CHAPTER 8

RESULTS AND DISCUSSION FOR MASS TRANSFER COEFFICIENTS

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8.1.0 RESULTS AND DISCUSSION FOR VOLUMETRIC LIQUID SIDE MASS TRANSFER COEFFICIENTS (k_La) :

The volumetric liquid side mass transfer coefficient is an extensively studied design parameter. However, the effect of wettability of packing materials, surface tensions and viscosities of the absorption media on the values of k_La have been investigated only during the past decade. Further, no attempt has been made in the literature to develop a generalised correlation for the k_La values during the past decade. Hence, the need was felt to reanalyse this data of k_La values along with previous data of the k_La values and to develop a generalised correlation which would take into account the wettability of packing materials (σ_c).

8.1.1 Critical analysis of data and mathematical modelling.

A data bank consisting of 235 points with 34 variations including system variations such as CO_2 - Water, CO_2 - aqueous electrolyte solutions, CO_2 - aqueous glycerol solutions, H_2 - water etc. and packings of different wettabilities such as ceramic, PVC polypropylene etc. reported in Table (5.4) could be used for analysing the effect of different variables on the values of k_La.

The parameters affecting $k_L a$ values are the liquid flow rate (L), packing size (d_p) [hence its dry surface area (a_t)], physical properties of the solvent/absorption media such as density (ρ_L) viscosity (μ_L), surface tension (σ) and the diffusivity of the solute gas in absorption media (D_L). Further it appears that the wettability of packing material also affects the values of $k_L a$ signifcantly.

(I) Effect of liquid flow rate (L) :-

It is observed that with an increase in the values of L, the values of $k_L a$ increase considerably. Thus, for example for observation numbers (1) and (10) under otherwise identical conditions of a_t = 330 m^2/m^3, σ = 71.3 mN/m, ρ_L = 997.1 kg/m^3, μ_L = 0.894 mNs/m^2 and D_L = 1.97 x 10^{-9} m^2/s, with an increase in the value of L from 0.47 kg/m^2-s, to 12.22 kg/m^2-s, the value of $k_L a$ (s^{-1}) increases from 2.278 x 10^{-3} to 26.944 x 10^{-3}. For all the other systems/variations under consideration similar conclusions can be drawn.

(II) Effect of packing size (d_p) :

With an increase in the size of packing ; hence a decrease in its dry surface area the values of $k_L a$ decreases. Thus, for example for observation numbers (19) and (21) under otherwise similar conditions of σ = 70.0 - 74.0 mN/m, ρ_L = 1070 kg/m^3, μ_L = 1.08 - 1.22 mNs/m^2, D_L = 1.54 x 10^{-9} - 1.63 x 10^{-9} m^2/s & L = 3.1 kg/m^2-s, with an increase in the packing size of ceramic Raschig rings from 0.013m to 0.038m (with decrease in a_t from 370 m^2/m^3 to 130 m^2/m^3), the value of $k_L a$ (s^{-1}) decreases from 8.23 x 10^{-3} to 5.64 x 10^{-3}. Under otherwise identical conditions, similar trend is observed for all the other systems/variations under consideration.

(III) Effect of density (ρ_L), viscosity (μ_L) and diffusivity (D_L) on the k_La values :

The values of k_La appear to decrease marginally with an increase in ρ_L. Thus, for example for observation numbers (4) and (25), under otherwise identical conditions of a_t = 330 m^2/m^3, σ = 71.3 - 73.2 mN/m, μ_L = 0.89 -1.008 mNs/m^2, D_L = 1.88 x 10^{-9} - 1.97 x 10^{-9} m^2/s and L = 1.2 kg/m^2-s, with an increase in the values of ρ_L from 997 kg/m^3 to 1070 kg/m^3 the value of k_La (s^{-1}) decreases from 5.278 x 10^{-3} to 3.950 x 10^{-3}.

With an increase in the viscosity of absorption media the values of k_La decrease appreciably. Thus, for example for observation numbers (182) and (187), under otherwise comparable conditions of a_t = 460 m^2/m^3, σ = 67.7 - 68.3 mN/m, ρ_L = 1160 - 1170 kg/m^3, D_L = 0.27 x 10^{-9} - 0.32 x 10^{-9} m^2/s and L = 16.7 - 18.8 kg/m^2-s, with an increase in μ_L from 10.8 m Ns/m^2 to 16.1 mNs/m^2, the value of k_La (s^{-1}) decreases from 7.6 x 10^{-3} to 4.38 x 10^{-3}. Similar conclusions can be drawn for the other systems under consideration wherein the μ_L values have been altered considerably.

With a decrease in the value of D_L, the values of k_La decrease considerably. Thus, for example for observation numbers (220) and (228), under otherwise identical conditions of a_t = 785 m^2/m^3, σ= 71.3 mN/m, σ_c = 61 mN/m, ρ_L = 997.1 kg/m^3, μ_L = 0.894 mNs/m^2 and L = 3.95 - 4.11 kg/m^2-s, with a decrease in the value of

D_L from 4.8 x 10^{-9} m^2/s (for H_2 - water system) to 1.97 x 10^{-9} m^2/s (for CO_2 - water system), the value of k_La (s^{-1}) decreases from 26.47 x 10^{-3} to 16.11 x 10^{-3}. Similar observation can be made for the other systems under consideration.

(IV) <u>Effect of σ and σ_c on k_La values</u> :-

The values of σ and σ_c also appear to affect the values of k_La considerably. With a decrease in the value of σ the value of k_La increases. Thus for example, for observation numbers (31) and (60) under otherwise comparable conditions of a_t = 367 m^2/m^3, ρ_L = 990.5 - 995.9 kg/m^3, μ_L = 0.813 - 0.889 mNs/m^2, D_L = 2.019 x 10^{-9} - 2.198 x 10^{-9} m^2/s and L = 2.72 - 2.86 kg/m^2-s, with a decrease in the values of σ from 71.6 to 56.0 mN/m, the value of k_La (s^{-1}) increases from 8.1 x 10^{-3} to 11.2 x 10^{-3}.

The effect of wettability of packing material on the value of k_La can be illustrated by comparing case (I) : a set of observations - (38 to 42) for ceramic Raschig ring to that of case (II) : a set of observations - (135 to 138) for polypropylene Raschig rings. Thus for example under otherwise comparable conditions of a_t = 190 m^2/m^3 σ = 71.4 - 71.6 mN/m, ρ_L = 996 kg/m^3, μ_L = 0.818 - 0.827 mNs/m^2, D_L = 2.15 x 10^{-9} - 2.18 x 10^{-9} m^2/s and L = 11.2 - 13.6 kg/m^2-s, when packing material of Raschig rings of size 0.025m is changed from ceramic to polypropylene, the value of σ_c decreases from 61 mN/m to 27.7 mN/m and consequently the value k_La decreases form 23.1 x 10^{-3} to 15.9 x 10^{-3} (s^{-1}). Thus the values of k_La do decrease substantialy when a material having poor wettability is used as a packing material.

<u>Mathematical modelling of k_La data :</u>

Since k_La is a product of 'k_L' and 'a', obviously the parameters affecting values of 'a' should be included in the correlation for k_La. In addition, the parameters affecting the k_L values like D_L, ρ_L, μ_L, a_t and L also have to be included explicitly. Thus, a correlation for k_La is likely to have the following structure with respect to the hydrodynamic and system parameters :-

$$k_L = f\ (L, \rho_L^{-1}, \mu_L^{-1}, \sigma^{-1}, \sigma_c, a_t, D_L) \tag{8.1}$$

When arranged in terms of dimensionless numbers, one obtains the following functional relationship :-

$$k_La = f(Re, We, Fr, (\sigma / \sigma_c), Sc) \tag{8.2}$$

where Sc is the Schmidt numbers (μ_L/ ρ_LD_L), Re is the Reynolds number, We is the Weber number and Fr is the Froude number. LHS and RHS of equation (8.2) can be made dimensionally consistent by incorporating a group ($\rho_L/ \mu_Lg)^{-1/3}$ and expressing equation (8.2) as under :-

$$k_La = C\ (Re)^{\alpha}\ (We)^{\beta}\ (Fr)^{\gamma}\ (\sigma / \sigma_c)^{\delta}\ (S_c)^{m}\ (\rho_L/ \mu_Lg)^{-1/3}\ a_t \tag{8.3}$$

In the above mentioned equation (8.3), the parameter D_L appears in the denominator but from equation (8.1) it is observed that k_La is directly proportional to D_L. Hence, the index 'm' of Schmidt number has to be negative. Moreover the magnitude of m is expected to be -0.5 in order to comply with the penetration theory model for mass transfer.

Thus, with an objective to develop a correlation for k_La by mathematical modelling as per equation (8.3), the relevant dimensionless groups [calculated using data reported in Table (5.4)] required for processing the data of k_La are tabulated in Table (8.1.1).

8.1.2 Statistical analysis for different correlations :

Processing of the data reported in Table (8.1.1) was done by the versatile and flexible modifed simplex algorithm of Nelder and Mead. The results obtained are reported in Table (8.1.2) and are discussed herewith. When all the five indices namely those of Reynold's number, Weber number, Froude number, (σ / σ_c) and Schmidt number, also the proportionality constant were regressed as per step (1), the following correlation was obtained wherein the values of % E_{avg}, % E_{abs} and % S_{dev} were 0.136, 10.03 and 0.18 respectively :-

$$k_La = 0.0422 \ [(Re)^{0.308} \ (We)^{0.212} \ (Fr)^{-0.004} \ (\sigma/\sigma_c)^{-0.27}] \times$$
$$\ldots \times [\ (Sc)^{-0.5} \ (\rho_L/\mu_L g)^{-1/3} \ a_t] \qquad (8.4)$$

However in the correlation of k_La, the indices of We, Fr, (σ / σ_c) obtained in the correlation of (a_p/a_t) should be retained. Otherwise it could lead to erroneous interpretation that k_L is dependent on parameters like (σ / σ_c) , We, Fr, etc. i.e.

$$k_La = f\ [(\sigma / \sigma_c), Fr, etc] \qquad (8.5)$$

Hence, the values of different indices of We, Fr, (σ / σ_c) were fixed as β = 0.222, γ = 0.002 and δ = -0.442 [obtained from (a_p/a_t)

Table - (B.1.1)

Results inclusive of processing parameters for volumetric liquid side mass transfer coefficient (k_La)

No.	Re	We $\times 10^5$	Fr $\times 10^5$	σ/σ_c	Sc $\times 10^{-2}$	MF	$k_La \times 10^3$ s^{-1} exp.	$k_La \times 10^3$ s^{-1} pred.	% err
1	1.60	0.95	0.76	1.168	4.55	6.84	2.278	2.188	3.96
2	2.35	2.06	1.63	1.168	4.55	6.84	3.056	2.899	5.13
3	3.39	4.27	3.39	1.168	4.55	6.84	4.444	3.783	14.88
4	4.14	6.37	5.06	1.168	4.55	6.84	5.278	4.380	17.01
5	4.90	8.90	7.07	1.168	4.55	6.84	6.111	4.948	19.03
6	6.50	15.67	12.44	1.168	4.55	6.84	6.944	6.083	12.41
7	9.42	32.91	26.13	1.168	4.55	6.84	9.167	7.975	13.00
8	14.12	74.05	58.80	1.168	4.55	6.84	12.222	10.722	12.27
9	30.13	337.02	267.61	1.168	4.55	6.84	23.889	18.642	21.96
10	41.43	637.16	505.94	1.168	4.55	6.84	26.944	23.521	12.70
11	3.82	3.21	0.89	1.168	4.55	4.04	2.778	2.168	21.97
12	17.53	67.40	18.69	1.168	4.55	4.04	8.889	6.586	25.90
13	74.89	1230.44	341.15	1.168	4.55	4.04	26.111	19.013	27.18
14	4.53	8.54	8.52	1.168	4.55	7.66	6.400	5.378	15.97
15	3.09	8.39	7.99	1.230	8.96	8.61	4.555	3.758	17.49
16	1.93	2.14	1.96	1.148	6.19	7.97	3.250	2.785	14.31
17	3.88	8.68	7.93	1.148	6.19	7.97	4.860	4.641	4.50
18	5.78	19.27	17.62	1.148	6.19	7.97	6.830	6.210	9.07
19	7.77	34.74	31.75	1.148	6.19	7.97	8.230	7.700	6.44
20	9.69	54.13	49.47	1.148	6.19	7.97	9.810	9.053	7.72
21	19.88	96.26	11.48	1.215	7.39	2.92	5.647	4.105	27.30
22	27.79	188.05	22.42	1.215	7.39	2.92	8.000	5.242	34.47
23	31.62	243.52	29.03	1.215	7.39	2.92	8.823	5.761	34.71
24	40.76	404.69	48.25	1.215	7.39	2.92	10.924	6.934	36.52
25	3.54	6.17	4.69	1.200	5.38	7.11	3.950	3.932	0.45
26	8.76	37.70	28.66	1.200	5.38	7.11	8.330	7.613	8.61
27	21.72	231.84	176.24	1.200	5.38	7.11	16.660	14.773	11.33
28	43.76	941.06	715.40	1.200	5.38	7.11	29.160	24.635	15.52
29	2.82	2.80	2.77	1.174	3.85	7.41	3.600	3.846	-6.85
30	5.72	11.21	11.08	1.174	3.74	7.38	6.000	6.467	-7.79
31	9.11	28.24	27.91	1.174	3.72	7.37	8.100	9.096	-12.30
32	12.14	47.47	46.93	1.174	3.50	7.30	10.100	11.307	-11.95
33	15.45	75.19	74.19	1.174	3.42	7.27	12.900	13.522	-4.82
34	19.14	113.32	112.05	1.174	3.35	7.25	14.500	15.863	-9.40
35	24.77	193.65	191.45	1.174	3.43	7.28	17.400	19.087	-9.69
36	39.20	479.31	473.92	1.174	3.38	7.26	24.300	26.739	-10.04
37	51.96	835.12	825.79	1.174	3.35	7.25	28.600	32.885	-14.98
38	27.55	135.80	35.84	1.170	3.76	3.82	9.400	9.106	3.13
39	43.45	333.94	88.07	1.169	3.72	3.81	12.500	12.728	-1.83
40	51.58	476.03	125.63	1.170	3.76	3.82	15.200	14.393	5.31
41	69.05	848.72	224.05	1.170	3.74	3.82	18.400	17.818	3.17
42	88.11	1388.91	366.53	1.170	3.76	3.82	23.100	21.275	7.90
43	101.25	1834.02	484.00	1.170	3.76	3.82	25.800	23.548	8.73
44	2.77	2.94	2.77	1.116	3.99	7.46	3.500	3.910	-11.72
45	9.41	33.24	31.27	1.116	3.90	7.43	8.500	9.579	-12.69
46	18.08	117.34	110.41	1.116	3.71	7.37	14.700	15.533	-5.67
47	25.02	220.23	207.25	1.116	3.63	7.35	17.600	19.755	-12.24
48	47.00	752.23	708.02	1.116	3.51	7.31	28.400	31.456	-10.76

