IEAGHG 8th Post Combustion Capture Conference

16th to 18th September 2025 Marseille, France

Design and optimisation of intensified carbon capture for natural gas power plants using rotating packed bed (RPB) technology

Olajide Otitoju[a], Alexandre Pactat[b], Samuel Heng[b], Miguel Abreu[b], Meihong Wang[a]*

[a]*School of Chemical, Materials and Biological Engineering, University of Sheffield, Sheffield S1 3JD, United Kingdom*
[b] *TotalEnergies OneTech, CSTJF-avenue Larribau, 64018-Pau, France*

Abstract

The rotating packed bed (RPB) technology offers a transformative solution for enhancing the efficiency and cost-effectiveness of post-combustion carbon capture (PCC) processes[1,2]. By utilizing RPBs as absorbers and strippers, we can significantly reduce the size and footprint of the systems involved. With the ability to operate at monoethanolamine (MEA) concentrations exceeding 55 wt%, RPBs present an opportunity to achieve superior absorption performance while also diminishing the energy demands associated with solvent regeneration [3]. However, despite its promise, the comparative evaluation of multiple RPB absorber-based CO_2 capture process designs (Figure 1) considering several absorber arrangements, exhaust gas recirculation (EGR) for CO2 enrichment of the incoming flue gas stream and monoethanolamine (MEA) concentrations has not been explored. Furthermore, the optimisation of this multiple RPB absorber-based CO_2 capture process incorporating an intercooling system between absorbers is yet to be reported.

This study presents a rigorous process simulation and optimization of rotating packed bed (RPB) absorbers for post-combustion CO_2 capture (PCC)) of a natural gas combined cycle (NGCC) power plant. It explores different RPB absorber designs options using 55 wt% and 75 wt% MEA solvent [2]. Four design options (which included Option 1—One RPB absorber with 55 wt% MEA and 75 wt% MEA, Option 2—Two RPB absorbers in parallel with only 75 wt% MEA, Option 3— EGR with One RPB absorber at 75 wt% MEA, and Option 4— EGR with two RPB absorbers in parallel at 75 wt% MEA.

A systematic comparison of the four design options based on footprint (packing volume), energy consumption and pressure drop provides insights into optimal RPB absorber design. The best-performing design (Option 4) significantly reduces absorber size (2–4 times smaller) and achieves a lower pressure drop (8.6 kPa) compared to other options. It also has a moderate rotor energy consumption of 402 kW which is lower than all the other options. Furthermore, incorporating an intercooling system between the absorbers in the best-performing design (Option 4) lowers the liquid phase temperature and facilitate enhanced CO_2 absorption performance by up to 12% compared to designs without intercooling.

* Corresponding author. Tel.: +01142227160
E-mail address: Meihong.Wang@sheffield.ac.uk

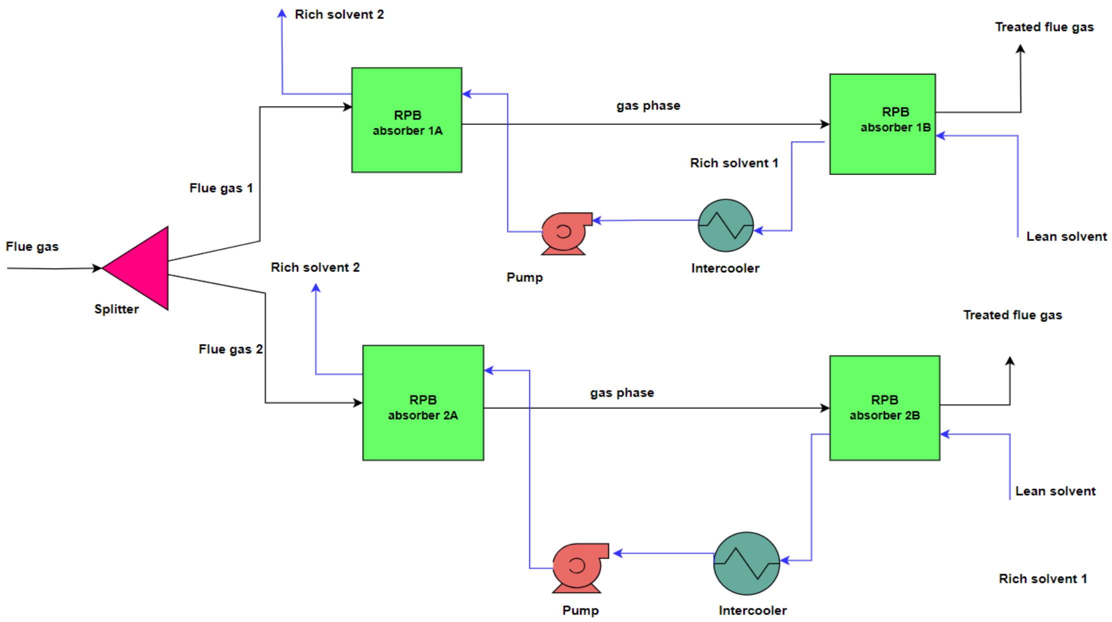

Figure 1: Two trains of RPB absorbers in series with external coolers between the RPB absorbers

An optimisation of the operating parameters to minimise the CO_2 capture cost of the multiple RPB absorbers based CO_2 capture process designs was conducted. Preliminary results indicate that the optimal operating conditions for the RPB absorbers include a rotor speed of 275–300 RPM, which provides the best balance between energy consumption and cost. An optimal liquid-to-gas (L/G) ratio of 0.9–1.0 kg/kg effectively minimizes CO_2 capture expenses while ensuring high efficiency. Furthermore, a strategic reduction in MEA solvent make-up by 10–20% could yield impressive annual savings. This is a striking contrast to the benchmark MEA-based PCC process using packed beds absorption columns, which incurs a much higher cost Our goal is to determine the set of operating parameters that will maximize CO_2 capture efficiency while minimising CO_2 capture costs for the whole RPB-based CO_2 capture process. Employing a multiple RPB absorber designs and cost-focused approach for the RPB-based CO_2 capture process, could bridge the gap between technical performance and economic viability, thus advancing sustainable carbon capture solutions.

Keywords: Post-combustion carbon capture; chemical absorption; rotating packed bed; intercooling system,;Natural Gas power plant; optimisation

---

References

[1] Jung H, Park N, Lee JH. Evaluating the efficiency and cost-effectiveness of RPB-based CO_2 capture: A comprehensive approach to simultaneous design and operating condition optimization. Appl Energy 2024;365:123251.
[2] Otitoju O, Oko E, Wang M. Modelling , scale-up and techno-economic assessment of rotating packed bed absorber for CO_2 capture from a 250 MW e combined cycle gas turbine power plant. Appl Energy 2023;335:120747.
[3] Joel AS, Wang M, Ramshaw C, Oko E. Modelling, simulation and analysis of intensified regenerator for solvent based carbon capture using rotating packed bed technology. Appl Energy 2017;203:11–25.