Fluor Solvent Testing at Technology Center Mongstad (Project 70814)

August 29, 2019

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Disclaimer

This material is based upon work supported by the U.S. Department of Energy under Field Work Proposal FWP-70814.

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One of the world’s largest engineering, procurement, fabrication, construction and maintenance companies
Providing innovative and integrated solutions for industrial facilities of varying sizes across the globe
More than 55,000 employees executing projects globally
Delivering capital efficient solutions
Proprietary CO₂ Technology: Econamine FG+
  – Recently developed a lean water solvent for CO₂ Capture
Fluor’s Gas Treating Solutions

- Fluor offers various gas treating solutions
- **Fluor Solvent**SM – Physical solvent to absorb H₂S and CO₂ at high pressure
- **Econamine**SM – Uses diglycolamine (DGA) for H₂S and CO₂ removal from natural gas streams
- **Econamine FG Plus**SM – Removal of CO₂ from low pressure, post-combustion flue gases
- Fluor has built over 425 gas processing facilities
  - Includes 30 Econamine FG+ plants built or licensed
What is the Relevance of Water Lean Solvents?

- Carbon capture solvents typically contain 60 to 65% water by weight.
- Fluor’s target is a solvent with less than 40 to 50% water.
  - ~5% reduction expected in heat rate and ~20% reduction expected in solvent circulation rate.
- Water provides a medium for ionic reactions to take place.
- But, water has several drawbacks.
  - High heat of vaporization.
  - High volatility.
  - High specific heat.
  - Low capacity for CO₂.
- Replacement of a portion of the water with other solvents offers an opportunity for energy consumption reduction.
In 2016 Fluor developed a water lean solvent that showed promise for a more energy efficient CO₂ capture.

Fluor worked with PNNL to measure the VLE of the new solvent system.

To establish the environmental performance of the solvent, Fluor conducted a degradation test at SINTEF in Norway.
Solvent Performance Testing

- VLE and kinetic data were measured for several different solvent mixtures
  - Thermodynamic and kinetic data developed
  - Solvent composition optimized

- Solvent degradation testing at SINTEF
  - 5-week testing with synthetic flue gas: 3.0 vol% CO2, 12% O2, and 10 ppmv NOx. Absorber/desorber temps: 40°C/117°C.
  - One solvent component found to produce an undesirable degradation product – replaced with alternate component
Based on the results:

- DOE approved funding for the demonstration of the new solvent at Technology Center Mongstad (TCM), Norway
- Subsequently, TCM also provided approval and funding for the test at their facility at Mongstad
Contracts

- **DOE/PNNL:**
  
  Contract May 8, 2018
  
  Fluor/PNNL managed the DOE-funded portion of the project:
  - Proprietary equipment (Solvent Maintenance System)
  - Solvent purchase
  - Installation of proprietary equipment and hook-ups
  - Solvent disposal
  - Deployment of personnel and travel costs

- **TCM Contract:**
  
  Contract June 18 2018
  
  - Use of the demonstration plant
  - All utilities
  - Operating staff
  - Emissions measurements
  - Analytical laboratory services
  - Office Facilities
Test Campaign Timeline (2019)

- January 23 – start of test campaign with Combined Heat and Power (CHP) Plant flue gas
- April 3 – begin transition to Refinery Fluid Catalytic Cracker (RFCC) flue gas configuration
- April 28 – operation fully changed to RFCC flue gas
- May 27 – final day of original test campaign
  - 2,700 hours of operation on CO₂ capture plant
- May 28 – Started test campaign extension period
- June 27 – end of test campaign
  - 3400 total hours of operation on CO₂ capture plant
# Project Schedule & Budget

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## DOE Funding:
- **Phase 1:** $284k
- **Phase 2:** $2,396k
- **Extended testing (6wks):** $425k
- **Total:** $3,105k
Technology Center Mongstad
Testing at TCM

- CHP Flue Gas Test Phase
  - January 23 to April 2
  - CHP Flue Gas Average Conc: 3.3 vol% CO$_2$, 15.6 vol% O$_2$

- RFCC Flue Gas Test Phase
  - April 3 to June 27
  - RFCC Flue Gas Average Conc: 12.6 vol% CO$_2$, 8.6 vol% O$_2$
Absorber Emissions During CHP Test Phase

- Average Absorber emissions during CHP test:
  - Component A: < 0.01 ppmv, Component C: < 0.01 ppmv, NH₃: < 3 ppmv

- Average Absorber emissions during RFCC test:
  - Component A: < 0.1 ppmv, Component C: < 0.2 ppmv, NH₃: < 3 ppmv
Simulator Performance

- Results of Aspen Plus model developed by Fluor were compared to plant measurements.

- Good agreement for absorber performance, but observed stripper performance was poor compared to simulated performance.
  - Analysis of stripper performance using a tuning parameter in the simulator revealed that the stripper was underperforming.
  - Lean Water Solvent circulation rate was too low.
  - Poor performance of stripper packing attributed to plant operating below minimum hydraulic design.
Simulator Performance

- Good agreement between simulated Absorber temperature profile and plant data
Simulator Performance

- Interfacial Area Factor (IAF) adjusted to match simulated profile to plant data
- Low IAF (0.35~0.5) needed to match simulated stripper profile to plant data
Solvent Maintenance System

- Installation at site
Solvent Maintenance System

- HSS levels stable when in operation
- Excellent Solvent Recovery
  - 93 to 95% solvent recovery (mass basis)
  - Very small waste production
  - No foaming with Lean Water Solvent
- Low metal concentration in solution
  - Low degradation rate
Test Campaign Highlights

- Successfully tested new water-lean solvent formula:
  - Heat Rate reduced by 5 to 6% compared to the current EFG+ solvent
  - Amine Circulation reduced by 20%

- Very low Absorber emissions:
  - Average amine emissions < 0.2 ppmv
  - Average ammonia emissions < 3 ppmv

- Validated Solvent Maintenance System on Lean water Solvent
  - 660 hours logged
  - Unit test successfully at up to 110% design capacity
  - 93 to 95% solvent recovery on average

- Solvent Maintenance System able to maintain impurities at a negligible concentration
Acknowledgements

- Thanks to the Department of Energy's Office of Fossil Energy and the National Energy Technology Laboratory for their funding, support and sponsorship.

- Thanks to the Technology Center Mongstad (TCM) for their funding, superb field support and guidance.
QUESTIONS