Abstract

Concentrated (30 wt%) piperazine (PZ) with the Advanced Flash Stripper (AFS) is a second generation amine-based post-combustion CO₂ capture process. In 2018, this technology was successfully demonstrated at the 0.6 MW National Carbon Capture Center (NCCC) in Wilsonville, Alabama on coal-fired flue gas for over 2000 hours. A heat duty of 2.1 GJ/tonne of CO₂ was achieved in the AFS and greater than 90% CO₂ removal was obtained in the absorber. Low amine oxidation rates were observed and amine aerosol emissions were minimized to 1 ppm when management strategies were implemented. Piperazine solubility was managed through robust engineering and no solids precipitated during the six unplanned shutdowns that occurred in the course of the pilot plant campaign.

To evaluate the flexibility of the PZ/AFS technology on natural gas combined cycle (NGCC) flue gas conditions (3.5% CO₂), a nine-week pilot plant campaign at NCCC was conducted using synthetic flue gas through the dilution of the coal-fired flue gas with air. Pump-around intercooling around the bottom packed bed of the absorber was added to test whether the direct contact cooler (DCC) could be bypassed and a pump-around loop would be sufficient to cool the hot inlet flue gas without impacting absorber performance.

Prior to loading PZ solvent, water testing and heat loss measurements were completed in the first half of February 2019. Testing with PZ began in the middle of February. Three weeks of factorial testing and six weeks of long term testing were completed. In the first week of testing, the absorber was operated with in-and-out intercooling and the DCC was operated at 30 and 40 °C with the inlet flue gas heated to 120 °C. In the second week, the absorber was configured to operate with pump-around intercooling around the bottom packed bed. The third week of testing, the DCC was turned off and the absorber was operated with and without the pump-around intercooling in operation. Absorber performance was evaluated at 80, 90 and 95% CO₂ removal and the AFS bypass flow rates were optimized to minimize heat duty.

During the course of the nine week campaign, corrosion coupons and electrical resistance probes were installed and monitored. Corrosion coupons that were tested include carbon steel, SS316, duplex, and hastelloy and were installed at high corrosion locations including the stripper hot rich, sump and hot lean. Oxidation mitigation strategies that include N₂ sparging and reducing AFS sump liquid level were implemented. Liquid samples were analyzed on a weekly basis to monitor PZ oxidative...
degradation. FTIR measurements on the absorber and water wash outlet were also completed to monitor amine aerosol emissions.

*Keywords*: Pilot plant; Piperazine; Natural Gas, Advanced Flash Stripper