ENVIRONMENTAL FRIENDLY FBC AND CFBC TECHNOLOGY

By A. Leelavinothan/DGM/BHEL
TECHNICAL PRESENTATION
ON
FLUIDIZED BED COMBUSTION BOILERS
(FBC)
Fluidised Bed Combustion Boilers

- Bubbling Fluidised Bed Combustion Boilers (AFBC)
- Circulating Fluidised Bed Combustion Boilers (CFBC)

- In-house
- Based on Lurgi Ljetes Babcock
**FBC Test Rigs**

**CFBC Test Facility - 1991**
(90 t/hr Hot water)

Enables evaluation of various fuels for
Combustion Characteristics
Ash Characteristics
Establishing Desulphurisation levels

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**BFBC Technology Development**

- **1981**: First 12 t/h Commercial Boiler commissioned
- **1984**: First 10 MW power plant for Washery Rejects
- **1987**: First 10 MW power plant for Straw
- **1992**: First 20 MW (100 t/h) power plant for Rejects and Char
- **2000**: Largest boiler in operation of 180 t/h (45 MW)
- **2002**: Export of 17 MW Boilers to PT IBR Indonesia
- **2008**: 3x18 MW Order from PT KPP, Indonesia
- **2009**: 2 X 180 t/hr BFBC Boiler order from JSPL, Angul

- 66 Boilers Contracted  Over 2.5 million operating hours
FBC – Introduction of Technology

Fluidization
Combustion in FBC
Circulation Loop
Boiler Components
What is Fluidization - 1?
What is Fluidization - 2?

Buoyancy Force (function of upward velocity)

Gravitational Force (function of particle mass)
What is Fluidization - 3?

Stoker Fired Fluidized Bed
Bubbling Fluidized Bed
Circulating Fluidized Bed
Pulverized Fuel Fired

Gravitational Force
Buoyancy Force

Gravitational Force is predominant
Buoyancy Force is balanced by Gravity Force
Buoyancy Force is more than Gravity Force
Buoyancy Force is predominant

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What is Fluidization - 4?

Stoker Fired

Bubbling Fluidized Bed

Circulating Fluidized Bed

Pulverized Fuel Fired

<1 m/s

<3 m/s

<8 m/s

<14 m/s
Combustion

For Combustion to be complete:

– Enough Oxygen/Air
– Adequate Ignition Energy
– Required Temperature
AFBC Boilers Status

• Technology developed in-house
• Boilers offered for burning a variety of fuels
  -- Coal, lignite, washery rejects
  -- Steel Plant wastes like Coal fines, kiln char
  -- Biomass (rice straw, rice husk, palm wastes, bagasse)
  -- Wastes (oil sludge, paper sludge, pelletised MSW)
• 66 boilers contracted so far
• Maximum capacity in operation 165 t/h
Principles of Fluidisation
Advantages of Fluidized Bed Boilers:

- Fuel flexibility:
- Fluidized bed boilers burn effectively a wide variety of fuels that include:
  - All kinds of coal, slurries from coal preparation
  - Coal water mixtures
  - Coal washery middlings and rejects
  - Rice husk and straw
  - Oil and Oil shales
  - Peat
  - Wood, Woodchips and Sawdust
  - Gas
  - Domestic refuse
  - Paint and varnish waste
  - Automobile tires (shredded)
  - Industrial wastes like DRI ash, ESP dust etc.;
### Samples of Fuels Tested

