IN THE NAME OF GOD

MATHEMATICAL MODELING AND EVALUATION OF CO_2 ABSORPTION BY K_2CO_3 SOLUTION IN TURBULENT CONTACT ABSORBER

BY

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TO MY DEAR TEACHER Mr. REZA SHAMI WHO

TAUGHT ME

HOW TO LIVE AND FOR WHAT I SHOULD LIVE

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ABSTRACT

MATHEMATICAL MODELING AND EVALUATION OF CO_2 ABSORPTION BY K_2CO_3 SOLUTION IN TURBULENT CONTACT ABSORBER

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The aim of this thesis is simulation of process for carbon dioxide absorption from a Turbulent Contact Absorber (TCA). For this purpose mass and momentum balance equations are written for a TCA. Then these equations are solved numerically by considering system conditions. In order to solve these equations numerically a computer program are written in Turbo Pascal language. To check the accuracy of the results experimental data were needed, but unfortunately there weren't any published experimental data in the literature. So we use a pilot scale turbulent contact absorber, which is located in unit operation labratory. of chemical engineering department - Shiraz university. To analyze carbon dioxide concentration a gas-analyzer is used.

Obtained results show the excellent rate of absorption and good efficiency of TCA in comparison with fixed beds.

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LIST OF SYMBOLS

Symbol

Δp	Total pressure drop
g	Acceleration due to gravity (9.807 m/s^2)
H_s	Static bed height (m)
d_{sp}	Diameter of spheres (m)
D	Internal diameter of the tower (m)
Ga	Gallilo number ($(g\, d^3{sp}\, \rho^2{}_{sp}) / \mu^2{}_l$)
Fr	Froude number ($u_l / (g\, d_{sp})^{1/2}$)
Re	Reynolds number ($\rho u\, d_{sp} / / \mu_l$)
We	Weber number ($d_{sp} u^2\, \rho / \sigma$)
u	Superficial liquid velocity (m/s)
U_{mf}	Minimum fluidization gas velocity of irrigating particles (m/s)
a_t	The ratio of the surface area of a packing to volume of it (m^{-1})
w_1	Width of column (m)
w_2	Length of column (m)
H	Height of channel (m)
Q	Liquid flow rate (m^3/s)
K	Constant of reaction

C	Concentration (mol / m^3)
J	Fick's diffusivity (mol / m^2.s)
A_i	Constant of eq. (4-4)
B_i	Constant of eq. (4-4)
C_i	Constant of eq. (4-4)
D_i	Constant of eq. (4-4)
E_i	Constant of eq. (4-4)
V	Velocity (m / s)
P	Pressure (pa)

Symbol

Greek letters

ρ	Density (Kg/m^3)
ε_{sp}	Void Fraction of spheres in dry static bed
f	Fraction of free open area of the bottom supporting
d	Equivalent diameter of free open area (m)
D	Internal diameter of the tower (m)
σ	Surface tension (N/m)
μ	Viscosity (kg / m.s)
υ	Cinematic viscosity (m^2 / s)
Δ	Flowing liquid length (m)

τ	Shear stress (pa)
Λ	Reaction zone length (m)
β_i	Constant of equation 4-21
γ_i	Constant of equation 4-21

Subscripts

f	Fluid
l	Liquid
s	Static
g	Gas
sp	Sphere
x	x direction
i	Interface
t	Turbulent

CHAPTER ONE
Beginning

1.1 Introduction

Absorption is probably the most important gas purification technique and is common to a great number of processes. It involves the transfer of a substance from the gaseous to the liquid phase through the phase boundary. The absorbed material may dissolve physically in the liquid or react chemically with it.

The great majority of absorbers used for gas purification operations are packed, plate or spray towers. These absorber types are interchangeable to a considerable extent. Although certain specific conditions may favor one over the other. In general packed towers are preferred for small installations, corrosive service, liquids with a tendency to foam, very high liquid/gas ratios, and applications where a low-pressure drop is desired. Although many packing are available, the most commonly used are Pall rings, saddles and grids.

Plate columns are frequently more economical because a higher gas velocity can usually be tolerated, and therefore a column of smaller diameter is required. They are practically suitable for large installations, clean, non-corrosive, non-foaming liquids, and low liquid flow rate applications.

special towers have been developed. Some of them are shower trays, which specifically are applicable to very high liquid flow rates such as those used in the absorption of CO_2 from ammonia-synthesis gas with water.

Spray contactors are of importance primarily where pressure drop is a major factor and where solid particles are present in the exhaust gas at atmospheric pressure. Several types of spray contactors, including the venture scrubber and ejector, are utilized for the removal of hydrofluoric acid, silicon tetra fluoride, and sulfur dioxide foam stack gases [1].

In addition to these devices special contactors have been developed to meet specific process requirements. These include gas-liquid–solid fluidized beds [2].

Gas-liquid-solid fluidization has seen considerable progress with respect to an understanding of the phenomena of gas-liquid-solid fluidization. This phenomenon can be classified mainly into four modes of operations. These modes are: concurrent three-phase fluidization with liquid as the continuous phase (Mode I-a); concurrent three-phase fluidization with gas as the continuous phase (Mode I-b); Inverse three-phase fluidization (Mode II-a); and fluidization represented by a turbulent contact absorber (TCA) (mode II-b). Mode II-a and II-d are achieved with a countercurrent flow of gas and liquid. Due to the complex nature of three-phase fluidization, however, various methods are possible in evaluating the operating and design parameters for each mode of operation.