Table - 8.1.1 (contd.)

No.	Re	We $\times 10^5$	Fr $\times 10^5$	σ/σ_c	Sc $\times 10^{-2}$	MF	$k_La \times 10^3$ s^{-1} exp.	$k_La \times 10^3$ s^{-1} pred.	% err
49	2.68	3.11	2.71	1.030	4.17	7.51	3.400	4.003	-17.75
50	9.34	36.00	31.28	1.030	3.94	7.45	9.400	10.052	-6.93
51	17.81	127.53	110.82	1.030	3.83	7.42	16.000	16.161	-1.01
52	23.10	211.14	183.50	1.030	3.77	7.40	17.700	19.594	-10.70
53	46.30	820.42	713.18	1.030	3.65	7.36	31.400	32.657	-4.00
54	2.56	3.22	2.64	0.970	4.42	7.59	3.600	4.015	-11.54
55	9.05	37.61	30.85	0.970	4.12	7.51	9.900	10.178	-2.81
56	17.27	137.11	112.46	0.970	4.12	7.51	14.900	16.321	-9.53
57	23.87	254.68	208.93	0.970	4.00	7.48	20.600	20.755	-0.75
58	45.94	920.15	754.97	0.970	3.89	7.45	30.900	33.604	-8.75
59	2.49	3.49	2.71	0.918	4.81	7.70	4.000	4.036	-0.90
60	8.77	40.25	31.28	0.918	4.45	7.61	11.200	10.230	8.66
61	16.05	134.35	104.40	0.918	4.43	7.60	15.300	15.923	-4.07
62	20.88	222.81	173.16	0.918	4.33	7.58	20.100	19.357	3.70
63	44.03	978.45	760.52	0.918	4.27	7.56	35.000	33.426	4.50
64	2.39	3.76	2.71	0.848	5.18	7.80	3.800	4.103	-7.99
65	8.30	42.90	30.85	0.848	4.86	7.73	10.200	10.280	-0.78
66	15.78	156.42	112.46	0.848	4.91	7.74	17.100	16.413	4.02
67	19.79	240.82	173.16	0.848	4.80	7.71	18.700	19.428	-3.89
68	40.58	991.64	713.10	0.848	4.69	7.69	29.600	32.911	-11.18
69	7.41	46.73	30.42	0.764	5.98	8.01	9.400	9.921	-5.54
70	14.06	164.67	107.18	0.764	5.84	7.98	14.900	15.886	-6.61
71	21.51	380.22	247.53	0.764	5.76	7.96	19.800	21.712	-9.66
72	40.62	1328.87	865.19	0.764	5.64	7.94	31.100	34.635	-11.37
73	3.05	3.07	3.03	1.790	3.59	7.33	3.600	3.413	5.19
74	5.97	11.74	11.60	1.790	3.59	7.33	6.000	5.569	7.18
75	9.16	27.62	27.30	1.790	3.59	7.33	8.500	7.611	10.46
76	13.66	61.52	60.81	1.790	3.59	7.33	11.100	10.195	8.15
77	17.87	105.23	104.00	1.790	3.59	7.33	13.400	12.402	7.45
78	24.93	204.69	202.31	1.790	3.59	7.33	15.400	15.811	-2.67
79	32.21	341.91	337.93	1.790	3.59	7.33	17.200	19.067	-10.86
80	44.07	640.00	632.55	1.790	3.59	7.33	21.000	23.970	-14.14
81	22.65	109.70	28.88	1.781	4.55	3.94	6.900	6.385	7.47
82	30.99	205.35	54.04	1.781	4.55	3.94	9.100	8.027	11.79
83	39.03	325.70	85.74	1.781	4.55	3.94	11.800	9.498	19.51
84	46.72	466.61	122.83	1.781	4.55	3.94	13.000	10.830	16.69
85	62.80	843.17	221.96	1.781	4.55	3.94	17.200	13.441	21.86
86	78.65	1322.40	348.11	1.781	4.55	3.94	20.000	15.840	20.80
87	93.31	1861.26	489.96	1.781	4.55	3.94	22.000	17.945	18.43
88	2.95	3.42	3.24	1.712	4.12	7.49	3.500	3.372	3.67
89	5.61	11.98	11.34	1.712	3.99	7.46	6.300	5.407	14.17
90	8.67	28.41	26.88	1.712	3.95	7.45	9.000	7.443	17.30
91	13.19	64.90	61.40	1.712	3.90	7.43	12.900	10.131	21.47
92	16.79	102.91	97.39	1.712	3.80	7.40	14.600	12.125	16.95
93	23.62	199.44	188.76	1.712	3.72	7.38	16.400	15.607	4.84
94	34.60	427.89	404.98	1.712	3.72	7.38	21.300	20.622	3.18
95	45.48	731.70	692.60	1.712	3.68	7.36	23.200	25.220	-8.70
96	2.74	3.28	2.83	1.563	4.17	7.51	4.200	3.390	19.29
97	5.41	12.81	11.08	1.563	4.17	7.51	7.700	5.575	27.59
98	12.87	72.43	62.62	1.563	4.17	7.51	14.400	10.492	27.14
99	16.15	113.99	98.55	1.563	4.17	7.51	15.600	12.380	20.64
100	22.04	212.26	183.50	1.563	4.17	7.51	19.200	15.534	19.09

Table – 8.1.1 (contd.)

No.	Re	We $\times 10^5$	Fr $\times 10^5$	σ/σ_c	Sc $\times 10^{-2}$	MF	$k_L a \times 10^3$ s^{-1} exp.	$k_L a \times 10^3$ s^{-1} pred.	% err
101	31.35	420.23	363.33	1.563	4.07	7.49	26.400	20.159	23.64
102	42.49	771.92	667.40	1.563	4.07	7.49	32.000	25.169	21.35
103	2.72	3.95	3.17	1.447	4.74	7.68	3.700	3.494	5.58
104	5.17	14.31	11.47	1.447	4.74	7.68	6.000	5.587	6.89
105	8.03	34.05	27.29	1.447	4.68	7.66	8.700	7.718	11.28
106	12.09	76.62	61.42	1.447	4.63	7.65	12.700	10.424	17.92
107	15.23	121.49	97.39	1.447	4.63	7.65	15.100	12.334	18.32
108	21.80	243.58	195.32	1.447	4.52	7.62	18.200	16.081	11.64
109	31.55	510.24	409.14	1.447	4.52	7.62	23.000	21.063	8.42
110	40.46	839.25	673.09	1.447	4.48	7.62	25.600	25.377	0.87
111	2.66	3.89	2.91	1.355	4.55	7.62	3.400	3.613	-6.26
112	5.22	15.06	11.24	1.355	4.55	7.62	5.600	5.919	-5.69
113	8.07	35.66	26.89	1.355	4.50	7.62	8.500	8.163	3.96
114	12.35	83.47	62.94	1.355	4.50	7.62	12.000	11.135	7.21
115	15.37	129.16	97.39	1.355	4.50	7.62	14.700	13.059	11.17
116	22.98	283.00	213.42	1.355	4.40	7.60	17.400	17.572	-0.99
117	30.74	506.50	381.96	1.355	4.40	7.60	20.300	21.731	-7.05
118	40.29	852.01	642.58	1.355	4.30	7.57	24.000	26.555	-10.65
119	2.54	4.02	2.83	1.270	4.80	7.70	3.900	3.633	6.85
120	5.00	15.52	10.95	1.270	4.80	7.70	6.000	5.950	0.84
121	7.92	38.11	26.90	1.270	4.69	7.67	9.200	8.354	9.20
122	12.00	87.45	61.72	1.270	4.69	7.67	12.900	11.312	12.31
123	14.92	135.29	95.49	1.270	4.69	7.67	16.400	13.265	19.11
124	21.04	263.68	186.12	1.270	4.59	7.65	17.000	17.100	-0.59
125	29.19	507.40	358.16	1.270	4.59	7.65	22.300	21.715	2.62
126	40.25	945.41	667.41	1.270	4.49	7.62	26.500	27.549	-3.96
127	2.48	4.13	2.83	1.232	5.06	7.77	3.900	3.614	7.34
128	4.93	16.35	11.21	1.232	5.06	7.77	7.000	5.969	14.73
129	7.63	39.23	26.90	1.232	5.06	7.77	9.200	8.216	10.70
130	11.59	90.47	62.02	1.232	5.06	7.77	12.500	11.145	10.84
131	14.53	142.28	97.55	1.232	5.06	7.77	13.800	13.149	4.72
132	20.56	278.38	190.87	1.232	4.94	7.74	19.400	16.992	12.41
133	28.68	529.81	363.34	1.232	4.82	7.71	21.400	21.740	-1.59
134	39.07	983.30	674.34	1.232	4.82	7.71	26.900	27.245	-1.28
135	36.45	242.04	64.09	2.585	3.85	3.84	9.600	7.835	18.38
136	45.64	379.59	100.51	2.585	3.85	3.84	10.100	9.234	8.57
137	56.10	573.43	151.84	2.585	3.85	3.84	12.800	10.735	16.14
138	71.63	934.98	247.57	2.585	3.85	3.84	15.900	12.832	19.30
139	3.57	10.57	9.62	1.239	8.55	8.47	4.000	4.135	-3.38
140	4.82	19.34	17.60	1.239	8.55	8.47	5.498	5.156	6.23
141	5.57	25.79	23.47	1.239	8.55	8.47	6.356	5.727	9.90
142	7.04	41.16	37.46	1.239	8.55	8.47	7.036	6.793	3.46
143	8.73	63.38	57.68	1.239	8.55	8.47	8.621	7.952	7.76
144	10.88	98.35	89.51	1.239	8.55	8.47	9.000	9.335	-3.72
145	12.93	138.94	126.44	1.239	8.55	8.47	10.980	10.590	3.55
146	14.39	172.06	156.58	1.239	8.55	8.47	11.600	11.449	1.30
147	3.45	19.34	16.73	1.259	14.49	9.39	3.924	3.962	-0.97
148	4.92	39.42	34.11	1.259	14.49	9.39	5.233	5.138	1.81
149	6.40	66.71	57.71	1.259	14.49	9.39	6.000	6.226	-3.76
150	8.10	106.93	92.51	1.259	14.49	9.39	7.445	7.396	0.66
151	9.62	150.89	130.54	1.259	14.49	9.39	8.000	8.386	-4.83
152	11.50	215.55	186.48	1.259	14.49	9.39	9.074	9.552	-5.27

Table - 8.1.1 (contd.)

