COP - Operational Results of Callide-A Oxyfuel Power Plant

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5th Meeting of the IEAGHG International Oxyfuel Combustion Research Network

29th October, 2015
Presentation outline

- Overview of Callide Oxyfuel Project
- Operation record and milestone
- Operation experience of oxyfuel boiler
- Summary of oxyfuel experiences
- Concluding comment
Callide Oxyfuel Process

<table>
<thead>
<tr>
<th>Items</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Generation output</td>
<td>30MWe</td>
</tr>
<tr>
<td>Coal</td>
<td>Mainly Callide coal (High ash, high moist and low S)</td>
</tr>
<tr>
<td>Furnace</td>
<td>Front firing (approx. W 6.1m x D 6.7m x H 17.0m)</td>
</tr>
<tr>
<td>Combustion equipment</td>
<td>3 mills and 6 burners</td>
</tr>
<tr>
<td>Supply O2 purity</td>
<td>&gt; 98%</td>
</tr>
<tr>
<td>Target CO2 at stack inlet</td>
<td>55wet% in oxy mode</td>
</tr>
</tbody>
</table>

**Diagram:**
- **Coal bin**
- **Mill**
- **Boiler**
- **H₂O remover**
- **GRF**
- **CPU**
- **Stack**
- **ASU**
- **O₂**
- **O₂**
- **N₂**
- **Heat recovery by feed water**
- **FGLPH**

**Callide Oxyfuel Project**
Callide Oxyfuel Project -footprint-

- **Project start**
- **Refurbishment and Retrofit**
- **Commissioning**
  - Air firing
  - ASU
  - CPU
  - Oxyfiring
- **Oxyfuel Demonstration**
- **Project Conclusion**

- 2008-2009: Boiler before retrofit
- 2010-2011: Boiler after retrofit
- 2012-2015: ASU
- 2016: CPU

Now
Retrofit to oxyfuel process

Original process

Coal bin — Mill — Boiler — AH — Stack

Oxyfuel process after retrofit

Coal bin — Mill — Boiler — H₂O remover — Heat recovery by feed water — FGLPH — Stack

Consideration items for retrofit

- To Install of ASU & CPU
- To avoid the low temperature corrosion around mill
- To keep the gas temperature at FF inlet
- To replace of fans
- To improve and confirm combustion
- Not to modify the high pressure parts (boiler itself)
Operation record & milestone on oxyfuel power plant

Boiler operation : 15,300 hrs
Generation : 14,800 hrs
Oxyfuel operation : 10,200 hrs
CO₂ capture plant operation : 5,600 hrs

First fire after retrofit : March 2011
First O₂ supply to boiler : March 2012
Oxyfuel boiler operational : June 2012
CO₂ capture plant operational : December 2012
Demonstration completed : March 2015
Operation experiences on oxyfuel boiler

- **Operation flexibility**
  - Various coal burning: Callide coal and Blend coal (FR: 1.8 – 2.8)
  - Load change: Max. 3%/min (0.9MW/min) achieved
  - Minimum load: 15MW (50%L) achieved
  - Optimization of mode transition: Achieved less than 1 hour
  - Rapid load decreasing: 24 to 18MW

- **Confirmation of characteristics**
  - Boiler inlet-O$_2$: 22 – 30 %wet
  - Direct-O$_2$: Increasing NOx & radiation transfer, decreasing UBC
  - Bypass operation of H$_2$O remover: +10% moisture in flue gas
  - Simulated staged combustion: Decreasing NOx
  - Exposure of materials for high and low temperature corrosion
  - In-furnace measurement: Upgrade of simulation tool

- **Reliability**
  - Operation hrs: over 10,000 hrs
  - Inspection of each equipment: Minor failure of instruments etc.
  - No significant issue for oxyfuel condition
Flame of air and oxy condition

**Flame of air:** 25MW

**Flame of oxy:** 25MW

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Flame of air and oxy condition