<table>
<thead>
<tr>
<th>Si No</th>
<th>Fuel</th>
<th>HHV kcal/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>COAL/LIGNITE</strong></td>
<td></td>
</tr>
<tr>
<td>A)</td>
<td>Singareni</td>
<td>4900</td>
</tr>
<tr>
<td></td>
<td>Chanda</td>
<td>4300</td>
</tr>
<tr>
<td></td>
<td>Bellampalli</td>
<td>2460</td>
</tr>
<tr>
<td></td>
<td>Assam Coal</td>
<td>7100</td>
</tr>
<tr>
<td></td>
<td>Neyveli Lignite</td>
<td>2800</td>
</tr>
<tr>
<td></td>
<td>J &amp; K Lignite</td>
<td>2090</td>
</tr>
<tr>
<td></td>
<td>Leco fines</td>
<td>6700</td>
</tr>
<tr>
<td></td>
<td><strong>MIDDINGS/REJECTS</strong></td>
<td></td>
</tr>
<tr>
<td>B)</td>
<td>Bhojudih</td>
<td>3100</td>
</tr>
<tr>
<td></td>
<td>Kathara</td>
<td>1900</td>
</tr>
<tr>
<td></td>
<td>Jamadoba</td>
<td>2100</td>
</tr>
<tr>
<td></td>
<td>Bokaro</td>
<td>1820</td>
</tr>
<tr>
<td></td>
<td>Mill rejects</td>
<td>2600</td>
</tr>
<tr>
<td></td>
<td>Coal Water slurry</td>
<td>2400</td>
</tr>
<tr>
<td></td>
<td><strong>BIO-MASS</strong></td>
<td></td>
</tr>
<tr>
<td>C)</td>
<td>Husk (Rice, Wheat)</td>
<td>3000</td>
</tr>
<tr>
<td></td>
<td>Straw (Rice, Wheat)</td>
<td>3300</td>
</tr>
<tr>
<td></td>
<td>Wood chips</td>
<td>4300</td>
</tr>
<tr>
<td></td>
<td>Bagasse</td>
<td>2100</td>
</tr>
<tr>
<td></td>
<td>Saw dust</td>
<td>6500</td>
</tr>
<tr>
<td></td>
<td>Groundnut shells</td>
<td>4200</td>
</tr>
<tr>
<td></td>
<td><strong>OTHER FUELS</strong></td>
<td></td>
</tr>
<tr>
<td>D)</td>
<td>Spent liquor</td>
<td>2400</td>
</tr>
<tr>
<td></td>
<td>Sludge from distillery</td>
<td>2420</td>
</tr>
<tr>
<td></td>
<td>Paper sludge</td>
<td>3400</td>
</tr>
<tr>
<td></td>
<td>Furnace Oil</td>
<td>10500</td>
</tr>
</tbody>
</table>

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Advantages of Fluidized Bed Boilers

- Curbing of NOx formation
- Sox absorption
- Formation of soft ash that has reduced potential for back pass superheater erosion
- No fouling and slagging
- Uniform temperature, hence least probability of local hot or cold spots
Fluidized Bed Combustion

- In a Fluidized Bed Combustion Boiler:
  - Process requires that Air Flow is UNIFORM across the entire cross-section (Air Distributor) hence Oxygen availability at all points ensured. Moreover due to the SLIP between Fuel and Air the same fuel faces fresh Oxygen layers.
  
  - There are millions of inert Bed particles all of them at about 850°C. This Thermal Heat store enables combustion of Fuels with widely varying Quality.

  - The entire bed is at ~ 850°C. This ensures that the last pre-requisite for good combustion is also met.
BFB Components

1. Steam Drum
2. Bed Superheater
3. Bed Evaporator
4. Convection Superheater
5. Economiser
6. Windbox
7. Air Distributor Plate
8. Hot Air Duct
9. Cold Air Duct
10. Air Preheater

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## List of BFB Boilers firing rejects