No.	Re	We $\times 10^5$	Fr $\times 10^5$	σ/σ_c	Sc $\times 10^{-2}$	MF	$k_La \times 10^3$ s^{-1} exp.	$k_La \times 10^3$ s^{-1} pred.	% err
153	6.75	23.36	36.41	3.998	4.55	9.53	5.555	5.445	1.97
154	10.63	57.89	90.23	3.998	4.55	9.53	8.330	7.584	8.96
155	15.92	129.92	202.49	3.998	4.55	9.53	11.110	10.186	8.31
156	20.95	224.78	350.33	3.998	4.55	9.53	13.492	12.443	7.78
157	26.24	352.76	549.79	3.998	4.55	9.53	15.897	14.667	7.74
158	31.70	514.81	802.34	3.998	4.55	9.53	18.370	16.837	8.34
159	15.67	125.80	196.06	0.986	4.55	9.53	14.470	18.692	-29.18
160	20.73	220.27	343.29	0.986	4.55	9.53	18.020	22.933	-27.26
161	26.21	351.85	548.36	0.986	4.55	9.53	21.750	27.208	-25.09
162	31.88	520.75	811.60	0.986	4.55	9.53	24.800	31.394	-26.59
163	10.75	58.36	90.99	0.989	4.54	9.51	11.110	14.115	-27.05
164	15.75	125.13	195.07	0.989	4.54	9.51	14.870	18.645	-25.39
165	20.74	217.06	338.38	0.989	4.54	9.51	18.510	22.797	-23.16
166	26.35	350.29	546.08	0.989	4.54	9.51	22.100	27.149	-22.84
167	31.88	512.77	799.38	0.989	4.54	9.51	25.230	31.200	-23.66
168	4.31	91.49	128.68	0.973	37.21	13.66	7.894	6.069	23.12
169	6.81	228.80	321.79	0.973	37.21	13.66	10.233	8.480	17.13
170	9.16	413.86	582.07	0.973	37.21	13.66	14.238	10.528	26.06
171	0.85	13.02	17.29	0.952	98.23	16.79	2.456	1.890	23.05
172	1.76	55.98	74.34	0.952	98.23	16.79	3.918	3.218	17.87
173	2.86	147.31	195.63	0.952	98.23	16.79	5.263	4.581	12.96
174	4.19	316.44	420.24	0.952	98.23	16.79	6.608	6.056	8.36
175	5.48	542.00	719.77	0.952	98.23	16.79	9.824	7.370	24.98
176	0.40	10.77	13.69	0.936	290.95	20.77	1.578	1.057	33.00
177	0.83	46.56	59.19	0.936	290.95	20.77	2.280	1.804	20.87
178	1.01	69.46	88.31	0.936	290.95	20.77	2.836	2.088	26.39
179	1.86	239.01	317.21	0.936	290.95	21.22	3.450	3.339	3.22
180	2.45	416.46	552.72	0.936	290.95	21.22	4.327	4.089	5.50
181	3.16	678.32	862.36	0.936	290.95	20.77	5.877	4.796	18.39
182	3.79	970.31	1233.57	0.936	290.95	20.77	7.602	5.466	28.10
183	0.46	31.65	39.55	0.927	509.65	23.66	1.695	1.208	28.76
184	0.75	86.05	112.24	0.927	509.65	24.17	1.988	1.772	10.86
185	1.08	180.92	235.98	0.927	509.65	24.17	2.397	2.324	3.03
186	1.85	513.54	641.61	0.927	509.65	23.66	4.093	3.339	18.42
187	2.26	766.71	957.90	0.927	509.65	23.66	4.385	3.865	11.86
188	3.75	12.41	55.76	1.168	4.55	16.26	9.833	11.780	-19.80
189	9.46	79.03	355.12	1.168	4.55	16.26	19.944	23.155	-16.10
190	1.80	2.88	12.93	1.168	4.55	16.26	5.694	6.910	-21.35
191	3.30	9.65	43.34	1.168	4.55	16.26	8.806	10.746	-22.03
192	2.43	5.22	23.44	1.168	4.55	16.26	6.944	8.586	-23.64
193	0.90	0.71	3.20	1.168	4.55	16.26	3.278	4.153	-26.69
194	1.22	1.31	5.90	1.168	4.55	16.26	4.333	5.189	-19.74
195	5.74	29.09	130.71	1.168	4.55	16.26	12.972	16.077	-23.94
196	1.55	2.12	9.50	1.168	4.55	16.26	4.833	6.176	-27.78
197	1.10	1.08	4.84	1.168	4.55	16.26	3.917	4.827	-23.25
198	0.53	0.25	1.13	1.168	4.55	16.26	2.292	2.842	-23.99
199	11.63	89.04	222.20	1.168	4.55	12.12	18.389	18.776	-2.10
200	3.54	8.24	20.55	1.168	4.55	12.12	7.556	7.874	-4.22
201	8.18	44.03	109.88	1.168	4.55	12.12	13.028	14.520	-11.45
202	6.64	29.01	72.39	1.168	4.55	12.12	10.694	12.468	-16.59
203	12.69	106.05	264.64	1.168	4.55	12.12	18.583	20.013	-7.69
204	15.14	150.81	376.32	1.168	4.55	12.12	21.444	22.757	-6.12

Table – 8.1.1 (contd.)

No.	Re	We x 10^5	Fr x 10^5	σ/σ_c	Sc x 10^{-2}	MF	$\bar{k}_L a$ x 10^3 s^{-1} exp.	$k_L a$ x 10^3 s^{-1} pred.	% err
205	5.31	18.57	46.33	1.168	4.55	12.12	9.972	10.594	-6.24
206	2.72	4.87	12.14	1.168	4.55	12.12	6.833	6.499	4.90
207	1.52	1.53	3.82	1.168	4.55	12.12	4.222	4.259	-0.88
208	10.84	77.27	192.81	1.168	4.55	12.12	16.694	17.828	-6.79
209	0.83	0.45	1.13	1.168	4.55	12.12	2.581	2.729	-5.76
210	2.29	3.45	8.61	1.168	4.55	12.12	5.667	5.731	-1.14
211	16.20	172.71	430.99	1.168	4.55	12.12	22.250	23.912	-7.47
212	17.79	208.36	519.95	1.168	4.55	12.12	21.556	25.607	-18.79
213	17.69	205.88	513.75	1.168	4.55	12.12	21.500	25.495	-18.58
214	0.90	0.72	3.23	1.168	1.87	16.26	5.972	6.503	-8.88
215	8.61	65.45	294.09	1.168	1.87	16.26	35.139	33.740	3.98
216	0.83	0.61	2.73	1.168	1.87	16.26	5.444	6.113	-12.28
217	4.95	21.62	97.13	1.168	1.87	16.26	25.333	22.519	11.11
218	3.94	13.73	61.67	1.168	1.87	16.26	18.417	19.078	-3.59
219	2.35	4.87	21.86	1.168	1.87	16.26	11.917	13.066	-9.64
220	5.86	30.31	136.17	1.168	1.87	16.26	26.472	25.474	3.77
221	1.84	3.00	13.50	1.168	1.87	16.26	10.444	10.958	-4.92
222	7.80	53.69	241.26	1.168	1.87	16.26	29.667	31.388	-5.80
223	9.72	83.39	374.68	1.168	1.87	16.26	36.389	36.859	-1.29
224	1.56	2.14	9.63	1.168	1.87	16.26	10.389	9.686	6.77
225	7.48	49.42	222.07	1.168	1.87	16.26	30.778	30.452	1.06
226	0.99	0.86	3.89	1.168	1.87	16.26	6.389	6.955	-8.86
227	1.52	2.03	9.12	1.168	1.87	16.26	9.556	9.496	0.62
228	5.64	28.09	126.24	1.168	4.55	16.26	16.111	15.874	1.47
229	1.51	2.00	9.00	1.168	4.55	16.26	6.028	6.054	-0.44
230	6.49	37.21	167.21	1.168	4.55	16.26	16.694	17.590	-5.36
231	3.38	10.07	45.23	1.168	4.55	16.26	10.861	10.914	-0.49
232	0.87	0.67	3.01	1.168	4.55	16.26	3.694	4.059	-9.86
233	13.22	154.35	693.52	1.168	4.55	16.26	27.556	29.563	-7.28
234	5.09	22.88	102.81	1.168	4.55	16.26	14.389	14.729	-2.36
235	1.69	2.51	11.28	1.168	4.55	16.26	6.583	6.575	0.13

Note : MF = $[\ a_t' \cdot (\rho_L / \mu_L g)^{-1/3}\ ]$

Table – (8.1.2)

Statistical analysis for different correlations of $k_L a$

Correlation Structure : :-

$$k_L a = C \cdot Re^{\alpha} \cdot We^{\beta} \cdot Fr^{\gamma} \cdot (\sigma / \sigma_c)^{\delta} \cdot Sc^{m} \cdot (\rho_L / \mu_L g)^{-1/3} \cdot a_t .$$

No.	C	α	β	γ	δ	m	% E_{avg}	% E_{abs}	% S_{dev}
Optimisation by the Modified Simplex algorithm of Nelder and Mead									
All parameters are iterated, base values of guesses were 0.4, 0.2, 0.002, −0.4, −0.5, and 1.0 for α, β, γ, δ, m, and C, respectively. Each indice value perturbed 50 % at a time.									
1	0.0422	0.308	0.212	−0.004	−0.27	−0.50	0.136	10.03	0.18.
δ value fixed as −0.442 (as obtained in the case of effective interfacial areas during gas absorption without reaction.). Other parameters iterated as in step 1.									
2	0.0617	0.295	0.214	0.0089	−0.442	−0.456	2.75	11.19	0.20.
β, γ and δ fixed as 0.222, 0.002 and −0.442 (as obtained in the case of effective interfacial areas during gas absorption without chemical reaction.). Other parameters iterated as in step 1.									
3	0.0606	0.294	0.222	0.002	−0.442	−0.4535	2.44	11.02	0.19.
β, γ and δ fixed as 0.222, 0.002 and −0.442 (as in previous step) in addition index of Sc (i.e m) fixed as −0.5 in concordance with the penetration theory. Only α and C were iterated as in step 1.									
4*	0.0833	0.286	0.222	0.002	−0.442	−0.50	2.48	11.48	0.20.

Note : The values of indices in the finalised generalised correlation are as per regression step marked by (*)

correlation developed in this investigation : Equation (7.7)] and the index of Sc was also fixed as m = -0.5. When the data on k_La was regressed accordingly as per step (4), the mathematical modelling of the data yielded the following correlation :-

$$k_La = 0.0833 \, [(Re)^{0.286} \, (We)^{0.22} \, (Fr)^{0.002} \,] \times$$

$$\ldots \times [\,(\sigma / \sigma_c)^{-0.442} \, (Sc)^{-0.5} \, (\rho_L / \mu_L g)^{-1/3} \, a_t] \quad (8.6)$$

The statistical analysis of correlation [Equation (8.6)] was as under :- The values of % E_{avg} % E_{abs} and % S_{dev} were 2.48, 11.48 and 0.2 respectively.

The statistical analysis of the correlation [Equation (8.6)] althought slightly inferior, it is not very much different from the previous correlation [Equation (8.4)]. Hence it can be considered as an appropriate equation which can be conveniently used for predicting most of the values of k_La within ± 20 % error range.

8.1.3 Comparison between the experimental values based on data bank and the predicted values of k_La :

The values of k_La obtained from the data bank and the values of k_La predicted by using the correlation : Equation (8.6) are tabulated in Table (8.1.3) and are plotted in Figure (8.1).

The detailed statistical analysis of the correlation [Equation (8.6)] can be described as follows :-

(i) The total number of points used in the correlation is 235 with 34 different variations inclusive of system variations.

