Alstom CFB boilers achieve high combustion efficiency with challenging discarded coal

Hugh Kennedy
16th July 2013
**Agenda**

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baima 300 MWe CFB demonstration plant</td>
<td>3</td>
</tr>
<tr>
<td>Emile Huchet 125 MWe captive power plant</td>
<td>9</td>
</tr>
<tr>
<td>Seward 2 x 260 MWe</td>
<td>13</td>
</tr>
<tr>
<td>Conclusion</td>
<td>16</td>
</tr>
</tbody>
</table>
Baima 300 MW_el CFB Demonstration Plant

- Technology: CFB
- Fuel: Anthracite
- Province: Sichuan, P.R.C.
- Capacity: 1025 t/h
- MS Pressure: 174 bar
- MS/HR Temperature: 540/540 °C
- FW Temperature: 281 °C
- Sulphur removal rate: 94%
- Emissions level, mg/Nm³ (@6%O₂ DG):
  - SO₂: 600
  - NOₓ: 250
  - Dust: 100

First 300 MW CFB Boiler in China
Baima 300 MW_{el} CFB Demonstration Plant

Owner: Sichuan Baima CFB Demonstration Power Plant Co Ltd.

( State Power Grid / Sichuan Bashu Development Company)

Milestones

- Contract signed  July 2002
- Contract into effect  April 2003
- Commercial operation  April 2006
- Performance tests  May 2007

Technical challenges

- Carbon burnout with anthracite
- Limestone consumption
  - Potential uncontrolled SO$_2$: 10 000 mg/Nm$^3$
  - Sulphur removal rate 94%
  - Added Ca/S < 2

The Baima Project also includes a ToT for CFBs 200-350 MW_{el}
### Baima performance tests

<table>
<thead>
<tr>
<th></th>
<th>BECR Perf test 1</th>
<th>BECR Perf test 2</th>
<th>Design</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Date</strong></td>
<td>26th June 2007</td>
<td>27th June 2007</td>
<td>BECR</td>
</tr>
<tr>
<td><strong>Coal quality stability</strong></td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td><strong>Coal LHV MJ/kg</strong></td>
<td>15.38</td>
<td>16.49</td>
<td>18.5</td>
</tr>
<tr>
<td><strong>Ash %</strong></td>
<td>43.5</td>
<td>40.5</td>
<td>35.3</td>
</tr>
<tr>
<td><strong>LHV boiler efficiency % (corr)</strong></td>
<td>&gt; 93</td>
<td>&gt; 93</td>
<td>&lt; 92</td>
</tr>
<tr>
<td><strong>Added Ca/S (corr)</strong></td>
<td>&lt; 1.5</td>
<td>&lt; 1.7</td>
<td>&lt; 2.0</td>
</tr>
<tr>
<td><strong>Sulfur capture %</strong></td>
<td>&gt; 95</td>
<td>&gt; 94</td>
<td>&gt; 94</td>
</tr>
<tr>
<td><strong>SO₂ emission mg/Nm³ @6% O₂ dry</strong></td>
<td>&lt; 600</td>
<td>&lt; 600</td>
<td>600</td>
</tr>
<tr>
<td><strong>CO emission mg/Nm³ @6% O₂ dry</strong></td>
<td>&lt; 150</td>
<td>&lt; 130</td>
<td>NA</td>
</tr>
<tr>
<td><strong>NOₓ emission mg/Nm³ @6% O₂ dry</strong></td>
<td>&lt; 100</td>
<td>&lt; 100</td>
<td>250</td>
</tr>
</tbody>
</table>

#### Successful performance tests with the worst coal

- Carbon heat loss < 3% LHV
- Carbon content in fly ash: 1.5 – 2.5%
Load variation from ~70% to 40% MCR:
- MS and HR temperatures close to full-load value
- Combustion temperature remains above 860°C
- CO emission drops from 80 to 50 mg/Nm³
- NOx emission remains below 100 mg/Nm³

Fluidised Bed Combustion and Gasification, Johannesburg - 16/07/2013 - P 3
Baima 300 MW<sub>el</sub> CFB Demonstration Plant

35% fuel flow reduction within 1 hour at constant output

Automatic boiler control despite coal quality variations
Coal quality the real challenge

- Ash content > 45% (out of the contractual range)
- Large amount of stones in the raw coal
- Very abrasive ash

- Rapid wear of secondary crusher hammers
- Required coal PSD never achieved
- Oversized particles including stones

- Stone build-up in the FBACs impacts heat transfer
- Erosion of water walls above the refractory tip
- Erosion of nozzles in the furnace
Agenda

Baima 300 MWe CFB demonstration plant

Page 3

Emile Huchet 125 MWe captive power plant

Page 9

Seward 2 x 260 MWe

Page 13

Conclusion

Page 16
Emile Huchet 125 MW_{el} CFB boiler

- **Customer:** SODELIF, France

- **Fuel:**
  - Coal washing plants byproduct
  - Ultra fine product: d50% =150 microns, d99% < 2 mm

- **Slurry**:
  - 30% ash
  - 33% moisture
  - 2500 Kcal/Kg (LHV)

- **Schlamms**:
  - 8% moisture,
  - 5000 Kcal/kg (LHV)

