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Mixed Salt Process (MSP) & Analytical Methods Validation in Pilot Plant Using Real Flue Gases

Stylianos Pachitsas[a]*, Christophe Benquet[b]

[a]*Baker Hughes, Via Felice Matteucci, 2, Florence 50127, Italy*
[b]*Baker Hughes, 24 Rue Johannes Kepler, Pau 64000, France*

Abstract

Robust and scalable technology deployments are key to addressing the "energy trilemma" – achieving energy security, affordability, and sustainability. Carbon capture, utilization, and storage (CCUS) has been identified as one of the key levers to achieve global decarbonization, especially for hard-to-abate sectors. However, several challenges remain in terms of scalability and economic competitiveness. Therefore, energy technology companies offering broad solutions have a competitive advantage. Baker Hughes offers a diverse portfolio of solutions – from equipment to service capabilities – spanning the energy and industrial ecosystem. CCUS is a strategic growth area within Baker Hughes' Industrial & Energy Technology (IET) business transitioning to net zero emissions. The company's ground-breaking technologies and solutions are accelerating CCUS development and adoption

Baker Hughes is a provider of equipment, technologies, expertise, and digital solutions across all parts of the CCUS value chains covering the decarbonization of energy and industry. The carbon capture technology portfolio relies on inorganic solvent-based process along with process intensification solutions.

The Mixed Salt Process (MSP) is a post-combustion, carbon-capture process (see Figure 1) that uses a novel solvent composition based on readily available potassium carbonate and ammonia technologies with improved reaction kinetics and easily complied with emission regulations. Preliminary data pointed out a number of advantages of MSP over conventional amine and potassium technologies, and the previous generation ammonia-based technologies. The solvent as an aqueous mixture of ammonia (NH_3) and potassium (K), is characterized by a high tolerance to industrial flue gas impurities (e.g. O_2, NO_x), high cyclic CO_2 loadings, low regeneration heat duty and optimized control of NH_3 slip. In addition, it is practically unaffected by the thermal or oxidative degradation and free from by-products of high toxicity. Absorbers operation near to atmospheric pressure and the operation of the CO_2 stripper in the pressure range of 10 bars to 20 bars minimize the energy penalty of both flue gas and CO_2 product compressions, and consequently gives clear comparative advantages in terms of capital investment and operating cost over conventional amine and potassium technologies. The utilization of potassium effect on solvent thermodynamic equilibrium significantly reduces the related capital and operating costs related to NH_3 slip control in comparison with the previous regeneration

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* Corresponding author. Tel.: +39 3499399697, *E-mail address:* Stylianos.pachitsas@bakerhughes.com

of NH_3-based technologies. The relative high operating temperatures, 20ºC to 40ºC, in absorption section, enhance the CO_2 absorption kinetics by reducing the required residence times of reactants in absorption columns. MSP is oriented to decarbonize middle to large scale industrial/energy CO_2 emitters. Baker Hughes granted the exclusive license to exploit MSP technology by SRI International since 2021. The MSP pilot with nominal CO_2 capacity of 10tpd at the National Carbon Capture Center (NCCC) is the pivot for the maturation of the current technology readiness level (TRL) of 4 to 6 and validation of analytical methods. The pilot project is under execution by SRI International and funded by US Department of Energy and Baker Hughes.

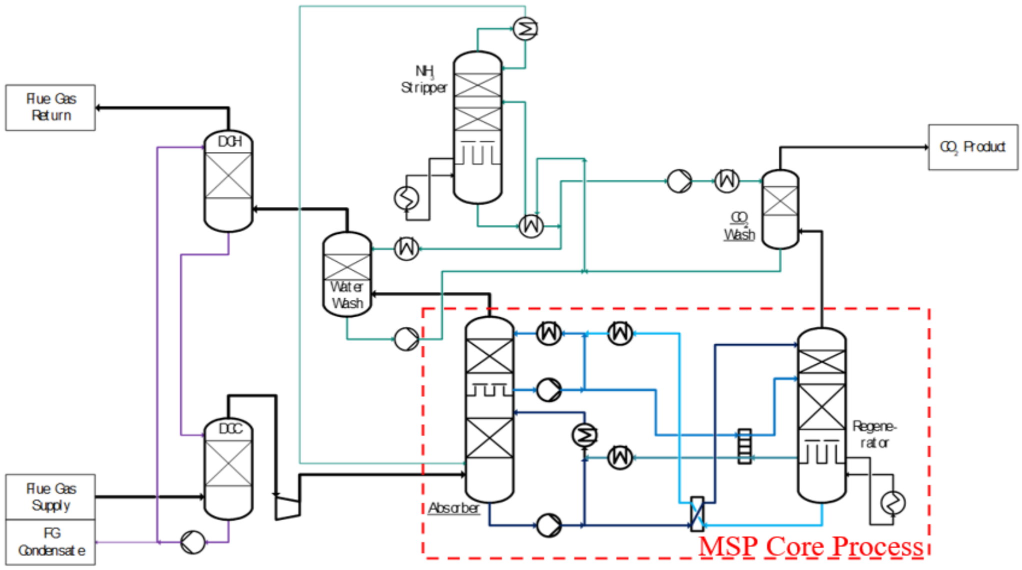

Figure 1 – Conceptual MSP process flowsheet [1]

This article presents the main results of the MSP test campaign that will take place at the NCCC along with the validation of specific analytical methods. Figure 2 illustrates the MSP pilot facility in NCCC which will be run using flue gases from coal and natural gas combustors, targeting a carbon capture rate (CCR) higher than 90%. The pilot plant line-up includes 2 absorbers and a 2-lean selected regenerator.