Table – (8.1.3)

Comparison between experimental values based on data bank and predicted values of $k_L a$

No.	$k_L a \times 10^3$ s^{-1} exp	$k_L a \times 10^3$ s^{-1} This work	% err	$k_L a \times 10^3$ s^{-1} Sherwood	% err	$k_L a \times 10^3$ s^{-1} Norman	% err	$k_L a \times 10^3$ s^{-1} Mohunta	% err
1	2.278	2.188	4.0	3.443	-51.2	2.454	-7.7	2.283	-0.2
2	3.056	2.899	5.1	4.425	-44.8	3.277	-7.3	3.049	0.2
3	4.444	3.783	14.9	5.608	-26.2	4.308	3.1	4.008	9.8
4	5.278	4.380	17.0	6.389	-21.1	5.008	5.1	4.659	11.7
5	6.111	4.948	19.0	7.122	-16.5	5.676	7.1	5.281	13.6
6	6.944	6.083	12.4	8.560	-23.3	7.018	-1.1	6.529	6.0
7	9.167	7.975	13.0	10.895	-18.8	9.270	-1.1	8.624	5.9
8	12.222	10.722	12.3	14.180	-16.0	12.565	-2.8	11.689	4.4
9	23.889	18.642	22.0	23.204	2.9	22.179	7.2	20.634	13.6
10	26.944	23.521	12.7	28.539	-5.9	28.162	-4.5	26.200	2.8
11	2.778	2.168	22.0	3.116	-12.2	3.179	-14.4	2.829	-1.9
12	8.889	6.586	25.9	10.216	-14.9	9.957	-12.0	8.863	0.3
13	26.111	19.013	27.2	31.713	-21.5	29.591	-13.3	26.340	-0.9
14	6.400	5.378	16.0	7.293	-13.9	5.834	8.8	5.480	14.4
15	4.555	3.758	17.5	5.752	-26.3	4.429	2.8	3.169	30.4
16	3.250	2.785	14.3	4.040	-24.3	2.967	8.7	2.542	21.8
17	4.860	4.641	4.5	6.367	-31.0	5.015	-3.2	4.297	11.6
18	6.830	6.210	9.1	8.251	-20.8	6.764	1.0	5.795	15.2
19	8.230	7.700	6.4	9.993	-21.4	8.436	-2.5	7.228	12.2
20	9.810	9.053	7.7	11.541	-17.6	9.962	-1.6	8.535	13.0
21	5.647	4.105	27.3	7.354	-30.2	8.040	-42.4	5.747	-1.8
22	8.000	5.242	34.5	9.549	-19.4	10.335	-29.2	7.388	7.7
23	8.823	5.761	34.7	10.562	-19.7	11.387	-29.1	8.140	7.7
24	10.924	6.934	36.5	12.876	-17.9	13.776	-26.1	9.847	9.9
25	3.950	3.932	0.5	5.978	-51.3	4.613	-16.8	3.914	0.9
26	8.330	7.613	8.6	10.765	-29.2	9.094	-9.2	7.716	7.4
27	16.660	14.773	11.3	19.426	-16.6	17.970	-7.9	15.249	8.5
28	29.160	24.635	15.5	30.628	-5.0	30.389	-4.2	25.787	11.6
29	3.600	3.846	-6.8	5.369	-49.1	4.093	-13.7	4.078	-13.3
30	6.000	6.467	-7.8	8.506	-41.8	6.959	-16.0	7.006	-16.8
31	8.100	9.096	-12.3	11.516	-42.2	9.871	-21.9	9.966	-23.0
32	10.100	11.307	-11.9	13.907	-37.7	12.268	-21.5	12.649	-25.2
33	12.900	13.522	-4.8	16.265	-26.1	14.697	-13.9	15.296	-18.6
34	14.500	15.863	-9.4	18.731	-29.2	17.292	-19.3	18.110	-24.9
35	17.400	19.087	-9.7	22.127	-27.2	20.961	-20.5	21.780	-25.2
36	24.300	26.739	-10.0	29.840	-22.8	29.596	-21.8	30.899	-27.2
37	28.600	32.885	-15.0	35.849	-25.3	36.571	-27.9	38.302	-33.9
38	9.400	9.106	3.1	14.349	-52.6	13.808	-46.9	13.129	-39.7
39	12.500	12.728	-1.8	20.483	-63.9	19.443	-55.5	18.573	-48.6
40	15.200	14.393	5.3	23.403	-54.0	22.100	-45.4	21.013	-38.2
41	18.400	17.818	3.2	29.387	-59.7	27.510	-49.5	26.206	-42.4
42	23.100	21.275	7.9	35.533	-53.8	33.021	-42.9	31.396	-35.9
43	25.800	23.548	8.7	39.602	-53.5	36.649	-42.0	34.846	-35.1
44	3.500	3.910	-11.7	5.310	-51.7	4.041	-15.5	3.969	-13.4
45	8.500	9.579	-12.7	11.768	-38.4	10.120	-19.1	10.024	-17.9

Table - 8.1.3 (contd.)

No.	$k_La \times 10^3$ s^{-1} exp	$k_La \times 10^3$ s^{-1} This work	% err	$k_La \times 10^3$ s^{-1} Sherwood	% err	$k_La \times 10^3$ s^{-1} Norman	% err	$k_La \times 10^3$ s^{-1} Mohunta	% err
46	14.700	15.533	-5.7	18.025	-22.6	16.546	-12.6	16.674	-13.4
47	17.600	19.755	-12.2	22.285	-26.6	21.132	-20.1	21.464	-22.0
48	28.400	31.456	-10.8	33.619	-18.4	33.955	-19.6	34.925	-23.0
49	3.400	4.003	-17.7	5.196	-52.8	3.940	-15.9	3.801	-11.8
50	9.400	10.052	-6.9	11.735	-24.8	10.084	-7.3	9.930	-5.6
51	16.000	16.161	-1.0	17.869	-11.7	16.378	-2.4	16.287	-1.8
52	17.700	19.594	-10.7	21.180	-19.7	19.924	-12.6	19.941	-12.7
53	31.400	32.657	-4.0	33.270	-6.0	33.551	-6.9	34.010	-8.3
54	3.600	4.015	-11.5	5.065	-40.7	3.825	-6.2	3.604	-0.1
55	9.900	10.178	-2.8	11.525	-16.4	9.872	0.3	9.533	3.7
56	14.900	16.321	-9.5	17.548	-17.8	16.035	-7.6	15.484	-3.9
57	20.600	20.755	-0.8	21.681	-5.2	20.463	0.7	19.971	3.1
58	30.900	33.604	-8.8	33.220	-7.5	33.475	-8.3	32.988	-6.8
59	4.000	4.036	-0.9	4.968	-24.2	3.740	6.5	3.408	14.8
60	11.200	10.230	8.7	11.292	-0.8	9.642	13.9	9.040	19.3
61	15.300	15.923	-4.1	16.740	-9.4	15.185	0.8	14.256	6.8
62	20.100	19.357	3.7	19.881	1.1	18.515	7.9	17.521	12.8
63	35.000	33.426	4.5	32.298	7.7	32.409	7.4	30.816	12.0
64	3.800	4.103	-8.0	4.852	-27.7	3.638	4.3	3.212	15.5
65	10.200	10.280	-0.8	10.932	-7.2	9.284	9.0	8.384	17.8
66	17.100	16.413	4.0	16.594	3.0	15.027	12.1	13.529	20.9
67	18.700	19.428	-3.9	19.244	-2.9	17.826	4.7	16.183	13.5
68	29.600	32.911	-11.2	30.712	-3.8	30.566	-3.3	27.967	5.5
69	9.400	9.921	-5.5	10.186	-8.4	8.553	9.0	7.113	24.3
70	14.900	15.886	-6.6	15.459	-3.8	13.839	7.1	11.605	22.1
71	19.800	21.712	-9.7	20.393	-3.0	19.048	3.8	16.057	18.9
72	31.100	34.635	-11.4	30.851	0.8	30.708	1.3	26.085	16.1
73	3.600	3.413	5.2	5.664	-57.3	4.352	-20.9	4.448	-23.6
74	6.000	5.569	7.2	8.759	-46.0	7.197	-19.9	7.356	-22.6
75	8.500	7.611	10.5	11.567	-36.1	9.920	-16.7	10.139	-19.3
76	11.100	10.195	8.1	15.006	-35.2	13.395	-20.7	13.692	-23.3
77	13.400	12.402	7.4	17.866	-33.3	16.381	-22.2	16.744	-25.0
78	15.400	15.811	-2.7	22.179	-44.0	21.024	-36.5	21.490	-39.5
79	17.200	19.067	-10.9	26.204	-52.3	25.484	-48.2	26.049	-51.4
80	21.000	23.970	-14.1	32.125	-53.0	32.238	-53.5	32.953	-56.9
81	6.900	6.385	7.5	12.229	-77.2	11.837	-71.6	10.513	-52.4
82	9.100	8.027	11.8	15.615	-71.6	14.973	-64.5	13.298	-46.1
83	11.800	9.498	19.5	18.694	-58.4	17.802	-50.9	15.811	-34.0
84	13.000	10.830	16.7	21.508	-65.4	20.371	-56.7	18.093	-39.2
85	17.200	13.441	21.9	27.090	-57.5	25.432	-47.9	22.587	-31.3
86	20.000	15.840	20.8	32.288	-61.4	30.107	-50.5	26.740	-33.7
87	22.000	17.945	18.4	36.892	-67.7	34.225	-55.6	30.397	-38.2
88	3.500	3.372	3.7	5.530	-58.0	4.235	-21.0	4.110	-17.4
89	6.300	5.407	14.2	8.396	-33.3	6.856	-8.8	6.733	-6.9
90	9.000	7.443	17.3	11.151	-23.9	9.511	-5.7	9.372	-4.1
91	12.900	10.131	21.5	14.656	-13.6	13.035	-1.0	12.912	-0.1
92	14.600	12.125	17.0	17.163	-17.6	15.639	-7.1	15.623	-7.0
93	16.400	15.607	4.8	21.447	-30.8	20.221	-23.3	20.367	-24.2
94	21.300	20.622	3.2	27.486	-29.0	26.923	-26.4	27.118	-27.3
95	23.200	25.220	-8.7	32.851	-41.6	33.070	-42.5	33.441	-44.1
96	4.200	3.390	19.3	5.275	-25.6	4.010	4.5	3.868	7.9

Table – 8.1.3 (contd.)

No.	$k_La \times 10^3$ s^{-1} exp	$k_La \times 10^3$ s^{-1} This work	% err	$k_La \times 10^3$ s^{-1} Sherwood	% err	$k_La \times 10^3$ s^{-1} Norman	% err	$k_La \times 10^3$ s^{-1} Mohunta	% err
97	7.700	5.575	27.6	8.215	-6.7	6.685	13.2	6.449	16.2
98	14.400	10.492	27.1	14.425	-0.2	12.799	11.1	12.348	14.2
99	15.600	12.380	20.6	16.716	-7.2	15.172	2.7	14.637	6.2
100	19.200	15.534	19.1	20.458	-6.6	19.155	0.2	18.480	3.7
101	26.400	20.159	23.6	25.750	2.5	24.974	5.4	24.299	8.0
102	32.000	25.169	21.3	31.376	1.9	31.371	2.0	30.523	4.6
103	3.700	3.494	5.6	5.246	-41.8	3.985	-7.7	3.658	1.1
104	6.000	5.587	6.9	7.969	-32.8	6.454	-7.6	5.926	1.2
105	8.700	7.718	11.3	10.613	-22.0	8.983	-3.2	8.289	4.7
106	12.700	10.424	17.9	13.859	-9.1	12.220	3.8	11.315	10.9
107	15.100	12.334	18.3	16.098	-6.6	14.526	3.8	13.450	10.9
108	18.200	16.081	11.6	20.346	-11.8	19.030	-4.6	17.770	2.4
109	23.000	21.063	8.4	25.873	-12.5	25.111	-9.2	23.448	-1.9
110	25.600	25.377	0.9	30.560	-19.4	30.406	-18.8	28.389	-10.9
111	3.400	3.613	-6.3	5.173	-52.1	3.920	-15.3	3.657	-7.6
112	5.600	5.919	-5.7	8.028	-43.4	6.509	-16.2	6.072	-8.4
113	8.500	8.163	4.0	10.719	-26.1	9.077	-6.8	8.465	0.4
114	12.000	11.135	7.2	14.132	-17.8	12.488	-4.1	11.645	3.0
115	14.700	13.059	11.2	16.287	-10.8	14.709	-0.1	13.717	6.7
116	17.400	17.572	-1.0	21.173	-21.7	19.908	-14.4	18.712	-7.5
117	20.300	21.731	-7.0	25.583	-26.0	24.764	-22.0	23.276	-14.7
118	24.000	26.555	-10.6	30.524	-27.2	30.357	-26.5	28.761	-19.8
119	3.900	3.633	6.9	5.045	-29.4	3.806	2.4	3.466	11.1
120	6.000	5.950	0.8	7.828	-30.5	6.319	-5.3	5.754	4.1
121	9.200	8.354	9.2	10.568	-14.9	8.932	2.9	8.203	10.8
122	12.900	11.312	12.3	13.843	-7.3	12.197	5.5	11.202	13.2
123	16.400	13.265	19.1	15.952	2.7	14.365	12.4	13.193	19.6
124	17.000	17.100	-0.6	19.962	-17.4	18.604	-9.4	17.220	-1.3
125	22.300	21.715	2.6	24.694	-10.7	23.781	-6.6	22.011	1.3
126	26.500	27.549	-4.0	30.464	-15.0	30.295	-14.3	28.265	-6.7
127	3.900	3.614	7.3	4.960	-27.2	3.733	4.3	3.331	14.6
128	7.000	5.969	14.7	7.754	-10.8	6.250	10.7	5.578	20.3
129	9.200	8.216	10.7	10.306	-12.0	8.679	5.7	7.746	15.8
130	12.500	11.145	10.8	13.522	-8.2	11.872	5.0	10.596	15.2
131	13.800	13.149	4.7	15.665	-13.5	14.070	-2.0	12.557	9.0
132	19.400	16.992	12.4	19.642	-1.2	18.264	5.9	16.441	15.3
133	21.400	21.740	-1.6	24.411	-14.1	23.467	-9.7	21.307	0.4
134	26.900	27.245	-1.3	29.846	-10.9	29.592	-10.0	26.868	0.1
135	9.600	7.835	18.4	17.833	-85.8	17.017	-77.3	16.045	-67.1
136	10.100	9.234	8.6	21.254	-110.4	20.145	-99.5	18.994	-88.1
137	12.800	10.735	16.1	24.964	-95.0	23.515	-83.7	22.172	-73.2
138	15.900	12.832	19.3	30.208	-90.0	28.247	-77.7	26.633	-67.5
139	4.000	4.135	-3.4	6.146	-53.6	4.800	-20.0	3.572	10.7
140	5.498	5.156	6.2	7.479	-36.0	6.021	-9.5	4.481	18.5
141	6.356	5.727	9.9	8.213	-29.2	6.707	-5.5	4.991	21.5
142	7.036	6.793	3.5	9.561	-35.9	7.993	-13.6	5.948	15.5
143	8.621	7.952	7.8	11.001	-27.6	9.397	-9.0	6.993	18.9
144	9.000	9.335	-3.7	12.689	-41.0	11.080	-23.1	8.246	8.4
145	10.980	10.590	3.6	14.197	-29.3	12.613	-14.9	9.386	14.5
146	11.600	11.449	1.3	15.219	-31.2	13.666	-17.8	10.170	12.3
147	3.924	3.962	-1.0	6.303	-60.6	4.906	-25.0	2.867	26.9

Table – 8.1.3 (contd.)

