Utilisation of Low Grade Fuels in Fluidised Bed Combustors

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Structure of Presentation

• South African Coal situation
• FBC 101
• Types of coals and fuels tested
• Test facilities
• Results
• Some examples of (CSIR) FBC in SA
• Conclusions and Recommendations
SA Coal Situation

- 250 Mt of coal mined per year
- Value R65 Bn
  - R34 Bn local sales
  - R31 Bn export sales
- Coal discarded in 2009: 67.5 Mt

Source: Prevost, X. 2010
FLUIDISATION MECHANISM

- AIR
- PLENUM CHAMBER
- FREEBOARD
- ROTAMETER
- U-TUBE MANOMETER
- FLUIDISATION MECHANISM

Diagramme showing a fluidisation mechanism with air entering through an air inlet, passing through a plenum chamber, then rising through a freeboard to a rotameter, and finally measuring the level in a U-tube manometer.
Fluidised Bed Combustion
Types of Coal Tested

- Discards (High ash)
- Duff (High fines content)
- Slurry/Slimes (Fine, high water content)
- Biomass sludge (Co-fired)
## Coal Analyses (H₂O, Prox, Ult, CV and AFT)

<table>
<thead>
<tr>
<th>ANALYSIS</th>
<th>Applicable Standard</th>
<th>Boschmans Duff</th>
<th>Tavistock Duff</th>
<th>Greenside discards</th>
<th>Utrecht Anthracite Discards</th>
<th>Goedehoop Slurry (ad)</th>
<th>Biomass Sludge (Coffee grounds)</th>
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<tbody>
<tr>
<td>MOISTURE</td>
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<td>Inh (%)</td>
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Test Facilities - NFBC
Test Facilities - MPFB
Results

• Performance Indicators
  • Thermal efficiency (heat to steam)
  • Combustion efficiency
  • “Operability”
Duff Combustion – Effect of Load

The graph shows the thermal efficiency (%) plotted against load (T/h steam) for two types of Duff: Tavistock Duff and Boschmans Duff. The thermal efficiency decreases as the load increases for both types of Duff. The graph indicates that Boschmans Duff has a slightly higher thermal efficiency compared to Tavistock Duff at the same load levels.
Discard Combustion (Greenside)—Grit Re-firing and Load

- Combustion eff. with grit refiring
- Combustion eff. Without grit refiring
- Thermal eff. with grit refiring
- Thermal eff. without grit refiring

Percentage efficiency vs. Load (T/h steam)
Anthracite Discards – Effect of Load

![Graph showing the effect of load on combustion and thermal efficiency. The graph plots load (T/h steam) on the x-axis and combustion and thermal efficiency (%) on the y-axis. The data points show a downward trend as load increases.]

- Combustion efficiency
- Thermal efficiency
Sulphur Capture – Sorbent Efficacy

Source: Petrie and North, 1989
Slurry Combustion
Slurry Combustion - Operation

- Temperature (deg C)
- Coal feed (kg/h)
- Oxygen (%)
- Time (mins)

Graph showing the relationship between temperature, coal feed, oxygen, and time during slurry combustion operation.
Slurry Combustion - Efficiencies

- Graph showing the relationship between % solids in slurry and thermal/combustion efficiency.
- Different markers represent combustion efficiency and thermal efficiency.

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Slurry Combustion – Char-Sand Agglomerates
Biomass Sludge Co-fired with Coal

- 26 tph of steam required
- 12 tph of sludge at 85% water content
- Co-fired with coal
- Effective moisture content in fuel 71%
- Proven through calculation and pilot plant test work
- Demonstrated at industrial scale
Biomass and Sludge co-firing

Sludge delivery

Buffer tanks

Sludge nozzle

Coal feeders
Biomass and Sludge co-firing

Waste heat boiler

View of plant
Fluidised Bed Industrial Applications

Duff-fired HGG

Co-fired Boiler

HSP Incinerator

Deodoriser
Conclusions

• FBC can utilise a wide range of “problem” (or “opportunity”) fuels

• Discard coal can be burnt at good thermal and combustion efficiencies
  • Crushing to < 6 mm required
  • Sulphur capture required (and proven), sorbent choice

• Anthracite discards are problematic, low combustion efficiency achieved
Conclusions (Contd)

• Duff (fine) coal can be utilised – Features required:
  • Grit refiring
  • Low fluidising velocities
  • Expanded freeboard

• Coal Slurries can be utilised
  • Inherent low thermal efficiency due to water content
  • Combustion efficiency higher than parent coal would suggest, and can be improved upon
  • Boiler design (in-bed HX) important – Excess air
Conclusions (Contd)

• Biomass wastes, including sludge, can be utilised
  • Co-firing can be beneficial wrt fouling and agglomeration
  • Dry waste autothermal
  • Wet waste can be co-fired with coal
  • For wet sludges, control complicated but possible, in-bed HX design critical (Excess air)
  • In-flight drying and inbed combustion need to be “balanced”
  • Deep bed assists in sludge dispersal
Important Issues

• Economics – you might be able to burn it, but does it make sense? Centralised vs decentralised
• Consider coal cost in R/GJ delivered and sorbent cost in R/t S removed
• De-watering of high moisture content fuels – CAPEX vs OPEX
• Possible operational problems with biomass (Na, K)
• BFBC vs CFBC (size does count)
Benefits from this research to the coal and boiler industries

- Technical viability of utilising a range of waste coals proven.
- Data available on combustion and thermal efficiencies (BFBC) on which to base economic decisions
- Design features highlighted, FBC is not “one size fits all”
- Reduction in the amount of coal discarded on the surface, thereby reducing a visible eye-sore
- Extending the lifetime of our finite coal reserves
Benefits from this research to the coal and boiler industries (contd)

- Minimising the emissions of greenhouse and acid gases formed by spontaneous heating and combustion of coal discard piles

- Eliminating the ground water pollution often found with discard coal dumps

- Providing energy from materials that are currently discarded and have already been mined/recovered, thereby eliminating the energy required to mine new coal for utilisation
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Thank You