Simultaneous measurement of concentration and flow fields in CO_2 absorption process

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Abstract:

In this study, a series of concentration and flow fields in CO_2 absorption process in the vicinity of gas-liquid interface were visualized experimentally. Chemical absorption process of CO_2 was focused on, two types of alkanolamine solutions, monoethanolamine (MEA) and methyldiethanolamine (MDEA), were used as chemical absorbents.

Once the CO_2 is contacted to alkanolamine solution, the solution immediately absorbs CO_2 and diffusion process of the absorbed CO_2 begins. The solution that absorbed CO_2 was denser than the original solution, leading to gravitational convection of CO_2-rich solution downward and poor solution upward. Convective transfer is a faster transport process than diffusion process, which utilizes to enhance the CO_2 absorption rate. To evaluate the effect of the convective transfer on CO_2 absorption, it is necessary to observe the transient CO_2 absorption process, namely concentration field and the flow field at the gas-liquid interface simultaneously. The purpose of this study is to develop the simultaneous visualization system for transient concentration and flow fields of CO_2 absorption process.

The measurement system of CO_2 absorption process is developed to combine Particle Image Velocimetry (PIV) and Mach-Zehnder type phase-shifting interferometer. To visualize flow field near the surface and interior of solution pool, the rotating system of laser sheet was applied. Velocity fields at two planes, vertically and horizontally near the interface, can be measured by using this experimental system. Phase-shifting interferometer has been utilized for the visualization of small area with spatially high resolution. The proposed system could visualize flow field by

PIV and simultaneously visualize concentration field by phase-shifting interferometer. Furthermore, Total amount of CO_2 absorption was estimated from phase-shifted data.

A series of clear visualized images of concentration and flow field in CO_2 absorption process were obtained. From the result of PIV analysis, downward flow was observed near the wall of experimental cell and upward flow was observed at the central region. The flow fields of two solutions were compared, then flow velocity of MEA is faster than MDEA. It can be observed that the flow generated by negative buoyant force stirred interior of reservoir and it contributes to the enhance rate of CO_2 absorption.