Reliable & Proven Design for Circulating Fluidized Bed Boiler CFB Power Plant by Sumitomo Heavy Industries Co., Ltd.

1. Sumitomo Heavy Industries in brief
2. Principals of CFB technology
3. Reliable design
4. Track Records
5. Modular CFB Boiler
1. Sumitomo Heavy Industries Co., Ltd. in brief

Corporate Profile

Head Office: Tokyo, Japan

President: Yoshinobu Nakamura

Founded: November 20, 1888

Incorporated: November 1, 1934

Capital: JPY 30,872 million (as of March 31, 2012)
  = MNT : 463,075 million (*JPY1 = MNT15)

Number of Employees: Consolidated, 18,139 (as of March 31, 2012)

Annual Revenue: Consolidated, JPY 624,100 million (for the 2011 Fiscal Year)
  = MNT : 9,361,500 million (*JPY1 = MNT15)
### 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**
Delivery Record of SHI’s CFB Power Plant

- Coal Fired Cogeneration × 15
- Coal Fired IPP × 5
- Biomass / Waste Fuel × 20
- Biomass / Waste Fuel (Under Construction) × 3

<table>
<thead>
<tr>
<th>Operation Year</th>
<th>JAPAN</th>
<th>Other Countries</th>
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<tbody>
<tr>
<td>1991–2000</td>
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<tr>
<td>2001–2010</td>
<td>17 units</td>
<td>9 units</td>
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<tr>
<td>2011–</td>
<td>4 units</td>
<td>5 units</td>
</tr>
<tr>
<td>Total</td>
<td>29 units</td>
<td>14 units</td>
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</table>

- CPF – 2006 130t/h
- SMP – 2004 196t/h, 50MWe
- IPS – 2001 475t/h, 149MWe
- NPA – 2008 170t/h
- NPS – 2008 280t/h
- NDT – 2008 180t/h
- NPI – 2008 230t/h
- HKP – 2006 195t/h, 41MWe
- TPI – 2008 65t/h, 12MWe
- KBP – 2011 137t/h, 33MWe
- NPF – 2007 230t/h
- OPT – 2008 300t/h
- SF4 – 1995 120t/h
- NPO – 2007 250t/h
- OMK – 1988 35t/h, 4.3MWe
- KGW – 1990 240t/h
- KPS – 2005 525t/h, 167MWe
- CHF – 1988 60t/h, 12MWe
- SOK – 1999 230t/h, 61MWe
- NSK – 1996 96t/h, 29MWe
- ONC – 2006 130t/h
- TBS – 2012, 450t/h × 2 (+1)
- JOP – 2011 200t/h × 2
- BCG – 2005 220t/h × 3
- VND – 2005 205t/h × 2

JAPAN: 29 units
Other Countries: 14 units
Foster Wheeler CFB Market Share

Foster Wheeler
CFB Market Leader in the world

FW 44%
Lurgi 3%
Harbin 3%
Metso 7%
SES 2%
Other 7%
Alstom 32%
Dongfang 2%

Sumitomo - Foster Wheeler
CFB Market Leader in Japan

SHI 52%
IHI 19%
NSC 3%
MES 8%
JFE 6%
MHI 12%
SES 2%
Other 7%

Total 25.1 GWe, 260 Units
(1996-2006)

TOTAL 52 units

Source: 2007 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
2. Principals of CFB technology

Bed Material circulation

Material behavior in each flue gas velocity phase

- Poor fluidization
- Start to fluidizing
- Materials reach to furnace top
- Material circulation

Furnace gas velocity:
- Slow
- Fast
**CFB Advantage against PC Boiler**

**FUEL Flexibility**
- Low Volatile, High Ash
- Low Melting temp, Low Grindability
  - Coal: Anthracite–Bituminous–Lignite
  - Waste: Biomass, TDF, RPF, Sludge
- High Volatile, Low Ash
- High Melting temp, High Grindability
  - High Cost Bituminous Only
  - Not Available

**SOx Emission**
- No DeSOx System
  - Limestone Injection Available (DeSOx >90%)
- Required Wet Scrubber FGD
  - Not Available

