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Review Article

Wetted Wall Column: Review on Studies and Investigations

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ABSTRACT

The mass transfer coefficients are strongly dependent on diffusivity. The diffusion along with convection explains mechanism of mass transfer coefficients. Various theories predict different dependence on diffusivity. Film theory, surface renewal theory, surface stretch theory etc. predict direct relation between mass transfer coefficients and diffusivity, though in different magnitude. The wetted column is normally used to study mass transfer coefficient in laminar region. Gas absorption with different solvents has been studied by various investigators. Studies indicated that lower cost, less toxicity of potassium carbonate can be advantage over monoethanolamine (MEA). The major drawback is low absorption rate owing to poor mass transfer. It was found that fluid flow rates and temperature had significant effects on the variables studied.

Key words: Mass transfer coefficient, diffusivity, temperature, pressure.

INTRODUCTION

Mass transfer studies include studies on diffusion and mass transfer coefficient. The mass transfer coefficients can be local or overall. Diffusivities of gases and liquids are differently dependent on temperature, pressure, molecular weights and interactions. [1-3] The laminar and turbent nature of flow causes wide range of values for mass transfer coefficients. [4-7] The mass transfer coefficients are strongly dependent on diffusivity. The diffusion along with convection explains mechanism of mass transfer coefficients. Various theories predict different dependence on diffusivity. Film theory, surface renewal theory, surface stretch theory etc. predict direct relation between mass transfer coefficients and diffusivity, though in different magnitude. The wetted column is normally used to study mass transfer coefficient in laminar region. Gas absorption has wide application in recovery and pollution control. [8-10] Gas absorption with different solvents has been studied by various investigators. Also modeling of the process and simulation has been reported. Current review summarizes research and studies on wetted wall column.

WETTED WALL COLUMN: REVIEW ON STUDIES AND INVESTIGATIONS

Ghosh et. al. carried out investigation on absorption of carbon dioxide in aqueous ammonia solution in a wetted wall column. [11] They assumed CO_2 absorption as pseudo first order reaction. They expressed the CO_2 molar flux as a function of partial pressure of CO_2, concentration of aqueous ammonia, temperature and gas-liquid contact area. They carried out experiments with gas mixture which was flue gas from typical coal fired power plant. They contacted the rich gas with the lean solvent. They applied Laplace Model to solve the partial differential model equation. They developed a mathematical model. This mathematical model was useful for studying effect of the

parameters like the concentration of aqueous ammonia, partial pressure of CO_2, temperature and gas-liquid contact area. Rodriguez et. al. used solutions of Alkanolamines for absorption of carbon dioxide in wetted wall column. [12] In their work, they investigated mass transfer parameters in different alkanolamines solutions. They performed absorption experiments in individual alkanolamines aqueous solutions and their respective blends. They determined effective interfacial area. In the experiments they used monoethanolamine (MEA) and 2-amine-2-methyl-1 propanol (AMP). They found that the average overall volumetric coefficients of mass transfer of the MEA was higher that of AMP.

Thaker and Varma, in their investigation, studied process modeling, simulation and design of multi pass falling film desorber. [13] In their investigation, they used two pass falling film columns. In their work they proposed a diffusion based mathematical model. This mathematical model was used by them to estimate effect of film thickness and column height on concentration of dissolved gas. They used MATLAB for simulation, which yielded results, in agreement with experimental data. Thee carried out an investigation on reactive absorption of carbon dioxide into promoted potassium carbonate solvents. [14] The most widely used technology for CO_2 removal is reactive absorption of CO_2 into amine solvents. Lower cost, less toxicity of potassium carbonate can be advantage over monoethanolamine (MEA). The major drawback is low absorption rate owing to poor mass transfer. According to him, development of a non-toxic and affordable promoter can encourage the use of potassium carbonate solvent systems for CO_2 capture. His studies indicated that an addition of a small amount of boric acid can accelerate the apparent pseudo-first-order rate constant. Solae et. al. carried out CFD studies of simulation of multiphase flow in structured packing's. [15] They carried out investigation on the effective area and the created liquid film in the structured packings. According to these studies, gas and liquid flow rates play significant role in the effective interfacial area of the packing. In complex geometries, CFD can play important role to provide information on the details of gas and liquid flows.

Grunig et. al. carried out an investigation on the multiphase flow inside the packing made up of wetted wire. [16] They also carried out experiments on liquid films on a single vertical wire in a counter current gas flow. They determined gas-side mass transfer by measuring the evaporation of water and aqueous polyvinylpyrrolidone solutions into air. The desorption of CO_2 from water into air was considered as measure of liquid-side mass transfer. They observed that mass transfer coefficients obtained were comparable to those appearing in common structured packings. They concluded that the wetted wire packing were suitable for absorption processes where a low pressure drop is favorable. Olutoye and Mohammed carried out investigation on packed column absorption for carbon dioxide-sodium hydroxide system. [17] They formulated a mathematical model and simulated the model by using a software. They used gravimetric methods for estimation of the total concentration of carbonate and hence the amount of carbon dioxide absorbed. Their experimental and simulated results indicated that the formulated model was a good representation of the system.

Jian et. al. carried out investigation on a wetted-wall column for SO_2 absorption. [18] They carried out modeling and simulation for absorption with aqueous ammonia solution. In their investigation, they determined the liquid-phase mass transfer coefficient and gas-phase mass transfer coefficients. They solved the model equations with appropriate boundary conditions and the valuation of the model parameters. They observed that numerical results were in good agreement with experimental results. Servia et. al. carried out studies on CO_2 absorption in a wetted

wall column. [19] In their investigation, they used piperazine solutions. Their emphasis was on modeling of the CO_2absorption.A rigorous two hydrodynamics and thermodynamics. In their work, they also investigated the gas-side mass-transfer coefficient.

Pantzali et. al. carried out research on hydrodynamic characteristics of the liquid layer during counter-current flow in inclined small diameter tubes. [20] They carried out experiments with different inclined angles. They found that considerable damping of the roll-wave amplitude due to rise in viscosities, delayed flooding initiation. Under conditions approaching flooding, significant changes were observed in liquid film. According to them, the electro-diffusion method was a useful non-intrusive tool for monitoring the instantaneous changes of the film thickness.

According to studies carried out by Roces, there is a direct proportionality between the concentrations of the solvent used and the percentage CO_2 absorbed. [21] They carried out an investigation by varying concentrations of sodium glycinate solutions at constant flow rates and temperature using a wetted-wall column. They expressed need to the allot more time for the solvent and the flue gas to reach equilibrium. Also they found that fluid flow rates and temperature had significant effects on the variables studied. Stec et. al. carried out investigation on the post-combustion CO_2 capture process. [22] They studied a standard system for chemical absorption-based CO_2 capture. Their studies indicated that split-flow modification coupled with a new solvent can decrease the energy demand to a considerable extent.

CONCLUSION

Various theories predict different dependence on diffusivity. Film theory, surface renewal theory, surface stretch theory etc. predict direct relation between mass transfer coefficients and diffusivity, though in different magnitude. The wetted column is normally used to study mass transfer coefficient in laminar region. Gas absorption with different solvents has been studied by various investigators. Studies indicated that lower cost, less toxicity of potassium carbonate can be advantage over monoethanolamine (MEA).Studies indicated a direct proportionality between the concentrations of the solvent used and the percentage CO_2 absorbed.

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