SE Dry-fed Coal Gasification Technology

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Agenda

• SINOPEC in Brief
• SINOPEC Technology Portfolio
• Sinopec SE Dry-fed Coal Gasification Technology
• Key Takeaways
One of the largest integrated energy & petrochemical company in the world

- Second largest crude oil & gas producer in China
- Largest oil refiner, with refining capacity ranking second in the world
- Largest producer and distributor of petrochemicals in China

1. Oil & Gas Exploration and Production | 303.5 million barrels of crude oil
2. Oil Refining | 235.5 million tons crude oil
3. Oil Product Marketing & Distribution | 194.8 million tons refined product
4. Chemicals | 11.04 million tons of ethylene
SINOPEC R&D Capability

R&D Framework of SINOPEC

SINOPEC


Sci. &Tech. Committee
22 members of CAS &CAE

SinopecTech
Catalyst Company
Sub Research Inst.
SRIPE
PEPRIS
SGRI
RIPP
DRIPP
BRICI
SRIPT
QDSEI
5 Engineering Inc.s
CAS and CAE academicians: 22
R&D professionals: 6000+

“1000 Talents Plan” experts: 7
State Engineering Design Masters: 19
Government Special Allowance Experts: 332
R&D professionals: 6000+

SINOPEC R&D Capability
SE Dry-fed Coal Gasification Technology

SE: Sinopec + ECUST

Sinopec started to cooperate with ECUST since 2011

Target:
- Medium Capacity: 1000~2000 TPD
- Extremely high AFT: >1500 °C

First Industry project:
- Sinopec Yangzi PetroChemical Co.
- Startup: Jan. 2014
Process Scheme

- Dry feeding: ~8 percentage point increase in cold gas efficiency
- Lined with membrane wall: suitability for high ash fusion temperature
- Top set up of burner: simple structure and operation, low investment

Operating pressure: 4.0 MPa
Capacity of single gasifier: 2000 t/d
Carbon conversion rate: >98%
Cold coal gas efficiency: >81%
CH₄ in syngas <100 ppm
Efficient gas (H₂+CO) > 88.0 vol%
Multi-Functional Burner

- Ignition, start-up and coal feeding in one burner.
- Direct current jet, simple structure.
- Excellent dispersion after mixing of several coal pipelines.
- Optimal channel setup provides long lifespan (about 1 year).

Ignition research with different fuel:
- LPG
- CH₄
Optimized Matching between Burner and Gasifier

Flow field research

- Simple flow field: jet-flow zone, reflux-flow zone and pipe-flow zone.
- High temperature zone located in center and uniform temperature distribution near the wall on the whole, which provides large operation flexibility in gasifier temperature.
- The temperature near the slag hole is slightly higher, which is favorable for slag discharging.
Online calibration system for flowrate meter of PC with high accuracy

Optimized aeration cone for Lock hopper

- Small weighing system can increase calibration accuracy effectively instead of the storage hopper.
- Online calibration during gasifier running, can decrease error due to zero drift or difference in coal type.

Optimized aeration cone decreases the probability of arching and increases discharge flowrate in Lock hopper.
Cleaning Technology for High Ash Content Syngas

- Ash content in coal is 20%~26%;
- Ash content in syngas of scrubber is less than 1mg/Nm3;
- No filter in Shift Reaction Unit;

- Low pressure drop.

- Quenching chamber technology
  - Spray from quenching ring, enhancing heat and mass transfer.
  - Bubble scrubbing with no slugging, and liquid level is stable and easy to control.

- Integration of Mixer + Cyclone + Scrubber for syngas cleaning:
  - Separate large particles firstly, then fine particles.
  - Low pressure drop.

Successfully applied in crude syngas cleaning unit of Guizhou Kaiyang Chemical Co. and Yangzi Petrochemical Co.
Black Water’s Heat Recovery Technology

Evaporative hot-water tower
(Flashing + direct heat exchange)

- Little fouling.
- High heat exchange efficiency.
- Convenient operation.

- Grey water temperature is increased to maximum extent, which enhances the ratio of water-syngas.
- Completely resolve the fouling and low efficiency in heat exchanger.
- Widely applied.
Demonstration of SE Gasification Technology

Demonstration plant of SE dry-fed coal gasification in Yangzi Co.