No.	k_La $\times 10^3$ s^{-1} exp	k_La $\times 10^3$ s^{-1} This work	% err	k_La $\times 10^3$ s^{-1} Sherwood	% err	k_La $\times 10^3$ s^{-1} Norman	% err	k_La $\times 10^3$ s^{-1} Mohunta	% err
148	5.233	5.138	1.8	7.945	-51.8	6.408	-22.5	3.745	28.4
149	6.000	6.226	-3.8	9.426	-57.1	7.805	-30.1	4.562	24.0
150	7.445	7.396	0.7	10.988	-47.6	9.316	-25.1	5.445	26.9
151	8.000	8.386	-4.8	12.289	-53.6	10.600	-32.5	6.195	22.6
152	9.074	9.552	-5.3	13.799	-52.1	12.117	-33.5	7.082	22.0
153	5.555	5.445	2.0	10.068	-81.2	9.268	-66.8	8.866	-59.6
154	8.330	7.584	9.0	12.863	-54.4	13.025	-56.4	12.461	-49.6
155	11.110	10.186	8.3	16.001	-44.0	17.637	-58.8	16.873	-51.9
156	13.492	12.443	7.8	18.553	-37.5	21.663	-60.6	20.724	-53.6
157	15.897	14.667	7.7	20.954	-31.8	25.651	-61.4	24.539	-54.4
158	18.370	16.837	8.3	23.205	-26.3	29.558	-60.9	28.276	-53.9
159	14.470	18.692	-29.2	15.862	-9.6	17.425	-20.4	16.670	-15.2
160	18.020	22.933	-27.3	18.452	-2.4	21.498	-19.3	20.567	-14.1
161	21.750	27.208	-25.1	20.939	3.7	25.626	-17.8	24.515	-12.7
162	24.800	31.394	-26.6	23.277	6.1	29.685	-19.7	28.398	-14.5
163	11.110	14.115	-27.0	12.863	-15.8	13.057	-17.5	12.563	-13.1
164	14.870	18.645	-25.4	15.805	-6.3	17.380	-16.9	16.723	-12.5
165	18.510	22.797	-23.2	18.339	0.9	21.368	-15.4	20.559	-11.1
166	22.100	27.149	-22.8	20.869	5.6	25.568	-15.7	24.601	-11.3
167	25.230	31.200	-23.7	23.130	8.3	29.496	-16.9	28.380	-12.5
168	7.894	6.069	23.1	8.140	-3.1	6.818	13.6	2.817	64.3
169	10.233	8.480	17.1	10.425	-1.9	9.615	6.0	3.972	61.2
170	14.238	10.528	26.1	12.234	14.1	12.008	15.7	4.960	65.2
171	2.456	1.890	23.1	3.876	-57.8	2.309	6.0	0.589	76.0
172	3.918	3.218	17.9	5.746	-46.7	3.989	-1.8	1.018	74.0
173	5.263	4.581	13.0	7.461	-41.8	5.733	-8.9	1.463	72.2
174	6.608	6.056	8.4	9.172	-38.8	7.637	-15.6	1.949	70.5
175	9.824	7.370	25.0	10.606	-8.0	9.345	4.9	2.385	75.7
176	1.578	1.057	33.0	2.837	-79.8	1.442	8.6	0.224	85.8
177	2.280	1.804	20.9	4.213	-84.8	2.497	-9.5	0.388	83.0
178	2.836	2.088	26.4	4.694	-65.5	2.901	-2.3	0.450	84.1
179	3.450	3.303	4.2	6.591	-91.0	4.648	-34.7	0.722	79.1
180	4.327	4.046	6.5	7.657	-77.0	5.724	-32.3	0.889	79.5
181	5.877	4.796	18.4	8.684	-47.8	6.818	-16.0	1.059	82.0
182	7.602	5.466	28.1	9.566	-25.8	7.798	-2.6	1.211	84.1
183	1.695	1.208	28.8	3.417	-101.6	1.788	-5.5	0.205	87.9
184	1.988	1.753	11.8	4.502	-126.5	2.623	-31.9	0.301	84.9
185	2.397	2.300	4.1	5.503	-129.6	3.466	-44.6	0.397	83.4
186	4.093	3.339	18.4	7.251	-77.2	5.084	-24.2	0.583	85.8
187	4.385	3.865	11.9	8.079	-84.2	5.908	-34.7	0.677	84.6
188	9.833	11.780	-19.8	9.778	0.6	8.899	9.5	8.904	9.4
189	19.944	23.155	-16.1	16.119	19.2	17.819	10.7	17.829	10.6
190	5.694	6.910	-21.3	6.590	-15.7	5.144	9.7	5.147	9.6
191	8.806	10.746	-22.0	9.135	-3.7	8.097	8.0	8.102	8.0
192	6.944	8.586	-23.6	7.738	-11.4	6.430	7.4	6.434	7.4
193	3.278	4.153	-26.7	4.521	-37.9	3.049	7.0	3.050	6.9
194	4.333	5.189	-19.7	5.331	-23.0	3.833	11.6	3.835	11.5
195	12.972	16.077	-23.9	12.307	5.1	12.249	5.6	12.256	5.5
196	4.833	6.176	-27.8	6.064	-25.5	4.584	5.2	4.586	5.1
197	3.917	4.827	-23.3	5.054	-29.0	3.559	9.1	3.561	9.1
198	2.292	2.842	-24.0	3.415	-49.0	2.065	9.9	2.066	9.9

Table - 8.1.3 (contd.)

No.	k_La $\times 10^3$ s^{-1} exp	k_La $\times 10^3$ s^{-1} This work	% err	k_La $\times 10^3$ s^{-1} Sherwood	% err	k_La $\times 10^3$ s^{-1} Norman	% err	k_La $\times 10^3$ s^{-1} Mohunta	% err
199	18.389	18.776	-2.1	15.376	16.4	16.688	9.2	16.291	11.4
200	7.556	7.874	-4.2	8.085	-7.0	6.834	9.5	6.671	11.7
201	13.028	14.520	-11.5	12.714	2.4	12.815	1.6	12.510	4.0
202	10.694	12.468	-16.6	11.359	-6.2	10.959	-2.5	10.701	-0.1
203	18.583	20.013	-7.7	16.119	13.3	17.819	4.1	17.394	6.4
204	21.444	22.757	-6.1	17.727	17.3	20.334	5.2	19.849	7.4
205	9.972	10.594	-6.2	10.070	-1.0	9.270	7.0	9.049	9.3
206	6.833	6.499	4.9	7.015	-2.7	5.611	17.9	5.477	19.8
207	4.222	4.259	-0.9	5.132	-21.5	3.635	13.9	3.548	16.0
208	16.694	17.828	-6.8	14.798	11.4	15.824	5.2	15.447	7.5
209	2.581	2.729	-5.8	3.692	-43.1	2.301	10.8	2.246	13.0
210	5.667	5.731	-1.1	6.392	-12.8	4.931	13.0	4.813	15.1
211	22.250	23.912	-7.5	18.388	17.4	21.395	3.8	20.885	6.1
212	21.556	25.607	-18.8	19.343	10.3	22.955	-6.5	22.407	-4.0
213	21.500	25.495	-18.6	19.281	10.3	22.852	-6.3	22.307	-3.8
214	5.972	6.503	-8.9	7.074	-18.5	4.774	20.1	4.777	20.0
215	35.139	33.740	4.0	23.912	31.9	25.916	26.2	25.931	26.2
216	5.444	6.113	-12.3	6.758	-24.1	4.481	17.7	4.483	17.7
217	25.333	22.519	11.1	17.731	30.0	17.106	32.5	17.116	32.4
218	18.417	19.078	-3.6	15.684	14.8	14.427	21.7	14.435	21.6
219	11.917	13.066	-9.6	11.853	0.5	9.778	17.9	9.784	17.9
220	26.472	25.474	3.8	19.424	26.6	19.416	26.7	19.428	26.6
221	10.444	10.958	-4.9	10.407	0.4	8.161	21.9	8.166	21.8
222	29.667	31.388	-5.8	22.667	23.6	24.061	18.9	24.075	18.8
223	36.389	36.859	-1.3	25.528	29.8	28.379	22.0	28.396	22.0
224	10.389	9.686	6.8	9.499	8.6	7.189	30.8	7.194	30.8
225	30.778	30.452	1.1	22.166	28.0	23.324	24.2	23.338	24.2
226	6.389	6.955	-8.9	7.435	-16.4	5.116	19.9	5.119	19.9
227	9.556	9.496	0.6	9.361	2.0	7.045	26.3	7.049	26.2
228	16.111	15.874	1.5	12.192	24.3	12.090	25.0	12.098	24.9
229	6.028	6.054	-0.4	5.976	0.9	4.491	25.5	4.494	25.5
230	16.694	17.590	-5.4	13.153	21.2	13.434	19.5	13.442	19.5
231	10.861	10.914	-0.5	9.241	14.9	8.228	24.2	8.233	24.2
232	3.694	4.059	-9.9	4.445	-20.3	2.978	19.4	2.980	19.3
233	27.556	29.563	-7.3	19.312	29.9	22.903	16.9	22.917	16.8
234	14.389	14.729	-2.4	11.534	19.8	11.195	22.2	11.201	22.2
235	6.583	6.575	0.1	6.352	3.5	4.888	25.8	4.891	25.7

(ii) The values of % E_{avg}, % E_{abs} and % S_{dev} were 2.48, 11.48 and 0.20 respectively.

(iii) From the 235 data points, 80 % of the predicted values of k_La (i.e. 189 data points) were within ± 20 % of the experimental data bank values, 65 % were within ± 15 % and 50 % were within ± 10 %.

(iv) 20 % of the points registered deviations greater than ± 20 % with the value of maximum deviation being ± 36 %.

Figure (8.1) shows a parity plot wherein the values of $(k_La)_{pred}$ have been ploted versus $(k_La)_{exp.(Lit)}$. The satisfactory fit in Figure (8.1) clearly reflects that equation (8.4) can correlate satisfactorily all the data obtained from various sources covering a wide range of variables as mentioned earlier.

The existing correlations of k_La have been surveyed in Chapter - (2). The most widely used correlation is the one proposed by Sherwood and Halloway [Equation (2.12)] which is not dimensionally consistent in nature. The values of k_La obtained by using this correlation are also reported in Table (8.1.3). The detailed statistical analysis of Sherwood and Halloway's correlation can be described as follows :-

(i) The values of % E_{avg}, % E_{abs} and % S_{dev} were -23.56, 29.4 and 0.37 respectively.

(ii) From the 235 data points, only 44% of predicted values of k_La (i.e. 104 data points) were within ± 20 % of the experimental data bank values and 35 % were within ± 15 %.

