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Reactive CFD study of solvent regeneration in a gas-liquid vortex reactor for CO_2 capture

Aim

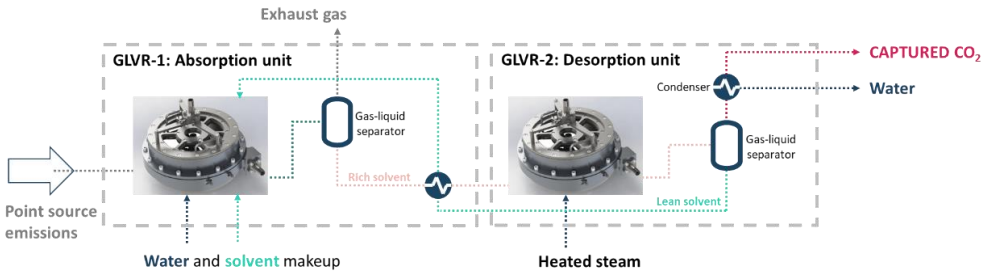
The objective of this thesis is to study the gas-liquid hydrodynamics and the reactive flow in a gas-liquid vortex reactor (GLVR) during the regeneration of a solvent used for CO_2 capture. Computational fluid dynamics (CFD) simulations will be performed.

Justification

Carbon dioxide (CO_2) is the primary cause of global warming. The use of amine-based solvents for chemical absorption in CO_2 capture has received significant attention due to its benefits, e.g. high efficiency and low cost, etc. Process intensification to achieve higher efficiencies in gas-liquid mass transfer can make CO_2 capture more cost-effective. The GLVR with the advantages of simple structure, small size and easy scale-up is a very valuable means for the process intensification of gas-liquid mass transfer processes, e.g. CO_2 capture in a solvent[2].

The entire CO_2 capture process consists of two steps: CO_2 absorption and CO_2 desorption (solvent regeneration). Previous research has shown remarkable improvement in the efficiency of the first step, CO_2 absorption, when using the gas-liquid vortex reactor (GLVR) technology. The cost of the second step, solvent regeneration, accounts for 80% of the cost of the entire CO_2 capture process[3]. Both issues are triggers to make a more comprehensive study of performing solvent regeneration in a GLVR.

The objective of this project is to investigate and evaluate the performance of the GLVR for solvent regeneration exclusively based on numerical data obtained using CFD simulations. The first step is to develop a CFD model that incorporates a heat and mass transfer model to simulate solvent regeneration in the GLVR. Next, the model will then be validated by comparing it to experimental results. Subsequently, to further improve the efficiency of solvent regeneration, the CFD model is used to examine the effect of adding different internal configurations within the vortex chamber.



Program

- Make a literature study on state-of-the-art solvent regeneration for CO_2 capture.
- Gain acquaintance with the commercial CFD package ANSYS Fluent and with coding UDF.
- Conduct CFD studies on reactive CO_2 desorption, validated with experimental data.
- Optimize the design and operating conditions of the GLVR for solvent regeneration.

1. Zhang, W., et al., Journal of Natural Gas Science and Engineering, 2020. 79.
2. Ouyang Y, et al. AIChE J. 2021:e17264.
3. Dowell, N., and N. Shah. International Journal of Greenhouse Gas Control 2013,13: 44-58.