SUMITOMO - FOSTER WHEELER CFB BOILER

Reliable & Proven Design
for Circulating Fluidized Bed Boiler
CFB Power Plant by Sumitomo

1. Sumitomo Heavy Industries in brief
2. Principals of CFB technology
3. Reliable design
4. Hard design improvement
5. Track Records
1. Sumitomo Heavy Industries in brief
Sumitomo Group in brief

A Member of Sumitomo Group

- Sumitomo Heavy Industries (SHI) -- Industrial Machinery & Engineering
- Sumitomo Chemical -- Fine Chemicals
- Sumitomo Metal -- Steel
- Sumitomo Mitsui Banking Co. -- Banking & Financing
- Sumitomo Corporation -- Corporation
- Sumitomo Electric -- Electrical/Optical Cable
- NEC -- Electronics
- Sumitomo Osaka Cement -- Cement & Ceramics
- Sumitomo Warehouse -- Logistics
- Mazda -- Automobile
- Asahi Beer -- Brewery
- Meidennsha -- Heavy Electrical
- Nippon Sheet Glass -- Glass
- Sumitomo Mitsui Construction -- General Construction

Total 47 companies, 266 thousand employees
Sumitomo Heavy Industries in brief

Products Line

Component Technologies for Coal Fired Power Plant

- Turbines and Pumps
- Boiler
- Pressure Vessels
- Water Treatment
- Cooling Tower
- Material Handling
- Bag Filter
- Ash Handling

Other Industrial Machinery

- Motor
- Plastic Molding Machine
- Crane
- Bridge
- Continuous casting machine
- Bulk freestier type continuousacker
Sumitomo - Foster Wheeler Alliance

Foster Wheeler (USA)  
Foster Wheeler (Finland)  
Sumitomo Heavy Industries

Technical Exchange Design Meetings

- Reference Data  
- Experience  
- Design Review

- R&D  
- Basic & Detail Design  
- Manufacturing  
- Construction  
- Start-up  
- Maintenance  
- After Sales Service

Foster Wheeler Boiler Shop Xinhu, China
Sumitomo - Foster Wheeler CFB Market Share

Foster Wheeler
CFB Market Leader in the world

Sumitomo - Foster Wheeler
CFB Market Leader in Japan

Total 881 Units
(1980-2008)

Total 55 Units
(1982-2009)

Source: 2008 McCoy Power Reports. All boiler types and sizes. Excludes domestic orders provided by domestic suppliers in China, India, Japan, and S. Korea. Other includes suppliers with less than 2% market share. Market Share based on MWe
## Delivery Record of SHI’s CFB Facilities

<table>
<thead>
<tr>
<th>Status</th>
<th>JAPAN</th>
<th>Other Countries</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>In Commercial</td>
<td>29 units</td>
<td>11 units</td>
<td>50 units</td>
</tr>
<tr>
<td>On Going</td>
<td>5 units</td>
<td>5 units</td>
<td></td>
</tr>
</tbody>
</table>

### Coal Fired Cogeneration x 13
- KMH2, Korea 400 t/h x 2 2014
- KMH, Korea 250 t/h x 2 2009
- JOP, China 200 t/h x 2 2011
- CPH, Taiwan 130 t/h 2012
- BCG, China 220 t/h x 2 (On Going)

### Coal Fired IPP x 5
- OGN, Japan 100 t/h, 25 MWe 2015
- OPT, Japan 300 t/h, 25 MWe 2008

### Biomass/Waste Fuel x 23
- HKP, China 195 t/h, 41 MWe 2006
- NKA, Korea 77 t/h, 16 MWe 2014
- OMF, Korea 230 t/h 2014

### Biomass/Waste Fuel x 8 (On Going)
- SF4, Japan 120 t/h 1995
- NPF, Japan 230 t/h 2007
- TPI, Japan 65 t/h, 12 MWe 2008
- NPI, Japan 230 t/h 2008
- KBP, Japan 137 t/h, 33 MWe 2011

### Coal Fired CPP x 2 (On Going)
- Antam 30MW (125t/h) x 2 2015
- Kalsel 1 115MW(406t/h)x2 2016 (LI)
2. Principals of CFB technology
2. Principals of CFB technology

2-2. Principally Fuel Flex Flex Furnace

- Gas temp.: 850 - 900°C
- Gas velocity: around 5.0 m/s

- Biomass < 50 mm
- Coal < 10 mm
- Limestone < 1 mm

- Long Combustion time
  Circulating combustion realizes better combustion efficiency for un-reactive fuels. Low volatile fuels etc.