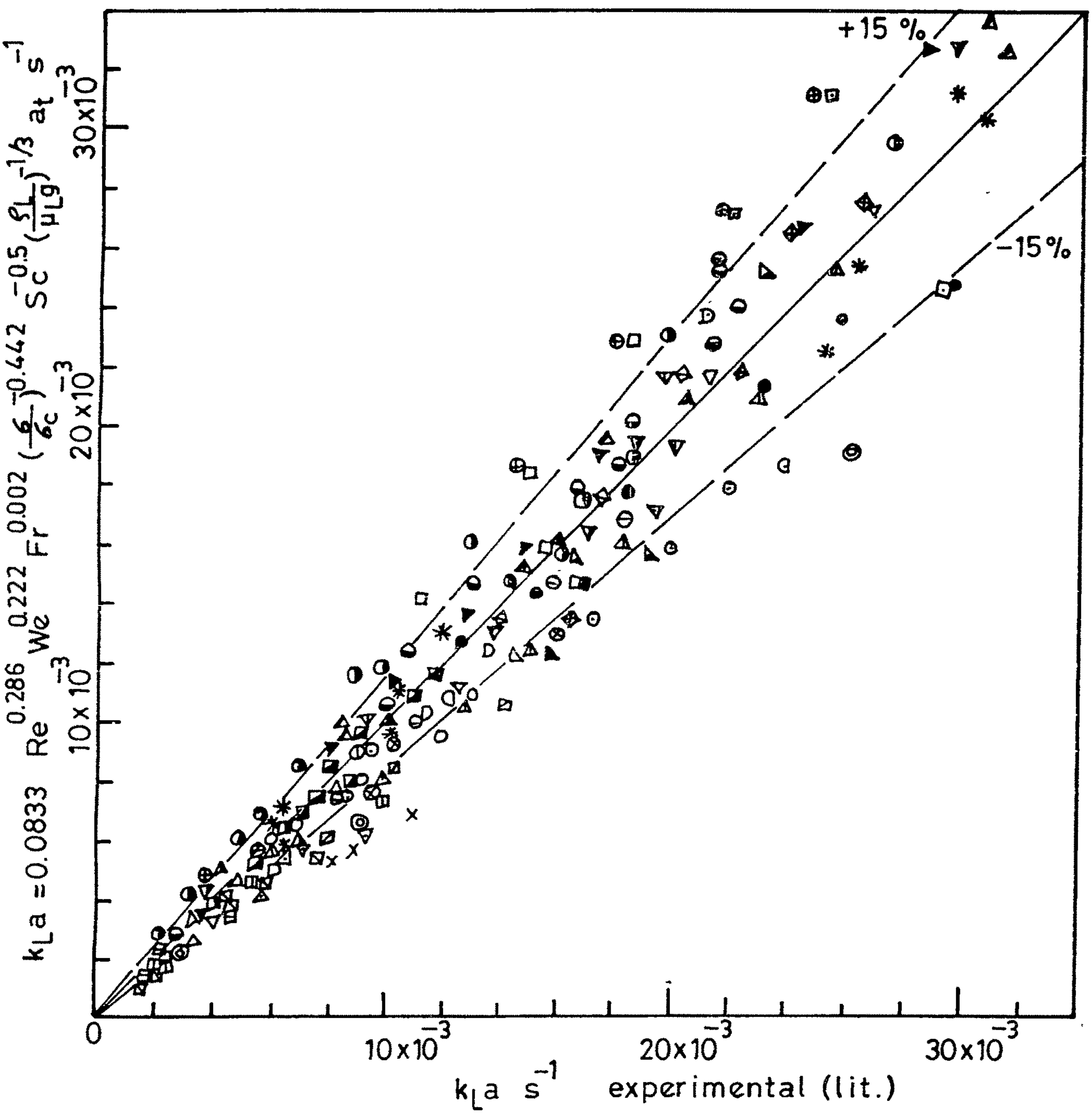

Fig.8.1 VOLUMETRIC LIQUID SIDE MASS TRANSFER COEFFICIENT. DURING PHYSICAL ABSORPTION.

COMPARISON OF PREDICTED vs. EXPERIMENTAL (LIT.) DATA.

LEGENDS FOR FIG. 8.1

Data No.	Relevant Information	Symbol
1-13	Hikita (40), CO_2- H_2O, C.R.R., 15mm, 25mm.	◐ ⊙
14-15	Danckwerts (19), C.R.R., 13mm, CO_2- H_2O;	⊿
	CO_2- aq. Na_2SO_4.	⊿
16-20	Richards (21), CO_2-1.8 M NaCl, C.R.R., 13mm.	Δ
21-24	Danckwerts (22), CO_2- aq. Na_2SO_4, C.R.R., 38mm.	x
25-28	Onda (28), O_2- aq. Na_2SO_3, C.R.R., 15mm.	◧
29-43	Sahay (41), CO_2-H_2O, C.R.R., 13mm, 25mm.	▲ ●
44-72	Sahay (41), CO_2- aq. isopropanol, C.R.R., 13mm,	
	σ = 62.8, 59.2, 56.0 mN/m.	▲ ◭ ▼
	σ = 52.0, 47.0 mN/m.	▼ ▽
73-87	Sahay (41), CO_2-H_2O, PVC.R.R., 13mm, 25mm.	D ○
88-134	Sahay (41), CO_2- aq. isopropanol PVC.R.R., 13mm,	
	σ = 68.5, 58.0, 54.0 mN/m.	◣ ◭ ⬖
	σ = 51.0, 49.0 mN/m.	⬖ ▽
135-138	Sahay (41), CO_2-H_2O, Polypropylene R.R., 25mm.	⊗
139-152	Joosten (42), CO_2- aq. $NaNO_3$, C.R.R., 13mm.	◪
153-162	Mangers (43), CO_2-H_2O, dp = 10mm,	
	PTFE R.R., Glass R.R.	⊖ ⊕
163-187	Mangers (44), CO_2-H_2O, aq.Glycerol, Glass R.R.,	
	d_p = 10mm, μ_L = 0.90, 2.88, 5.50 mNs/m².	□ ⧄ ◫
	μ_L = 10.8, 16.0 mNs/m².	⧅ ⊟
188-213	Onda (45), CO_2-H_2O, C.R.R., 6mm, 8mm.	◐ ◒
214-227	Onda (46), H_2-H_2O, C.R.R., 6mm.	✱
228-235	Onda (46), CO_2-H_2O, C.R.R., 6mm.	◑

(iii) 20 % of the points registered deviations greater than 50 % with the values of maximum deviation being -129 %.

The correlation by Norman [Equation (2.13)] was also used to predict the values of k_La, which have been tabulated in Table (8.1.3). The detailed statistical analysis of Normans correlation can be described as follows :-

(i) The values of % E_{avg}, % E_{abs} and % S_{dev} were -9.79, 18.21 and 0.34 respectively.

(ii) From the 235 data points, 69 % of the predicted values of k_La (i.e. 162 data points) were within ± 20 % of the experimental data bank values and 55 % were within ± 15 %.

(iii) 12 % of the data points registered deviations greater than -40 % with the value of maximum deviation being -99 %.

The only existing generalised correlation which is dimensionally consistent is due to Mohunta et al. [Equation (2.14)]. The values of k_La were also obtained by Mohunta's correlation and are reported in Table (8.1.3).

The detailed statistical analysis of the correlation can be described as follows :-

(i) The values of % E_{avg}, % E_{abs} and % S_{dev} were 5.9, 22.7 and 0.36 respectively.

(ii) From the 235 data points, 66 % of the predicted values of k_La (i.e. 155 data points) were within ± 20 % of the experimental values and 50 % were within ± 15 %.

(iii) 15 % of the points registered deviations greater than ± 40 % with the values of maximum deviation being - 88 %.

Therefore, based on the detailed statistical analysis of the different correlations inclusive of the correlation developed in this investigation, it can be concluded that the correlation [Equation (8.6)] developed in this investigation is expected to be superior in comparison to the existing correlations for predicting $k_L a$.

The unusually high error in most of the existing correlations stems from the fact that none of these correlations incorporate the effect of wettability of packing material and surface tension effect on the values of $k_L a$. It can be easily visualised that a poorly wettable packing such as those made of polymeric materials would provide very low values of effective interfacial area and hence very low values of $k_L a$.

Further most of the existing correlations are able to predict the $k_L a$ values only under conditions wherein the values of viscosity are not significantly greater than those of water.

Hence it can be concluded that the correlation for $k_L a$ [Equation (8.6)] developed in this investigation is a truly generalised dimensionally consistent correlation wherein the effect of all the parameters has been rationally and adequately incorporated.

The validity of the generalised correlation [Equation (8.6)] developed in this investigation was further checked by applying this

Table - (8.1.4)

Comparison between the experimental values (literature) and the predicted values of $k_L a$ for system having high viscosity of absorption media

System : Desorption of O_2 from water and viscous solutions.

No.	T	a_t	ρ_L	μ_L	σ	D_L	L	$k_L a$	$k_L a$	% err
						$\times 10^9$		$\times 10^3$	$\times 10^3$	
	^oC	m^2/m^3	kg/m^3	mNs/m^2	mN/m	m^2/s	$kg/m^2 s$	s^{-1}	s^{-1}	
								exp	pred.	
1	30.0	190	996.0	0.80	72.0	2.84	4.00	13.00	10.60	18.46
2	30.0	190	996.0	0.80	72.0	2.84	5.87	18.40	14.05	23.65
3	30.0	190	996.0	0.80	72.0	2.84	7.78	22.80	17.27	24.23
4	30.0	190	996.0	0.80	72.0	2.84	9.90	26.30	20.62	21.61
5	30.0	190	996.0	0.80	72.0	2.84	12.66	31.50	24.69	21.60
6	30.0	190	996.0	0.80	72.0	2.84	14.90	34.78	27.83	19.98
7	30.0	190	996.0	0.80	72.0	2.84	17.60	40.00	31.45	21.37
8	30.0	190	996.2	2.35	70.3	2.69	5.32	8.00	7.93	0.86
9	30.0	190	996.2	2.35	70.3	2.69	7.27	10.80	9.97	7.68
10	30.0	190	996.2	2.35	70.3	2.69	11.08	15.00	13.59	9.40
11	30.0	190	996.2	2.35	70.3	2.69	14.90	18.00	16.89	6.16
12	30.0	190	996.2	2.35	70.3	2.69	18.90	20.00	20.11	-0.56
13	30.0	190	1093.0	3.08	70.4	1.00	5.21	5.65	4.19	25.91
14	30.0	190	1093.0	3.08	70.4	1.00	8.51	8.30	6.00	27.70
15	30.0	190	1093.0	3.08	70.4	1.00	12.51	10.90	7.96	26.95
16	30.0	190	1093.0	3.08	70.4	1.00	16.73	13.20	9.86	25.33
17	30.0	190	1093.0	3.08	70.4	1.00	18.71	15.20	10.70	29.61
18	30.0	190	1141.0	7.27	69.1	0.55	4.44	2.18	1.89	13.33
19	30.0	190	1141.0	7.27	69.1	0.55	8.15	3.70	2.95	20.28
20	30.0	190	1141.0	7.27	69.1	0.55	13.36	5.20	4.24	18.45
21	30.0	190	1141.0	7.27	69.1	0.55	16.15	6.00	4.87	18.77
22	30.0	190	1141.0	7.27	69.1	0.55	18.53	6.52	5.39	17.29

correlation to the latest literature data on k_La obtained by Delaloye et al.(188). The values of k_La obtained by using the correlation developed in this investigation [Equation (8.6)] and the experimental values of k_La for the system O_2-aqueous glyerol wherein particularly the viscosities of absorption media were varied substantially are listed in Table (8.1.4), from which it is evident that the agreement between the experimental and predicted values is within ± 25 %.

8.2.0 RESULTS AND DISCUSSION FOR TRUE GAS SIDE MASS TRANSFER COEFFICIENTS (k_G)

Data bank for gas side mass transfer coefficients can be classified under four different cases as under :-

CASE (I) : Overall gas side mass transfer coefficients (K_Ga).

CASE (II) : Volumetric gas side mass transfer coefficient (k_Ga) obtained by chemical technique.

CASE (III) : Volumetric gas side mass transfer coefficient (k_Ga) during vaporization.

CASE (IV) : HTU data for vaporization.

These data banks can be used to obtain the values of true gas side mass transfer coefficients (k_G).

The values of true gas side mass transfer coefficients for physical absorption have been obtained by various investigators from the corresponding values of the volumetric gas side mass transfer coefficient (k_Ga) by dividing them with either values of total surface area per unit packed volume (a_t) or the wetted surface area (a_w). Both these approaches appear to be inappropriate. The values of effective interfacial area availiable for mass transfer during physical absorption (a_p) and that during chemical absorption (a_c) also that during vaporization (a_v) are different. Further, the values of a_w and a_t are not equal. Hence, it is obvious that the values of k_G obtained by different investigators do not represent the real values of k_G and can be called as the apparent values of k_G.

Hence, the data banks for "Gas side mass transfer coefficients" were reanalysed in this investigation. The real values of k_G were obtained from the k_Ga values by dividing these values by the appropriate values of effective interfacial area.

