Twin IHI Gasifier (TIGAR®)

Current Status of Indonesian Demonstration Project and its Business Plan

October 18th, 2016
GSTC 2016 @Vancouver, Canada

TIGAR PJ Group
Business Development Department
Energy & Plant Operations
IHI Corporation
IHI Corporation Profile

Established: 1853 (163rd Anniversary in 2016)
Capital: 107.1 Billion JPY (0.9 Billion USD)
Employees: 29,494
Affiliated companies: 84 (in Japan) 175 (in Overseas)
Net sales: 1,539.3 Billion JPY (13 Billion USD)

--Information is on consolidated basis and is corrected as of March 2016--

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

Industrial Systems and General-Purpose Machinery 26%
Aero Engines, Space & Defense 33%
Social Infrastructure & Offshore Facilities 11%
Resources, Energy & Environment 29%

Total Sales Volume (Year end March, 2016)

Global Network

Overseas Office
Global Subsidiary Company

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IHI’s strategy for Clean Coal Technology

- Several types of boilers for the best usage of fuel
- Increasing plant efficiency by the improvement of steam condition
- CO₂ capture and storage by Oxy-fuel combustion in Callide, Australia
- Flexible & lower-cost gasifier for effective utilization of low rank coal and biomass

* PFBC: Pressurized Fluidized Bed Combustion
  CFB: Circulating Fluidized Bed
Introduction of Twin IHI GAsifieR - TIGAR®

- Principle of TIGAR®
  IHI has been developing TIGAR® for both coal and biomass gasification based on in-house Circulating and Bubbling fluidized bed (CFB & BFB) technologies.

- OPERATION CONDITION
  - Atmospheric pressure
  - Low temperature
Introduction of Twin IHI GAsifieR - TIGAR®

Applications of TIGAR®

- High CO+H₂
- High Calorific
- N₂-free
SYNGAS (CO+H₂)

PRODUCTS
- CO+H₂
- CH₄
- H₂

APPLICATIONS
- Thermal use
  - Dryer
  - Ceramic Kiln
- Gas Turbine fuel
- Gas Engine fuel
- Power generation
  - Combined Heat & Power
- Synthetic
  - Natural Gas
- Ammonia (NH₃)
  - (Raw materials)
- Fuel Cell

SYNGAS (CO+H₂)

- High CO+H₂
- High Calorific
- N₂-free

Gas Cleaning

Shift Reaction

Tar Cracker

Methanation

Liquefaction
- Dimethylether
- Methanol

Synthesis

Transportation fuel

Chemical Raw Material

Gas

Liquid

TIGAR®

Low Cost
(Material/Feedstock)

High Value
(Production)

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5
Development of TIGAR®

TIGAR® development process needs numerous facilities. In order to commercialize, each test plant from Lab to Prototype scale serves different purposes.

<table>
<thead>
<tr>
<th>Lab Scale Testing</th>
<th>Bench Scale Testing</th>
<th>Pilot Plant Testing</th>
<th>Prototype Plant Testing</th>
<th>Commercialized Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batch</td>
<td>0.1T/D</td>
<td>6T/D</td>
<td>50T/D</td>
<td>300～1000T/D</td>
</tr>
</tbody>
</table>

- **Batch**
  - Tests of basic reaction rate @IHI Yokohama
  - Tests of gasification performance @IHI Yokohama

- **0.1T/D**
  - Tests of continuous operation @IHI Yokohama
  - Tests of overall process long operation performance @PTIGI Indonesia

- **6T/D**
  - More than 2267 hours Total operation time

- **50T/D**
  - 2100 hours as of Sept 2016
  - Scheduled for 4000 hours Total operation time in 2017

- **300～1000T/D**
  - TIGAR × 4 units (1 reserve)
  - Coal feed: 3000 T/D
  - (Substantially NH₃: 1000 T/D)

At Present

More than 2267 hours Total operation time

2100 hours as of Sept 2016

Scheduled for 4000 hours Total operation time in 2017

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Purpose of 50T/D Prototype TIGAR®

- Check the maintenance durability in long operation (Total 4,000 hr operation) using Indonesia lignite.
- Confirmation of TIGAR performance and reliability, and reflect in commercial plant engineering.
- Demonstration of TIGAR gasification technology for future clients.

