The Swing Adsorption Reactor Cluster (SARC) for Post Combustion CO_2 Capture: Experimental Proof-of-Principle

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Highlights

- A cluster of multistage fluidized bed reactors cycling carbonation and regeneration steps.
- Combination of temperature and vacuum swings for sorbent regeneration.
- Heat integration between carbonation and regeneration steps using a heat pump.

1. Introduction

The SARC concept is an adsorption-based technology that aims at minimizing the energy penalty of CO_2 capture. It consists of a cluster of reactors running simultaneously and alternating sorbent carbonation and regeneration steps to ensure steady state processing of a flue gas stream (Figure 1.a). Heat is transferred from carbonation to regeneration using a heat pump that can work very efficiently if the temperature difference between the two stages is minimized by applying a partial vacuum in the regeneration step.

A multistage fluidized bed reactor configuration was proposed to be used for the SARC reactor to maximize CO_2 uptake by the sorbent [1]. Heat transfer tubing, containing the heat pump working fluid, transfers heat between the reactors in the cluster. Competitive CO_2 energy penalty could be achieved using the SARC concept applied to a coal-fired power plant [1].

2. Methods

CFD simulations have shown that a 2 cm ID reactor can have a gas back mixing as low as a multistage fluidized bed reactor proposed for the SARC concept. Similar to the multistage reactor, such a narrow reactor tube will prevent the large-scale solids circulation patterns typical in bubbling fluidized beds. A 2 cm ID reactor is therefore being constructed to test different sorbents under real SARC conditions. Temperature and vacuum swings will be established in the reactor to complete the SARC cycle; a tracer and cold water are used for the temperature swing while a vacuum pump is used for the vacuum swing (Figure 1.a). polyethyleneimine (PEI) and alkali metal-based sorbents developed at KRICT will be tested in the reactor. The performance of these sorbents (in terms of CO_2 capture efficiency and CO_2 purity) under relevant SARC conditions will be quantified based on analysis of the sampled gasses at the reactor outlet.

3. Results and discussion

This study will show the SARC concept behaviour with different sorbents and will give the basis for the design and construction of a 20 cm ID SARC reactor with inserted heat transfer tubes. Experimental results will also prove the working principle of the SARC concept and identify the most suitable sorbents for subsequent demonstration tests in the 20 cm reactor.

CFD simulations have shown that the final SARC reactor configuration will have the different bed stages separated by a mesh to reduce solids back mixing and to maximize CO_2 uptake. As can be seen in Figure 3, only the case with tightly grouped internals dividing the reactor in separate stages can achieve the desired axial segregation in sorbent CO_2 loading.

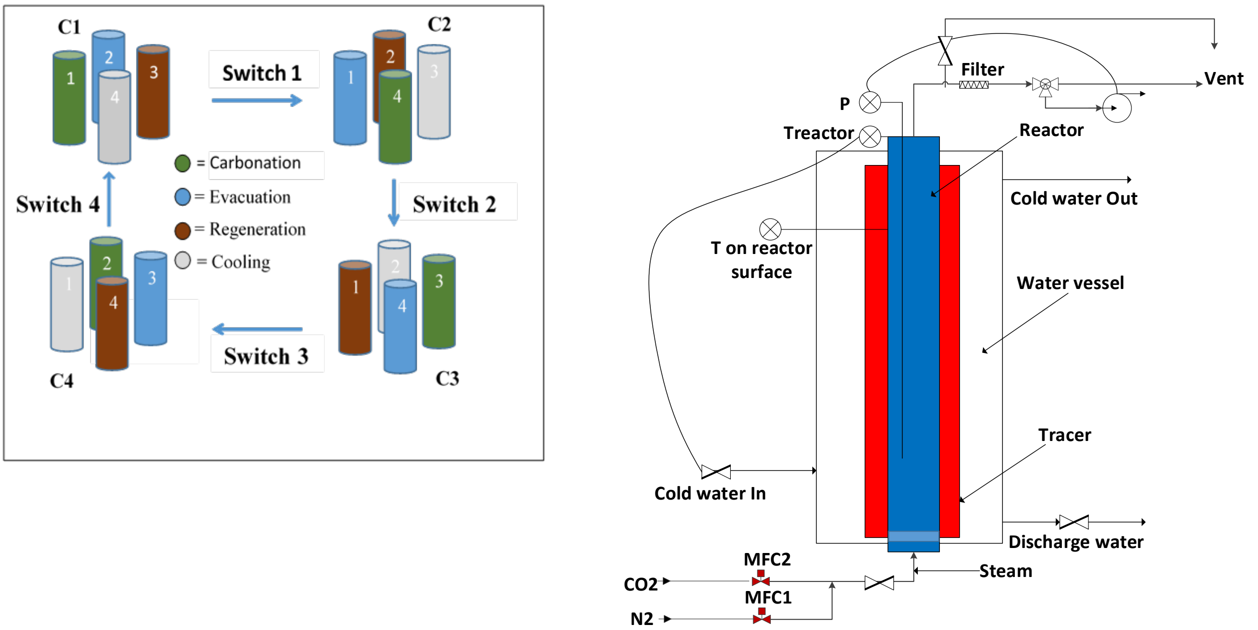

Figure 1. a) SARC reactor cluster formed of four multistage reactors for steady operation; b) P&ID of the small SARC reactor experimental set up

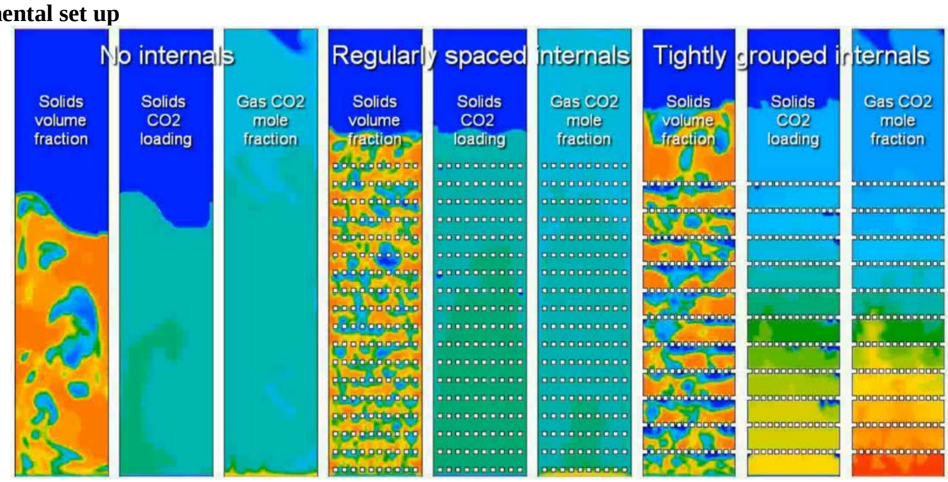

Figure 2. Snapshots from three CFD simulations of the 20 cm reactor with different internal tube arrangements.

References

1. Zaabout, A., M.C. Romano, S. Cloete, A. Giuffrida, J. Morud, P. Chiesa, and S. Amini, *Thermodynamic assessment of the swing adsorption reactor cluster (SARC) concept for post-combustion CO2 capture.* International Journal of Greenhouse Gas Control, 2017. **60**: p. 74-92.