### Bharat Heavy Electricals Limited

<table>
<thead>
<tr>
<th>S.No</th>
<th>Customer</th>
<th>No of units</th>
<th>Steam flow t/hr</th>
<th>Steam temp °c</th>
<th>Steam pressure kg/cm² (g)</th>
<th>Ash content %</th>
<th>Fuel heating value kcal/kg</th>
<th>Electrical capacity MWₑ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tata Iron &amp; Steel company Collieries (TISCO), Jamadoba</td>
<td>1</td>
<td>56</td>
<td>400</td>
<td>24</td>
<td>60</td>
<td>1770</td>
<td>10</td>
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<tr>
<td>2</td>
<td>Coal India Limited, kathara</td>
<td>2</td>
<td>53</td>
<td>485</td>
<td>65</td>
<td>60</td>
<td>2700</td>
<td>10</td>
</tr>
<tr>
<td>3</td>
<td>Coal India Limited, Moonidih</td>
<td>2</td>
<td>53</td>
<td>485</td>
<td>65</td>
<td>60</td>
<td>2700</td>
<td>10</td>
</tr>
<tr>
<td>4</td>
<td>TISCO, West Bokaro</td>
<td>1</td>
<td>62</td>
<td>400</td>
<td>24</td>
<td>67.6</td>
<td>1550</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>TISCO, West Bokaro</td>
<td>1</td>
<td>62</td>
<td>400</td>
<td>24</td>
<td>67.6</td>
<td>1550</td>
<td>10</td>
</tr>
<tr>
<td>6</td>
<td>Jindal Strips Ltd., Raigarh</td>
<td>2</td>
<td>100</td>
<td>430</td>
<td>35</td>
<td>60</td>
<td>2000</td>
<td>20</td>
</tr>
<tr>
<td>7</td>
<td>Jindal Steel &amp; Power Ltd., Raigarh,</td>
<td>4</td>
<td>165</td>
<td>540</td>
<td>94</td>
<td>45</td>
<td>3000</td>
<td>55</td>
</tr>
<tr>
<td>8</td>
<td>Bhushan Steel &amp; Strips Limited</td>
<td>1</td>
<td>120</td>
<td>540</td>
<td>94</td>
<td>60</td>
<td>2500</td>
<td>25</td>
</tr>
<tr>
<td>9</td>
<td>Bhushan Steel &amp; Strips Limited</td>
<td>2</td>
<td>75</td>
<td>485</td>
<td>66</td>
<td>60</td>
<td>2500</td>
<td>15</td>
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</table>
## JSPL Raigargh fired rejects – Analysis

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Design coal</th>
<th>Worst coal</th>
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<tbody>
<tr>
<td>Carbon</td>
<td>34.52</td>
<td>25.55</td>
</tr>
<tr>
<td>hydrogen</td>
<td>3</td>
<td>3.2</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Oxygen</td>
<td>4.2</td>
<td>4</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.78</td>
<td>0.75</td>
</tr>
<tr>
<td>Moisture</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>Ash</td>
<td>45</td>
<td>49</td>
</tr>
<tr>
<td>HHV (kcal / kg)</td>
<td>3000</td>
<td>2700</td>
</tr>
</tbody>
</table>
Overview of 165 t/h AFBC Boiler at Jindal Steel & Power
Similarity BFBC - CFBC

- Gas Solid contact systems
- Flameless Combustion – 850 C (no slagging)
- Fuel - Crushed only (Pulveriser eliminated)
- Immense Ignition Energy (Bed Particles at 850 C)
- Uniform Oxygen Availability
- High Slip Velocity between Gas and Solids (Better Combustion)
- High Thermal Inertia and Inert Material content (No FSSS)
- Combustion Criteria (like bed temperature, velocity)
- Operational Experience (like erosion, air nozzle performance)
- In-situ Capture of Sox and NOx
CFB – Circulation Loop

The circulation loop consists of

1. Combustor
2. Cyclone
3. Standpipe
4. Loop Seal
CFB Boiler – Process Flow
SLPP – FBHE WW Problem

Plan View of SLPP CFBC Boiler
FBHE – Unique Control Option

For Variation in Fuel Quality

Load

Combustor

Conv. Pass

FBHE

Comb. Temp.

Without FBHE

With FBHE

Heat duty

Combustor

Conv. Pass

FBHE

Heat duty

Load

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# Operation Status of major CFBC units

