Kawasaki ICFB Boiler
(Internal Circulating Fluidized Bed Boiler)
Standing Position of ICFB

**BFB**
- Small ~ Middle size
- Applicable for low heating value fuel (Paper sludge, wood chip etc.)
- Low height boiler

**CFB**
- Middle ~ Large size
- Co-firing of coal and other recycle fuel
- Bed temp. control by ash circulation
- Tower type boiler

**ICFB**
- Small ~ Middle size (50~150t/h)
- Bed temp. control by BM circulation
- Applicable for low heating value fuel
- Applicable for high heating value fuel
- Applicable for corrosive fuel
- Same boiler height with BFB

**Hybrid Type**
Combustion System of ICFB

- Fuel
- Fluidizing air for heat recovering cell
- Fluidizing air for circulating cell
- Fluidizing air for combustion cell
- Heat recovering cell
- Embedded Superheater
- Double partition wall
- Embedded Evaporator
- Secondary air
- Freeboard
- Tertiary air
- Flow direction of bed material
- Incombustible
- Circulating cell
Fluidized bed and furnace

1. Large furnace
   Three (3) "T" (retention Time, high Temp., Turbulence) is important for complete combustion without emission of dioxin. Furnace is designed to have large volume to keep long retention time.

2. Tertiary air nozzle and two-stage nose
   Large two-stage nose is provided for turbulence and mixture of flue gas after blowing tertiary combustion air.

3. Heat recovering cell
   Fluidizing air of heat recovering cell is heated through the bed and flowed out from the upside of partition wall to freeboard as secondary combustion air.
Fluidized bed and furnace

4. Double partition wall
Double partition walls are provided to prevent not only combustion in heat recovering cells but also influx of corrosive gas from combustion cell.

5. Fluidizing air nozzle
Fluidizing air nozzles are arranged uniformly and designed for 50-100% of boiler load.

6. Embedded heat exchanger
Approx. 35-45% of boiler heat recovery is absorbed by embedded heat exchanger (final superheater and embedded evaporator) which can be sized in small heating surface due to high heat transfer rate in fluidized bed.

7. Fuel chute
Fuel is supplied in combustion cell only, and is burned in the combustion cell with low temperature under poor air, and burned out completely in the freeboard with high temperature under rich air.
8. Refractory wall
Water walls of fluidized bed and freeboard on the bed are covered with refractory to keep suitable combustion atmosphere.

9. Operating condition
Relation of operating condition among combustion cell, heat recovering cells, and BM circulation cells, that is, bed temperature and fluidized air velocity for each cell, is important.

10. Water circulation
Large size downcomer is arranged for achieving suitable natural circulation of boiler water. Forced circulation system of boiler water is applied to embedded evaporator and double partition walls with high heat transfer rate to keep suitable water circulation performance.
# Fuel Application

## Fuel application

<table>
<thead>
<tr>
<th>Fuel combination</th>
<th>BFB</th>
<th>ICFB</th>
<th>CFB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood Chip mono-firing</td>
<td>◎</td>
<td>◎</td>
<td>▲</td>
</tr>
<tr>
<td>Wood Chip + RDF or RPF</td>
<td>◎</td>
<td>◎</td>
<td>▲</td>
</tr>
<tr>
<td>RPF or RPF mono-firing</td>
<td>▲</td>
<td>◎</td>
<td>▲</td>
</tr>
<tr>
<td>Coal + Wood Chip</td>
<td>◎</td>
<td>◎</td>
<td>◎</td>
</tr>
<tr>
<td>Coal + RDF or RPF</td>
<td>▲</td>
<td>◎</td>
<td>◎</td>
</tr>
<tr>
<td>Coal mono-firing</td>
<td>▲</td>
<td>◎</td>
<td>◎</td>
</tr>
<tr>
<td>Wood Chip + Paper Sludge</td>
<td>◎</td>
<td>◎</td>
<td>▲</td>
</tr>
</tbody>
</table>

◎ Good  ○ Average  ▲ Poor
Feature of ICFB

1. High combustion efficiency

- Stable ignition & combustion by Dense bed
  ⇒ Low heating value fuel, High moisture fuel can be applied.

- Constant combustion temperature by BM circulating

- Low NOx combustion by multi air feeding and low air-ratio
  Combustion cell air ⇒ Primary air
  Circulation & Heat recovery cell air ⇒ Secondary air
  Freeboard air ⇒ Tertiary air

- High efficiency combustion by sufficient retention time in the furnace
Feature of ICFB

2. Low level erosion / corrosion

● Separation of combustion zone and heat absorption zone by double partition wall
  - Fuel can be completely fed into combustion cell
  - Mild atmosphere of heat recovery cell
    ⇒ Arrangement of final SH is applicable!

