Study of the post-combustion CO_2 capture applied to conventional and partial oxy-fuel cement plants

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Carbon dioxide emitted from the cement industry represents 30% of the total annual CO_2 released by the industrial sector. Reducing carbon dioxide industrial emissions became one of the most investigated issues nowadays. For this purpose, it is necessary to optimize the application of Carbon Capture and Storage (CCS) or Carbon Capture and re-Use (CCU) to all the major CO_2-emitting industries. The present communication is focusing on the application of CCU to the cement industry, more specifically on the CO_2 capture step.

The objective of this work is to test the applicability to the cement industry of an innovative capture technique called partial oxyfuel combustion capture. This technology combines a O_2-enriched air combustion involving a CO_2 more concentrated flue gas (20 %<y_{CO2}<70 %) compared to a conventional combustion and allowing the application of a CO_2 post-combustion capture using amine solvents. Indeed, thanks to a more CO_2-concentrated flue gas and the choice of an adequate solvent, this process assures a decrease of the regeneration energy [1-3] in the amine plant (compared to the conventional post-combustion) as well as reducing the cost of O_2 production (O_2-enriched air) in the Air Separation Unit (ASU) compared to total oxyfuel conditions (pure O_2).

In our first studies, the performances of several solvents were evaluated thanks to continuous tests carried out at lab scale (cables-bundle contactor) considering high CO_2 contents ($y_{CO2,in}$ = 20-60 vol.%). Simple and activated solvents were screened in such conditions and compared: primary alkanolamines (Monoethanolamine (MEA)), secondary alkanolamines (Diethanolamine (DEA) and Methylmonoethanolamine (MMEA)), tertiary alkanolamines (N-methyldiethanolamine (MDEA)), sterically hindered amines (2-amino-2-methyl-1-propanol (AMP) and 2-amino-2-hydroxylmethyl-1,3-propanediol (AHPD)), cyclical di-amines (Piperazine (PZ)) and non-cyclical tetramines (Triethylenetetramine (TETRA)). Based on the results obtained at lab scale [4], semi-continuous tests at micro-pilot scale (Fig. 1) were conducted for the best solvents screened and results were confirmed (Fig. 2): for the simple solvents, the system MMEA 30% presents the best absorption performances and the use of the activated solutions of AMP or DEA with PZ 5 wt.% leads particularly to high absorption performances both in conventional and high CO_2 contents conditions, the performances becoming even better than conventional solvents such as MEA 30 wt.% (all values are taken once the regime phase of the test is achieved). Simulation tests of the micro-pilot unit using Aspen Hysys software V8.8 for MEA 30% and experimental results (Fig. 3) for all the solvents showed that **the regeneration energy decreases when increasing the CO_2 content in the gas to treat.**

As a prospect, further works will present for the most performant solvents, a complete and optimized study including both the energy costs associated to the O_2 production (ASU) for the partial oxy-fuel conditions and the costs (OPEX and CAPEX) of the post-combustion CO_2 capture process applied in the cement industry.

