Demonstration of Twin IHI Gasifier (TIGAR) for lignite coal

~ IHI Gasification technology~

IHI Corporation
PT. IHI Gasification Indonesia
Company Profile (IHI Corporation)

- Founded: 1853
- Net Sales: JPY 1,456 bil. (USD 12,120 mil)
- Works: 8
- Branch Offices: 17 (Japan), 15 (Overseas)
- Employees: 28,533

Information is on consolidated basis and is corrected as of March 2015

The First Steamship Built by Japanese Private Company – “Tsu-un maru”.

Global Network

- Overseas Office
- Global Subsidiary Company

Sales by business segment (on consolidated basis)

- Aero Engines: 30%
- Industrial Systems: 28%
- Social Infrastructure: 13%
- Resources, Energy and Environment: 29%
IHI Business Areas

Resources, Energy and Environment
(Boiler, Gas Turbine/Gas Engine, LNG Terminal, Process Plant, Nuclear Equipment, etc.)

Aero, Engines and Space Development
(Jet Engine, Rocket)

Social Infrastructure and Offshore Facilities
(Bridge, Transportation System, Security, etc.)

General-Purpose Machinery
(Compressor, Separator, Turbo charger, etc.)

Industrial Systems and General-Purpose Machinery
(Steel Manufacturing Furnaces, Heat/Surface Treatment Equipment, Logistics Systems, Material Handling Equipment, etc.)

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1. Characteristics of TIGAR

- Components of TIGAR are based on mature Fluidized Bed technology
- The low grade material (lignite, biomass) can be gasified, and applied to chemical raw material, fuel

**Combustor**
(heat emission)

- Atmospheric pressure
- Low temperature

**Gasifier**
(heat absorption)

**High temperature bed materials are circulated**

**Unreacted char is burned with air**

**Applicable Fuel**

**Coal (lignite)**

**Biomass**

**Steam gasification**

**Syngas (CO, H₂)**

**Methane**

**DME**

**Coal**

**Biomass**

**Application**

- GT, GE Fuel
- Direct reduction iron making
- Fuel cell
- NH₃
- SNG
- Chemical feedstock
- Auto fuel

**Syngas component**

- Hydrogen rich gas

<table>
<thead>
<tr>
<th>Syngas component</th>
<th>CH₄ 9%</th>
<th>CO₂ 19%</th>
<th>CO 18%</th>
<th>H₂ 51%</th>
<th>Other HC 3%</th>
</tr>
</thead>
</table>

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2. Feature of TIGAR

- Similarity between CFB and TIGAR

**Operation**
- Operation philosophy of TIGAR is similar to CFB
- Easy familiarization by operator

**Maintenance**
- Conventional equipment can be adopted
- Familiar maintenance know-how

- TIGAR has been developed based on CFB as mature technology, so TIGAR has same features such as good fuel flexibility and environmental adaptation.

**IHI’s CFB experience**
- Steam Flow Rate: ~310 ton/hr (Max. 1500ton/day as Lignite feed rate)
- Since 1992
- Delivery Record: Japan, China, Thailand

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2. Feature of TIGAR

- Similarity of Key Components between CFB and TIGAR

Key components of TIGAR and equipment such as coal feeder and fans are similar to CFB. In addition, size of the commercial plant of TIGAR is within IHI’s experienced CFB.
2. Feature of TIGAR

- Fuel variety and simple fuel supply system

- Easy utilization of Lignite and Biomass because of operation under atmospheric pressure

- Applying simple feeding system to gasifier by gravity.
  (Now Using little amount of seal Nitrogen)

- Only rough crushed (Bulk)!
  No special preparation!

- Lignite
  - Particle size: 10mm under
  - Total moisture: <35~45%*

  *As received base is acceptable

- Wood

- Biomass is available, too

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2. Feature of TIGAR

① Lower CAPEX and simple Operation & Maintenance  
- Lower pressure and lower temperature in operating condition
② Simple Fuel preparation  
- Coarse size and higher moisture are acceptable
③ No N₂ contamination in Syn-gas, No ASU for gasification, because of Steam gasification

