Oxycombustion of Heavy Liquid Fuels

Tidjani Niass
Chief Technologist, Carbon Management Research Division
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Outline

1 Oxycombustion in Saudi Aramco Context
2 Synergies with Refineries
3 CO₂ Capture Performance
4 Roadmap
CCS is a critical element in the global quest to reduce CO₂ emissions

Source: IEA, 2015
Saudi Aramco has capabilities on whole CCUS value chain

- Separation
- Fluid Transport
- Conversion
- Sub-Surface
- CO₂ Capture
- CO₂ Transport
- CO₂ Utilization
- CO₂ Storage
**CO₂ Capture Routes**

**Post-Combustion**
CO₂ removal from flue gas after combustion has happened

- Fuel, Air → Power & Heat → CO₂ Separation → CO₂
- H₂O, N₂, O₂

**Pre-Combustion**
CO₂ removal from syngas before combustion happen

- Fuel, Air/O₂/Steam → Gasifier/Reformer → CO+H₂ → Shift, Gas cleanup
- CO₂ Separation → H₂/Syngas, Air → Power/Heat/H₂ → CO₂
- H₂O, N₂, O₂

**Oxy-Combustion**
Produce highly concentrated CO₂ flue gas

- Fuel, Air → Power & Heat → CO₂ → O₂
- Air Separation → N₂, Ar, He

**Pressure (Bar) CO₂ (%vol)**

<table>
<thead>
<tr>
<th>Pressure (Bar)</th>
<th>CO₂ (%vol)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3-15%</td>
</tr>
<tr>
<td>10-80</td>
<td>20-40%</td>
</tr>
<tr>
<td>1</td>
<td>75-95%</td>
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</table>
Why Oxycombustion for heavy residues?

- Quasi independent of fuel type
- Widely investigated
- New solvent and sorbent in existing processes

Post-combustion

- Promising technique
- Little work performed on liquid fuel
- Possible innovation:
  - Burner
  - Steam cycle

Oxy-combustion

- Gasification is widely investigated
- Available technology
- CO₂ capture quasi independent of fuel type

Pre-combustion

Oxy-combustion has the highest potential in efficiency and innovation
Challenges of Oil Heavy Residues (OHR) firing

Difficult to combust in classical Air systems

- High viscosity
- High Carbon Content (CCR 15%+)
- High Sulfur (5%+) & V (100 ppm+) Content

High Energy Penalty

- High temp. for atomization
- High steam to fuel atomization ratio
- Light cutter stock is used to handle difficult fuels

High temp. for storage and transport
Challenges of Oil Heavy Residues (OHR) firing

Difficult to combust in classical Air systems
• High viscosity
• High Carbon Content (CCR 15%+)
• High Sulfur (5%+) & V (100 ppm+) Content

Power and industry Sectors
• Primarily based on fossil fuels
• Double power capacity in next 2-3 decades

Oxycombustion allows direct firing of OHR
• Cutter Stock saving
• Improved fuel combustibility
• Lower NOx Emissions
• CO₂ concentrated Flue Gases
• Retrofit technology (for existing park)
Oxycombustion Activities

Fuel Handling
- CO₂ effect on HR viscosity
- HR transport

Design
- Air PP
- Oxy PP

CFD
- Burner
- Boiler

Process
- Air PP
- Oxy PP
- Economics

Testing
- CO₂ atomization
- Combustion
Oxy-combustion is a good fit to Refining

- Significant synergies for an oxy-combustion boiler in a refinery

Improved
- Fuel flexibility
- Refining margins

Increased Productivity
- FCC
- SRU

Optimized Process Configuration
- Fuel blanketing
- CCR purging
- Catalyst changeout
- Analytical gas

Improved
- Fuel handling
- Atomization
- Petrochem.
15 MWth Testing Campaign

Saudi Aramco Program tested in Alstom facility, Windsor, CT
First of a kind VR oxy-firing campaign

• 1100 bbl
15 MWth Testing Campaign

Saudi Aramco Program tested in Alstom facility, Windsor, CT
First of a kind VR oxy-firing campaign
• 1100 bbl

Competitive Advantages
• Improved Combustion (90% less CHL)
• 50% lower NOx Emissions
• Successful CO₂ atomization
• Matching Heat flux profiles
Gas Processing Unit

Produce required purity CO₂ stream
- Refrigeration based process
- Optional distillation column for high CO₂ purity (Food or EOR grades)
Energy performance
Heavy residue oxycombustion vs. postcombustion

Power Plant Net Efficiency Penalty

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<tr>
<th></th>
<th>Ref.</th>
<th>CAP(*)</th>
<th>MEA</th>
<th>Adv. MEA</th>
<th>Oxy</th>
<th>Opti Oxy</th>
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<tbody>
<tr>
<td>Penalty (%)</td>
<td>0</td>
<td>25</td>
<td>26</td>
<td>22</td>
<td>23</td>
<td>19</td>
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(*) Chilled Ammonia Process
Oxycombustion Roadmap

2012 - 2015

• Economic viability
• Successful combustion testing campaign
• Refining synergies
• High CO₂ capture rate
• High CO₂ purity
• No major roadblock

≥ 2015

• Building the case for large scale pilot
• Design, Build and Operate a large scale Oxycombustion pilot for difficult for burn liquid fuels

Passed Stage Gate
Summary

Oxycombustion has been developed mainly for coal and gas

Saudi Aramco Oxycombustion project close the fuel gap

- Oxycombustion offers good synergies with refineries
- 90% CO2 capture meeting CO2-EOR specifications was achieved
- Oxycombustion improve the combustibility of difficult to burn liquid fuels
- Saudi Aramco oxycombustion technology provides technical solution for oil fired power plants
Thank You