Three or more industrial analytical technologies will be tested to monitor gas and liquid compositions from at least 11 sampling points in the industrial process. The experimental results obtained during the dynamic and continuous operations will support the qualification of the analyzers for industrial deployment.

The key objectives of test campaigns are:

i) the sensitivity analysis of MSP process considering primary and secondary operating parameters
ii) evaluation of process robustness – system responses to transient/ramp operation and long-term testing
iii) validation of plant performance considering baseline operation at 90% capture rate

The gained data are going to improve the process designing tools and procedures, and control architecture philosophy and systems. The process optimization and scale-up through NCCC pilot plant are considered as critical steps in the commercialization roadmap of MSP technology.

Parallel to MSP validation in the pilot facility, lab research activities focused on solvent characterization (vapor – liquid equilibrium) and solvent recovery through the induced crystalization – percipitation of ammonium and potassium salts using CO_2 product are under execution. The obtained data are going to be utilized on the optimization of MSP process and process design tools resulting in the reduction of MSP plant operating cost and enhancing the sustainability of MSP process.

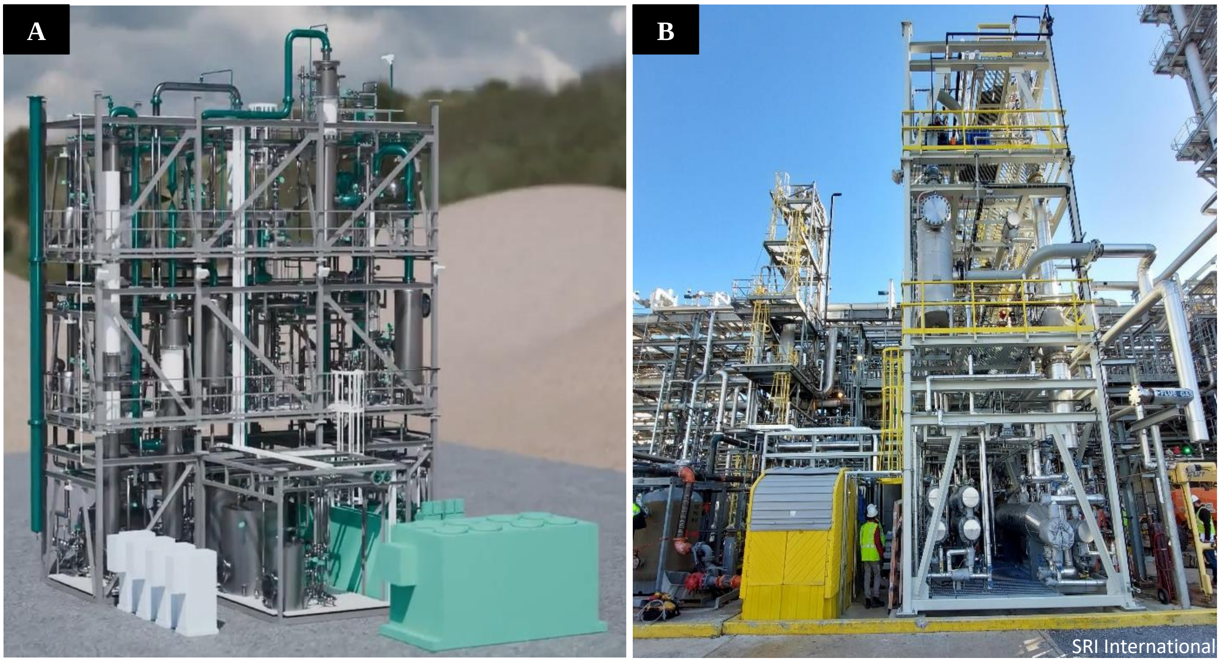

Figure 2 – A) MSP pilot facility 3D illustration and B) Front view of MSP pilot facility in NCCC

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Keywords: CO_2 capture; Mixed Salt Process; ammonia; potassium carbonate;

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[1] Pachitsas, Stylianos and Benquet, Christophe, Techno-Economic and Validation Approach of Mixed Salt Process (MSP) In Pilot Plants Using Flue Gases (December 18, 2024). Proceedings of the 17th Greenhouse Gas Control Technologies Conference (GHGT-17) 20-24 October 2024, Available at SSRN: https://ssrn.com/abstract=5063091 or http://dx.doi.org/10.2139/ssrn.5063091