- Large heat capacity in Furnace (Bed)
  Large heat capacity makes high moisture fuels stable combustion. High moisture coal, Biomass, Peat etc.

- Controlled (designed) Furnace temperature
  Reasonable Emission control
  Avoiding clinkers / Slugging
  Low melting Ash (>1150°C) Fuel NOx SOx

- Well Fluidization in Bed Area
  Fluidization makes fuel spreading, crushing, and avoiding heat spot
  Large size fuels, various figure fuels, Renewable Fuels (Tire, RPF, etc)

Please see VIDEO of CFB Boiler.
Sumitomo – Foster Wheeler CFB Fuel Experiences

Coals (Lignite, Bituminous, Anthracite), low grade coal, pet-coke
Renewable energy fuels (Biomass, TDF, RPF, Sludge, etc.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Range</th>
<th>Typical Fuel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>Up to 60%</td>
<td>Lignite Coal, Peat, Sludge</td>
</tr>
<tr>
<td>Ash</td>
<td>Up to 76%</td>
<td>Waste Coals</td>
</tr>
<tr>
<td>Sulfur</td>
<td>Up to 8%</td>
<td>Waste Coals, Petcoke</td>
</tr>
<tr>
<td>Volatiles</td>
<td>Down to 0%</td>
<td>Petcoke</td>
</tr>
<tr>
<td>LHV(AR)</td>
<td>Down to 1,500 kcal/kg</td>
<td>Waste Coals, Biomass</td>
</tr>
</tbody>
</table>
3. Reliable design
CFB pilot combustion test -Test facility

SHI Niihama Laboratory
Ehime pref., Japan

-Outline-
Thermal input 1 MWth
Furnace φ 600 × 20mH

-All fuels are tested by the pilot facility before actual commercial boiler design.

-Every single fuel & co-combustion technology are developed by means of this facility.

-More than 100 combustion tests were held in past 9 years.
Pilot Plant Combustion Test with Actual Fuel

SHI has its own pilot scale CFB plant in Japan
4. Hard design improvement
Foster Wheeler Compact CFB Design

Conventional CFB  
= [PLATE CYCLONE]  

Sumitomo  
= [WATER-COOLED CYCLONE]

Old Technology  
(originated by Ahlstrom)  

Advanced Technology  
(developed by Foster Wheeler and licensed to Sumitomo)
Water-Cooled Cyclone

Conventional CFB [Plate Cyclone]
- Outer Insulation
- Refractory
- Wear-Resistant Refractory

No Expansion Joint

Compact CFB [Water-Cooled Cyclone]
- Insulation
- Refractory
- Water-Wall Tubes

Need Expansion Joint

180 mm
120 mm
Total 300 mm
Thick Refractory

50 – 80 mm
Thin Refractory
5. Track records
149 MWe Coal-Fired CFB – Reheat unit
J-Power/Taiheiyo Cement, Itoigawa, Japan

Start-up: July 2001
Steam Flow: 475 t/h
Steam Pressure: 17 MPa
Steam Temperature: 569/541 °C
Power Output: 149 MWe
Fuel: Semi-Anthracite
Emission SO₂: 90 ppm (6% O₂)
Emission NOx: 120 ppm (6% O₂)
Service: IPP
Gross Plant Efficiency: 42.8% (LHV)

<Outstanding Features>
1. 1st large CFB with reheat in Japan
2. 40% to 100% daily swing operation
149 MWe Coal-Fired CFB – Reheat unit
J-Power/Taiheiyo Cement, Itoigawa, Japan

