The Oxy-combustion Burner Development for the Lacq CO₂ Pilot

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Lacq CO\textsubscript{2} Pilot
Pilot location - Total Exploration & Production France

- Washington
- Lacq

- Gas field
- Oil field
- NG Storage
CCS Lacq pilot plant – Major challenges

- Industrial scale 30MWth oxycombustion unit with gas
- Revamping of a conventional boiler
- CO$_2$ transport and injection for 2 years
- 120 kt CO$_2$ storage in a depleted reservoir
- First CO$_2$ injection for storage in France
- Public acceptance with consultation and dialogue
- French and international legal framework not frozen
Boiler revamping

- Existing boiler revamping with CO₂ recycling.
- 40 t/h steam 60b/450°C (30MWₜₜ) to HP network.
- Alstom in charge of boiler revamping works.

Cryogenic Air Separation Unit

- Standard ASU packaged plant
- 240 tpd O₂
- LP: 1.8 bar abs
- Variable purity (95-99.5% O₂)
- No oxygen storage
Construction

ASU

ASU

Flue Gas Recycle

Boiler

Boiler

Oxy-burner quarls
Oxy-burner development
Challenges for oxy-burner concept:
- In-furnace heat flux management
- Minimize flue gas recycle (FGR)
- High viscosity / high density liquid fuels
- High sulfur and high metals content
- Use of usual materials

Air Liquide’s oxyburner concept achieves:
- Fuel flexibility for gas & liquid fuels
- Variable flue gas recycle rate
- Air mode for transient operation
- Important turndown ratio
- Oxy-flame stability with uneasy fuels
- Optimum operating procedures (air-oxy mode)
Air Liquide Oxy-burner Principle

No external oxygen mixing:
- Intrinsic oxygen flames advantages: flame stability, turndown ratio, uneasy fuels.
- Improved operating safety: dedicated pure oxygen circuit all along distribution system.
- Additional flexibility to adjust FGR rate.

Synthetic air approach

Air Liquide oxy-burner
Oxy-burner Development path

- **Upscaling know-how**
- **CFD modeling using proprietary code**
  - Specific to oxy-combustion
  - Fine tuned with oxy-combustion experimental data

**Size**

- 8 MW
- 1 MW

**1 MW prototype AL-R&D center rig**

**8 MW oxy-burner design for Lacq boiler**

**4 x 8 MW burners being set up in Lacq boiler**

- 2006
- 2006-2007
- 2008
1 MWth Oxy-combustion Test Rig

- Versatile and functional test rig
  - Variable FGR rate and temperature
  - Liquid / gas fuel feed capability
  - Cold wall configuration
  - Combustion monitoring
  - Emission control
Experimental Results at 1 MWth Test Rig

- High CO₂ concentration achieved:
  - 94% vol dry systematically.
  - Importance of pressure control along FGR circuit to avoid air in-leakages.
  - Slightly positive pressure in chamber.

- Views of 1 MW oxy-burner prototype with natural gas:

\[ \text{FGR rate} = \frac{x}{y} \]
Experimental Results at 1 MWth Test Rig

- Controlled heat flux with reduced FGR
- Adjustable flame length
- Air mode for transient operation
- Large turndown ratio (10%)
- Oxyflame stability with uneasy fuels
- Rehearsal of burner operating mode

Heat transfer to walls:

<table>
<thead>
<tr>
<th>FGR rate</th>
<th>Max heat transfer/avg</th>
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<tbody>
<tr>
<td>0.94</td>
<td>1.50</td>
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<tr>
<td>1.5</td>
<td>1.45</td>
</tr>
<tr>
<td>2.18</td>
<td>1.40</td>
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<tr>
<td>2.44</td>
<td>1.35</td>
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Gas temperature at walls:

<table>
<thead>
<tr>
<th>FGR rate</th>
<th>Max Temp/Outlet Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.94</td>
<td>1.28</td>
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<tr>
<td>1.5</td>
<td>1.26</td>
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<td>2.18</td>
<td>1.24</td>
</tr>
<tr>
<td>2.44</td>
<td>1.22</td>
</tr>
</tbody>
</table>

FGR rate = x / y
Oxy-burner Implementation into Lacq Boiler

- Retrofitting of an air-fired boiler
  - Oil & Gas boiler configuration
  - Fixed geometry:
    - 4 horizontal burners
    - Chamber: L 5 m; W 4.5m; H 6-7m
- Careful sealing at every interface to minimize air in-leakage
- Fluid distribution control and measurement
- Operating mode
- Safe operation Safety analysis
- Tests and measurement plans

Openings for the 4 existing air-fired natural gas burners

Existing measurement port
Conclusions

- Total CO2 Lacq pilot will demonstrate integrated scheme (from capture to storage) feasibility at industrial scale
- Oxy-combustion is a proven technology that facilitates CO$_2$ capture.
- Air Liquide oxy-burner concept - with separate injection of oxygen and flue gas recycle - enables safe oxygen handling for oxy-combustion in boilers.
- Oxy-burner performances demonstrated in a 1MW boiler
  - fuel flexibility
  - Turndown
  - FGR rate flexibility
  - air to oxy transition
- Scale-up of the oxy-burner to 8 MW
- Start-up of the retrofitted oxy-boiler is scheduled early 2009.
Thank you!

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