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Membrane contactors for intensified post combustion carbon dioxide capture by gas–liquid absorption in MEA: A parametric study

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ABSTRACT

Post combustion carbon dioxide capture raises tremendous chemical engineering challenges. For the first generation of industrial installations, gas liquid absorption in chemical solvents is classically considered to be the best available technology. Two major bottlenecks have however to be solved in order to achieve technico-economical targets: decrease the energy requirement of the process (e.g. through novel solvents or heat integration approaches) and decrease the size of the installation (through process intensification).

This study intends to explore the possibilities and limitations of membrane contactors, which are considered as one of the most promising strategy for intensified CO_2 capture by gas–liquid absorption. A very large number of studies is continuously reported on this topic, including materials, mass transfer or process design issues, but a rigorous evaluation of their effective potential in terms of intensification is still lacking. Moreover, controversial results have been reported such as intensification factors, compared to packed columns, ranging between 10 and 0.8 on a total unit volume basis.

This unclear situation results from different factors. First, experimental comparison of membrane contactors vs. packed absorption columns performances is indeed seldom. Second, the evaluation of membrane contactors is systematically performed at laboratory scale, under operating conditions which do not necessarily reflect industrial operation (i.e. fresh amine solutions are used, limited capture ratio are achieved). These simplifying assumptions have obviously to be reconsidered if a realistic comparison for industrial operation is aimed. More importantly, pressure drop levels, which are known to be very small for packed columns (typically 50 mBar on the gas side for an industrial packed column), have to be considered in order to minimize the energy impact of the process. An analysis combining intensification and pressure drop aspects for membrane contactors design, with solvent flowing inside the fibers, and the associated trade-off, which, to our knowledge, has not been achieved for CO_2 absorption, is presented based on experimental and simulation results. Practical guidelines on the set of conditions for membrane materials (i.e. permeability and thickness), fiber geometry (external diameter, thickness) and module design (length, packing factor) which enable a significant process intensification effect are finally proposed.

Keywords: Gas absorption; Carbon capture; Membranes; Contactor; Intensification; MEA

1. Introduction

The capture of carbon dioxide from large emission sources for storage purposes is intensively investigated as a key mean in order to mitigate greenhouse gases emissions (Davidson and Metz, 2005). This strategy, classically referred as CCS (for carbon capture and storage) raises tremendous engineering problems. It includes indeed a large variety of situations and processes, through three major steps of the technological chain: CO_2 capture and compression thanks to a separation process, transport (most often in a pipe) and geological storage in an appropriate location. For instance, the storage framework addresses numerous unsolved questions, such as the prediction of the CO_2 leakage rate from a given geological

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