Flame of air: 25MW

Flame of oxy: 25MW
Combustion characteristics

- Achievement of 30MW operation at both air and oxy condition.
- CO$_2$ conc. is over 70% at 30MW and is more than targeted value.
- NO in Oxy is decomposed, due to the recirculation. NO emissions is decreased to less than half.
- There is no significant difference on SO$_2$ emissions.
- SO$_3$ in Oxy is much higher at boiler outlet, however SO$_3$ after fabric filter is very low level.
- Most of Hg is captured in ash at fabric filter.
- Carbon-in-ash in Oxy is lower, due to longer residence time.
CEMS NO & SO₂ (stack inlet)

Corrective value:

\[ \text{SO}_2\text{corr} = \text{NO} \times \frac{12}{\text{CO}_2} \]

Corrective value:

\[ \text{NOcorr} = \text{NO} \times \frac{12}{\text{CO}_2} \]
Operation range

Aim
- Secure the operation flexibility
- Mode transition as low load as possible

Turn-down test
Load was gradually decreased the load from 24MWe, monitoring the operation condition and flame, and controlling boiler inlet-O₂ as needed.

Results
- Achieved 15MW(50%L) operation with 2 mills and 24% and 23% boiler inlet-O₂.
- Achieved 21MW mode transition
Direct-O₂ testing

Aim
- Improvement of combustion

Test
- Each burner have 2(two) O₂ lances.
- Pure O₂ is directly injected into flame.

Condition
Generation : 24 to 29 MWe
Inlet-O₂ : 27%wet constant
Capacity of direct-O₂ : - 10% of total O₂ supply

Results
By injecting O₂,
- Increasing NO, but decreasing carbon-in-ash
- Brighter flame, and increasing radiation heat transfer.
Direct-O$_2$ testing

**NO**

![NO concentration graph](image)

**Carbon-in-ash**

![Carbon-in-ash graph](image)

**Flame**

- No direct-O$_2$
- 4% direct-O$_2$
- 11% direct-O$_2$
Exposure test of materials for high temperature corrosion

Aim

- Confirmation of impact on corrosion under oxyfuel atmosphere.
- Mainly confirmation of the possibility for carbonization

Test

- Exposure for 6 materials: HR6W, CC2115, CC2328, SA213TP347HFG, Alloy 263/617
- Located at inlet of Secondary SH ( - 1030 degree C)
- Material temperature controlled
- 3 different exposure time in oxy condition (Target : 2000, 4000, 6000 hours)
Exposure test of materials for high temperature corrosion

Exposure results

- 2000, 3900 and 6600 hours exposure in oxy condition within 2600, 4900 and 8800 hours exposure in total
- 58 – 65 % CO₂, 600 – 1200 ppm SO₂, 20 – 24 % H₂O in oxy condition

Analysis

- Cross-sectional observation (macro, micro), EPMA(for distribution of Fe, S and so on), Hardness, thickness

Current situation

- Just completed all of the analysis for all materials
- Under evaluation
Summary of operation experiences

- Completed all of scheduled test items
- Obtained the invaluable operation data and know-how.
- Achieved the stable oxyfuel operation and targeted CO$_2$ concentration to CPU.
- Obtained the behavior of NO, NO$_2$, SO$_2$, SO$_3$, Hg etc. in the boiler process
- Achieved almost same operation flexibility with air such as turn-down, load change and so on. However, further consideration or development such as run-back, full integration of ASU, oxyfuel boiler and CPU etc. would be necessary.
Concluding comments

- World first and largest Oxyfuel Power Plant for CO₂ capture.
- Possible to convert to oxyfuel power plant, even no capture-ready power plant, in case of retrofit.
- We are now ready for scale-up of oxyfuel power plant.
- We need to continue to make an effort to commercialize the large-scale oxyfuel power plant from the outcome in Callide Oxyfuel Project.
- We would like to say sincerely thanks to the members of our Project, Australia and Japan Governments and many supporters.
Thank you!

for more information:  www.callideoxyfuel.com