Results and estimations of the 5,000 Hour Durability Test at the Nakoso Air Blown IGCC plant (including other activities)

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Schematic Diagram of IGCC

Coal → Gasifier → Porous Filter → Gas Turbine → Combustor → Wet Gas Clean-Up → Gypsum recovery

ASU → Air → Gasifier → Boost-up Compressor → Char → Slag

O2 → N2

(For coal and char transport N2)
Main Feature of Air-blown IGCC

• Net thermal efficiency is higher than other IGCC designs.

• Carbon conversion rate is more than 99.9%.

• Gasifier design requires no refractory maintenance.

• Operation is to be stable.
## Specification of IGCC Demonstration Plant

<table>
<thead>
<tr>
<th>Capacity</th>
<th>250 MW gross</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Coal Consumption</strong></td>
<td>approx. 1,700 metric t/day</td>
</tr>
<tr>
<td><strong>System</strong></td>
<td></td>
</tr>
<tr>
<td>Gasifier</td>
<td>Air-blown &amp; Dry Feed</td>
</tr>
<tr>
<td>Gas Treatment</td>
<td>Wet (MDEA) + Gypsum Recovery</td>
</tr>
<tr>
<td>Gas Turbine</td>
<td>2,200 °F-class (50Hz)</td>
</tr>
<tr>
<td><strong>Efficiency (Target Values)</strong></td>
<td></td>
</tr>
<tr>
<td>Gross</td>
<td>48% (LHV) 46% (HHV)</td>
</tr>
<tr>
<td>Net</td>
<td>42.5% (LHV) 40.5% (HHV)</td>
</tr>
<tr>
<td><strong>Flue Gas Properties (Target Values)</strong></td>
<td></td>
</tr>
<tr>
<td>SOx</td>
<td>8 ppm</td>
</tr>
<tr>
<td>NOx</td>
<td>5 ppm</td>
</tr>
<tr>
<td>Particulate</td>
<td>4 mg/m³N</td>
</tr>
<tr>
<td>(16%O₂ basis)</td>
<td></td>
</tr>
<tr>
<td>Target</td>
<td>Past years</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>------------</td>
</tr>
<tr>
<td>Safe and Stable Operation</td>
<td>250MW</td>
</tr>
<tr>
<td>Long Term Continuous Operation</td>
<td>&gt;2000hr</td>
</tr>
<tr>
<td>Net Thermal Efficiency</td>
<td>&gt;42.5% (LHV basis)</td>
</tr>
<tr>
<td>Carbon Conversion Rate</td>
<td>&gt;99.9%</td>
</tr>
<tr>
<td>Environmental Performance</td>
<td>SOx &lt;8ppm</td>
</tr>
<tr>
<td></td>
<td>NOx &lt;5ppm</td>
</tr>
<tr>
<td></td>
<td>Dust &lt;4mg/m3N</td>
</tr>
<tr>
<td>Coals</td>
<td>Bituminous</td>
</tr>
<tr>
<td></td>
<td>Sub-bituminous</td>
</tr>
<tr>
<td>Start-up Time</td>
<td>&lt;18hr</td>
</tr>
<tr>
<td>Minimum Load</td>
<td>50%</td>
</tr>
<tr>
<td>Load Change Rate</td>
<td>3%/min</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Durability &amp; Maintainability</td>
<td>Evaluate during 5000hr test</td>
</tr>
<tr>
<td>Economy estimation</td>
<td>Less than or equal to PCF power generation cost</td>
</tr>
</tbody>
</table>

(1) This presentation
(2) Report
(3) Future years
Main contents of this presentation

(1) Results of 5,000 hour durability test
   (including the following contents)
   • Flexibility in coal type test
   • Load Change rate test
(2) This year’s other activity
   • Additional flexibility in coal type test
   • Economy estimation
(3) Test plan in the next year and after
• Target was accomplished (5,013hr operation) within one year.

• Flexibility in coal type test and load change rate test were also conducted during the test period.

• Forced outages were experienced in several times due to mainly auxiliary facility incidents in the former period while almost continuous operation were achieved in the latter period.

• The causes of the auxiliary facilities incidents were identified and remedy measures were established.
### Flexibility in coal type test-1: Contents of coals

<table>
<thead>
<tr>
<th></th>
<th>#1 (Design coal)</th>
<th>#2 North American PRB coal</th>
<th>Indonesian Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chinese Shenhua Coal Jan, 2009</td>
<td>Feb, 2010</td>
<td></td>
</tr>
<tr>
<td>Indonesian Coal</td>
<td>#3 (A) Mar, 2009</td>
<td>#4 (B)* Sep, 2010</td>
<td></td>
</tr>
<tr>
<td>Gross Calorific Value (air dry)</td>
<td>27,120</td>
<td>26,670</td>
<td>26,370</td>
</tr>
<tr>
<td>Total Moisture (as received)</td>
<td>15.4</td>
<td>25.3</td>
<td>21.7</td>
</tr>
<tr>
<td>Total Sulphur (air dry)</td>
<td>0.25</td>
<td>0.39</td>
<td>0.25</td>
</tr>
<tr>
<td>Proximate Analysis (air dry)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inherent Moisture</td>
<td>7.5</td>
<td>8.0</td>
<td>7.9</td>
</tr>
<tr>
<td>Fixed Carbon</td>
<td>51.3</td>
<td>47.4</td>
<td>45.2</td>
</tr>
<tr>
<td>Volatile Matter</td>
<td>32.3</td>
<td>39.1</td>
<td>42.5</td>
</tr>
<tr>
<td>Ash</td>
<td>8.9</td>
<td>5.5</td>
<td>4.4</td>
</tr>
<tr>
<td>Fusibility of Coal Ash</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow Temperature</td>
<td>1225</td>
<td>1420</td>
<td>1260</td>
</tr>
</tbody>
</table>

(*)Conducted after the durability test
Stable power generation using various coals was confirmed.