<table>
<thead>
<tr>
<th>Plant / Country</th>
<th>Capacity</th>
<th>Fuel</th>
<th>Status</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilt, Bhigwan</td>
<td>55 MW (175 t/h) Coal</td>
<td>In oprn</td>
<td>1999</td>
<td></td>
</tr>
<tr>
<td>SLPP-I, Surat</td>
<td>2x125 MWe Lignite</td>
<td>In oprn</td>
<td>2000</td>
<td></td>
</tr>
<tr>
<td>RVUNL, Giral</td>
<td>2x125 MWe Lignite</td>
<td>In oprn</td>
<td>2007</td>
<td></td>
</tr>
<tr>
<td>GACL, Kodinar</td>
<td>3x135 t/h Lignite</td>
<td>In oprn</td>
<td>2007</td>
<td></td>
</tr>
<tr>
<td>GSECL, Kutch</td>
<td>1x75 MWe Lignite</td>
<td>In oprn</td>
<td>2008</td>
<td></td>
</tr>
<tr>
<td>NLC Barsingsar</td>
<td>2x125 MWe Lignite</td>
<td>In oprn</td>
<td>2009</td>
<td></td>
</tr>
<tr>
<td>SLPP-II Surat</td>
<td>2x125 MWe Lignite</td>
<td>In oprn</td>
<td>2009</td>
<td></td>
</tr>
<tr>
<td>NLC Neyveli</td>
<td>2x250 MWe Lignite</td>
<td>In oprn</td>
<td>2011</td>
<td></td>
</tr>
<tr>
<td>BORL, MP</td>
<td>3x275 t/h PetCoke</td>
<td>In oprn</td>
<td>2010</td>
<td></td>
</tr>
<tr>
<td>PT IBR, Indonesia</td>
<td>1x120 t/h Indo coal</td>
<td>In oprn</td>
<td>2010</td>
<td></td>
</tr>
<tr>
<td>Koniambo, New Caledonia</td>
<td>2x135 MWe Aus. coal</td>
<td>commg</td>
<td>2011</td>
<td></td>
</tr>
<tr>
<td>PT Adaro, Indonesia</td>
<td>2x126 t/h Indo coal</td>
<td>commg</td>
<td>2011</td>
<td></td>
</tr>
</tbody>
</table>

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BHEL CFBC Boiler Timeline

- **2009**: 2x30 MW PT MSW, Indonesia
  - 1x120 t/h First Export order received from PT BR, Indonesia

- **2008**: 1 x 135 t/h Repea Order received from GACL
  - 3 x 275 t/h Petcoke fired units from BORL

- **2007**: 2 x 135 MW order received from KNS, New Caledonia
  - 2 x 125 MW repeat order received from SLPP

- **2006**: 2 x 125 MW NLC – Baringsar
  - 125 MW repeat order received from RVUNL, Giral

- **2005**: 2 x 250 MW order received from Neevelli Lignite Corporation

- **2004**: 2 x 135 t/hr M/s Gujarat Ambuja cement

- **2003**: Collaboration with LLB ends

- **2002**: Collaboration with LLB

- **2001**: Test Facility installed

- **2000**: First CFB boiler (175 t/hr) installed at BILT, Bhigwan

- **1999**: First Utility reheated boiler (2x125 MW) installed at SLPP, Mangrol

- **1998**: 125 MW, RVUNL, Giral

- **1997**: Collaboration with LLB ends

- **1996**: 75 MW order received from GEB, Kutch

- **1995**: 2 x 135 t/hr M/s Gujarat Ambuja cement

- **1994**: 1 x 135 t/hr M/s Gujarat Ambuja cement

- **1993**: 100% ownership transferred from BHEL

- **1992**: Test Facility installed

- **1991**: Collaboration with LLB

- **1990**: Test Facility installed

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# Fuel Samples Test Fired

Custom Design for Each Fuel

Lignite of various region has different composition

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Gujarat Surat/Bhavnagar</th>
<th>Rajasthan Giral</th>
<th>Tamil Nadu Neyveli</th>
<th>Impact on Design</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphur</td>
<td>1.0/4.0</td>
<td>&lt;6.0</td>
<td>&lt;1.0</td>
<td>Desulphurization levels, Limestone System, Ash system</td>
</tr>
<tr>
<td>Moisture</td>
<td>&lt;42</td>
<td>&lt;15</td>
<td>&lt;55</td>
<td>Furnace Size, Fan Sizing, Fuel System</td>
</tr>
<tr>
<td>HHV (kcal/kg)</td>
<td>3090</td>
<td>3000</td>
<td>2300</td>
<td>Furnace Size, Fan Sizing, FBHE Sizing</td>
</tr>
<tr>
<td>Ash</td>
<td>&lt;19</td>
<td>&lt;20</td>
<td>&lt;14 Marcasite (Fe₂S)</td>
<td>Ash System, Optimal choice of combustor temperature, FBHE Sizing</td>
</tr>
</tbody>
</table>
Location: Bhigwan, Maharashtra