References

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Figures

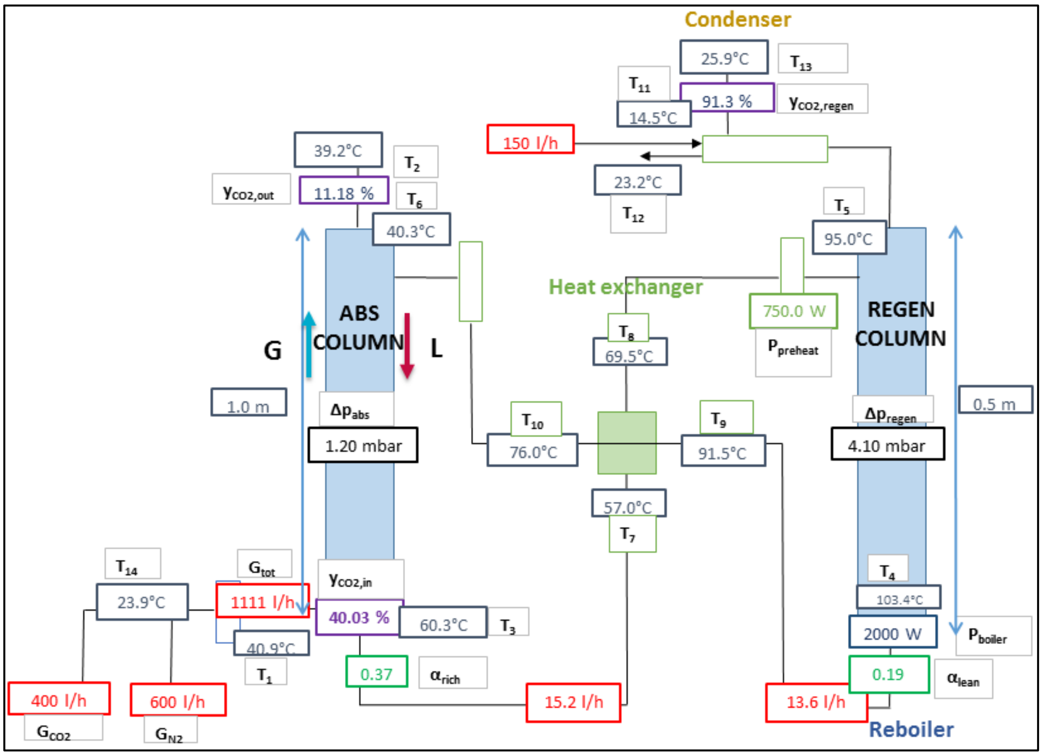

Figure 1: *Scheme of the absorption-regeneration micro-pilot unit*

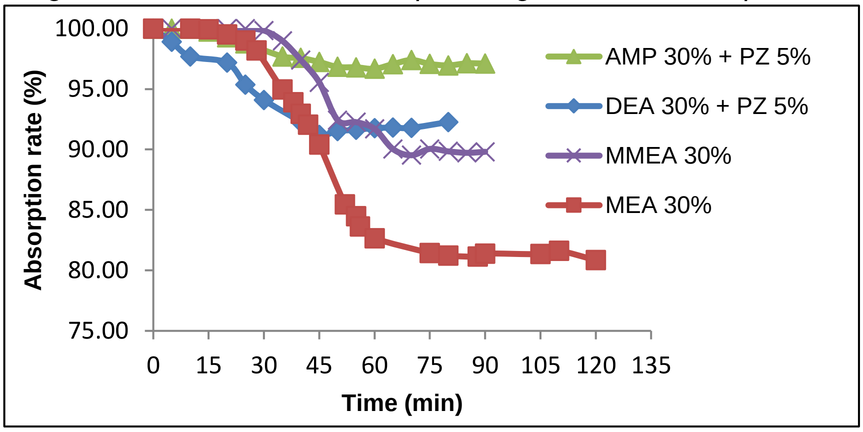

Figure 2: *Best absorption performances at micro-pilot scale for $y_{CO2,\ in}$=40% (L= 14 l/h; G= 1111 l/h)*

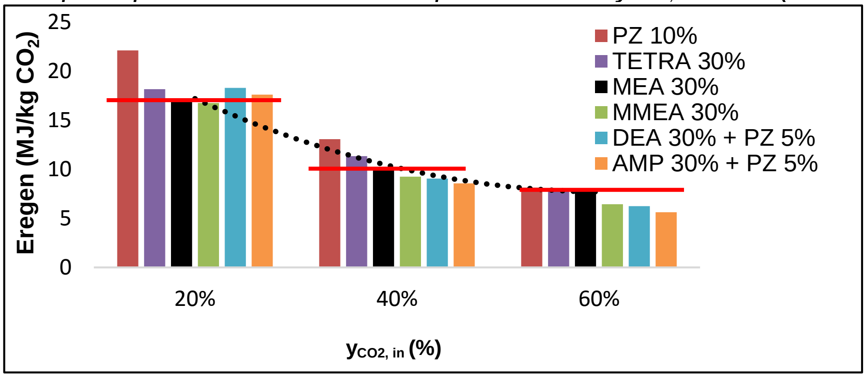

Figure 3: *Comparison of the regeneration energies of the solvents for each $y_{CO2,in}$*