8.2.1 Results for true gas side mass transfer coefficient (k_G) :

The real values of true gas side mass transfer coefficients for physical absorption were obtained from the undermentioned four cases :-

<u>CASE (I)</u> : <u>Values of k_G obtained from overall gas side mass transfer coefficient</u> (K_Ga) :

The existing literature data on K_Ga reported in Table (5.5 A) incorporating 17 variations including system variations such as ammonia - water, acetone - water, methanol - water etc. were used initially to obtain the values of k_Ga from which subsequently the values of k_G were estimated.

In order to obtain the values of $k_G a$ from the reported values of $K_G a$, the methodology listed in section (4.1.0) of Chapter - (4) : General Considerations was used. The values of volumetric liquid side mass transfer coefficient during physical absorption ($k_L a$) were estimated under otherwise identical conditions mentioned for the $K_G a$ data reported in Table (5.5 A) by using the generalised correlation [Equation (8.6)] developed in this investigation. The values of Henry's, constant were estimated by using the appropriate equation/data mentioned in Chapter - (4). Thus, the values of $k_G a$ were estimated by using Equation - (4.1).

For the Case (I) under consideration, the effective interfacial area available for mass transfer during physical absorption based on the static area model developed in this investigation in Chapter - (6), the following equation holds good :-

$$k_G a = k_G a_p = k_G a_{dy} = k_G (a_w - a_{st}) \tag{8.7}$$

Hence, the values of 'a_{dy}' are obtained for the Case (I) under consideration by calculating the values of a_w and a_{st} using the generalised correlations developed in this investigation [Equations (7.3) and (7.16) respectively] and subtracting the a_{st} values from the a_w values. Thus the values of $k_L a$, a_w, a_{st}, a_{dy}, H, $k_G a$ and k_G were obtained under otherwise identical conditions mentioned for the $k_G a$ data bank reported in Table (5.5 A). Results obtained for Case (I) under consideration are reported in Tables (8.2.1 A) and (8.2.1 B).

Table – 8.2.1 (A)

Results for $k_L a$ inclusive of physical properties of liquids and processing parameters required for obtaining true gas side mass transfer coefficients (k_G).

No	ρ_L kg/m^3	μ_L mNs/m^2	σ mN/m	σ/σ_c	$D_L \times 10^9$ m^2/s	a_w m^2/m^3	a_{st} m^2/m^3	a_{dy} m^2/m^3	$k_L a \times 10^3$ s^{-1}
1	996.6	0.867	71.8	1.281	2.430	43.7	16.7	27.0	2.342
2	996.6	0.867	71.8	1.281	2.430	55.0	18.8	36.2	3.862
3	996.6	0.867	71.8	1.281	2.430	69.5	21.1	48.4	6.433
4	996.6	0.867	71.8	1.281	2.430	43.7	16.7	27.0	2.345
5	996.6	0.867	71.8	1.281	2.430	54.7	18.7	36.0	3.825
6	996.6	0.867	71.8	1.281	2.430	69.7	21.2	48.6	6.480
7	996.6	0.867	71.8	1.281	2.430	43.7	16.7	27.0	2.345
8	996.6	0.867	71.8	1.281	2.430	43.7	16.7	27.0	2.345
9	996.6	0.867	71.8	1.281	2.430	43.7	16.7	27.0	2.345
10	996.6	0.867	71.8	1.281	2.430	69.5	21.1	48.4	6.433
11	996.6	0.867	71.8	1.281	2.430	79.8	22.7	57.1	8.691
12	996.6	0.867	71.8	1.281	1.204	43.7	16.7	27.0	1.651
13	996.6	0.867	71.8	1.281	1.204	54.8	18.7	36.1	2.704
14	996.6	0.867	71.8	1.281	1.204	43.7	16.7	27.0	1.651
15	996.6	0.867	71.8	1.281	1.204	54.8	18.7	36.1	2.704
16	996.6	0.867	71.8	1.281	1.204	69.5	21.1	48.4	4.529
17	996.6	0.867	71.8	1.281	1.204	79.8	22.7	57.1	6.118
18	996.6	0.867	71.8	1.281	1.204	43.6	16.7	27.0	1.646
19	996.6	0.867	71.8	1.281	1.204	54.8	18.7	36.1	2.704
20	996.6	0.867	71.8	1.281	1.204	69.5	21.1	48.4	4.529
21	996.6	0.867	71.8	1.281	1.757	43.7	16.7	27.0	1.994
22	996.6	0.867	71.8	1.281	1.757	54.9	18.8	36.2	3.281
23	996.6	0.867	71.8	1.281	1.757	69.5	21.1	48.4	5.471
24	996.6	0.867	71.8	1.281	1.757	43.7	16.7	27.0	1.994
25	996.6	0.867	71.8	1.281	1.757	54.8	18.7	36.1	3.267
26	996.6	0.867	71.8	1.281	1.757	69.5	21.1	48.4	5.471
27	996.6	0.867	71.8	1.281	1.757	79.8	22.7	57.1	7.391
28	996.6	0.867	71.8	1.281	1.757	43.7	16.7	27.0	1.994
29	996.6	0.867	71.8	1.281	1.757	55.1	18.8	36.3	3.298
30	996.6	0.867	71.8	1.281	1.757	69.5	21.1	48.4	5.471
31	996.6	0.867	71.8	1.281	1.757	79.8	22.7	57.1	7.391
32	996.6	0.867	71.8	1.281	1.757	43.7	16.7	27.0	1.994
33	996.6	0.867	71.8	1.281	1.757	54.8	18.7	36.1	3.267
34	996.6	0.867	71.8	1.281	1.757	69.5	21.1	48.4	5.471
35	996.6	0.867	71.8	1.281	1.757	79.8	22.7	57.1	7.391
36	996.6	0.867	71.8	1.281	1.757	43.7	16.7	27.0	1.994
37	996.6	0.867	71.8	1.281	1.757	54.8	18.7	36.1	3.267
38	996.6	0.867	71.8	1.281	1.757	69.5	21.1	48.4	5.471
39	996.6	0.867	71.8	1.281	1.373	43.6	16.7	26.9	1.755
40	996.6	0.867	71.8	1.281	1.373	55.0	18.8	36.2	2.903
41	996.6	0.867	71.8	1.281	1.373	69.5	21.1	48.4	4.835
42	996.6	0.867	71.8	1.281	1.373	69.5	21.1	48.4	4.835
43	996.6	0.867	71.8	1.281	1.373	79.8	22.7	57.1	6.533
44	996.6	0.867	71.8	1.281	1.373	79.8	22.7	57.1	6.533

Table – 8.2.1 A (contd.)

No	ρ_L kg/m^3	μ_L mNs/m^2	σ mN/m	σ/σ_c	$D_L \times 10^9$ m^2/s	a_w	a_{st} (m^2/m^3)	a_{dy}	$k_L a \times 10^3$ s^{-1}
45	996.6	0.867	71.8	1.281	1.373	43.6	16.7	27.0	1.758
46	996.6	0.867	71.8	1.281	1.373	55.0	18.8	36.2	2.903
47	996.6	0.867	71.8	1.281	1.373	54.5	18.7	35.8	2.851
48	996.6	0.867	71.8	1.281	1.373	69.5	21.1	48.4	4.835
49	996.6	0.867	71.8	1.281	1.373	69.5	21.1	48.4	4.835
50	996.6	0.867	71.8	1.281	1.373	69.5	21.1	48.4	4.835
51	996.6	0.867	71.8	1.281	1.373	79.8	22.7	57.1	6.533
52	996.6	0.867	71.8	1.281	1.373	79.8	22.7	57.1	6.533
53	996.6	0.867	71.8	1.281	1.373	79.8	22.7	57.1	6.533
54	996.6	0.867	71.8	1.281	1.373	43.7	16.7	27.0	1.763
55	996.6	0.867	71.8	1.281	1.373	43.7	16.7	27.0	1.763
56	996.6	0.867	71.8	1.281	1.373	55.0	18.8	36.2	2.903
57	996.6	0.867	71.8	1.281	1.373	55.0	18.8	36.2	2.903
58	996.6	0.867	71.8	1.281	1.373	54.8	18.7	36.1	2.888
59	996.6	0.867	71.8	1.281	1.373	55.0	18.8	36.2	2.903
60	996.6	0.867	71.8	1.281	1.373	54.8	18.7	36.1	2.888
61	996.6	0.867	71.8	1.281	1.373	69.5	21.1	48.4	4.835
62	996.6	0.867	71.8	1.281	1.373	69.5	21.1	48.4	4.835
63	996.6	0.867	71.8	1.281	1.373	69.5	21.1	48.4	4.835
64	996.6	0.867	71.8	1.281	1.373	69.5	21.1	48.4	4.835
65	996.6	0.867	71.8	1.281	1.373	79.8	22.7	57.1	6.533
66	996.6	0.867	71.8	1.281	1.373	79.8	22.7	57.1	6.533
67	996.6	0.867	71.8	1.281	1.373	79.8	22.7	57.1	6.533
68	996.6	0.867	71.8	1.281	1.373	43.7	16.7	27.0	1.763
69	996.6	0.867	71.8	1.281	1.373	43.7	16.7	27.0	1.763
70	996.6	0.867	71.8	1.281	1.373	54.8	18.7	36.1	2.888
71	996.6	0.867	71.8	1.281	1.373	54.8	18.7	36.1	2.888
72	996.6	0.867	71.8	1.281	1.373	54.0	18.6	35.4	2.797
73	996.6	0.867	71.8	1.281	1.373	69.5	21.1	48.4	4.835
74	996.6	0.867	71.8	1.281	1.373	69.5	21.1	48.4	4.835
75	996.6	0.867	71.8	1.281	1.373	79.8	22.7	57.1	6.533
76	996.6	0.867	71.8	1.281	1.373	79.8	22.7	57.1	6.533
77	996.6	0.867	71.8	1.281	1.373	43.7	16.7	27.0	1.763
78	996.6	0.867	71.8	1.281	1.373	54.8	18.7	36.1	2.888
79	998.2	1.008	71.2	1.167	1.276	143.6	79.2	64.4	8.340
80	998.2	1.008	71.2	1.167	1.299	143.6	79.2	64.4	8.414
81	998.2	1.015	71.2	1.167	1.275	143.6	79.1	64.5	8.310
82	998.2	1.029	71.2	1.167	1.275	143.6	78.9	64.7	8.259
83	998.3	1.015	71.4	1.170	1.234	143.3	79.0	64.3	8.158
84	998.2	1.003	71.4	1.170	1.275	143.3	79.2	64.1	8.338
85	998.2	0.996	71.8	1.177	1.318	142.6	79.1	63.5	8.443
86	998.1	0.996	71.8	1.177	1.333	142.6	79.1	63.5	8.491
87	998.1	1.003	71.4	1.170	1.246	143.1	79.1	64.0	8.212
88	998.2	0.982	71.4	1.170	1.242	143.1	79.4	63.7	8.278
89	998.0	0.974	71.2	1.167	1.254	143.9	79.8	64.2	8.439
90	997.9	0.970	71.2	1.167	1.311	144.0	79.8	64.1	8.645
91	997.9	0.996	71.2	1.167	1.306	143.9	79.5	64.5	8.526
92	998.1	0.982	71.2	1.167	1.322	143.9	79.6	64.3	8.634
93	998.0	0.974	71.2	1.167	1.282	101.3	66.7	34.5	3.968
94	998.9	1.112	73.3	1.202	1.322	132.0	74.8	57.2	6.899

Table - 8.2.1 A (contd.)

