$$y = \frac{x}{K\sqrt{\theta + \epsilon}} \qquad (10)$$

was used to transform Equations (3), (4), and (5). A set of transformed equations was approximated by the time centered, implicit finite-difference equations by the same procedure as adopted by Brian and Beaverstock (1965). These implicit equations were simplified by linearizing the reaction terms. A set of simultaneous linear equations was solved by the method of tridiagonal equations.

Figure 2 presents the computational results of the relationship between enhancement factor and modulus $\sqrt{M}$ as a parameter of s when q equals 7.32 and r_B equals 0.588, which corresponds to RNH_2 concentration equal to $2.45 \cdot 10^{-4}$ mole/cm^3. In order to obtain the solution to $\sqrt{M}$ equal to 300 shown in Figure 2, approximately 10 min. of FACOM 230-60 computer time was required. Computed enhancement factors gradually increase from those for gas absorption with the second-order irreversible reaction with an increase of $\sqrt{M}$, as would be expected. By comparing the experimental data at the value of C_{BO} equal to $2.45 \cdot 10^{-4}$ mole/cm^3 with theoretical curve, the ratio of reaction rate constants s amounts to 10^{-5}. Experimental results suggest that only the first chemical reaction needs to be considered in all practical situations because the very maximum contact time likely to occur in such equipment is no more than half a minute with the exception of the process where liquid is recirculated.

NOTATION

C = concentration in liquid phase, mole/cm^3
D = diffusivity in liquid phase, cm^2/s
k = reaction rate constant, liters/(g-mole)(s)
K = arbitrary constant in Equation (10)
M = $\pi\theta/4$
N = time average mass transfer rate, mole/(cm^2)(s)
q = C_{B0}/C_{Ai}
r_B = D_B/D_A
r_R = D_R/D_A
s = k_{II}/k_I
t = gas-liquid contact time, s
x = $z\sqrt{k_I C_{B0}/D_A}$
y = transformed distance variable defined by Equation (10)
Y_A = C_A/C_{Ai}
Y_B = C_B/C_{B0}
Y_R = C_R/C_{B0}
z = distance from the interface into liquid, cm
ϵ = arbitrary constant in Equation (10)
θ = $k_I C_{B0} t$
ν = stoichiometric coefficient in the reaction of the form, $A + \nu B \rightarrow$ products
Φ = enhancement factor

Subscripts

A = dissolved gas A (carbon dioxide)
B = liquid reactant B (RNH_2)
i = gas-liquid interface
R = intermediate product R ($RNHCOORNH_3$)
0 = initial value
I = first reaction step, Equation (1)
II = second reaction step, Equation (2)

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Heat Transfer in a Packed Bed

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Bhattacharyya and Pei (1975) have developed a model which separates particle-to-particle and fluid-to-particle contributions to heat transfer in a packed bed. The model is then applied to data for the turbulent flow region. Experimental data are reported for a microwave heated system which was used to obtain steady state data with air as the fluid. Additional data are presented by Balakrishnan and Pei (1974) with the conclusion that heat transfer for spherical particles in the fluid-particle mode is represented by

$$j_h = 0.018\ (Ar/Re^2_{pm})^{1/4} \qquad (1)$$

Equation (1) is shown to apply to data in the particle Reynolds number range of 100 to 800. This Reynolds number range is in the turbulent flow region for packed beds, so one would expect that particle-to-particle heat transfer would represent a minor contribution to total heat transfer. Mass transfer in packed beds without heat transfer provides fluid-to-particle data without a particle-to-particle contribution. Thus, Equation (1) should apply as the mass transfer analogue to experimental data for packed bed mass transfer in the turbulent region. McCune and Wilhelm (1949) report isothermal data for 2-napthol in water and Gaffney and Drew (1950) for succinic acid in n-butanol and aqueous acetone. Table 1 compares these data with values calculated from Equation (1).

It is apparent that Equation (1) does not represent these particle-to-fluid data.