### Flexibility in coal type test-2: Generation output

1. **#1 Chinese Shenhua coal**
   - Gross output MW: 250MW
   - Syngas MJ/m³(NLHV): 4.0

2. **#2 North American PRB coal**
   - Gross output max: 200MW
   - Syngas MJ/m³(NLHV): 4.0

3. **#3 Indonesian coal (A)**
   - Gross output max: 479MW
   - Syngas MJ/m³(NLHV): 4.0

4. **#4 Indonesian coal (B)**
   - Gross output 150MW
   - Syngas MJ/m³(NLHV): 4.0

(Conducted after the durability test)
Load change rate test

- Load Change rate 2.4%/min was confirmed.
- Some adjustment would be required for achieving the target value (3.0%/min).
Auxiliary facility incident-1

Leakage from Gland of Rotary Valve below Porous Filter

**Cause**
Inadequate tightening of a packing caused the gas leakage from the gland.

**Countermeasure**
Proper control of tightening the packing at the gland
Auxiliary facility incident-2

Forced Outage of Slag discharge Conveyor

**Cause**

Scraper of the drag chain conveyor meandered and stuck onto the gutter of the bottom plate causing overload to the conveyor motor.

**Countermeasure**

Improvement in the conveyor structure
Auxiliary facility incident-3

Pulverized coal leakage from bag filter

*Cause*

A bag filter was damaged to leakage by the unexpected passage of the pulverized coal through the baffle palate.

*Countermeasure*

The baffle plate was reinforced to withstand the pulverized coal pressure.
Auxiliary facility incident-4

Leakage of Extraction air Cooler

**Cause**
Cooler tubes for extraction air were damaged.
Leakage occurred due to the stress corrosion cracking.

**Countermeasure**
The tube material was changed to titanium.
Auxiliary facility incident-5

Leakage of Char Gasifier Burner Cooling Tube

**Cause**

The char accompanied by the secondary air eroded the burner cooling water tube.

**Countermeasure**

The disposition of the burner was adjusted.

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Diagram:

- **Char burner**
- **R- Pulverized Coal burner**
- **C- Pulverized Coal burner**
- Combustor
- Reductor

(1) Results of 5,000 hour durability test -10
• Inspection work in June and this fall after the test has been conducted to check the deterioration in the main facility components or functional disorder. No major defects have been observed for the moment.

• Overall estimation on the effects to the facilities by the durability test would be summarized and reflected in the reliability as well as economy estimation.
(2) This year’s other activity -1

• Indonesian (B) sub-bituminous coal was tried and the maximum stable load was confirmed in 150MW output.

• Stable operation in 90% ASU output was confirmed. Additional lowering ASU output is under investigation to reduce the house power.

• Trip happened due to the trouble of the motor for the amine circulation pump.
Economy estimation

- Construction cost is to be almost 20% higher than conventional PCF at commercial stage.

- Fuel cost could be almost 20% lower than PCF at commercial stage because of higher efficiency.

- Maintenance cost is to be estimated while conducting maintenance work in the plant.

- Next year, we will conduct maintenance outage by law, which would bring about the information for the estimation.

- Cost-reduction in facility is under study such as reducing the components, reflecting the various test results.
(3) Test Plan in the next year and after

• Improvement in operation
  – Additional flexibility test: other types of sub-bituminous coal
  – Minimum load test, load change rate test to realize better operation performance

• Estimation on reliability and economy
  – Validate the effectiveness of the past countermeasure to the facilities
  – Economy of commercial IGCC in future reflecting the more realistic maintenance cost

• FS with CCS attachment
  – Japanese government is performing feasibility study of CCS project, utilizing the Nakoso IGCC. CCP is and will be cooperated with this activity.
Concluding remark

• CCP is conducting the test in step-by-step approach.

• The result and estimation is almost within our expectation.

• Still, more work should be required.

• In the end, CCP would like to enhance the reliability and maintainability of the air-blown IGCC and finalize the competitive price, complying with the user’s expectation.
Thank you!
(As of September 30, 2010)

<table>
<thead>
<tr>
<th>Operating Time</th>
<th>GT Operation by Syngas</th>
<th>9,676 hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasifier Operation</td>
<td></td>
<td>9,786 hrs</td>
</tr>
<tr>
<td>Power Generation</td>
<td>Cumulative gross output</td>
<td>1,992 GWh</td>
</tr>
<tr>
<td>Fuel Consumption</td>
<td>Cumulative coal consumption</td>
<td>667 kton (metric)</td>
</tr>
</tbody>
</table>
30% subsidy

30% subsidy

METI: Ministry of Economy, Trade and Industry

Joint project agreement

70% contribution

Personnel

EPC Contract

Operator, etc.

Mitsubishi Heavy Industries, Ltd.

Hokkaido EPCo.
Tohoku EPCo.
Tokyo EPCo.
Chubu EPCo.
Hokuriku EPCo.
Kansai EPCo.
Chugoku EPCo.
Shikoku EPCo.
Kyushu EPCo.
J-POWER CRIEPI

Joban Joint Power Co., Ltd.

Mitsubishi Heavy Industries, Ltd.

METI