<table>
<thead>
<tr>
<th>Gasifier type</th>
<th>IHI-TIGAR-</th>
<th>Entrained bed</th>
<th>Moving bed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluidized bed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure</td>
<td>Atmospheric</td>
<td>&gt;3MPa</td>
<td>&gt;3MPa</td>
</tr>
<tr>
<td>Temperature</td>
<td>800-1,000℃</td>
<td>&gt;1,400℃</td>
<td>&gt;1,400℃</td>
</tr>
<tr>
<td>Gasification agent</td>
<td>Steam</td>
<td>Oxygen</td>
<td>Oxygen</td>
</tr>
<tr>
<td>Fuel particle size</td>
<td>&lt;10mm</td>
<td>&lt;0.1mm</td>
<td>&lt;0.1mm</td>
</tr>
<tr>
<td>Fuel configuration</td>
<td>Bulk, powder</td>
<td>Powder</td>
<td>Slurry</td>
</tr>
<tr>
<td>Residue</td>
<td>Dry Ash</td>
<td>Slag</td>
<td>Slag</td>
</tr>
</tbody>
</table>

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3. Development of TIGAR

History

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>Basic Test</td>
</tr>
<tr>
<td>2009</td>
<td>6TPD Pilot Plant</td>
</tr>
<tr>
<td>2010</td>
<td>50TPD Prototype Plant EPC</td>
</tr>
<tr>
<td>2011</td>
<td>Demonstrating Test</td>
</tr>
<tr>
<td>2012</td>
<td>Commercial Plant</td>
</tr>
<tr>
<td>2013</td>
<td>Japanese Government (METI*) Support</td>
</tr>
<tr>
<td>2014</td>
<td></td>
</tr>
<tr>
<td>2015</td>
<td></td>
</tr>
<tr>
<td>2016</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td></td>
</tr>
</tbody>
</table>

Japanese Government (METI*) Support

*Ministry of Economy, Trade and Industry

6t/d@Yokohama, JAPAN

50t/d@Kujang, INDONESIA

Commercial plant image

Coal feed : 3000 t/d
(Substantially NH₃ : 1000 t/d)
3. Development of TIGAR

Design method of gasifier

TIGAR design method has been constructed by several fundamental experiments and simulations, and confirmed at Pilot Plant. Using this method, 50t/d demonstration plant was designed.

Target fuel
- Capacity
- Temperature
- S/C
- Combustion Air

Design Condition

Gasification behavior

Prediction of coal residence time in the gasifier

6t/d pilot plant @ Yokohama

Prediction of gasification efficiency
4. 50t/d Demonstration at Indonesia

Purpose

① Check the maintenance durability in long operation (Total 4,000 hr operation) using Indonesia lignite.

② Confirmation of TIGAR performance and reliability, and reflect in commercial plant engineering.

③ Demonstration of TIGAR gasification technology for future clients.

<50t/d plant spec>

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal feed rate</td>
<td>50 t/d (as received, 43% moisture)</td>
</tr>
<tr>
<td>Syngas output</td>
<td>1,800 m³N/h-dry</td>
</tr>
<tr>
<td>Steam generation</td>
<td>4.5 t/h (2.0MPaG, 513deg.C)</td>
</tr>
<tr>
<td>Site area</td>
<td>100m × 80m</td>
</tr>
</tbody>
</table>
4. 50t/d Demonstration at Indonesia

Organization chart

- METI
  Ministry of Economy, Trade and Industry
- Ministry of Industry
- Ministry of state-owned enterprises
- PT. Pupuk Indonesia (PIHC)
- PT. Pupuk Kujang
- ARDEMR
  Agency of Research and Development of Energy and Mineral Resource
- MEMR
  Ministry of Energy and Mineral Resources
- IHI Corporation
  PT. IHI Gasification Indonesia
- IHI
  tekMIRA

Government Talk
Cooperation
Support

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## 4. 50t/d Demonstration at Indonesia

### History

<table>
<thead>
<tr>
<th>Year</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>Month</td>
<td>1-6</td>
<td>7-12</td>
<td>1-3</td>
<td>4-6</td>
<td>7-9</td>
</tr>
</tbody>
</table>

- **Construction**
  - Project Agreement
- **Commissioning**
  - First fire
  - First gasification
  - Full Load
  - Opening Ceremony
- **Operation**
  - Operation, Maintenance, Evaluation
  - Total Operation ~ 4000hr

*Signing Ceremony, 13 February 2013*

*First Gasification, 17 January 2015*

*Inauguration Ceremony, 26 February 2015*
4. 50t/d Demonstration at Indonesia

Site Overview
4. 50t/d Demonstration at Indonesia

Process flow

- Material Handling
- TIGAR
- Steam Drum
- HRA
- Bag Filter
- Exhaust Pipe
- O2 Supply System
- N2 Supply System
- LPG System
- Instrumentation Air System
- Cooling Water System
- Amine Supply System
- Emergency Generator
- Gas purification (high pressure)
- Gas purification (low pressure)
- Incinerator
- Waste water treatment
- Utility System
- O2 Supply System
- N2 Supply System
- LPG System
- Instrumentation Air System
- Cooling Water System
- Amine Supply System
- Emergency Generator