Fuel: Coal HHV–3240 kcal/kg

Boiler Parameters:
- SH Steam: 175 t/h, 107.5 kg/cm²(g), 525°C

Start-up: January 1998

Total hours logged: 89700

The Plant’s Availability has been over 99.1% and is in continuous operation between planned shutdowns.
Performance test conducted and all the guaranteed parameters achieved.
SLPP- I  2 x 125 MWe

- Location: Mangrol, Surat Dt, Gujarat
- Fuel: Lignite (50% M & 2.5% S)
  HHV: 2500 to 5500 kcal/kg
- Design fuel kcal/kg: 4250 (actual fired 3000)
- Boiler Parameters
  SH Steam: 390 t/h, 132 ata, 540°C
  RH Steam: 350 t/h, 32.5 ata, 540°C
- Start-up: Feb 2000, Feb 2000
- Op hours: 51500, 54500
- The Plant’s availability has been over > 92% since 2000
- Performance test conducted and all the guaranteed parameters achieved

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# SLPP Lignite Analysis

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Design</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>% 43.30</td>
<td>30.75</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>% 3.14</td>
<td>3.48</td>
</tr>
<tr>
<td>Sulphur</td>
<td>% 1.20 (2.5)</td>
<td>1.18</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>% 0.81</td>
<td>0.43</td>
</tr>
<tr>
<td>Oxygen (by diff.)</td>
<td>% 8.53</td>
<td>7.61</td>
</tr>
<tr>
<td>Moisture</td>
<td>% 24.00</td>
<td>42.44</td>
</tr>
<tr>
<td>Ash</td>
<td>% 19.02</td>
<td>14.10</td>
</tr>
<tr>
<td>HHV</td>
<td>kcal/kg</td>
<td>4250</td>
</tr>
</tbody>
</table>
### SLPP - Lignites Used

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Worst</th>
<th>Best</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Carbon</td>
<td>%</td>
<td>18.72</td>
</tr>
<tr>
<td>Volatile Matter</td>
<td>%</td>
<td>25.65</td>
</tr>
<tr>
<td>Moisture</td>
<td>%</td>
<td>47.5</td>
</tr>
<tr>
<td>Ash</td>
<td>%</td>
<td>8.12</td>
</tr>
<tr>
<td>Sulphur*</td>
<td>%</td>
<td>0.98</td>
</tr>
</tbody>
</table>

| HHV             | kcal/kg | 2306  | 4775  |

* - The Sulphur in Lignite varies between 0.3 and about 2.0 %
SLPP Performance

SLPP Boiler Availability

SLPP Boiler Mean Time to Repair

SLPP Continuous Operation in Hours

Plant Load Factor (%)

SLPP Performance
GACL – 3 x 135 t/h CFBC Boilers

- Location: Kodinar, Junagadh Dt, Gujarat
- Fuel: Coal + Lignite (40% M & 6% S)
- Design fuel kcal/kg: HHV – 5200 Coal, HHV – 3500 Lignite

- Boiler Parameters
  - SH Steam: 135 t/h, 88 ata, 515 °C

- Start-up:
  - Unit #1: Feb 2007
  - Unit #2: Nov 2007
- Total hours logged:
  - Unit #1: 17000
  - Unit #2: 10200
- Performance test conducted and all the guaranteed parameters achieved
RVUNL (Giral) – 2 x 125 MWe CFBC Boiler

- Location: Giral, Barmer Dt, Rajasthan
- Fuel: Lignite (40% M & 6% S)
- Design fuel kcal/kg: HHV – 3000
- Boiler Parameters
  - SH Steam: 405 t/h, 132 ata, 540 °C
  - RH Steam: 336 t/h, 32.5 ata, 540 °C
- Total hours logged: 15000, 10000
GSECL (Kutch) – 75 MWe CFBC Boiler

• Location: Panandhro, Kutch Dt, Gujarat
• Fuel: Lignite (30% M & 4% S)
  : HHV - 2000 to 2600 kcal/kg
• Design fuel kcal/kg: HHV – 2621

