Post-Combustion CO_2 Capture Solvents: Bridging the Knowledge Gap through Long-Term Testing.

Mike Ownsworth[1*], Mathieu Lucquiaud[1], Jon Gibbins[1]
[1]Dept of Mechanical Engineering, University of Sheffield
mjownsworth1@Sheffield.ac.uk

Background

Removal of carbon dioxide from industrial and combustion flue gasses before they enter the atmosphere, e.g. from CCGT, BECCS power plants, EfW plants and industrial facilities (cement, steel, chemical, glass, paper and ceramics.)

- "Assess your solvent's performance, including reclaiming needs and atmospheric emissions modelling. Determine this via realistic pilot (or full-scale) tests using representative (or actual) flue gases and plant operating patterns over at least 12 months." (1)
- Little information is readily available about successful strategies for amine solvent recovery and management, especially for long-term operations.
- Information about the relative cost of reclaiming or replacement is often absent.
- Investigate improved monitoring of solvent, process performance, and atmospheric emissions.
- The outcome of the project will be of interest to regulators, future industrial users and technology developers.

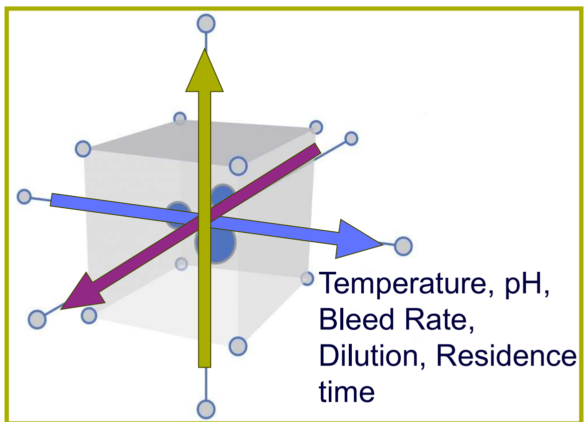


Figure 3: DoE, factors to be considered.

"On the Shoulders of Others"

- Lucas Joel - Lab based pilot. Used for CoDAC / SMART (2)
- Marcin Pokora - Analytical & reclaiming methodology (3)
- Aisha Ibrahim – Loading and degradation sensing by algorithm from density, viscosity and temperature. (4)

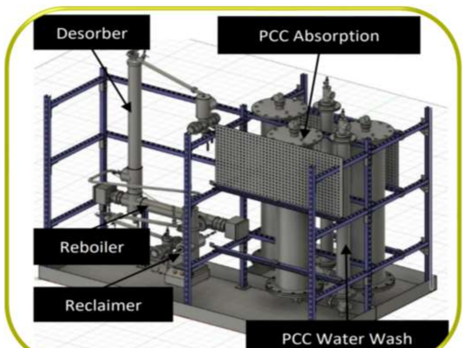
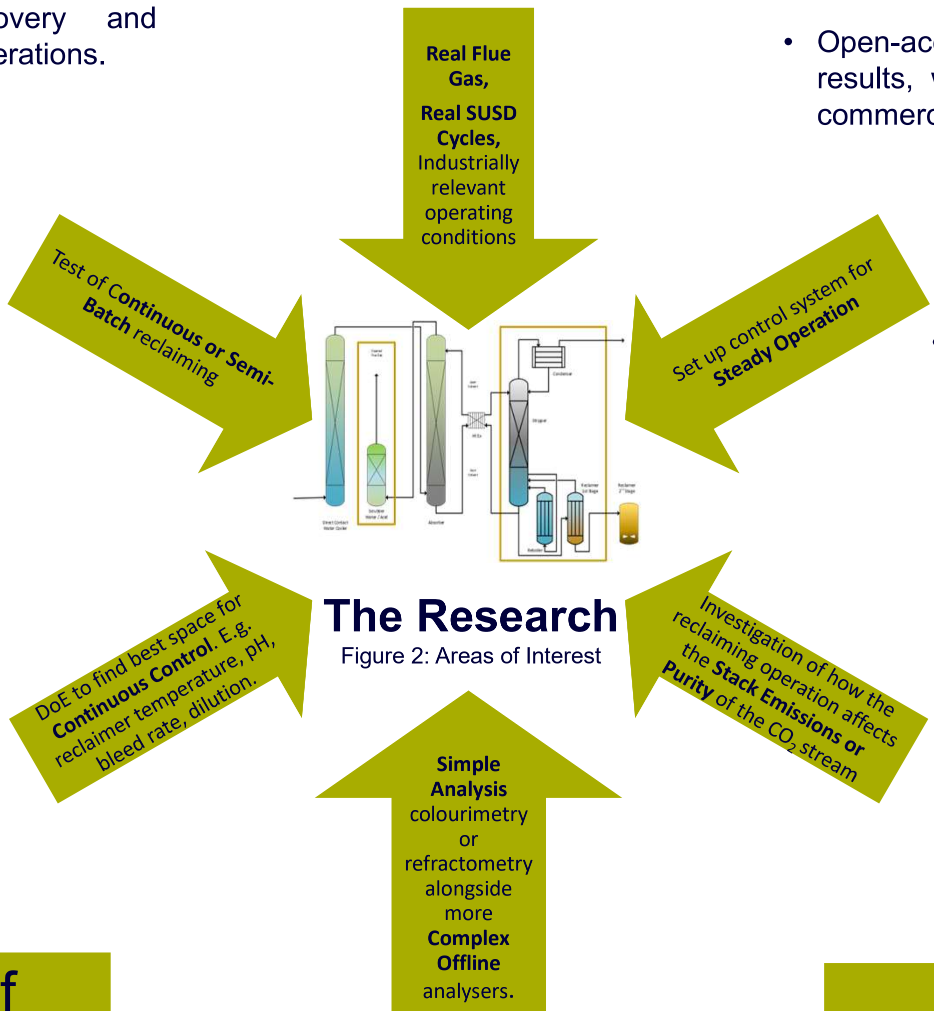


