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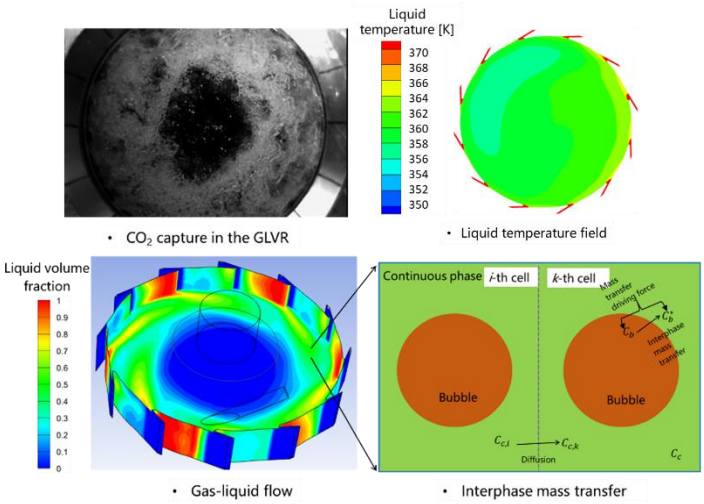
Reactive CFD study of solvent regeneration in a gas-liquid vortex reactor for the CO_2 capture

Aim

The objective of this thesis is to study the gas-liquid hydrodynamics and the reactive flow during solvent regeneration in a gas-liquid vortex reactor (GLVR) by computational fluid dynamics (CFD) simulations.

Justification

Carbon dioxide (CO_2) is the primary cause of global warming. The use of amine-based solvents for chemical absorption of CO_2 has received significant attention due to its benefits, e.g. high efficiency and low cost. Process intensification to achieve high efficiency in gas-liquid mass transfer can make CO_2 capture more cost-effective. The gas-liquid vortex reactor (GLVR) with its 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[2].



• CO_2 capture in the GLVR • Liquid temperature field

• Gas-liquid flow • Interphase mass transfer

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 CO_2 absorption using the GLVR. However, the cost of solvent regeneration accounts for 80% of the cost of the entire CO_2 capture process[3]. The latter triggers to also make a comprehensive study of solvent regeneration in GLVR, done in this project.

The objective of this project is to investigate the intensification process and evaluate the performance of the GLVR for solvent regeneration, exclusively based on computational fluid dynamics (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. The model will then be validated by comparing it to available experimental results. Subsequently, to further improve the efficiency of solvent regeneration, the CFD simulations will examine different internal configurations within the vortex chamber.

Program

- Literature study on state-of-the-art solvent regeneration for CO_2 capture.
- Gain acquaintance with the commercial CFD package ANSYS Fluent and coding UDF.
- Conduct CFD studies on reactive CO_2 desorption, validated with experimental data.
- Optimization of 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.

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