Customizing Syngas Specifications with E-Gas™ Technology Gasifier

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Outline

- E-Gas™ Gasifier Features
- Multi Fuel, Multi Products Gasification Technology
- Major Reactions In the E-Gas™ Gasifier
- E-Gas™ Operations Customized to the Application
- Gasifier Operational Control
- Summary
E-Gas™ Gasifier

**KEY FEATURES**
- Two Stage Design
- Slurry Fed
- Oxygen Blown
- Entrained Flow
- Continuous Slag Removal
- Refractory Lined

**ADVANTAGES**
- Two Stage Design Enables Operating Flexibility to Produce Syngas for Multiple Products

**E-Gas™** two stage gasifier for carbon conversion and heat recovery
E-Gas™ Multi-Fuel, Multi-Product Gasification Technology

Feedstock Options

- Coal
- Pet Coke

E-Gas™

Gasification Products
- Slag
- Elemental Sulfur

Clean Low-cost Syngas

Intermediate Methane
- Power & Steam

Intermediate Methane

Low Methane
- Hydrogen
- Ammonia
- CO
- Methanol
- FT Products

High Methane
- SNG
Major Reactions In the E-Gas™ Gasifier

2nd Stage

CO + H2O ↔ H2 + CO2  (Water Gas Shift)  Slight Exothermic
CO + 3H2 ↔ CH4 + H2O (Methanation)  Exothermic
COAL/COKE → CHAR  Endothermic

1st Stage

CO + H2O ↔ H2 + CO2  (Water Gas Shift)  Slight Exothermic
C + H2O → H2 + CO  (Water Gas)  Endothermic
C + CO2 → 2CO  (Boudouard)  Endothermic
C + O2 → CO2  (Combustion)  Very Exothermic

Hot Gas To Be Quenched

Other Constituents are: H2S, COS, NH3, HCN, N2, Ar, Slag
E-Gas™ Operations Customized to the Application

- 2nd Stage Temperature Control
  - Quench hot gas from 1st Stage in the 2nd Stage
  - Thermal heat from 1st Stage converted to chemical energy

- Options
  1. Add cooled recycle gas to the 2nd Stage
  2. Add quench water to the 2nd Stage
  3. Add quench steam to the 2nd Stage
  4. Partial or full slurry quench to the 2nd stage
  5. Adjust gasifier operating pressure
Gasifier Operational Control

Gasifier Operation

Recycle Syngas Quench
Water/Steam Quench
Second Stage Slurry
Pressure
First stage Slurry

Steam Production

Syngas
Hydrogen
CO
Methane

Oxygen

Slag

Char

ConocoPhillips  E-Gas™
IGCC Application with Maximum Carbon Capture
(Add Just Enough Steam/Water to meet Carbon Capture Requirement)

Gasifier Operation
- Syngas Quench
- Steam/Water Quench
- Partial Slurry Quench
- Pressure
- First Stage Slurry
- Oxygen

\[ \text{CO} + 3\text{H}_2 \leftrightarrow \text{CH}_4 + \text{H}_2\text{O} \] (Methanation) Very Exothermic

Carbon Capture Vs Methane Make

ConocoPhillips | EGas

Technology for Gasification
Chemical And FT Applications
(Add More Steam/Water to drive WGS to Increase H2:CO Ratio)

Gasifier Operation
Syngas Quench
Steam/Water Quench
Partial Slurry Quench
Pressure

First stage Slurry
Oxygen

\[
\text{CO} + \text{H}_2\text{O} \leftrightarrow \text{H}_2 + \text{CO}_2 \quad \text{(Water Gas Shift) Slight Exothermic}
\]
SNG Application

Gasifier Operation
- Syngas Quench
- Steam/Water Quench
- Full Slurry Quench

Pressure
- First stage Slurry

Oxygen

\[ \text{CO} + 3\text{H}_2 \rightleftharpoons \text{CH}_4 + \text{H}_2\text{O} \quad \text{(Methanation)} \]

\[ \text{CH}_4 \text{ Range: 2\%-7\%} \]

\[ (\text{H}_2 + \text{CO}) \text{ Vs. Methane Make} \]

\[ \text{Methane Make} \]

\[ \text{H}_2 + \text{CO} \]

Very Exothermic
SUMMARY

1. E-Gas™ gasifier operating flexibility
   - E-Gas™ two-stage gasifier is more flexible than single stage
   - 2nd stage allows customization to match the syngas application

2. E-Gas™ gasifier performance
   - Exceed 90% carbon capture
   - Control H₂/CO ratio for CTL plants
   - Increase CH₄ production in gasifier for SNG plants

3. E-Gas™ process performance modeling
   - Independent study evaluations are typically incorrect
   - E-Gas™ process proprietary empirical model required to accurately predict performance
Back Up Slides
Cold Gas Efficiency Varies With Methanation

Efficiency Vs Methane Make

Methane Make

Effcy %
Cold Gas Efficiency Varies With H₂:CO Ratio

![Graph showing Cold Gas Efficiency vs H₂:CO Ratio]

- **Effcy** axis range: 0 to 79.00%
- **H₂:CO Ratio** axis range: 0 to 1.5
Syngas – For Chemicals Feedstock

ASU

Recycle Char

Gasification

HTHR/Dry Char

CO-Shift

LTHR/AGR


cO2

Syngas @ H2:CO ratio

CO2

H2S

Sulfur Removal

Sulfur

Water Gas Shift Reaction

CO + H2O ⇌ H2 + CO2

Slurry Prep

O2

Slag

High Pressure Steam

HTHR: High Temp Heat Recovery

LTHR: Low Temp Heat Recovery
Syngas for IGCC – Without Carbon Capture

ASU

Recycle Char

Gasification

HTHR/ Dry Char

Power

LTHR/ AGR

Slag

Power + Steam

O₂

Slurry Prep

H₂S

Sulfur

Sulfur Removal

HTHR: High Temp Heat Recovery
LTHR: Low Temp Heat Recovery
Syngas for IGCC With Maximum Carbon Capture

1. Syngas production
   - ASU
   - Slurry Prep
   - Gasification
   - Slag

2. CO2 capture
   - HTHR/Dry Char
   - CO-Shift
   - LTHR/AGR

3. Sulfur removal
   - H2S
   - Sulfur

4. Power generation
   - Power + Stream
   - H2
   - H2+N2

5. Water Gas Shift Reaction
   - CO + H2O ⇌ H2 + CO2

HTHR: High Temp Heat Recovery
LTHR: Low Temp Heat Recovery
Syngas for Substitute Natural Gas (SNG)

**ASU**

\( \text{O}_2 \)

\[ \text{Recycle Char} \]

\[ \text{Gasification} \rightarrow \text{HTHR/ Dry Char} \rightarrow \text{CO-Shift} \rightarrow \text{LTHR/AGR} \rightarrow \text{Methanation} \]

\[ \text{SNG} \]

\[ \text{Slag} \]

\[ \text{CO}_2 \]

\[ \text{H}_2\text{S} \]

\[ \text{Sulfur Removal} \]

**Water Gas Shift Reaction**

\[ \text{CO} + \text{H}_2\text{O} \rightarrow \text{H}_2 + \text{CO}_2 \]

**Methanation Reaction**

\[ \text{CO} + 3\text{H}_2 \rightarrow \text{CH}_4 + \text{H}_2\text{O} \]

HTHR: High Temp Heat Recovery

LTHR: Low Temp Heat Heat Recovery