EVALUATION OF NOVEL TECHNOLOGIES FOR CO_2 CAPTURE

EXECUTIVE SUMMARY

The Energy & Environmental Research Center (EERC), along with Neumann Systems Group, Inc. (NSG), conducted a project to evaluate the NSG NeuStream™-C system, an advanced gas contactor, which has the potential to significantly reduce the cost of postcombustion solvent-based CO_2 capture. The system, which consists of a three-stage absorber and four-stage stripper, was designed and built by NSG and installed at the EERC's combustion test facility (CTF). It uses a proprietary contacting system that has been shown to reduce costs at the bench-scale level.

The objectives of this project were to design and fabricate the pilot-scale NeuStream-C system, perform system design verification, integrate and install the NeuStream-C system on the EERC CTF, perform shakedown and initial verification testing, perform system baseline testing, define and design system modifications for optimization based on baseline testing, perform system optimization testing including testing of multiple solvents from other technology suppliers, evaluate and compare baseline testing results to the current results of the EERC's conventional solvent system, perform an economic analysis of the system at different points in the optimization to determine feasibility, and perform a sensitivity analysis to include the parameters of importance when considering scale-up.

The system was designed, fabricated, and verified by NSG during the spring and summer of 2011. Integration and installation of the system at the EERC occurred at the beginning of September 2011, and shakedown testing commenced at the beginning of October 2011.

Shakedown testing was conducted for 9 days and was successful in that operational problems were identified and fixed for future testing. Testing was performed at the EERC using the pilot-scale NeuStream-C system on a 100–260-standard-cubic-foot-per-minute stream of coal-derived flue gas. The baseline solvent used for this project was 30 wt% monoethanolamine (MEA) with water.

System calibration and baseline testing were conducted from November 7 to 10, 2011. During this phase of testing, the CO_2 capture rate varied from 30% to 50% depending on conditions. Several modifications were made to the NSG stripper after this run to improve performance, including the addition of extensions to the stripping sections.

Optimization testing began with a test run on December 19–20, 2011. On the first day of testing, the NSG absorber was paired with the EERC's conventional stripper, and on the second day, the NSG absorber was used with the NSG stripper. At a 190-scfm flue gas flow rate, both systems achieved CO_2 capture rates in the 40% to 50% range, and the working capacity or the solvent was 0.07, indicating that further improvements needed to be made to the stripper. A model of the NSG system was created which confirmed this hypothesis.

During the next optimization run, from January 9–11, 2012, both the solvent flow rate and the flue gas flow rate were varied to determine the performance of the NSG system at different conditions. A solution of 30 wt% MEA with water was used as the solvent. The best CO_2 capture numbers were achieved for high solvent flow rates and lower flue gas flow rates, with a maximum capture rate of 80% at 90 scfm and 15 gpm. However, the working capacity remained flat as process conditions changed, indicating that further changes needed to be made to the stripper.

Before the next optimization run, an additional heat exchanger was added between the absorber and the first stripper section to increase the amount of heat in that area of the stripper and improve performance.

Two solvents, 30 wt% MEA with water and 8 molar piperazine (8 M PZ), were used for the next optimization run which was conducted from February 27, 2012, to March 2, 2012. Maximum CO_2 capture rates obtained during this run were approximately 75% for MEA and 90% plus for 8 M PZ. During this run, an absorber modification was also tested to see if higher flue gas velocities would affect efficiency. The absorber modification did not have any apparent effects, either positive or negative, on system performance.

Two final weeks of testing in mid to late 2012 looked into two final changes to the stripper operation: giving independent heat to each stripper vessel and allowing independent control of each vessel, essentially allowing it to be operated in a 2-stage flash configuration. These changes improved the lean loading of the solvents, reducing the loading to levels expected during typical operation. This resulted in improved performance of MEA, raising the capture rate to over 85%. Performance of 8 M PZ was limited because of difficulties maintaining steady state during limited testing.

Performance of the system is an improvement over traditional systems in that the specific surface area has been increased from 100 to 200 to almost 300 m^2/m^3. Additionally, the gas flow through the system can be increased with no significant pressure penalty.

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