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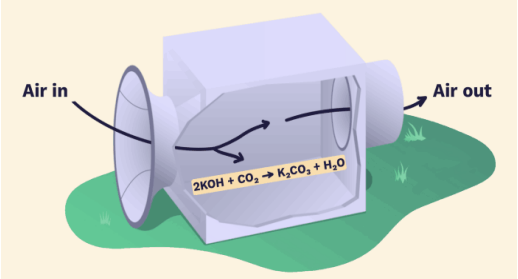
Process intensification of direct air capture

Aim

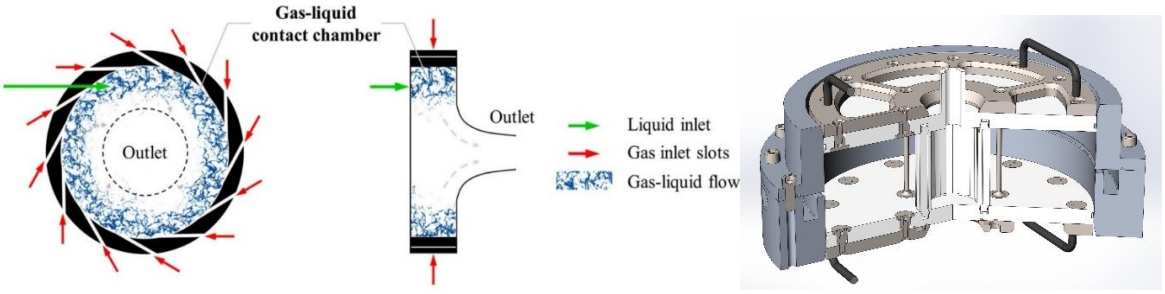
The objective of this work is to develop a process intensification technology for Direct Air Capture (DAC) based on vortex technology, by developing a process simulation embedded with a 1D gas-liquid vortex reactor (GLVR).

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 a liquid or a solid sorbent 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 high capital costs and energy requirements. 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 the high dissolution of carbon dioxide 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 Gas Liquid Vortex Reactor (GLVR) technology.

GLVR is an intensified reactor developed at the LCT (UGent), designed for gas-liquid applications. It consists of a static fluidization chamber in which the gas is injected tangentially through multiple inlet slots inducing the rotation and therefore the heat and mass transfer between the gas and liquid phase. It has already been confirmed that GLVR has great potential for process intensification due to its favorable gas-liquid hydrodynamics and micromixing efficiency[2]. When new PI equipment is developed, it does not exist in available Aspen modules. Therefore, in order to perform the unit analysis, the developed PI equipment, in which case is the vortex reactor, needs to be embedded using a user-defined module. For a comprehensive study, a process simulation and a techno-economic analysis are essential in order to completely evaluate the cost drivers of DAC and further the potential of the developed technology compared to other developed or under-developing DAC technologies. For this purpose, the Aspen Custom Modeler will be used to build a 1D process simulation embedded with a GLVR.



Program

- Literature study on the state-of-the-art DAC technology.
- Develop a 1D reactor model of GLVR that can be compiled in Aspen.
- Embed the GLVR model in Aspen Plus and develop a process simulation for DAC.
- Perform a techno-economic analysis and identify the cost drivers of DAC process.

1. M. Ozkan, S. P. Nayak, A. D. Ruiz and W. Jiang, *Iscience*, 2022, 103990.
2. Y. Ouyang, M. N. Manzano, R. Wetzels, S. Chen, X. Lang, G. J. Heynderickx and K. M. Van Geem, *Chemical Engineering Science*, 2021, **246**, 116970.

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