- **Steam Conditions:** 367 t/h, 155 bar, 545/540°C
- **Emission levels (mg/Nm³ @6%O₂ DG):**
  - SO₂: 330
  - NOₓ: 300

CFB-based power plant to burn low grade coal residues
Cyclones were designed to achieve the highest collection efficiency.
Emile Huchet 125 MW$_{el}$ CFB boiler

Actual performances match computerized PSD forecast

<table>
<thead>
<tr>
<th>Performance test</th>
<th>Schlammen</th>
<th>Slurry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unburnt carbon loss, % LHV</td>
<td>1.4</td>
<td>1.2</td>
</tr>
<tr>
<td>Unburnt carbon in bottom ash, %</td>
<td>1.2</td>
<td>1.0</td>
</tr>
<tr>
<td>Unburnt carbon in fly ash, %</td>
<td>6.0</td>
<td>5.6</td>
</tr>
<tr>
<td>Fly Ash - Bottom Ash split, % - %</td>
<td>70/30</td>
<td>60/40</td>
</tr>
<tr>
<td>Agenda</td>
<td>Page</td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>------</td>
<td></td>
</tr>
<tr>
<td>Baima 300 MWe CFB demonstration plant</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Emile Huchet 125 MWe captive power plant</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Seward 2 x 260 MWe</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Conclusion</td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>
Seward  2 x 260 MWe CFB boilers

- Customer: Reliant Resources, USA
- Commissioning: 2004
- Steam Conditions:
  - Capacity: 2 x 872 t/h
  - Pressure: 174 bar
  - SH/RH Temperature: 541/541°C

- Fuel: Pennsylvania
- 2 millions tonnes of mining waste coal on site
- 100 millions within 80 km

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon</td>
<td>% wt</td>
<td>29.32 (25-35)</td>
<td></td>
</tr>
<tr>
<td>Volatile matter</td>
<td>%</td>
<td>11 ( 9-30)</td>
<td></td>
</tr>
<tr>
<td>Sulphur</td>
<td>%</td>
<td>2.75 (2 – 4.25)</td>
<td></td>
</tr>
<tr>
<td>Ash</td>
<td>%</td>
<td>51 (25-58)</td>
<td></td>
</tr>
<tr>
<td>Moisture</td>
<td>%</td>
<td>8.7 ( 7 – 12)</td>
<td></td>
</tr>
<tr>
<td>Heating Value</td>
<td>MJ/kg</td>
<td>12.8 (11.6-14)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Kcal/kg</td>
<td>3050</td>
<td></td>
</tr>
</tbody>
</table>
Seward  2 x 260 MWe CFB boilers

Three-bay arrangement:
- Coal feeding on the front wall.
- Three aligned cyclones
- 2 x FBAC
- 2 x FBHE

<table>
<thead>
<tr>
<th>Emission levels</th>
<th>mg/Nm³ @ 6 % O₂</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO₂</td>
<td>or sulphur removal</td>
<td>780</td>
</tr>
<tr>
<td>NOₓ</td>
<td></td>
<td>95%</td>
</tr>
<tr>
<td>Particulates</td>
<td></td>
<td>130</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40</td>
</tr>
</tbody>
</table>

- Proprietary NID™ dry scrubber
- SNCR

Clean Power from Waste Coal
Agenda

- Baima 300 MWe CFB demonstration plant - Page 3
- Emile Huchet 125 MWe captive power plant - Page 9
- Seward 2 x 295 MWe - Page 13
- Conclusion - Page 16
Conclusions

- Correctly applied CFB efficientlycombusts discard coal
- Full fuel knowledge is mandatory:
  - Coal rank
  - Ash chemical composition
  - Uncontrolled moisture
  - Fuel PSD
  - Coal fragmentation and ash attrition
- Required low load performance drives the CFB technology choice
- $\text{SO}_2$ and $\text{NO}_x$ emissions may drive back-end treatment options
  - NID$^\text{TM}$ dry scrubber
  - SNCR

Alstom leverages off its relevant experience to offer discarded fuel-fired CFB
**Alstom - CFB Product portfolio**

<table>
<thead>
<tr>
<th>Three Bay Arrangement</th>
<th>Dual Grate Arrangement</th>
<th>USC CFB Platform</th>
</tr>
</thead>
<tbody>
<tr>
<td>From 100 MW to 350MW class</td>
<td>350MW class</td>
<td>660 MW and up</td>
</tr>
<tr>
<td>Up to 4 cyclones in line</td>
<td>External bed technology</td>
<td>+6 % increased efficiency</td>
</tr>
</tbody>
</table>

**CFB installed base over 13,000 MWe with 140 references**

- 175 bars – 565°C/565°C
- 175 bars – 565°C/565°C
- 275 bars - 600°C/620°C
Alstom CFB Product portfolio

Leading CFB technology Supplier

- 3-Bay Arrangement
- Over 13GW installed based
- up to 350MW
- 175 bar – 565/565°C

Dual Grate Arrangement

USC CFB Platform 660 MW and up

- 275 bar - 600°C/620°C
- +6 % increased efficiency

Fuel combustion expertise

World class supplier of SC/USC
PC-fired boiler up to 1100MW

290 bar – 600/620°C

Leveraging boiler technology experience