CHAPTER 1

INTRODUCTION

Generally , analyses of performance in adsorption processes with regard to mass transfer deal with the calculation of breakthrough curves . Such curves are calculated using values of adsorption rates and other properties of the fluids and adsorbents involved . In order to understand fluid phase flow behavior of adsorption systems , the assumption of piston flow in the system is often made . However , several practical engineering applications need to use more rigorous characteristics of real flow patterns . This certainly implies a consecutive requirement of relationships between axial dispersion data and its use for rational design methods of equipment . Since the constant pattern breakthrough is the simplest condition for equipment design , thus the existence of axial dispersion will effect to a smaller or larger extent the form of the asymptotic constant pattern of breakthrough curves .This has been reported to alter the stable mass transfer zone to some extent (1 , 2) . Despite the importance of longitudinal dispersion data mentionned , insufficient work has been done previously in adsorption columns of small diameters in which a majority of adsorption data is obtained . Table 1 shows some of the previous work that has been done . This present work will deal with measuring axial dispersion coefficients but in different ranges of variables .

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Table 1.1 Summary of Experimental Axial Dispersion Data for Gases in Packed Columns

INVESTIGATORS	SYSTEM FLUID/TRACER	INPUT	PACKING TYPE	PARTICLE DIAMETER d_p (cm)	TUBE INNER DIAMETER d_t (cm)	TUBE LENGTH L (cm)	TUBE/PARTICLE DIAMETER RATIO d_t/d_p	POROSITY OF BED	Re	Pe	Sc	TORTUOSITY FACTOR	Pe'_{∞}
BELLA AND WEBER (3) (1969)	CH_4/He	PULSE	GLASS SPHERE	1.83	7.44	150	4.07	0.365	0.128 - 1.60	0.30 - 1.730	1.90 - 2.20	-	-
CARBERRY AND BRETTON (4) (1958)	He/AIR	PULSE	SPHERE	0.63	2.55	90	4.05	0.365	0.046 - 0.42	0.015 - 0.10	0.3	0.67	2.0
CHAO AND HOELSCHER (5) (1966)	H_2/N_2	PULSE	GLASS CHIPS	0.255	2.58	15	10.12	0.425	0.5 - 20.0	0.55 - 1.0	0.27	-	-
EDWARD AND RICHARDSON (6) (1968)	AIR/Ar	PULSE	GLASS BEADS SAND DIAKON	0.06 - 0.45 0.159 0.144	9	24	20 - 150 56.6 62.5	0.368 - 0.410	0.008 - 5.0	0.022 - 4.0	0.7	0.73	3.0
EVAN AND KENNY (7) (1966)	N_2/H_2 N_2/He N_2/C_2H_6 N_2/Ar Ar/N_2	PULSE	LEAD SHOT GLASS BEADS RASCHIG RINGS	0.21 0.039 0.256	2.55	315	12.14 77.27 10	0.374 0.36 0.6	0.5 - 10.0	0.06 - 2.0	0.3 0.35 1 0.8 0.85	0.69	2.0
Mc HENRY AND WILHELM (8) (1957)	H_2/N_2 CH_4/N_2	FREQUENCY	GLASS SPHERE	0.32	4.96	27.6 - 87.3	15.56	0.388	100 - 400	1.88) 0.155	0.3 - 1.0	-	1.88
VOLKOV (1986)	N_2/H_2	PULSE AEROSOL	DIATOMITE SPHEROCHROME	0.036 0.052 0.075	10	40	133 - 277	-	1.0 - 20	0.1 - 0.5	-	-	-

SOURCE : DATA COLLECTED FROM ORIGINAL PAPERS AS MENTIONNED

1.1 Previous studies of axial dispersion for gas system in packed beds

- The development of models for dispersion in packed beds

The Fickian-like or diffusion model in packed beds has been studied by many investigators during the last three decades . Carberry and Bretton (4) applied this approach to their work and found that for $Re < 1$, axial dispersion coefficients were about equal to the calculated molecular diffusivity for both gases ; while Mc Henry and Wilhelm (8) obtained Peclet numbers of about 2 at high Reynolds numbers (in the range of 26 - 1000) .

A number of explanations of axial dispersion behavior through a number of models have been made . In the mixing cell model of Deans and Lapidus (10), interstices between packing elements are idealized as perfectly stirred mixers which give rise to dispersion - type behavior . For Hinduja et al's cross flow model (11) , exchange of fluid between stagnant and flowing parts of the empty space in the bed is used to model dispersion without requirements of exit boundary conditions in the mathematical treatment .