**NOx Emission**
- No DeNOx System
  - SNCR (Urea Injection) Available (DeNOx >50%)
- Requires SCR
  - Not Available

**Maintenance**
- No Pulverizer, Slugging, Wet FGD
  - Less Wearing, Long Life Refractory
- Required for Pulverizer, DeSlugging FGD, (SCR)

**Installation Cost**
- Even to PC with FGD
3. Reliable design

3-1. CFB pilot combustion test - Test facility

SHI Niihama Laboratory
Ehime pref., Japan

- Outline -

Thermal input 1 MWth
Furnace
Φ600 x 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
3. Reliable design

3-2. CFB pilot combustion test – Getting Information

CFB PILOT COMBUSTION TEST

After basic lab. Analysis
SHI perform pilot test all PJ

Real Fuels

Combustion and emission

Corrosion information

Ash property

Fouling and fluidization
3. Reliable design

3-3. Design feedback – Together with Customers

SHI cares Customers continuously through Service Work. Operation Advise and Service with Customers.

Reflect to Design

Numerical simulation & evaluation

Foster Wheeler experiences & technical exchange meeting

Commercial plant operation data

Combustion test results with real fuel

After service

Operation years

Delivery

SHI’s experiences in commercial plant
4. Track Record

4-1. SHI experienced Fuels (Including co-firing)

*LHV = Lower Heating Value
*Fuel Ratio = Volatile Matter(%) / Fixed Carbon(%)
4. Track Record

4-2. Experienced High Ash & Low Ash Fuels

- Experienced High Ash & Low Ash Fuels
- Over 30%

**Graph:***
- Coal boiler
- Biomass boiler

- **VND**
  - 56MWex 2 units
  - High Ash Lignite
  - Over 30%

- **BCG**
  - 220t/h x 3 units
  - High Ash Anthracite

- **KMH**
  - 250ton/hx 2 units
  - Indonesian Coal + TDF

- **TBS (under construction)**
  - 131MWe
  - x 2 units

- **KBP**
  - 33MWe

**Legend:**
- Normal level
- Less than 2%
- Over 30%
4. Track Record

4-3. Experienced Coal (Moisture & Ash content)

*Heating value is LHV basis
<table>
<thead>
<tr>
<th>No.</th>
<th>Start Up</th>
<th>Customer</th>
<th>Mill</th>
<th>Boiler Spec</th>
<th>Fuel</th>
<th>CO2 Reduction</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Capacity</td>
<td>Temperature</td>
<td>Pressure</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ton/h</td>
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<td>kg/cm²</td>
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</tbody>
</table>

**Boiler Spec**
- Capacity: ton/h
- Temperature: ℃
- Pressure: kg/cm²

**Fuel**
- Coal
- Petcoke

**CO2 Reduction**
- ton-CO2/y
- Max:30%
- under estimate

**Boiler Type**
- Coal Fired Cogeneration
- Coal Fired IPP
- Biomass / Recycle Fuel

**Customer**
- KOCHI
- TOSA
- TONIOKA
- ASAHIKAWA
- CHUETSU PULP
- TAIHEYO CEMENT
- NIPPON STEEL
- KOBE STEEL
- OMIKENSHI
- CHUETSU PULP
- TAIHEYO CEMENT
- SUMITOMO OSAKA CEMENT
- VINACOAL
- NIPPON PAPER
- OJI PAPER
- NIPPON DAISHOWA PAPERBOAD
- NIPPON PAPER
- NIPPON PAPER
- NIPPON PAPER
- KUMHO PETRO CHEMICAL
- KUMHO PETRO CHEMICAL - II
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
Steam flow: 130 t/h
Steam press.: 11.9 MPa
Steam temp.: 541 °C

Fuel:
- 83% TDF
- 13% Biomass
- 4% Sludge

Emission:
- SO₂ <90 ppm (6% O₂)
- NOx <250 ppm (6% O₂)

<Outstanding Features>
1. The highest TDF mixing ratio in CFB
2. Special Design for TDF/Biomass
   - Step-grid type furnace bottom for wire contained TDF
   - TDF, Biomass feeding system
   - INTREX Superheater
4. Track records

