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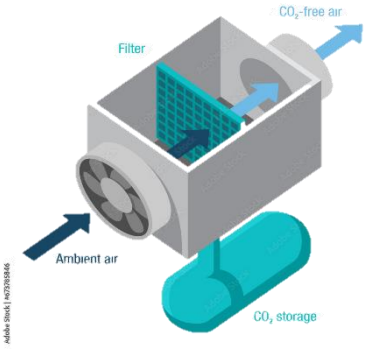
Process intensification of solid-based direct air capture using vortex technology

Aim

The objective of this work is to enhance the efficiency of solid-based Direct Air Capture (DAC) focusing on the development and evaluation of novel sorbent regeneration methods within a vortex reactor system.

Justification



Global warming calls for an emergency need for the reduction of GHG emissions. The atmospheric concentration of carbon dioxide has increased to over 400 ppm. According to Paris Agreement, the target is to achieve an increase in the global average temperature below 2 °C by the end of the century. Direct Air Capture (DAC), which refers to the extraction of carbon dioxide from the air by using either liquid or solid sorbents to capture CO_2 is a promising technology. The development of DAC has seen significant advancements, however, the overall cost is still high due to elevated energy requirements, high capital costs and need for advanced materials. In order for the technology to be viable on a large scale, this cost needs to be reduced. The main challenge that needs to be addressed is associated to the high dissolution of CO_2 in the air. The technology can be optimized in the areas of air contactors, solvents/sorbents and regeneration methods[1]. This need for process intensification (PI) of direct air capture led to the conception of this project which is based on the vortex technology.

Gas-Solid System

Vortex technology is able achieve process intensification by overcoming mass and heat transfer limitations[2]. In gas-solid systems, tangential gas injection creates a high-velocity rotating flow that enhances fluidization, overcoming traditional challenges of fluidized beds associated with gravitational forces. This rotational motion significantly improves heat and mass transfer between the gas and solid phases. It has already been confirmed that gas-solid vortex reactors have great potential for process intensification due to their advantageous hydrodynamic properties[3]. However, their performance in specific applications, such as DAC, requires further exploration. This project will focus on evaluating the adsorption-desorption cycle of various sorbents under novel regeneration methods within a vortex reactor system, paving the way for optimized and cost-effective DAC technology.

Program

- Literature study process intensification of DAC technology with focus on innovative sorbent regeneration methods.
- Experimental method development for solid-based DAC using vortex technology.
- Evaluation of sorbents and novel regeneration techniques for solid-based DAC in the vortex reactor.
- Model development of the gas-solid adsorption-desorption cycle.

1. M. Ozkan, S. P. Nayak, A. D. Ruiz and W. Jiang, *Iscience*, 2022, 103990.
2. A. Kourou, S. Chen and Y. Ouyang, *Current Opinion in Chemical Engineering*, 2024, **46**, 101056.
3. X. Lang, Y. Ouyang, S. Dutta, S. Chen, L. Li, G. Heynderickx and K. M. Van Geem, *Powder Technology*, 2023, **427**, 118749.

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