50T/D Plant specification

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

Waste Water Treatment area
Gasifier(TIGAR®)
Control Building
Utility area
Machinery House
LPG Storage area
Syngas Purification area
Coal Yard
Material Handling area
Waste Water area

Gas Purification area

Control Center

Coal yard

Gasifier structure and Coal crusher area
50T/D Prototype TIGAR®, 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)
50T/D Prototype TIGAR®, Indonesia

- **Process flow**

  ![Diagram of process flow](image)

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

- **Key Processes**
  - Remove tar
  - O2 supply
  - De sulfurization
  - De carbon dioxide
  - Remove dust
  - Gas cooling

- **Additional Notes**
  - **Tar Cracker**
  - **Amine Supply**
  - **Steam for gasification**
  - **Air for combustion**

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Operation results

- Total about 2,100hr operation (as of September 2016)
- Without drying, roughly crushed lignite were accepted
- With Indonesian operators, we succeeded to ensure the stable operation
- Optimization of operation are still needed

East Kalimantan Coal

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
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<tbody>
<tr>
<td>TM (ar)</td>
<td>42%</td>
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<tr>
<td>Ash (adb)</td>
<td>8%</td>
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<tr>
<td>VM (adb)</td>
<td>38%</td>
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<tr>
<td>FC (adb)</td>
<td>37%</td>
</tr>
<tr>
<td>Total Sulphur (adb)</td>
<td>0%</td>
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<tr>
<td>Gross Calorific Value (ar)</td>
<td>3380 kcal/kg</td>
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Japanese and Indonesia operators in the control room during first operation

East Kalimantan Coal

To crush and sieve at <10mm
50T/D Prototype TIGAR®, Indonesia

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<td></td>
<td>EPC</td>
<td>DEMO OPERATION</td>
<td>DEMO OPERATION</td>
<td>Demolish</td>
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**Stable** Operation temperature and syngas flow rate/normalized coal supply (accumulated)

**Stable** Syngas composition after Tar Cracker outlet

Almost no CH4 Shows Effective tar cracker!

*Seal N2 for Coal feeding line are detected.
Marketability of lignite gasification - Indonesian Fertilizer Industry

NH₃ manufacturing capacity of Pupuk Indonesia holdings (PIHC) Group

- Iskandar Muda: 1100 t/d, 1200 t/d
- Kaltim: 1800 t/d, 1800 t/d, 1000 t/d, 1000 t/d
- Pusri: 1350 t/d, 790 t/d, 1200 t/d, 1200 t/d
- Kujang: 1160 t/d, 1000 t/d
- Petrokimia Gresik: 1350 t/d

~16000T/D NH₃ production in Total!
## Indonesia Lignite Gasification Project: Ammonia

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<tbody>
<tr>
<td>Demonstration of Prototype plant</td>
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<tr>
<td>FEED</td>
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<tr>
<td>Order/Plant construction</td>
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- **Currently**
- Target site: Fertilizer plant
- Capacity: Syngas supply by TIGAR for 1000~2500 T/D Ammonia production
- Feedstock: Lignite

### Diagram

- **Natural Gas**
- **Reformer**
- **Ammonia Process**
- **Urea Process**
- **Lignite (ATPK, etc)**
- **Gasifier TIGAR**
- **H₂**
- **Change!**

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IHI has obtained Japanese Government’s Grants for Low Rank Coal Utilization from Japan Coal Energy Center - JCOAL.

In 2015, IHI has come to an agreement with Polish organizations (PGE and IchPw) to do the feasibility study on methanol production from Polish coal by using TIGAR.
Lignite Gasification Project: Hydrogen

- Hydrogen based society using TIGAR technology
  Hydrogen society will be coming soon in the near future.

We would like to contribute with our technology towards the hydrogen based society for the future.

- raw materials of fertilizer
- carrier of hydrogen
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.

Commercialized TIGAR is currently at feasibility study step for Ammonia, Methanol and also Hydrogen production both in overseas and in Japan.

We would like to contribute for effective use of resources by TIGAR technology for various applications.

This presentation is based on results obtained from TIGAR® Prototype plant project subsidized by Ministry of Economy, Trade and Industry (METI) and New Energy and Industrial Technology Development Organization (NEDO).

Poland Project is supported by Japan Coal Energy Center (JCOAL)
“Thank you for your kind attention”

IHI
Realize your dreams