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EXPERIMENTAL AND MODELING OF CO_2 REMOVAL FROM GAS MIXTURES USING MEMBRANE CONTACTORS PACKED WITH GLASS BEADS

by

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Abstract

Natural gas is one of the major natural resources in UAE which carries significant amounts of acid gases. For the purpose of utilizing or liquefying, the gas must be pre-treated by separating the major non-hydrocarbon gases, namely CO_2. Typical CO_2 separation processes involve separation using sorbents or solvent, cryogenic or membrane. Among these processes, the chemical absorption considered to be the most effective process to remove CO_2. However, this process carries several drawbacks such as flooding, foaming, entraining, channeling, and most importantly high capital and operating costs. An integrated unit called gas absorption membrane (GAM) consists of combining chemical absorption process with membrane contactors has also been investigated. The heat exchanger concept is being applied by membrane gas absorptions where it allows the indirect contact between the two fluids; the gas mixture flows in the inner side of hydrophobic microporous membrane fibers while the liquid absorbent flows in the outer side of the microporous membrane. At the pores opening of the membrane, a gas-liquid interface is formed where the gas is being absorbed and reacted. The aim of this study is to investigate the performance of gas absorption membrane (GAM) in capturing carbon dioxide at elevated pressure (up to 25 bars) in which the shell compartment is packed with glass beads. The purpose of packing is to enhance fluid mixing and reduce resistance in the liquid phase. Two commercial microporous hollow fiber membranes (PFA and PTFE) were used in this investigation. Different parameters were studied and compared with modules without beads; these parameters include the effect of gas and liquid flow rates, solvent type (NaOH, MEA, EDA, DEA, and DETA), inlet solvent concentration and beads size. All these parameters were studied as a function of pressure. Additionally, the overall mass transfer coefficients obtained from the experimental data were compared with those of the modeling. The results indicated up to % 20 improvements in % CO_2 removal in packed modules as compared with the modules without beads. As expected, increasing the gas flow rate had a negative effect on % CO_2 removal while increasing solvent inlet concentration enhanced % CO_2 removal. Increasing the inlet liquid flow rate and the type of solvents had almost no effect on % CO_2 removal. Decreasing the beads size increases the solvent velocity in the module and thus increases the % CO_2 removal. The experimental overall mass transfer coefficient agreed well with those calculated from the theory which proves the reliability of experimental data.

Keywords: Carbon dioxide, hollow fiber membrane contactors, Absorption, microporous hollow fiber membranes, gas-liquid interface.