Testing and Feasibility Study of an Indirectly Heated Fluidized-Bed Coal Gasifier

Benjamin D. Phillips

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Project Sponsor:

[Wyoming logo]

Project Participants:

[Emery Energy Company logo]
[University of Utah logo]
[Kiverdi logo]
Emery Energy Company Overview

• We are technology owners and developers of thermal conversion technologies including Gasification and Pyrolysis

• We provide engineering services, equipment supply and technology licensing for both coal and non-coal feedstocks

• We have ongoing interest in advancing existing gasification processes to reduce overall capital & operating costs

• Emery is actively supporting multiple development stage projects:
  – Hybrid CTL/GTL projects
  – Blended Biomass + Waste-to-Liquids projects
  – Various heat/power projects
Study Objectives

• Evaluate the merits of a indirectly heated gasifier

• Use existing pilot scale equipment to confirm viability and gain preliminary technical information

• Use results and other commercial data for preliminary design for commercial module of 500+ TPD

• Apply this design to the production of:
  – Fischer-Tropsch fuels
  – Hydrogen production plus CO₂ for use in EOR
  – Other syngas uses (MeOH, niche chemicals, etc.)
Emery IH-BFB Gasifier Concept

• IH-BFB (Indirectly Heated-Bubbling Fluidized Bed)
• Provide process heat using combustion flue gas and super-heated steam for fluidization and direct reagent
• Eliminate costs associated with pure Oxygen supply
• Eliminate slag formation and minimize refractory wear (use of Fluidized Bed)
• Reduce syngas cooling requirements (lower syngas exit temps)
Simplified Schematic

1. Coal Receiving & Sizing (to 3/8” at as rec’d moisture)
2. Coal Feed System
3. Combustor
4. Emery IH-BFB Gasifier
5. Ash/Char Removal
6. Cyclones
7. Syngas Cooler/Boiler
8. Super Heater
9. Economizer
10. Start-up Flare

Flow Arrows:
- Natural Gas (optional) to Combustor
- Air to Combustor
- Hot Flue Gas from Combustor to Super Heater
- Flue Gas from Super Heater to Combustor
- Superheated Steam from Super Heater to Steam and Char
- Water to Economizer
- Waste heat, VTA or CO₂ Capture from Economizer
- BFW to Cyclones

Components:
- 3” minus Run of Mine Coal
- Char
- Hot Raw Syngas
- Char
- Steam
- Coal

Company Logo: Emery Energy Company
Fluidized Bed Gasification Tests

- **Objective:** Investigate gasification of PRB coal with steam in indirectly-heated fluidized bed
  - Syngas composition
  - Fuel conversion
- **Testing conducted at University of Utah using an existing bubbling bed gasifier**
- **Test conditions**
  - 20, 30 and 40 lb/hr coal feed rates
  - Steam flow 40 or 65 lb/hr
  - Bed temperatures 1250 to 1450°F
- **Measure syngas composition and carbon remaining in bed material to determine conversion**
Fluidized Bed Gasifier

- Bubbling bed
  - 10 inch ID
  - 55 inch bed height
- Max 40 lb/hr coal
  - 150 kW
- 80 in-bed heaters totaling 32 kW
- Max T 1550°F
- Steam fluidized
- Hot gas filter
Fluidized Bed Testing Results

- Syngas composition (dry N$_2$-free)
  - H$_2$: 48 - 64%
  - CO: 4 - 11%
  - CO$_2$: 24 - 35%
  - CH$_4$: 3 – 11%
- Carbon conversion 36-85%
- Operational performance
  - Generally stable operation
  - No problems with tar fouling
  - No problems with bed agglomeration
  - Some feeding challenges initially
  - Relatively high char carryover to filter
Fluidized Bed Testing Summary

- Multiple factors contribute to observed results
  - Degree of devolatilization vs. temperature
  - Char gasification rate vs. temperature
  - Gas-phase reactions (e.g. WGS) vs. T and steam/fuel ratio
- At low temperatures (< 1250 °F) there is limited char gasification; conversion results mostly from pyrolysis
- Regression analysis yielded the following formula for $\frac{H_2}{CO}$ ratio as function of steam/coal ratio and temperature:
  \[
  \frac{H_2}{CO} = 2.77(\text{steam/fuel}) + 0.003(\text{bed temp})
  \]
Cost Comparison Assumptions

• Capital and operating costs are based on 500 TPD coal to gasifier operation
• Shell gasifier costs are scaled from 30,000+ TPD to 500 TPD to match initial module size of Emery IH-BFB
• No ASU on Emery system
• Compressor required on Emery system
• Emery IH-BFB gasifier would require additional 80 - 100 TPD of coal or nat. gas equivalent**
• WGS is reduced on Emery system due to higher H2/CO
• Tar/Oil Management Still required on Emery system

**Incremental coal and corresponding CO2 production, roughly equates to CO2 that would be produced by equivalent off-site coal-based power plant to supply power to an Air Separation Unit. Furthermore, CO2 capture and use or sequestration would be applied to the Emery IH-BFB configuration just as it would be applied to other coal gasification plants.
Illustrative Capital Cost Comparison
Shell vs. Emery IH-BFB

**Note: we have assumed cost parity for syngas conditioning & FT synthesis for the sake of this illustration. We assume the tar handling cost penalty for Emery IH-BFB equates to higher water-gas-shift costs for Shell system. Further study is required for these areas of comparison.**
Investment Comparison

- Installed cost of the Emery Gasifier is $35M to $40M vs. Shell at system at $150M to $160M

- The total Emery cost of coal to liquids including the Fischer Tropsch system is $150 million vs. Shell total cost of $277 million.

- Estimated Capex and Opex savings of ~40% (when including FT Plant) and 13% respectively compared to Shell gasifier.

- Emery payback period cut in half for overall return on capital
Development Steps

I. Implement a 10 to 20 ton/day process development unit

II. Conduct parametric testing to gain deeper knowledge on heat transfer, influence of steam, etc.

III. 100 to 200 TPD Demonstration Facility
   A. Engineering and Design (6 - 8 months)
   B. Implement a demonstration gasifier, preferably co-located with other coal assets (i.e. power plant) (12 - 18 months)
   C. Begin FT Fuels and/or a Hydrogen/CO2 production to produce final products and operate the plant as a commercial asset (6 months)

IV. Develop Commercial Scale 500 TPD or 1,000 TPD reactor design. Install multiple units for larger production applications
Past Fluid Bed Coal Gasifier (lignite)
(Installed in Texas and designed by Emery engineers and indicative of small 100 to 200 tpd demo required for commercialization)
Conclusions

• Indirect heating is capable of driving gasification process as theorized.
• Removal of ASU, reduced operating pressures/temperatures significantly reduces Capex/Opex, even while accounting for downstream compression requirements.
• High H2 production can lead to alternate H2 + CO2 production scheme (vs. just FT fuels) and can support Wyoming Refinery needs plus EOR industry needs.
• Improved payback periods enable smaller, distributed facilities to be realized.
• Very appealing, lower cost approach to syngas production from Coal
Thank you

contact:

info@emeryenergy.com
157 Pierpont Avenue
Salt Lake City, Utah 84101 USA
+1.801.364.8283