Gasifier pressure: 4.0MPa
Capacity: 1000TPD, 70000Nm³(CO+H₂)/h
Product: Hydrogen

- Air → ASU (24000Nm³/h) → Oxygen → SE gasification (1000 t/d)
- Coal → Syngas → CO Shift → Shift gas → Rectisol (Condensate, Purified gas)
- H₂S → S recovery (H₂S, Tail gas)
- Compressor (CO₂)
- PSA (66800Nm³/h) → PSA (Hydrogen)
Demonstration of SE Gasification Technology

Feeding and Gasification unit

Black water unit

Coal milling unit
Operation advantages

Performance of SE dry-fed gasification

- Coal type: **Blend coal (Anthracite 60% + Bitumite 40%)**
- Ash content: **17% - 20%**
- **AFT:** **1260 °C -1400 °C**

<table>
<thead>
<tr>
<th>Carrier gas</th>
<th>Pressure</th>
<th>Oxygen flowrate</th>
<th>Coal flowrate</th>
<th>CO</th>
<th>H2</th>
<th>CO2</th>
<th>N2</th>
<th>CO+H2</th>
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<tbody>
<tr>
<td></td>
<td>MPa</td>
<td>kg/h</td>
<td>t/h</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
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<tr>
<td>CO2</td>
<td>3.9</td>
<td>34000</td>
<td>40</td>
<td>67.49</td>
<td>22.42</td>
<td>9.82</td>
<td>0.21</td>
<td>89.87</td>
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</table>

<table>
<thead>
<tr>
<th>Temper. °C</th>
<th>Load %</th>
<th>Oxygen consum. Nm3/kNm3 (CO+H2)</th>
<th>Coal consum. kg/kNm3 (CO+H2)</th>
<th>CO+H2 content %</th>
<th>Fine slag/coarse slag kg/kg</th>
<th>Carbon in fine slag wt%</th>
<th>Carbon in coarse slag wt%</th>
<th>Carbon conversion %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1400-1550</td>
<td>100</td>
<td>~340</td>
<td>~560</td>
<td>~89</td>
<td>3:7 - 4:6</td>
<td>~30</td>
<td>&lt; 3</td>
<td>&gt; 98</td>
</tr>
</tbody>
</table>
Operation advantages

- Multi-functional burner for start-up and running.
- Visualized flame for the gasifier start-up, more reliability.
- Short start-up time span (~40min).
- Total running time is 181 days for the first burner without any reparation.
Quick response of SiC temperature monitor directly reflecting temperature level and slag layer state.
The most effective indicator for the gasifier temperature monitoring.

Conventional indicator of gasifier temperature:
- Content of CH$_4$ or CO$_2$ (~10min delay)
- Steam production (~8min delay)
- Slag shape (30~40min delay)
Operation advantages

Competence in high gasifier temperature

Guizhou coal property with high FT

<table>
<thead>
<tr>
<th>Proximate analysis (adb, Wt%)</th>
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<tbody>
<tr>
<td>M</td>
<td>A</td>
<td>V</td>
<td>Fc</td>
<td></td>
</tr>
<tr>
<td>1.43</td>
<td>28.42</td>
<td>22.90</td>
<td>47.25</td>
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</tbody>
</table>

Ultimate analysis (adb, Wt%)

| C | H | O | N | S |
| 59.68 | 3.24 | 2.32 | 1.05 | 3.86 |

FT = 1522°C

Carbon in coarse slag

<table>
<thead>
<tr>
<th>Date</th>
<th>Carbon in coarse slag</th>
<th>Carbon in fine slag</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014.2.7</td>
<td>0</td>
<td>22.12</td>
</tr>
<tr>
<td>2014.2.8</td>
<td>0</td>
<td>5.34</td>
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<td>33.54</td>
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<td>2014.4.25</td>
<td>1.02</td>
<td>28.95</td>
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<td>2014.5.8</td>
<td>1.25</td>
<td>35.38</td>
</tr>
<tr>
<td>2014.5.9</td>
<td>0.78</td>
<td>26.25</td>
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</tbody>
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Blend coal
Ash content: 20%
FT: 1399°C

Ratio of fine to coarse slag = 3:7

Coarse slag shape
Operation advantages

- Smooth slag layer, and acceptable distribution of layer thickness.
- The outlet of slag is round and clean, no slag accumulation.
- Reasonable temperature distribution is favorable for the slag discharge.
Application of SE Gasification Technology

- MTO project in Zhongan Coal Chemicals Co. (7 Gasifiers, 1500t/d, to startup at April 2019).


- SNG project in Xinjiang Energy Chemicals Co. (10 Gasifiers, 2000t/d)
Key takeaways

- Integration of “reaction + quenching” with single burner at the top of gasifier, membrane water-wall, bubbling-bed scrubbing and solid slag discharging.

- Multi-functional gasification burner which integrates the function of gasifier ignition, temperature rising and pulverized coal gasification. The structure is simple, and the operation and control are convenient and reliable.

- A wide range of gasification operating pressure (4.0-6.5 MPag), large capacity of single gasifier (up to 2.000 t/d), carbon conversion rate >99%, cold coal gas efficiency >83%, CH$_4$ in product syngas <100 ppm (dry base), efficient gas (H$_2$+CO) is > 88.0vol% (dry base).