NUMERICAL SIMULATIONS ON CARBON DIOXIDE ABSORPTION BY ALKANOLAMINE SOLUTIONS IN HOLLOW FIBER MEMBRANE CONTACTORS

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Summary

The shell side fluid flow is usually characterized as a plug flow model or by the utmost Happel's free surface theory which represents some shortcomings due to the randomly spacing and arrangement of the fibers in the cartridge. This paper presents mathematical and numerical investigations on the gas-liquid absorption of carbon dioxide in alkanolamine solutions in a hollow fiber membrane contactor device. The reactive absorption mechanism was built based on computational fluid dynamics (CFD) of momentum and mass transport conservation laws in all three compartments involved in the process, i.e. the gas phase, the membrane barrier and the liquid phase. The liquid absorbing solution is flown in the fiber bore in which the velocity is assumed to obey a fully developed laminar flow, and the gas mixture is circulated counter-currently to the liquid flow in the shell side where the velocity is characterized by the Navier-Stokes momentum balance equations. The rigorous model consisting of a set of highly non-linear partial differential equations is rewritten in dimensionless form and numerically solved. The model allows predicting the liquid concentration in the fiber compartment, and the gas velocity and concentration profiles in the shell side all in radial and axial directions. The average outlet gas and liquid concentrations, the reactive absorption rates, and the gas removal efficiencies are parametrically simulated with operational parameters such as gas and liquid flowrates, fresh inlet gas and amine concentrations.

Keywords: Carbon dioxide removal, Hollow fibre membrane, Reactive absorption, Mathematical modeling, Navier-Stokes momentum equations.

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