High Efficiency Low Emissions Coal Thermal Power Generation Technology (The Osaki CoolGen Project of Oxygen-blown IGCC Demonstration)

Jan. 16, 2017
Osaki CoolGen Corporation

Company Profile

Company name: OSAKI COOLGEN CORPORATION

Founded: July 29, 2009

Location: Hiroshima Prefecture, Japan

Investing enterprises: Chugoku Electric Power Co., Inc. (Energia) Electric Power Development Co., Ltd (J-POWER)

Line of business: Construction of large-scale demonstration plant for oxygen-blown IGCC technology and carbon dioxide capture technology and conducting of tests using such plant
Osaki Kamijima

Area: About 43 km²

Outline

1. Significance of IGCC Development
2. Features of the IGCC Technology and System
3. Overview of the Osaki Coolgen (OCG) Project
4. State of Construction work progress and Manufacturing work progress
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1. Significance of IGCC Development
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Coal-fired Power Generation  
- The Status in Japan -

- Energy self-sufficiency in Japan = about 5%
- Coal-fired generation ⇒ Essential for the best mix of energy
  ( Positioned as the Base Load Power Generation in the Basic Energy Plan due to Supply Stability, Economic Efficiency, Safety )

Replacement Demand of Coal-fired generation in Japan ⇒ 37 GW (for the 35 years after 2020)
Coal-fired Power Generation
- Percentage of each generation resource in 2013 -

<table>
<thead>
<tr>
<th>Country</th>
<th>Coal</th>
<th>Oil</th>
<th>LNG</th>
<th>Nuclear</th>
<th>Hydro</th>
<th>Renewable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>32%</td>
<td>14%</td>
<td>39%</td>
<td>1%</td>
<td>8%</td>
<td>6%</td>
</tr>
<tr>
<td>Russia</td>
<td>15%</td>
<td>1%</td>
<td>50%</td>
<td>16%</td>
<td>17%</td>
<td>0%</td>
</tr>
<tr>
<td>Europe</td>
<td>26%</td>
<td>2%</td>
<td>17%</td>
<td>25%</td>
<td>16%</td>
<td>15%</td>
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<tr>
<td>World</td>
<td>41%</td>
<td>4%</td>
<td>22%</td>
<td>11%</td>
<td>16%</td>
<td>6%</td>
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<tr>
<td>Germany</td>
<td>47%</td>
<td>1%</td>
<td>11%</td>
<td>16%</td>
<td>4%</td>
<td>22%</td>
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<tr>
<td>U.S.</td>
<td>40%</td>
<td>1%</td>
<td>27%</td>
<td>19%</td>
<td>6%</td>
<td>7%</td>
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<tr>
<td>Denmark</td>
<td>41%</td>
<td>1%</td>
<td>10%</td>
<td>0%</td>
<td>48%</td>
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<tr>
<td>India</td>
<td>73%</td>
<td>2%</td>
<td>5%</td>
<td>3%</td>
<td>12%</td>
<td>5%</td>
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<tr>
<td>China</td>
<td>75%</td>
<td>2%</td>
<td>8%</td>
<td>17%</td>
<td>4%</td>
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</tr>
</tbody>
</table>

Source: Energy balances of OECD countries 2015(IEA)/ Energy balances of non-OECD countries 2015(IEA)

➢ 41% of world generation resource is the Coal

Coal-fired Power Generation
- Current Global Status and Future Prospects -

➢ Coal-fired power generation in the world = 30% or more
⇒ Key role in Global Power Demand for Sustainable Development

➢ CO2 emission from Coal-fired power generation = about 30%
⇒ Key issue of reducing CO2 emissions for Sustainable Development
Significance of Osaki Coolgen project

Global Sustainable Development
We must:
- Use low cost coal efficiently for increased Power Demand
- Drastically reduce CO₂ emissions against Global Warming

In Resources Importing Countries (as Japan)
- Coal is indispensable to achieve stable power supply

Development of Efficient Clean Coal Technology

Osaki Coolgen Project: A Top-Class IGCC solution

(Step-1) **IGCC**: Integrated coal Gasification Combined Cycle
- High-Efficiency & Environmental Performance & Reliability