TABLE 1. COMPARISON OF EXPERIMENTAL AND CALCULATED DATA

System	Re_{pm}	Experimental j_D	Calculated j_D Equation (1)	Calculated j_D Equation (2)
2-naphthol, water	140	0.171	0.0415	0.171
2-naphthol, water	2 820	0.061	0.009	0.065
Succinic acid, aq. acetone	263	0.225	0.175	0.184
Succinic acid, *n*-butanol	510	0.143	0.029	0.143

Hughmark (1972) presented a correlation for mass transfer data in packed beds that also represented heat transfer data. The heat transfer data were obtained with simultaneous mass transfer

$$\frac{kD_e}{\mathfrak{D}} = 0.22 \left(\frac{D_e u_e}{\nu}\right)^{2/3} (N_{Sc})^{1/3} \qquad (2)$$

Galloway and Sage (1970) used an instrumented copper sphere, 3.8 cm diameter, which was provided with a small calorimeter to obtain heat transfer to flowing air in a packed bed of uniform diameter spheres. Lindauer (1967) obtained heat transfer data for particles to air in a packed bed with the cyclic temperature method. Figure 1 shows the Galloway and Sage data and the Lindauer data for 0.048 cm tungsten spheres and 0.32 cm steel spheres for comparison with Equation (2). Good agreement is observed. This agreement of heat and mass transfer data confirms that particle-to-particle transfer is negligible in the turbulent region because the mass transfer correlation represents data without particle-to-particle transfer.

The Bhattacharyya and Pei data for 0.32 and 0.76 cm are also shown by Figure 1. It is apparent that these data, which are claimed to represent fluid-to-particle heat transfer, are inconsistent with the fluid-to-particle mass transfer correlation and the apparent fluid-to-particle heat transfer data.

NOTATION

Ar = Archimedes number, $D^3 g\rho(\rho_s - \rho)/\mu^2$
D = diameter of solids
D_e = equivalent diameter of channel
$\mathfrak{D}$ = molecular diffusivity
G = superficial mass velocity of fluid
g = acceleration due to gravity
j_D = Colburn mass transfer factor
j_h = Colburn heat transfer factor
k = mass transfer coefficient
N_{Pr} = Prandtl number
N_{Sc} = Schmidt number
Re_{pm} = modified Reynolds number, $DG/\mu(1 - \epsilon)$
u_e = actual velocity in packing channels

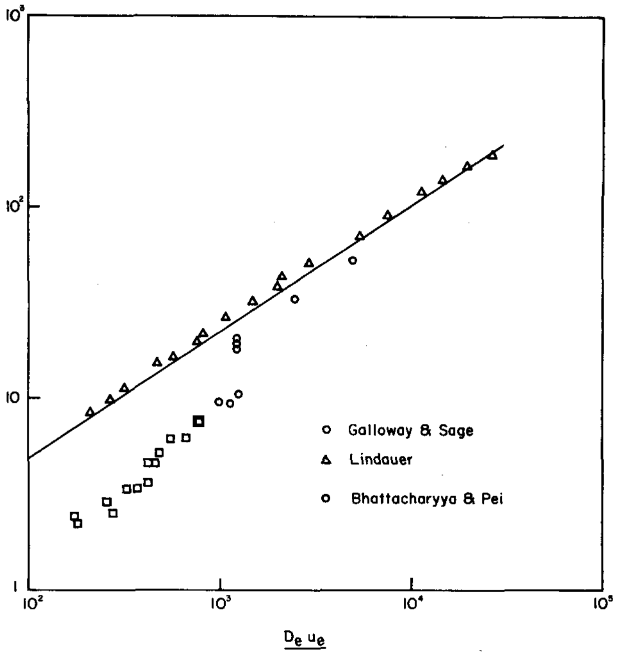

Fig. 1. Packed bed heat transfer.

Greek Letters

ϵ = packing void fraction
μ = fluid viscosity
ν = fluid kinematic viscosity
ρ = fluid density
ρ_s = solids density

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Miscibility Considerations in the System Propane-Hexatriacontane

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Rowlinson's discovery of the partial miscibilities of lower paraffinic hydrocarbons with their higher homologues has resulted in a large number of systems being studied, in which the prime cause of immiscibility seems to be the difference in size of the two components. With the discussion restricted primarily to paraffinic components, the following is known: methane is immiscible with *n*-hexane across a narrow temperature range, though it is completely miscible with all paraffinic components C_5 and lower in chain size (Davenport and Rowlinson, 1963). In an inter-