Learnings from pilot plant test of a precipitating process for CO$_2$ scrubbing from flue gas

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Abstract
The first pilot campaign with SINTEF’s precipitating absorbent PAS6 was carried out during Sept. – Oct. 2017 using a packed and a plate column arranged in series. Campaign was preceded by upgrade of the existing infrastructure to enable a precipitating process capture that include the design, fabrication and installation of a slurry handling model. In-absorber solvent precipitation during CO$_2$ capture has been demonstrated in this campaign. Several operational, science and engineering experience were gained. Results show that precipitate crystals dissolve within 65°C providing opportunity for industrial waste (low-grade) heat utilization in part of solvent regeneration.

1. Introduction

A CLIMIT-Demo project INSPIRE aims at validation and demonstration of an innovative process for CO$_2$ capture, by integration of a novel solvent developed at SINTEF Materials and Chemistry (SINTEF) and novel contactor developed at Westec Environmental Solutions (WES). An output from the international collaboration between SINTEF, WES and CMC RI will be a CO$_2$ capture technology ready for further upscale and larger scale demonstration at the Technology Centre Mongstad, TCM (Norway) or at the National Carbon Capture Center, NCCC (USA) or a selected industrial site.

1.1. Background and motivation

Phase-changing, solvent systems have been identified as one of the emerging post combustion technologies with potential to significantly reduce cost of CO$_2$ removal [1] [2]. Lower specific reboiler duty could be achieved with precipitating solvent systems as cycle capacity is enhanced by higher driving force at high loading and lower capital cost maybe achieved with novel contactors that can enhance mass transfer through froth formation concept [3].

This work presents learnings, experiences and results from the first of three pilot plant demonstrations in this project. The SINTEF/NTNU Gløshaugen pilot is first equipped with a plate column, slurry reactor, designed by SINTEF to allow precipitation in the absorber during CO$_2$ absorption. In the second demonstration, a novel WES contactor [4] is deployed in the pilot plant for testing.

The campaign objectives include:
- Design and fabrication of a slurry handling units for the SINTEF/NTNU pilot plant
- Modification and implementation of new units necessary to operate a precipitating phase change system in the existing pilot plant
- Demonstration of an in-absorber precipitating process for CO$_2$ scrubbing from flue gas
- Investigate the possibilities for the use of waste heat for solvent regeneration.
- Gain science, engineering and operational experience from the preliminary pilot campaign

2. Pilot plant test

The precipitating CO$_2$ capture process campaign is carried out in the SINTEF/NTNU lab pilot plant. The pilot plant was a combined column/membrane contactor plant, and has since been used to test a lot of different
solvent systems, e.g. MEA [5], potassium sarcosine [6], and liquid-liquid phase change system [7]. This plant is now modified for a precipitating CO₂ capture process to enable in-absorber precipitation by installation of slurry handling units, in yellow, as shown in the block diagram (see Figure 1).

The pilot plant has absorber of 0.15 m diameter equipped with 4.23 m Sulzer BX structured packing and a desorber column of 0.1 m diameter with 3.57m packing height of the same packing material as in the absorber. Its capacity is 150m³/h and 540kg/h of gas and liquid flow respectively. The plant uses synthetic flue gas and is operated as a closed system pilot plant where both gas and liquid are recycled. It has produced CO₂ capacity of 10kg CO₂/h.

Figure 1 Block diagram of the lab-pilot plant showing existing (gray) and implemented (yellow) infrastructure for precipitate process demonstration.

3. Results
Experiences and learnings with in-absorber precipitation during CO₂ capture including slurry handling unit selection and design are presented. Test results including, capture efficiency, loading and cycle capacity from the campaign for a precipitating CO₂ absorption are presented. Crystal formation, dissolution and particle size distribution including energy use for precipitate dissolution with respect to industrial waste heat utilization are presented. Figure 2 show image from in-absorber precipitation while Figure 3 show temperatures and energy use in the dissolution section during the campaign.
Figure 2: In-absorber solvent precipitation during test campaign.

Figure 3: Temperatures and heat duty in the dissolution section.

4. Conclusions

Existing SINTEF/NTNU Gløshaugen pilot plant was upgraded for slurry handling after a slurry-handling unit has been designed, fabricated and installed. In-absorber solvent precipitation during CO₂ capture was demonstrated in this pilot demonstration campaign. Several operational, science and engineering experience were gained. Results show that industrial waste (low-grade heat) can be utilized in part of solvent regeneration.
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References