(Step-2) (Step-3)
**IGCC + CO₂ Capture → IGFC + CO₂ Capture**

R&D for Future of Coal-fired Power Generation

Fuel Cell (FC)
- (MCFC)
- (SOFC)

Integrated coal gasification combined cycle (IGCC)

HRSG

Gasifier Gas turbine Steam turbine

Pulverized coal fired (PCF)

boiler Steam turbine

Super critical (SC)

38%

Ultra SC (USC)

39 - 41% (base)

Advanced USC (A-USC)

46 - 48%

Efficiency :Net / High heat value

Integrated coal gasification fuel cell combined cycle (IGFC)

55% (~)

(CO₂ reduction about ▲ 30%)

1300°C IGCC

1500°C IGCC

1700°C IGCC

46 - 48% (~)

(CO₂ reduction about ▲ 15%)
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Development history of the "EAGLE" gasifier

Coal Energy Application for Gas, Liquid, and Electricity

OCG demonstration Plant
(1,180t/d / 2015 ~ / Osaki)

EAGLE Pilot Plant
(150t/d / 2002 ~ 2013 / Wakamatsu)

HYCOL Pilot Plant
(50t/d / 1990 ~ 1993 / Sodegaura)

Process Development Unit
(1t/d / 1981 ~ 1985 / Katsuta)

Scale Up
Coal Gasification Image

Inside of gasifier

Volatile matter + carbon → Ash → Heat → Char

Gasification

CO (carbon monoxide) + H₂ (hydrogen) + CH₄ (methane) + O₂ (oxygen) → Slag + Ash

The "EAGLE" gasifier mechanism

Upper stage: Lean Oxygen
Coal → Char
Char + CO₂ + H₂O → CO + H₂

Lower stage: Rich Oxygen
Coal + O₂ → CO₂ + H₂O

High-efficiency gasification + Stable slag discharge
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Schedule of the Osaki Coolgen Project

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<tbody>
<tr>
<td>Environmental Assessment</td>
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<td>NEDO research project</td>
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<tr>
<td>Step-1</td>
<td>Oxygen blown IGCC</td>
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<tr>
<td>Step-2</td>
<td>IGCC with CO2 Capture</td>
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<tr>
<td>Step-3</td>
<td>IGFC with CO2 Capture</td>
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**STEP1 System Flow**

- **Coal gasification unit**
- **Gas clean-up unit**
- **Sulfur recovery unit**
- **Air separation unit**
- **Waste water treatment**
- **Combined cycle unit**
- **Flare unit**

Diagram showing the flow of gases and processes involved in the coal gasification and sulfur recovery unit.
### STEP1 Major Specifications

<table>
<thead>
<tr>
<th>Main Units and Utilized Existing Equipment</th>
<th>Spec</th>
</tr>
</thead>
</table>
| **Coal Gasification Unit** *(New Construction)* | Oxygen-Blown Single-chamber  
Two-staged Spiral-flow Entrained Bed  
Coal feed : 1,180 t/day |
| **Gas Clean up Unit** *(New Construction)* | Wet Desulfurization Unit : Methyl-diethanol Amine (MDEA)  
Sulfur Recovery Unit : Limestone Wet Scrubbing |
| **Air Separation Unit** *(New Construction)* | Pressurized Cryogenic Separation Type |
| **Combined Cycle Unit** *(New Construction)* | GT (MHPS : H100 1300°C class, adopted Multi-Cluster burner)  
Total Plant output : 166MW (gross) |
| **Wastewater Treatment Unit** *(New Construction)* | Gas Clean up Unit, Wastewater Treatment |

Utilized Existing Equipment:  
Wastewater Treatment, Stack, Coal Stock and Conveying system, etc.

