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Revamping and operation of a CO_2 capture pilot by amine absorption in simulated industrial conditions at CRM group

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Abstract

CO_2 capture is regarded as the ultimate step for limiting unavoidable CO_2 emissions in the industry. As such, it is the main focus of the HECO2 Saturn project which brings together the main sectors of the heavy industry in Wallonia (lime, glass, stainless steel and chemical industries) with two universities, a few SMEs and an applied R&D centre, CRM Group.

In the frame of this project, an old pilot absorption plant at CRM Group was revamped into a modern multi-solvent pilot with a high degree of instrumentation. This plant will be used to assess absorption capture costs in the conditions of industrial partners, by precisely recreating these conditions, including gas composition, pressure, temperature, and potentially pollutants and dust.

Revamping of the existing capture plant at CRM Group

Dated from the end of the 80's, this plant was part of a much larger facility dedicated to coal liquefaction. It was initially designed to capture CO_2 and H_2S from the incoming gas using MDEA (25%) at high pressure on the absorber side (10-50 bar). As an utility in a larger facility, it was equipped only with minimum sensors and automation.

The first step to revamp and modernize this capture plant was to carry out a complete assessment of the existing equipment. The absorber column was cleaned and left with its original packing (Melapak 250X) but the stripper was upgraded, notably by adding a top washing section for recycling the condensates. Most of the pipes and pumps were replaced and more than 120 sensors/measurement instruments were added to allow a fine tuning of process conditions. The original automation was fully replaced with a state-of the-art system.

A unique feature of this pilot is the tailor- made production of the inlet gas stream, which is assembled by mixing pure gases (CO_2, CO, H_2, CH_4, N_2, O_2, …), then by adjusting pressure, temperature and moisture. This allows us to test CO_2 capture on literally any type of industrial fumes or on pressurized pre-combustion gases (e.g. syngas from gasification plants), industrial gases (e.g. blast furnace gas), etc. In order to limit the consumption of pure gases, the outlet streams from the two columns are re-combined and recycled through a necessary blower and a pre-conditioning column. Another feature of that plant is the separated heat exchangers for rich and lean amine flows (no double flow heat exchanger as in conventional amine capture plants). This allows the process to be started-up faster and additional energetic options to be studied.

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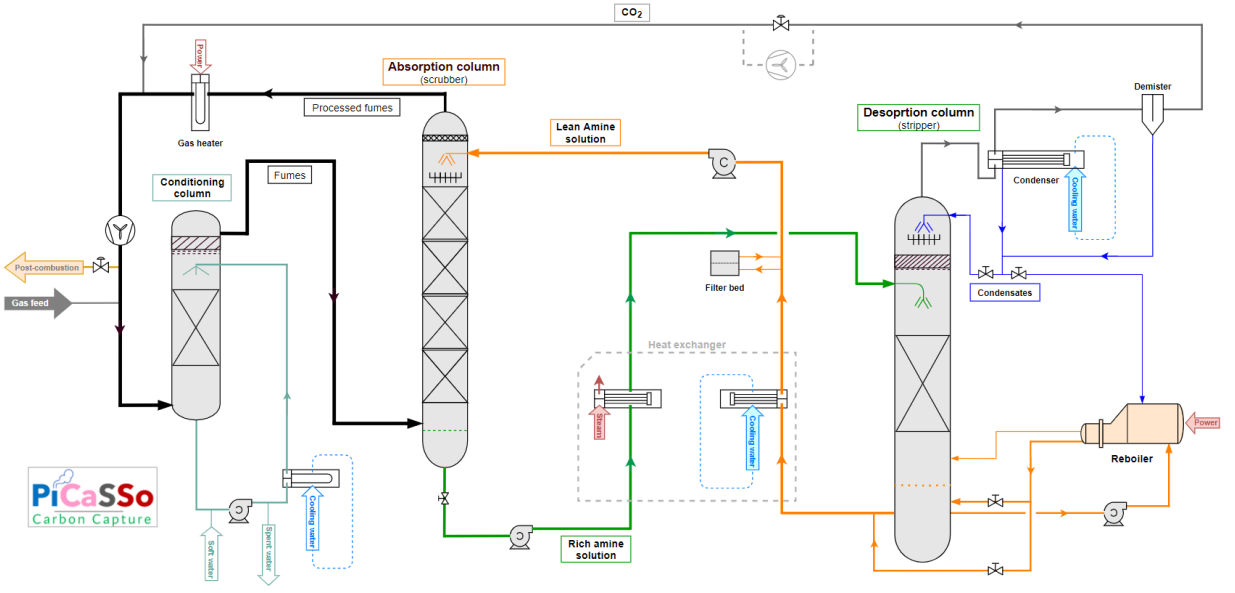
The main characteristics of this plant are as follows: 400 to 800 Nm³/h inlet gas capacity, 6 barg maximum pressure at absorber, 0.5 to 3 t/h solvent flow and 50 to 200 kg/h CO_2 captured (5 tpd unit).



Simplified flowsheet of PICASSO pilot plant

Specification of industrial capture conditions

In the frame of the HECO2 Saturn Project, the pilot plant will be used to precisely assess absorption capture costs in the conditions of each industrial partner, i.e. the lime, glass, stainless steel and chemical industries.
In each partner plant, CRM group scrutinised emission sources for flow, composition, pollutants and variability. When multiple sources were present, a selection was carried-out to maximise capture with minimum capture efforts and costs. For sources exhibiting high variability in flow or composition, specific technical solutions were designed to buffer fluctuations and facilitate capture.

Operation of the capture plant

The new pilot plant was successfully commissioned at CRM group and the tests in industrial conditions are under way. The exact industrial conditions are simulated not only by reproducing the main composition of the fumes, but also by injecting small amounts of specific pollutants (SO_X, NO_X, NH_3, etc) or fine dust in the inlet gas, when these are regarded as potentially having an impact on the capture process.

In agreement with project partners, 3 conventional solvents will initially be tested: conventional MEA 30% as reference, CESAR-1 (AMP/PZ) as new benchmark, then activated MDEA (MDEA/PZ) as a conventional alternative. Others solvents will be tested later, following the preferences of industrial partners and their contacts with technology suppliers for a possible future implementation in their plant(s). First results of the capture tests will be presented in the full paper.

Keywords : CO_2 capture; amine absorption; pilot plant; post-combustion capture; pre-combustion capture