Emission counter-measures in post-combustion CO_2 capture: Demonstration at pilot plant scale

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Keywords: pilot plant, emissions, counter-measure, acid wash, aerosols

ABSTRACT

One of the objectives of the OCTAVIUS project is the demonstration of emission counter-measures for post-combustion CO_2 capture. To accomplish it, an acid wash was designed and commissioned at TNO's CO_2 capture pilot plant, which is connected to a coal-fired power plant.

TNO's pilot plant is located at Maasvlakte (The Netherlands) and is connected to E.ON's coal-fired power plant. The power plant produces between 4 and 7 kton of flue gas, from which a small stream is taken and directed to the CO_2 capture pilot plant. This pilot plant can capture approximately 250 kg/h of CO_2 using a typical amine scrubbing system.

When using monoethanolamine (MEA) as solvent for post-combustion CO_2 capture, it is known that ammonia (NH_3) is produced by the reaction of dissolved oxygen with the amine (known as oxidative degradation). Ammonia is a volatile component and its emission must be controlled for SHE reasons. By adding a water-wash on the top section of the absorber, the temperature of exiting flue gas can be controlled, reducing the emissions of NH_3 and vapour MEA. However, with a single water wash, some emission can still occur. Therefore, an acid wash was installed to further reduce this emission.

The acid wash was designed in Aspen Plus® in order to determine the packing height necessary to remove 90% of 10 mg NH_3/Nm^3 of flue gas. The installed system consisted of a fixed-bed column with 1.26 m of structured packing (Sulzer). The flue gas flow through the acid wash was approximately 720 Nm^3/h with the rest of the settings variable. The standard settings were 50 L/min liquid flow, pH 3 (H_2SO_4) and constant liquid and gas temperatures of 40 °C (same as absorber flue gas outlet).

Figure 1 shows the acid wash before being connected to the pilot plant.

Figure 1. Drawing and picture of the acid wash

An FTIR (provided by Laborelec) took samples of the gas phase before and after the acid wash (switching every 30 min). In this way, the concentrations of NH_3 and MEA in the gas phase could be monitored on-line to evaluate the efficiency of the acid wash. During the testing campaign, several settings were varied, including liquid flow, gas flow, acid strength (pH) and temperature. For some of the settings, additional NH_3 equivalent to total of 150 mg/Nm^3 was injected into the flue gas to test the acid wash under extreme conditions.

Figure 2 shows the reduction of NH_3 emissions at different acid strengths (pH), for experiments carried out with and without additional NH_3 spiking of the flue gas. For all experiments in which the acid had a pH below 5, the NH_3 at the outlet remained below 2 mg/Nm^3 (efficiency ~99 % for experiments with spiking). For pH ~ 7, the NH_3 at the outlet was 11 and 8 mg/Nm^3 for experiments with and without spiking, respectively. For the experiment with spiking, this NH_3 outlet concentration still meant 92 % removal efficiency; whereas, for the non-spiked experiment, the removal efficiency was only 16 %. For experiments at pH 8 (starting with water and not adding any acid), when spiking was applied, the capture efficiency was reduced to 18%. For experiments at pH 8 without spiking, steady-state was not reached and at some point of the experiment, NH_3 was even being desorbed from the solvent back to the flue gas due to the limited solubility of NH_3. The data obtained from this work will be used to validate and fine-tune the models already available so as to facilitate scale-up.

TNO's capture plant has the possibility to operate in two ways: with and without aerosol emission. This advantage was taken as an opportunity to evaluate the efficiency of the acid wash to reduce MEA aerosol emissions. The results are being processed and will be discussed in the paper/presentation.

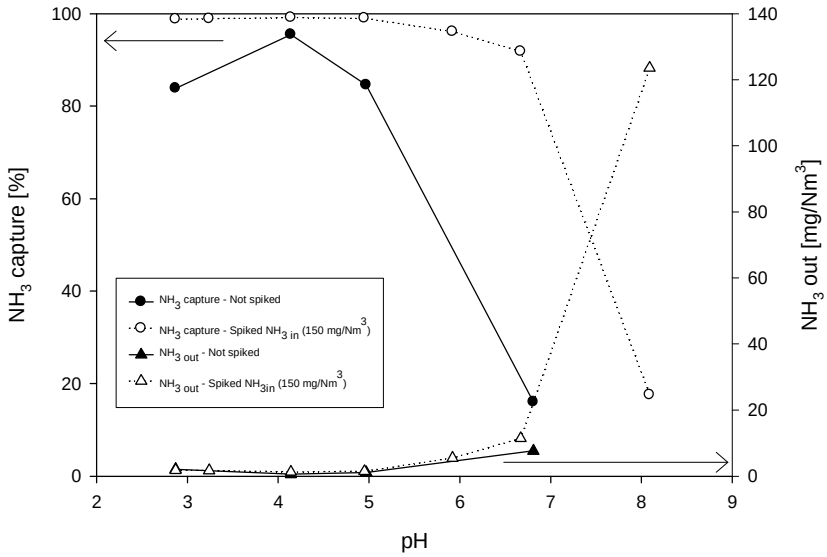

Figure 2. Ammonia removal efficiency and concentration of ammonia at the acid wash outlet at different acid strengths (pH). Data shown for experiments with and without additional NH_3 spiking of the flue gas.

The research leading to these results has received funding from the European Community's Seventh Framework Programme FP7 under grant agreement n° 295645 (OCTAVIUS).