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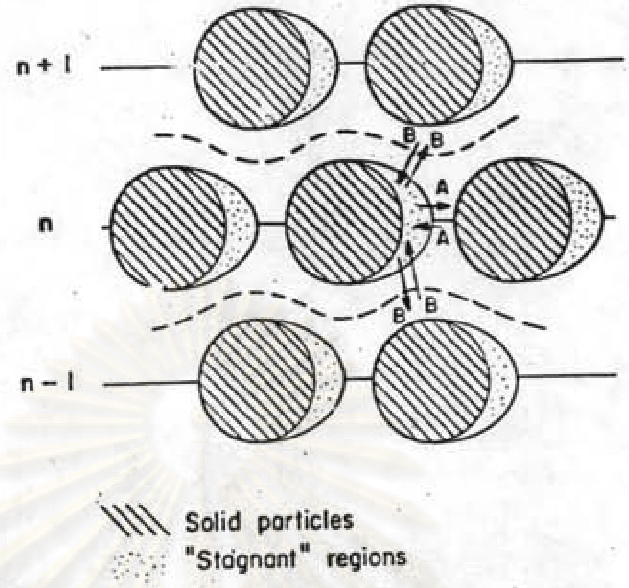

Figure 1.1 Schematic of bed showing stagnant and flowing regions. ⇄A indicates exchange between stagnant and flowing regions in the same layer. ⇄B indicates exchange between stagnant and flowing regions in adjacent layers.

The model of volume average for basic microscopic concentration was introduced by Carbonnel in 1980 (12) . The alternating flow model of Klingman and Lee(13) views dispersion in packed beds as a sequence of streamline plugs that must repeatedly split and merge as the bulk fluid tranverses the vessel .

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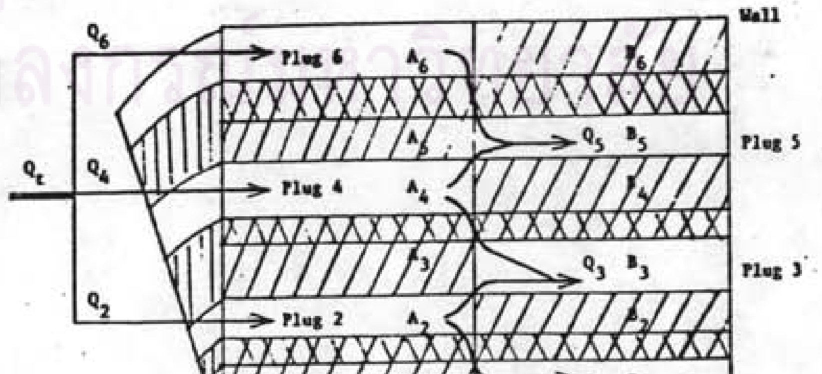

Figure 1.2 One AFM repeating A/B cell, $N_{rad} = 6$.

Upon these Fickian and Non - Fickian models , neither describes dispersion behaviors occuring in packed bed exactly; however, each model developed is relevant to each specific case.

A number of studies have been made on boundary conditions themselves . Kreft and Zuber (14) presented the solution for infinite and semi - infinite media in the case of a tracer . For low Peclet numbers they found prominent differences between the solutions for different injection - detection modes . They indicated that the theory of age - distribution function applies only if the tracer is injected and measured in flux . Parulekar and Ramkrishna (15) presented a formulation to derive a general set of boundary conditions which fit the mold of the self - adjoint operator theory . They also discussed actual solutions to different cases (16 ,17) . Kolev (18) compared numerical inversion methods used for solving the axial dispersed plug flow model in the Laplace domain by expanding it into series of orthogonal functions . He found methods employing Chebyshov polynomials of the first kind and Fourier sine series giving the best results with respect to precision and less computation time .

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1.2 Statement of the problem

This axial dispersion study was prompted by three main reasons :

First , no previous reports ever cited the measurement of axial dispersion on tubes containing very small particles ; nevertheless , this is a topic that plays a role in actual adsorption equipment design . Secondly , although the actual geometry of adsorbent beds are directly pertinent to dispersion aspects , few experiments have dealt with active adsorbents being used as packing . Finally little data lies in the flow rate region we are interested in and where axial dispersion may be a major factor influencing adsorption phenomena .

1.3 Objective of the study

To determine a relationship for axial dispersion coefficients of a gas flowing through a packed bed of 3 ^{0}A molecular sieve carbon adsorbents as a function of flow rates and sizes of adsorbent particles and tube diameter .

1.4 Scope of study

The features of this analysis will be based upon the following criteria and restrictions :

1. The packed column will be filled with adsorbent pellets which pores will be too small to adsorb either carrier gas or tracer

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gas , and at the same time the adsorbent will be devoid of other gases which could desorb during the experiments .

2. Four particle sizes in the range between 0.45 to 1.00 mm were chosen to yield a suitable tube to particle diameter ratio greater than 10 ,

3. Four flow rates with Reynolds numbers up to 2 , were used in this set of experiments .

4. Experimental conditions of 45 ^{0}C and atmospheric pressure were used in the study .

5. The experimental system will be simulated with a mathematical model and based on closed-closed boundary conditions since it most closely resembles the experimental system .

6. An impulse response method will be used in the measurement of longitudinal dispersion .

Under the above experimental system , axial dispersion coefficients will be measured , interpreted in terms of Peclet numbers (Pe) , and compared with the mathematical model .

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