### STEP1 Targets

<table>
<thead>
<tr>
<th>Item</th>
<th>Targets</th>
</tr>
</thead>
</table>
| **Efficiency** | Net Efficiency : 40.5% (HHV), 42.7%(LHV)  
Gross Efficiency : 48.0%(HHV), 50.6%(LHV)  
The Highest Efficiency in 170MW class in the world. Equivalent to Net efficiency 46%(HHV), 49%(LHV), Gross efficiency 53%(HHV),56%(LHV) when applied to 1,500°C class GT(already developed) in a commercial plant(higher output) |
| **Emission Level** | SOx : 8ppm, NOx : 5ppm, Particulate : 3mg/m³N (as 16%O₂ equivalent)  
Top class Environmental Performance in the world. |
| **Coal Variety Compatibility** | Confirmation of coal range for gasification.  
To expand to high ash fusion temp. coal from low ash fusion temp. coal. |
| **Plant Reliability** | To obtain the prospect that plant availability will be more than 70%/year by 5000hr long term durability test. |
| **Plant Controllability & Operability** | Load change rate : 1-3%/min.  
To obtain controllability equivalent to commercial operations. |
| **Economy** | To obtain the prospect that the generating cost in the commercial stage will be the same or less than PCF. |
Plan for STEP2 / CO₂ Capture

To demonstrate IGCC with CO₂ capture to achieve stable generation and high thermal efficiency

<table>
<thead>
<tr>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂ Capture rate</td>
</tr>
<tr>
<td>CO₂ removal rate for CO₂ capture unit</td>
</tr>
<tr>
<td>Purity of captured CO₂</td>
</tr>
</tbody>
</table>

**STEP2 Targets**

<table>
<thead>
<tr>
<th>Item</th>
<th>Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic Performance</strong></td>
<td><strong>CO₂ Capture rate : 90%</strong></td>
</tr>
<tr>
<td></td>
<td><strong>CO₂ Purity : 99%</strong></td>
</tr>
<tr>
<td><strong>Plant Efficiency</strong></td>
<td>Optimization of operating conditions</td>
</tr>
<tr>
<td></td>
<td>- Steam/CO ratio</td>
</tr>
<tr>
<td></td>
<td>- Auxiliary power</td>
</tr>
<tr>
<td></td>
<td>⚪ Targeted to achieve 40%(net, HHV) efficiency while 90% of CO₂ is captured in newly-installed IGCC (with 1500°C class GT)</td>
</tr>
<tr>
<td><strong>Operability &amp; Reliability</strong></td>
<td>Establishing O&amp;M procedures for IGCC system combined with CO₂ Capture</td>
</tr>
</tbody>
</table>
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## First step: IGCC Construction Progress

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major Events</td>
<td>Mar</td>
<td>May Nov</td>
<td>Dec Jan</td>
<td>Jul</td>
<td>Nov</td>
<td>Apr</td>
<td>Jul Aug</td>
</tr>
<tr>
<td>▼ Start of Civil work</td>
<td>▼ Start of HRSG on site</td>
<td>▼ Start of SGC on site</td>
<td>▼ Start of Gasifier on site</td>
<td>▼ Power reception for commissioning</td>
<td>▼ Pressurization test of piping</td>
<td>▼ Gas turbine start-up</td>
<td>▼ Gasifier start-up by coal</td>
</tr>
</tbody>
</table>

- Design, Manufacturing, Construction, Operation
First step: Mechanical completion

Gasification Unit

Gasifier
To jackup Gasifier
Coal banker
HRSG duct
Coal feeding hoppers
Coal Gasification Facilities

Gasifier and Syngas Cooler were manufactured in MHPS works, and were shipped to the site. (SGC: Nov. 2014, Gasifier: Dec. 2014)

Gasifier
Gasifier to produce combustible gas from coal by thermal decomposition
- Length 39.7m × Ø4.6m
- Weight 440t
- Total height of gasification unit Approx. 75m

SGC
Steam generator by heat recovery from syngas
- Length 41.0m × Ø4.3m
- Weight 625t

Gas Clean Up unit, Sulfur Recovery Unit
Combined cycle unit

Heat Recovery
Steam Generator

Turbine building

Gas turbine

Steam turbine

Generator

Air separation unit

Air compressor building

Column cold box

Liquid N2

Heat exchanger

Absorber
Waste water treatment unit / CO₂ capture area

Commissioning
- Gas turbine start-up
- Gasifier start-up by coal
Commissioning  ■ Start of generation by coal

Thank you

http://www.osaki-coolgen.jp/english