• Boiler Parameters
  SH Steam: 315 t/h, 95 ata, 540 °C
BORL Petcoke fired CFB Configuration

Proximate Analysis: %

- Moisture: 12.00
- Volatile Matter: 10.00
- Ash: 0.20
- Fixed Carbon: 77.80
- HHV Kcal/kg: 7616

Ultimate Analysis: %

- Carbon: 78.07
- Hydrogen: 3.17
- Nitrogen: 0.78
- Sulphur: 5.63
- Oxygen (by Diff): 0.15
- Moisture: 12.00
- Ash: 0.20

Parameter                Unit      BMCR

- MS Flow at MSSV outlet t/hr: 275
- MS Press at MSSV outlet kg/cm²(g): 110
- MS Temp at MSSV outlet °C: 510±5
- FW Temp at Eco Inlet °C: 110
**PTIBR 1x120t/hr CFB Configuration**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>BMCR</th>
</tr>
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<tbody>
<tr>
<td>MS Flow at MSSV outlet</td>
<td>t/hr</td>
<td>120</td>
</tr>
<tr>
<td>MS Press at MSSV outlet</td>
<td>kg/cm²(g)</td>
<td>63</td>
</tr>
<tr>
<td>MS Temp at MSSV outlet</td>
<td>°C</td>
<td>485±5</td>
</tr>
<tr>
<td>FW Temp at Eco Inlet</td>
<td>°C</td>
<td>197.5</td>
</tr>
</tbody>
</table>

**Proximate Analysis: %**
- Moisture: 9.40
- Volatile Matter: 34.05
- Ash: 22.30
- Fixed Carbon: 34.25
- HHV Kcal/kg: 5486

**Ultimate Analysis: %**
- Carbon: 57.36
- Hydrogen: 3.29
- Nitrogen: 0.84
- Sulphur: 0.40
- Oxygen(by Diff): 6.41
- Moisture: 9.40
- Ash: 22.30
NLC Neyveli 2x250MWe CFB Configuration

Ultimate Analysis, % By Weight

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Design</th>
<th>Worst</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td></td>
<td>27.50</td>
<td>23.20</td>
</tr>
<tr>
<td>Hydrogen</td>
<td></td>
<td>2.20</td>
<td>1.86</td>
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<tr>
<td>Sulphur</td>
<td></td>
<td>0.70</td>
<td>1.00</td>
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<tr>
<td>Nitrogen</td>
<td></td>
<td>0.20</td>
<td>0.17</td>
</tr>
<tr>
<td>Oxygen (bydiff)</td>
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<td>10.40</td>
<td>8.77</td>
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<tr>
<td>Moisture</td>
<td></td>
<td>50.50</td>
<td>51.00</td>
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<tr>
<td>Ash</td>
<td></td>
<td>8.50</td>
<td>14.00</td>
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<tr>
<td>HHV, kcal/kg</td>
<td></td>
<td>2650</td>
<td>2300</td>
</tr>
</tbody>
</table>

Parameter | Unit
---|---
Type of Circulation | Natural
SH/RH Flow | t/hr | 845 / 716.5
SH/RH Pres. kg/cm²(g) | 175 / 43.8
SH/RH Tem. | ºC | 540 / 540
FW Tem. | ºC | 256
Effect of Particle Size

Coarser Fuel leads to de-fluidisation & clinkering in combustor & poor burnout

Coarser limestone particle leads to poor sulphur capture as capture is solid – gas reaction occurs at the surface

Finer Limestone feed escapes out of primary loop reduced sulphur capture and issues at backpass
Normal Solids Circulation in CFB Boiler

LHS Cyclone

RHS Cyclone

Lignite Flow

SA Flow

Lignite Flow

SA Flow

LHS Sealpot

RHS Sealpot

PA Flow
**Sulphur Capture Reactions**

- **Calcination - heat**
  - $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$

- **Sulphation + heat**
  - $\text{SO}_2 + \text{CaO} \rightarrow \text{CaSO}_4$

- **Fuel S + O\textsubscript{2} – SO\textsubscript{2}**
Thank You