

Impact of high temperature lithium sorbents capture systems on plant's units operation

Susana Garcia¹, Alisdair J. Stewart¹, M. Mercedes Maroto-Valer¹

¹Centre for Innovation in Carbon Capture and Storage (CICCS), School of Engineering and Physical Sciences, Heriot-Watt University, Edinburgh EH14 4AS, United Kingdom

Abstract

Physisorbents like zeolites, activated carbons, carbon molecular sieves, carbon nanotubes and MOFs have been extensively studied for CO₂ separation by pressure (PSA) and thermal swing (TSA) adsorption[1-3]. However, their capacities at elevated temperatures (> 100°C) are low and they lose CO₂ selectivity under wet conditions[4]. In recent years, CO₂ capture at high temperatures (450-700°C) based on regenerable sorbent materials has received increasing attention as an alternative to aforementioned low-temperature CO₂ capture adsorbents. The use of high temperature sorbents provides both high CO₂ adsorption capacity and CO₂ selectivity at temperatures between 450 and 700°C. Considering the wide range of materials tested, lithium silicate (Li₄SiO₄) has shown the largest CO₂ sorption capacity and the fastest CO₂ sorption rate over a wide range of temperatures and CO₂ concentrations [5]. However, a process integration study in order to assess the impact of these carbon capture systems on units operation of power plants or industrial facilities is still lacking. Typically, existing carbon capture units operate at low temperature and are often the final process unit on a flue gas stream. A high temperature CO₂ capture system however, will be more likely installed further upstream. Depending on the source of the CO₂, the flue gas stream of which it is a constituent may undergo a variety of different processes, such as being utilized for heat recovery or being subjected to various treatment stages before it is released to the atmosphere. In post-combustion CO_2 capture, carbon capture units typically operate at low temperatures and there are often no process units downstream of the capture plant. However, if a high temperature CO₂ capture unit is to be implemented, it is likely that many of those process units would be downstream of the capture plant if it is to operate within the optimum temperature range. At present, the potential impact on the plant's process units performance when operating a lithium sorbent high temperature capture process is not well understood, and therefore, identifying how the capture plant affects various flue gas lines within industry is critical to understanding its technical viability.

The scope of this project is to understand how the installation of a high temperature lithium sorbent carbon capture system on different flue gas lines affects the performance of existing air pollution treatment units and/or heat recovery units, and to determine whether those carbon capture units are a viable option for the flue gas streams considered. In this work, two different flue gas lines, from an IGCC plant and a from a hydrogen reforming plant are investigated. The process flowsheet diagrams are developed with the commercial software package Aspen Plus 8.6 to simulate the steady-state performance of the plants. A base-case model for each process, where no carbon capture unit is installed, has been developed so base-level performance of each process unit can be established for comparison. The effect on process equipment that the carbon capture unit would have, such as changes to the size of heat recovery units, drops in efficiency of other flue gas

treatment equipment and reduction in the amount of steam raised over a flue gas line, is evaluated by comparing the results of the simulations with the base-case scenarios for each flue gas line. The results from this study will ultimately allow conclusions to be drawn as to the validity of the capture unit on a given process, and moreover to ascertain the optimum flowsheet arrangement for a lithium sorbent high temperature carbon capture unit for the given plant.

References:

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