● Low fluidizing velocity of heat recovery cell (1/2~1/3 of BFB)
  ⇒ Prevention of erosion of embedded tube

● Heat transfer coefficient is very large (more than 5 times of convection heating area)
  ⇒ Compact design of embedded tube
Feature of ICFB

3. High Reliability

● Low erosion of upper furnace and convection heating area
  • No explosion of BM (Bed Material)
    ⇒ No need of countermeasure of erosion for furnace upper part
  • Low dust concentration at convection heating area
    ⇒ Low risk of erosion of convection heating tube

● Simple circulating system of Bed Material
  • Circulating area of BM is the bottom of furnace only
  • No cyclone ⇒ No maintenance of cyclone refractory
Feature of ICFB

4. Easy Operation & Easy Maintenance

● Bed temperature control ⇒ Stable evaporation
  - Heat absorption can be controlled by air flow of circulating cell
  - Heat absorption of embedded tube can be controlled by operating temperature of heat recovery cell

● Limited maintenance area
  - Main maintenance area is “Bed area” and “Material handling system” only
    - Low fouling of convection heating area
    - Low erosion of furnace upper area and convection tube
## Omuta Recycle Power

<table>
<thead>
<tr>
<th>Boiler Type</th>
<th>ICFB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evaporation</td>
<td>91 t/h</td>
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<tr>
<td>Steam Press.</td>
<td></td>
</tr>
<tr>
<td>Steam Temp.</td>
<td>8.14MPa × 503 °C</td>
</tr>
<tr>
<td>Fuel</td>
<td>RDF</td>
</tr>
<tr>
<td>Fuel Consumption</td>
<td>RDF: 315 t/d</td>
</tr>
<tr>
<td>Emission</td>
<td></td>
</tr>
<tr>
<td>NOx: 65ppm</td>
<td></td>
</tr>
<tr>
<td>SOx: 3.0m³N/h</td>
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</tr>
<tr>
<td>HCl: 32.5mg/m³N</td>
<td></td>
</tr>
<tr>
<td>Dust: 20mg/m³N</td>
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<tr>
<td>DXN: 0.1ngTEQ/m³N</td>
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</tr>
<tr>
<td>CO: 100ppm</td>
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</tr>
<tr>
<td>(O₂=12%, dry)</td>
<td></td>
</tr>
<tr>
<td>Plant site</td>
<td>Fukuoka prefecture</td>
</tr>
<tr>
<td>Delivery year</td>
<td>2003</td>
</tr>
</tbody>
</table>

### Pellet type RDF
### Tokushu Tokai Paper Co., Ltd. /Shimada mill

<table>
<thead>
<tr>
<th>Boiler type</th>
<th>ICFB</th>
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<tbody>
<tr>
<td>Evaporation</td>
<td>75 t/h</td>
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<tr>
<td>Steam Press.</td>
<td>9.81MPa × 501 °C</td>
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<tr>
<td>Steam Temp.</td>
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<tr>
<td>Fuel</td>
<td>Waste wood chip, RPF, Waste plastic</td>
</tr>
<tr>
<td>Fuel Consumption</td>
<td>Wood chip: 9.0t/h, Waste Plastic: 2.2t/h, RPF: 0.8t/h</td>
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<tr>
<td>Emission</td>
<td>NOx: 50ppm (O₂=6%, dry)</td>
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<tr>
<td></td>
<td>SOx: 10ppm (O₂=12%, dry)</td>
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<tr>
<td></td>
<td>HCl: 100ppm</td>
</tr>
<tr>
<td></td>
<td>Dust: 0.04g/m³N</td>
</tr>
<tr>
<td></td>
<td>DXN: 0.1ngTEQ/m³N</td>
</tr>
<tr>
<td></td>
<td>CO: 100ppm</td>
</tr>
<tr>
<td>Delivery year</td>
<td>2006</td>
</tr>
</tbody>
</table>

**Images:**
- Wood chip
- RPF
### Korea/Iksan city  Commerce & Industry Energy Co., Ltd.

**Boiler type**: ICFB  
**Evaporation**: 75 t/h  
**Steam Press. Steam Temp.**: 6.37MPa × 450 ℃  
**Fuel**: RDF, Coal  
**Fuel Consumption**:  
- RDF: 210 T/D  
- Coal: 65.5 T/D  
  (RDF&Coal co-firing)  
**Emission**:  
- NOx: 70ppm  
- SOx: 30ppm  
- HCl: 20ppm  
- Dust: 0.02g/m³N  
- DXN: 0.1ngTEQ/m³N  
- CO: 50ppm  
  (O₂=12%,dry)  
**Delivery year**: 2012

**Pellet type RDF (& Coal)**
Kawasaki, working as one for the good of the planet

“Global Kawasaki”