30
Cr(VI)	100	---
Cr_{total}	500	<50
Ni	500	50
Cu	2000	55
Zn	2000	20
As	100	<1
Hg	20	<50
Pb	500	100

6. Manufacturing of bricks

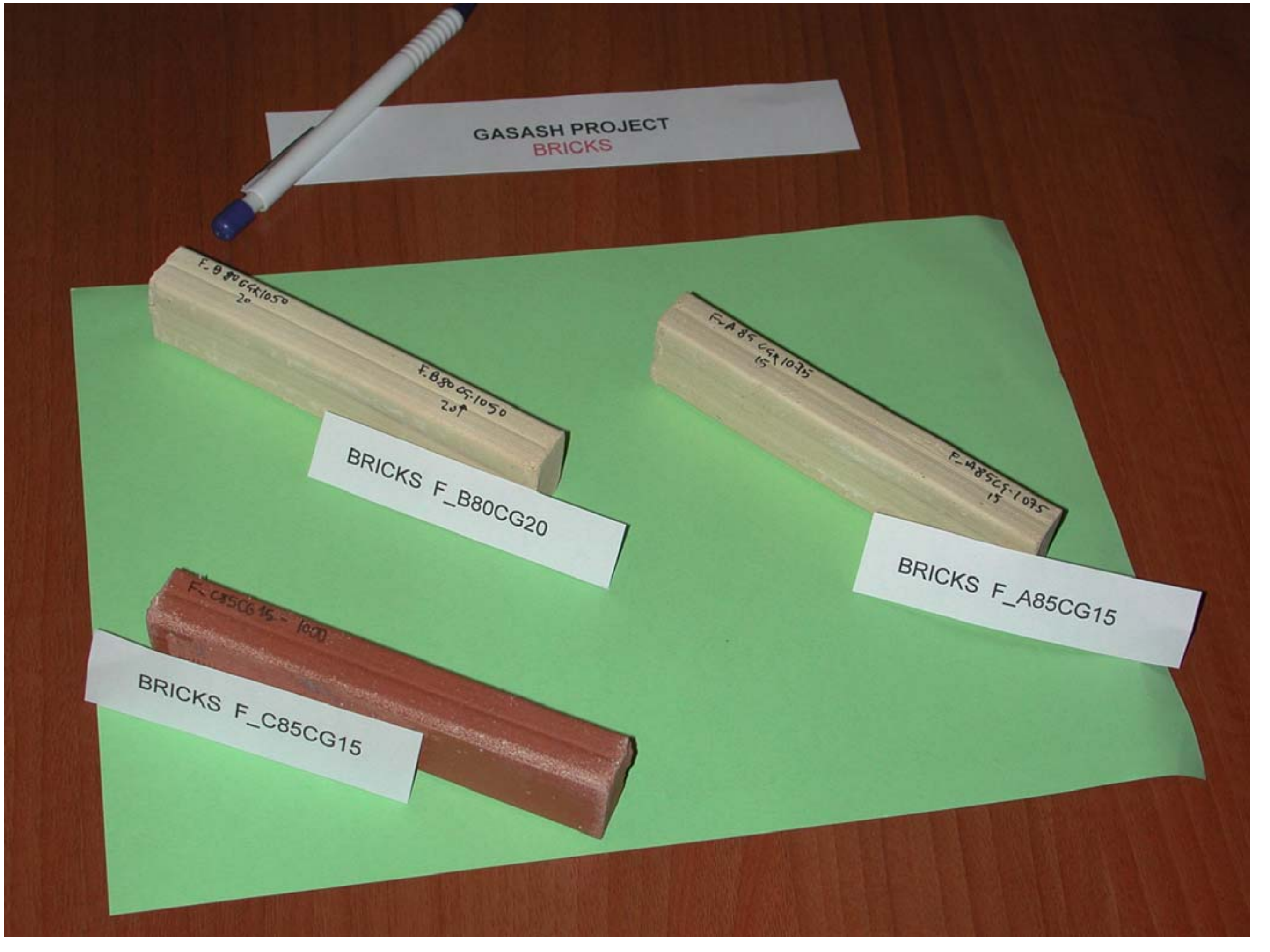
Preparation

- Three types of blends prepared by adding ash to the clays as organic material
- Ash content in bricks up to 20%
- Three clay bodies tested (representative to the used in facing bricks)

Tests

- Mechanical tests (standard for bricks)
- Fire test (similar to the tunnel kiln firing)
- Leaching tests

6- Manufacturing of bricks



6. Manufacturing of bricks

Results

– Mechanical tests showed that the three clay bodies tested are very near (slightly below using 20%) the requirements for facing bricks, i.e. HD clay masonry units

– Environmental tests (leaching) favorable

Optimisation

– There are two routes for further testing:

- Reduction of ash quantity (from 20% to 15%)
- Bricks with special insulating thermal and acoustic properties (body strength need to be slightly improved to meet UNE-EN 771-1)

7. Conclusions

- Existing (combustion) options for utilisation of fly ash are not valid for the ash derived from the FBG of orujillo (pretreatment is needed)
- Demonstration that fly ash from FBG of orujillo has potential as the main constituent in lightweight wallboards (60% ash) and bricks (20% ash)
- Optimisation of the blend composition for the lightweight plates and the bricks are under study

Acknowledgements

- The authors acknowledge the financial support for this research by the Commission of Science and Technology, European Commission and Junta de Andalucía.
- We also acknowledge Cerámicas Malpesa (Bailén, Spain) for its help in preparing the brick samples.

Thank you for your attention

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