Performance Evaluation and Process Development of Amine Solid Sorbent for CO_2 Capture from Cement Production Plant

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Rapid increase in CO_2 concentration in the atmosphere is suggested to cause the detrimental impact to the environment and demands the CO_2 emission rate to be reduced from power and chemical industries. Cement production is known to be the second largest CO_2 emission source, following power production industry. Approximately 2/3 of the CO_2 emission from cement production is from the calcination reaction of limestone and 1/3 from fuel combustion for heating rotary kiln. Though cement flue gas shares many similarities in composition with coal-fired power plant flue gas, it contains significant higher concentration of O_2, H_2O, NO_x, and fines.

In a collaboration project with Norcem, a Norwegian cement producer, RTI was selected to develop a lab-scaled demonstration unit which utilizes the porous solid amine sorbent to evaluate the effectiveness together with long term stability of the material for CO_2 capture under cement flue gas condition. Polyethyleneimine impregnated on porous silica (PEI/SiO_2) sorbent was made in-house and subjected to multiple cycles of CO_2 absorption/regeneration using Packed-Bed Reactor system. The CO_2 capture performance and stability of PEI/SiO_2 was evaluated under simulated coal-fired flue gas, simulated cement flue gas without SO_2 and simulated cement flue gas with 100 ppm of SO_2 by performing 100 cycles of CO_2 absorption/regeneration at each flue gas condition. The result shows that PEI/SiO_2 exhibits similar CO_2 loading despite the large difference in composition between coal-fired flue gas and cement flue gas. Significant degradation and reduction in CO_2 loading was observed when 100 ppm of SO_2 was introduced to cement flue gas. Post analysis of the sorbent by ATR-IR revealed that sulfate-amine salt was formed under presence of SO_2 which reduced the amount of CO_2 absorption sites.

Development on the process aspect of this project resulted in a packed-bed reactor system with flue gas pretreatment unit equipped at the front-end of the process. The Automated Sorbent Testing Rig (ASTR) was designed specifically to handle cement flue gas with minimal involvement from user to operate. ASTR was commissioned and operated under simulated cement flue gas at RTI facility prior to installation at Norcem's cement production plant in Brevik, Norway. Once installation of flue gas feed system to ASTR is fully completed, CO_2 loading and performance stability of the sorbent will be evaluated under real cement flue gas. A set of parametric study will also be conducted on site to evaluate system performance with variation that typically found in cement flue gas quality.