All of actual performances find everything satisfactory

<table>
<thead>
<tr>
<th>Guaranteed items</th>
<th>Guarantee value</th>
<th>Actual performance</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiler efficiency</td>
<td>%-LHV</td>
<td>91.6</td>
<td>91.6-92.1</td>
</tr>
<tr>
<td>Gross plant efficiency</td>
<td>%-LHV</td>
<td>42.8</td>
<td>43.3-43.5</td>
</tr>
<tr>
<td>NOx emission</td>
<td>ppm</td>
<td>Less than 120</td>
<td>61-73</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Less than 90</td>
<td>59-64</td>
</tr>
<tr>
<td>SO₂ emission</td>
<td>ppm</td>
<td>Less than 30</td>
<td>2-7</td>
</tr>
<tr>
<td>Dust in flue gas</td>
<td>mg/Nm³</td>
<td>Less than 12</td>
<td>12</td>
</tr>
<tr>
<td>Cold start</td>
<td>hours</td>
<td>Less than 8</td>
<td>7.5</td>
</tr>
<tr>
<td>Warm start</td>
<td>hours</td>
<td>±2</td>
<td>±2</td>
</tr>
<tr>
<td>Load change rate</td>
<td>%/min</td>
<td>±2</td>
<td>±2</td>
</tr>
</tbody>
</table>

Notes:
- 6%O₂-dry basis
- After 50 hours or later from shut down
- Before 50 hours or less from shut down
- Calc. code: JIS
- 50-75-100 %MCR
205 t/h x 2  Lignite-Fired CFB
VND-PROJECT, Vietnam

Steam flow  2 x 205 t/h
Steam press.  13 MPa
Steam temp.  540 °C
Power Output  56 MWe x 2 units
Fuel  Lignite
     Ash(30%), S(6%)
     T.M.(19%)
Emission  SO₂ <191 ppm(6%O₂)
          NOx <490 ppm(6%O₂)

<Outstanding Features>
- First CFB Boiler operated in Vietnam
- First coal-fired IPP project in Vietnam
- First power business by VINACOAL
- Minemouth project using high ash(30%), high sulfur(6%) lignite
TUAS POWER LTD, Singapore

3 x 450t/h CFB

Start-up
Unit 1 April 2013
Unit 2 November 2013
Unit 3 (not decided yet)

Steam Flow 3 x 450 t/h
Steam Pressure 10.5 MPa
Steam Temperature 510 °C
Fuel Indonesian Low Rank Coal
PKS Max 20%
Service Co-Generation

<Outstanding Features>
- Singapore’s first Coal fired Power Plant

Unit 1 had successfully achieved 100% load at first trial in January 2013.
Nippon Daishowa Paperboard, Otake, Japan

280t/h, Coal/Sludge CFB

- Start-up: April 2009
- Steam Flow: 280 t/h
- Steam Pressure: 10.3 MPa
- Steam Temp.: 535 °C
- Boiler Efficiency: 90.3%
- Power Output: 30 MWe + 18 MWe
- Fuel: 99% Indonesian Satui Coal, 1% Paper Sludge
- Emission SO₂: 30 ppm (6% O₂)
  NOx: 80 ppm (6% O₂)
  Dust: 30 mg/m³N (6% O₂)

Service: Cogeneration

<Coal Comparison Information>

<table>
<thead>
<tr>
<th>Carbon</th>
<th>Volatile</th>
<th>Ash</th>
<th>S</th>
<th>HHV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satui Coal</td>
<td>43.8%</td>
<td>45%</td>
<td>11.1%</td>
<td>0.85%</td>
</tr>
<tr>
<td>Berau Coal</td>
<td>50.5%</td>
<td>44%</td>
<td>5.5%</td>
<td>0.64%</td>
</tr>
</tbody>
</table>

<Outstanding Features>

1. CFB firing Coal
2. Special Design for Coal
   1) Furnace Bottom Kick-out Tube Design
   2) Compact Separator (Water-Cooled Cyclone)