Air for combustion
Steam for gasification
Tar Cracker
4. 50t/d Demonstration at Indonesia

Layout

- Gas Purification area
- Waste Water area
- Gasifier structure area
- TIGAR Control Center
- Utility area
- Machinery house
- LPG area
- Coal yard
- Coal handling system

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4. 50t/d Demonstration at Indonesia

Plant photo

Waste Water area

Gas Purification area

Control Center

Gasifier structure and Coal crusher area

Coal yard
4. 50t/d Demonstration at Indonesia

Coal delivery

Design Coal: “East Kalimantan coal” 3400kcal/kg GAR at 43% moisture

4000 ton coal on 230 ft Barge

Loading at coal jetty

Truck transports coal from stockyard near port to the TIGAR site. TIGAR site have 10 days stockyard (500ton)

Unloading at port (near Jakarta)

From East Kalimantan to Jawa
# Test schedule

<table>
<thead>
<tr>
<th>RUN</th>
<th>Description</th>
<th>Year 2015</th>
<th>Year 2016</th>
<th>Year 2017</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUN1</td>
<td>(East Kalimantan coal, Adjustment)</td>
<td>4 5</td>
<td>6 7 8</td>
<td>9 10 11 12</td>
</tr>
<tr>
<td></td>
<td>Evaluation, Maintenance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RUN2</td>
<td>(East Kalimantan coal, Performance test)</td>
<td></td>
<td>2</td>
<td>3 4 5 6 7 8 9 10 11 12</td>
</tr>
<tr>
<td></td>
<td>Evaluation, Maintenance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RUN3</td>
<td>(East Kalimantan coal, Another coal, )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluation, Maintenance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RUN4</td>
<td>(Another coal, Biomass)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Evaluation, Maintenance</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Plant Demolition**

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**Plan**

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4. 50t/d Demonstration at Indonesia

Operation Result

➤ Total 700hr gasification operation
➤ Without drying, roughly crushed lignite were accepted

East Kalimantan Coal

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TM (ar)</td>
<td>42%</td>
</tr>
<tr>
<td>Ash (adb)</td>
<td>8%</td>
</tr>
<tr>
<td>VM (adb)</td>
<td>38%</td>
</tr>
<tr>
<td>FC (adb)</td>
<td>37%</td>
</tr>
<tr>
<td>Total Sulphur (adb)</td>
<td>0%</td>
</tr>
<tr>
<td>Gross Calorific Value (ar)</td>
<td>3380kcal/kg</td>
</tr>
</tbody>
</table>

Example of operation

crush < 10mm
Operation Result

➤ With Indonesian operators we succeeded to ensure the stable operation
➤ Optimization of operation are still needed

Composition of Gasifier outlet syngas

- H₂ 48%
- CO₂ 21%
- CO 21%
- CH₄ 4%
- N₂ 9%

* Seal N2 for Coal feeding line are detected.
5. Marketability of lignite gasification  
- Why Indonesia?

Energy situation in Indonesia

Policy of Indonesia energy supply
The 1st JAPAN-INDONESIA ENERGY FORUM, 2013

Indonesia Coal Resources
WEC, Survey of Energy Resources 2010

Natural gas Utilization in Indonesia
The 1st JAPAN-INDONESIA ENERGY FORUM, 2013

- Important source of foreign exchange acquisition by LNG export
- Energy security
5. Marketability of lignite gasification - Indonesian Fertilizer Industry

NH₃ manufacturing capacity of Pupuk Indonesia holdings (PIHC) Group

- **Pusri**
  - 1350 t/d
  - 790 t/d
  - 1200 t/d
  - 1200 t/d

- **Kujang**
  - 1160 t/d
  - 1000 t/d

- **Iskandar Muda**
  - 1100 t/d
  - 1200 t/d

- **Kaltim**
  - 1800 t/d
  - 1800 t/d
  - 1000 t/d
  - 1000 t/d

- **Petrokimia Gresik**
  - 1350 t/d
6. Conclusion

- TIGAR is based on CFB technology, and steam gasification. It has the feature of easy O&M, fuel flexibility (Lignite, Biomass), H2 rich syngas.

- From the 50t/d Demonstration operation in Indonesia, we are getting data for commercial plant. And we will prove and appeal above TIGAR’s merit through 4000hr demonstration operation.

- We would like to contribute for effective use of resources by TIGAR technology.
Thank you for your attention!

IHI
Realize your dreams