33 MWe 100% Woody biomass-fired CFB
Kawasaki Biomass Power, Kawasaki, Japan

Start-up: February 2011
Steam flow: 137 t/h
Steam press.: 10.2 MPa
Steam temp.: 513°C
Power output: 33 MWe
Fuel: Woody biomass

Ash (2.2%-AR)

Emission SOx: 3ppm (Act. O₂)
NOx: 30ppm (6% O₂)

Service: PPS

<Outstanding Features>
1. 1st 100% biomass firing CFB in Japan
2. Meet stringent Emission Requirements
   DeNOx with ammonia gas injection (SNCR) + Catalyst (SCR)
   DeSOx with Wet type flue gas scrubber
World Largest Tropical Biomass Fired CFB

Tuas Power Ltd., Tembusu BMCC Project
(Biomass & Clean Coal Cogeneration), Jurong Island, Singapore

-Plant Spec Summary-

Completion of Works: Dec 2012
Steam Generation: 450 t/h
Steam Pressure: 10.5 MPa
Steam Temperature: 510 °C
Power Output: 100MWe+Steam
Fuel: Biomass(PKS*)
   Coal
*PKS=Palm Kernel Shell

4. Track records
Sumitomo- Foster Wheeler
Introduction of Modular CFB Boiler
5. Modular CFB Boiler

Sumitomo - FW Modular CFB Basic Concept

1. Boiler Specification
   Type: Sumitomo-FW CFB
   Capacity: 25t/h
   Steam Pressure: 5.4 ~ 6.4 MPaG
   Steam Temperature: 450 ~ 480°C

2. Design
   Furnace: Water tube with Kick-out Design
   Separator: Water tube with refractory
   Furnace Bottom: Step grid or Arrow Head

3. Fuel
   Coal, Biomass

4. Emission
   SOx: In furnace de SOx
   NOx: Low temperature 2 step combustion
        SNCR (Urea injection)
   Dust: Bag filter

Concept and Effect
1. Shorter Delivery Time → Improvement of ROI
2. Reduction of Construction Cost
3. High performance & High Reliability
5. Modular CFB Boiler

An Example of GHG Emission Reduction Project in a Local Area

Advantages:
(1) Producing Heat and Electricity
(2) Mitigating Air Pollution (NOx and SOx)
(3) Possibility of Using Biomass and Waste
(4) Reducing Consumption of Coal

A local Heat Only Boiler (HOB) in Tuv Aimag, Mongolia

A Modular CFB Boiler (Capacity: 1MB-10MB)
5. Modular CFB Boiler

Shorter Delivery (Site Construction)
5. Modular CFB Boiler

Shorter Delivery (Project Schedule)

Design innovations

- Boiler size 25t/h package design
- Module construction

Impact for construction

<table>
<thead>
<tr>
<th>Period</th>
<th>Unit</th>
<th>Large scale boiler</th>
<th>Small package boiler</th>
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<td>Period</td>
<td>day</td>
<td>239</td>
<td>103</td>
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<tr>
<td>Man-hour</td>
<td>man</td>
<td>32,330</td>
<td>9,525</td>
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Typical Project schedule
### Modular CFB Boiler

#### Modular CFB (Performance Design)

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<tr>
<th>Operating Condition</th>
<th>Biomass 100%</th>
<th>Coal 100%</th>
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<tbody>
<tr>
<td>Weather Condition</td>
<td>(Japan)</td>
<td>(Japan)</td>
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<tr>
<td>Boiler Capacity</td>
<td>t/h</td>
<td>25</td>
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<tr>
<td>Boiler Load</td>
<td>% MCR</td>
<td>100</td>
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<tr>
<td>Fuel Calorific Value (LHV)</td>
<td>kcal/kg(AR)</td>
<td>2,706 (TM 35%)</td>
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<td>Fuel Consumption</td>
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<td>Bottom Ash t/h</td>
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<td>Sand Feed t/h</td>
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<td>Emission</td>
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<tr>
<td>SOx ppm(O2 6%)</td>
<td>100</td>
<td>190</td>
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<tr>
<td>NOx ppm(O2 6%)</td>
<td>150</td>
<td>130</td>
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<tr>
<td>Dust mg/Nm$^3$(O2 6%)</td>
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Баярлалаа !!
Thank You for Listening !!
ご清聴有難うございました !!