Figure 5: General Arrangement of Lab Test Rig (Joel et al,2024)

Figure 1: SMART test rig inside laboratory at Sheffield



The Research

Figure 2: Areas of Interest

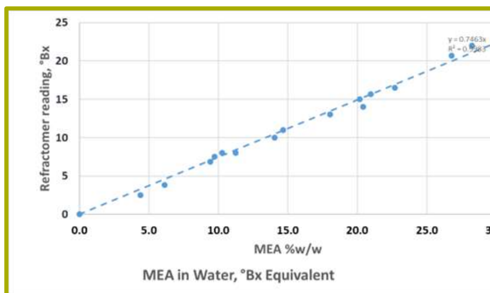


Figure 8: Refractive Index for Reclaimed MEA Concentration

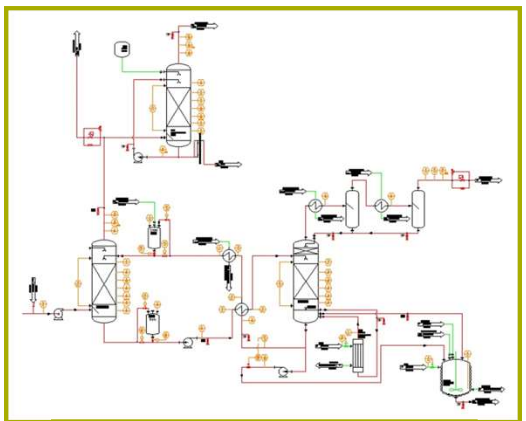


Figure 6: Initial PFD of Site Based SMART

The Research

Factors affecting amine solvent management in long-term operation of amine plants. Implications for solvent testing at small scale

- Experimental and initially uses a laboratory test rig operated at **industrially representative process conditions** over a long period of testing, supported with data and samples provided by UK commercial projects.
- Address a knowledge gap in long-term testing of solvent management techniques, online monitoring of degradation, effective reclaiming and the effect on atmospheric emissions.
- Open-access solvent to allow for publication of the results, with **transferrable learnings** applicable to commercial, proprietary solvents.
- Optimized solvent management strategies and more efficient and environmentally sustainable CCS operations.
- Improving understanding of relevant instrumentation techniques to support the permitting of new post-combustion CO2 capture facilities.

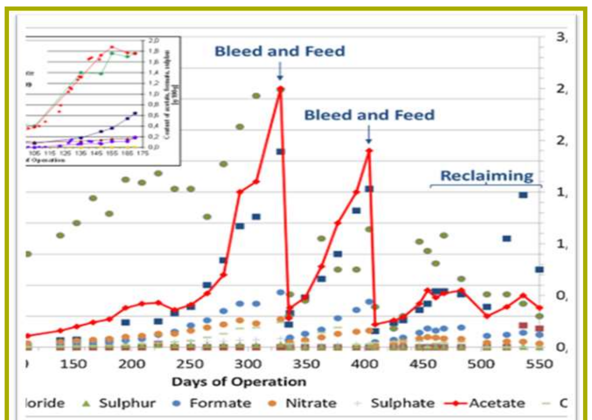


Figure 4: Accelerating Degradation. Moser et al, 2020 (5)

Management of Accelerating Degradation

Most reported trials are done with simulated flue gas which excludes contaminants.

- Contaminants in real Flue gas **NOx, SOx, CO, fly ash**, other particulates.
- Notably the TCM Mongstad and Niederaussem trials use a real flue gas.

Figure 7: Increasing Solvent `

This studentship is supported by the UKRI EPSRC CDT-GIF training grant (EP/Y03550X/1).

References:

1) Environment Agency. Guidance : Post-combustion carbon dioxide capture: best available techniques (BAT) guidelines. 2021. https://www.gov.uk/guidance/post-combustion-carbon-dioxide-capture-best-available-techniques-bat (Accessed:31/3/25)
2) Joel, L., Pokora, M., Ibrahim, A., Lucquiaud, M., Michailos, S. and Gibbins, J., 2024. SMART-Solvent Management At Reduced Throughput–a prototype demonstration plant. Available at SSRN 5064129.
3) Pokora, M., Joel, L., Ibrahim, A., Lucquiaud, M., Michailos, S. and Gibbins, J. (2024) 'An experimental investigation of optimum conditions for continuous two-stage reclaiming of MEA solvent inventories from commercial plants', *Available at SSRN 5064077.*
4) Ibrahim, A., Lucquiaud, M., Gibbins, J., Akram, M. and Gheit, A. (2024) 'Effective Real-time Monitoring of Solvent Loading and Concentration for Commercial Amine Post-Combustion Capture Control and Optimisation', Available at SSRN 5076098.
5) Moser, P., Wiechers, G., Schmidt, S., Garcia Moretz-Sohn Monteiro, J., Charalambous, C., Garcia, S. and Sanchez Fernandez, E. (2020) 'Results of the 18-month test with MEA at the post-combustion capture pilot plant at Niederaussem – new impetus to solvent management, emissions and dynamic behaviour', *International Journal of Greenhouse Gas Control,* 95.