No	ρ_L kg/m^3	μ_L mNs/m^2	σ mN/m	σ/σ_c	$D_L \times 10^9$ m^2/s	a_w m^2/m^3	a_{st} m^2/m^3	a_{dy} m^2/m^3	$k_L a \times 10^3$ s^{-1}
95	998.9	1.112	73.3	1.202	1.322	114.0	69.4	44.6	5.014
96	998.9	1.112	73.3	1.202	1.322	147.1	79.0	68.1	8.724
97	998.7	1.081	73.2	1.199	1.365	143.1	78.3	64.8	8.451
98	998.5	1.052	73.0	1.197	1.408	143.3	78.7	64.6	8.702
99	998.5	1.046	72.9	1.196	1.417	146.8	79.7	67.1	9.216
100	998.8	1.087	73.2	1.200	1.356	158.3	82.3	76.0	10.469
101	998.7	1.073	73.1	1.199	1.377	127.7	74.0	53.7	6.638
102	998.4	1.031	72.9	1.195	1.441	135.8	76.8	59.0	7.890
103	997.3	0.916	72.1	1.182	1.648	95.7	65.6	30.1	4.121
104	996.9	0.884	71.9	1.179	1.717	90.9	64.3	26.6	3.818
105	996.9	0.884	71.9	1.179	1.717	81.6	60.9	20.7	3.015
106	997.5	0.931	72.2	1.184	1.618	142.5	80.1	62.5	9.667
107	997.5	0.954	72.1	1.182	1.573	142.7	79.8	62.9	9.436
108	997.8	0.960	72.4	1.188	1.562	137.4	78.2	59.2	8.663
109	996.7	0.866	71.8	1.176	1.758	141.6	80.8	60.9	10.220
110	996.5	0.855	71.7	1.175	1.784	138.3	80.0	58.3	9.827
111	996.8	0.872	71.8	1.177	1.744	138.2	79.7	58.5	9.617
112	996.7	0.866	71.8	1.176	1.758	143.3	81.3	62.0	10.482
113	996.3	0.863	71.7	1.176	1.765	143.4	81.3	62.0	10.526
114	996.7	0.866	71.8	1.176	1.758	143.3	81.3	62.0	10.482
115	996.4	0.846	71.6	1.173	1.806	143.5	81.7	61.9	10.756
116	996.2	0.836	71.5	1.172	1.831	143.6	81.8	61.8	10.897
117	996.2	0.836	71.5	1.172	1.831	143.6	81.8	61.8	10.897
118	996.4	0.846	71.6	1.173	1.806	143.5	81.7	61.9	10.756
119	996.0	0.820	71.4	1.170	1.872	143.8	82.2	61.7	11.129
120	995.6	0.800	71.2	1.167	1.926	144.0	82.6	61.5	11.435
121	995.6	0.800	71.2	1.167	1.926	144.0	82.6	61.5	11.435
122	995.4	0.785	71.0	1.165	1.968	144.2	82.9	61.4	11.674
123	995.1	0.778	70.9	1.163	1.991	144.4	83.0	61.3	11.804
124	995.8	0.807	71.3	1.169	1.906	143.9	82.4	61.5	11.319
125	996.6	0.862	71.7	1.176	1.211	93.4	65.5	27.9	3.432
126	996.6	0.862	71.7	1.176	1.211	99.1	67.5	31.6	3.904
127	996.8	0.872	71.8	1.177	1.195	104.7	69.2	35.4	4.351
128	996.6	0.862	71.7	1.176	1.211	92.7	65.2	27.5	3.376
129	996.5	0.862	71.6	1.174	1.213	99.2	67.5	31.7	3.911
130	996.5	0.862	71.6	1.174	1.213	104.6	69.3	35.3	4.394
131	996.1	0.825	71.4	1.171	1.274	92.9	65.8	27.2	3.542
132	995.7	0.804	71.2	1.168	1.312	99.5	68.4	31.1	4.212
133	995.7	0.804	71.2	1.168	1.308	105.0	70.3	34.7	4.725
134	995.3	0.781	71.0	1.164	1.357	94.2	66.8	27.4	3.842
135	995.3	0.781	71.0	1.164	1.357	99.7	68.8	30.9	4.350
136	995.4	0.792	71.1	1.166	1.335	105.1	70.5	34.6	4.814
137	996.7	0.872	71.8	1.177	1.195	93.3	65.3	28.0	3.388
138	996.6	0.862	71.7	1.176	1.211	99.1	67.5	31.6	3.904
139	996.4	0.851	71.6	1.174	1.229	105.1	69.6	35.4	4.490
140	995.5	0.791	71.1	1.165	1.337	68.9	31.5	37.4	3.350
141	995.5	0.791	71.1	1.165	1.337	72.1	32.2	39.9	3.700
142	995.5	0.791	71.1	1.165	1.337	72.1	32.2	39.9	3.700
143	995.3	0.781	71.0	1.164	1.357	72.2	32.3	39.8	3.752
144	995.3	0.781	71.0	1.164	1.357	72.2	32.3	39.8	3.752

Table - 8.2.1 A (contd.)

No	ρ_L kg/m^3	μ_L mNs/m^2	σ mN/m	σ/σ_C	D_L $\times 10^9$ m^2/s	a_w	a_{st} (m^2/m^3)	a_{dy}	$k_L a$ $\times 10^3$ s^{-1}
145	995.6	0.800	71.2	1.167	1.320	67.9	31.2	36.7	3.214
146	995.6	0.791	71.1	1.165	1.337	72.1	32.2	39.9	3.700
147	995.3	0.776	71.0	1.164	1.367	72.2	32.4	39.8	3.777
148	995.6	0.800	71.2	1.167	1.320	67.9	31.2	36.7	3.214
149	995.5	0.791	71.1	1.165	1.337	72.3	32.3	40.0	3.723
150	996.3	0.841	71.6	1.173	1.246	47.7	12.9	34.8	2.735
151	996.8	0.872	71.8	1.178	1.195	45.0	12.4	32.6	2.330
152	997.1	0.899	72.1	1.181	1.154	47.3	12.7	34.6	2.526
153	997.3	0.918	72.2	1.183	1.127	42.4	12.0	30.4	1.945
154	997.5	0.933	72.2	1.184	1.107	45.1	12.3	32.8	2.194
155	997.4	0.923	72.2	1.183	1.120	47.4	12.7	34.8	2.474
156	997.3	0.918	72.2	1.183	1.127	42.5	12.0	30.6	1.961
157	997.0	0.894	72.0	1.180	1.161	44.8	12.4	32.5	2.255
158	997.2	0.909	72.1	1.181	1.140	36.3	11.1	25.3	1.405
159	997.3	0.918	72.2	1.183	1.127	39.2	11.5	27.7	1.640
160	996.1	0.830	71.4	1.171	1.265	45.1	12.6	32.6	2.453
161	996.3	0.842	71.5	1.173	1.245	47.9	12.9	34.9	2.752
162	995.8	0.810	71.3	1.273	2.625	43.8	16.9	26.9	2.518
163	995.8	0.810	71.3	1.273	2.625	43.8	16.9	26.9	2.518
164	995.8	0.810	71.3	1.273	2.625	43.8	16.9	26.9	2.518
165	995.8	0.810	71.3	1.273	2.625	43.8	16.9	26.9	2.518
166	995.8	0.810	71.3	1.273	2.625	43.8	16.9	26.9	2.518
167	995.8	0.810	71.3	1.273	2.625	43.8	16.9	26.9	2.518
168	995.8	0.810	71.3	1.273	2.625	40.7	16.3	24.4	2.139
169	995.8	0.810	71.3	1.273	2.625	43.4	16.8	26.6	2.466
170	995.8	0.810	71.3	1.273	2.625	46.6	17.4	29.1	2.876
171	995.8	0.810	71.3	1.273	2.625	51.3	18.3	33.0	3.548
172	995.8	0.810	71.3	1.273	2.625	56.2	19.2	37.0	4.325
173	996.0	0.818	71.3	1.170	2.596	83.0	24.4	58.6	9.568
174	995.8	0.809	71.3	1.168	2.629	73.7	23.0	50.7	7.465
175	995.8	0.809	71.3	1.168	2.629	83.0	24.4	58.6	9.685
176	1000.0	1.350	74.8	1.225	1.530	67.1	11.8	55.3	6.303
177	1000.0	1.280	74.4	1.220	1.634	46.6	9.9	36.7	3.001
178	1000.0	1.440	74.8	1.225	1.425	67.1	11.7	55.4	5.907
179	1000.0	1.400	74.6	1.222	1.473	67.2	11.7	55.5	6.093
180	1000.0	1.470	74.8	1.226	1.393	67.2	11.6	55.5	5.796
181	1000.0	1.470	74.8	1.226	1.393	51.6	6.6	45.1	4.952
182	1000.0	1.440	74.8	1.225	1.425	51.6	6.6	45.1	5.056
183	1000.0	1.350	74.8	1.225	1.530	35.7	5.5	30.2	2.419

Table - 8.2.1 (B)

Observed values of k_G obtained from K_Ga data bank inclusive of processing parameters.

No.	L	G	$K_Ga \times 10^2$	$k_La \times 10^3$	H $\times 10^2$	$k_Ga \times 10^2$	a_{dy}	$k_G \times 10^3$
	---kg/m^2 s---		kmol/m^3 sa	s^{-1}	a/kmol/m^3	kmol/m^3 sa	m^2/m^3	kmol/m^2 sa
1	0.679	0.244	2.767	2.342	1.938	3.589	27.0	1.330
2	1.348	0.258	4.049	3.862	1.938	5.081	36.2	1.404
3	2.712	0.248	4.760	6.433	1.938	5.558	48.4	1.149
4	0.681	0.537	3.915	2.345	1.938	5.788	27.0	2.143
5	1.330	0.537	6.585	3.825	1.938	9.882	36.0	2.745
6	2.740	0.553	7.652	6.480	1.938	9.924	48.6	2.044
7	0.681	0.663	4.983	2.345	1.938	8.472	27.0	3.137
8	0.681	0.825	5.695	2.345	1.938	10.758	27.0	3.984
9	0.681	0.797	5.428	2.345	1.938	9.844	27.0	3.645
10	2.712	0.766	11.478	6.433	1.938	17.547	48.4	3.629
11	4.096	0.716	11.256	8.691	1.938	15.029	57.1	2.631
12	0.681	0.118	0.943	1.651	4.534	1.273	27.0	0.471
13	1.339	0.129	1.522	2.704	4.534	2.043	36.1	0.566
14	0.681	0.245	1.428	1.651	4.534	2.350	27.0	0.870
15	1.339	0.239	2.416	2.704	4.534	4.061	36.1	1.125
16	2.712	0.262	3.123	4.529	4.534	4.544	48.4	0.940
17	4.096	0.250	4.342	6.118	4.534	6.403	57.1	1.121
18	0.678	0.564	2.033	1.646	4.534	4.622	27.0	1.714
19	1.339	0.505	3.261	2.704	4.534	7.196	36.1	1.994
20	2.712	0.561	4.760	4.529	4.534	9.096	48.4	1.881
21	0.681	0.144	1.659	1.994	0.518	1.734	27.0	0.642
22	1.347	0.138	2.776	3.281	0.518	2.903	36.2	0.802
23	2.712	0.136	2.861	5.471	0.518	2.940	48.4	0.608
24	0.681	0.254	2.171	1.994	0.518	2.301	27.0	0.852
25	1.339	0.247	4.133	3.267	0.518	4.423	36.1	1.225
26	2.712	0.254	5.294	5.471	0.518	5.574	48.4	1.153
27	4.096	0.237	5.339	7.391	0.518	5.546	57.1	0.971
28	0.681	0.559	3.688	1.994	0.518	4.079	27.0	1.511
29	1.356	0.555	6.229	3.298	0.518	6.904	36.3	1.902
30	2.712	0.557	9.343	5.471	0.518	10.250	48.4	2.120
31	4.096	0.582	11.123	7.391	0.518	12.063	57.1	2.112
32	0.681	0.803	5.250	1.994	0.518	6.079	27.0	2.251
33	1.339	0.734	8.898	3.267	0.518	10.361	36.1	2.870
34	2.712	0.814	12.502	5.471	0.518	14.181	48.4	2.933
35	4.096	0.698	12.991	7.391	0.518	14.293	57.1	2.502
36	0.681	1.192	8.097	1.994	0.518	10.255	27.0	3.798
37	1.339	1.287	13.347	3.267	0.518	16.933	36.1	4.691
38	2.712	1.279	18.686	5.471	0.518	22.706	48.4	4.695
39	0.677	0.140	1.504	1.755	0.570	1.581	26.9	0.587
40	1.348	0.140	2.202	2.903	0.570	2.302	36.2	0.636
41	2.712	0.141	3.212	4.835	0.570	3.339	48.4	0.690
42	2.712	0.138	3.604	4.835	0.570	3.764	48.4	0.778
43	4.096	0.141	3.359	6.533	0.570	3.460	57.1	0.606
44	4.096	0.140	4.138	6.533	0.570	4.293	57.1	0.751

Table – 8.2.1 B (contd.)

No.	L	G	$K_G a$ $\times 10^2$	$k_L a$ $\times 10^3$	H $\times 10^2$	$k_G a$ $\times 10^2$	a_{dy}	k_G $\times 10^3$
	---kg/m^2 s---		kmol/m^3 sa	s^{-1}	a/kmol/m^3	kmol/m^3 sa	m^2/m^3	kmol/m^2 sa
45	0.678	0.244	2.002	1.758	0.570	2.141	27.0	0.794
46	1.348	0.245	3.648	2.903	0.570	3.930	36.2	1.086
47	1.316	0.237	3.484	2.851	0.570	3.744	35.8	1.045
48	2.712	0.245	4.493	4.835	0.570	4.745	48.4	0.981
49	2.712	0.244	4.716	4.835	0.570	4.994	48.4	1.033
50	2.712	0.245	4.938	4.835	0.570	5.244	48.4	1.084
51	4.096	0.243	5.917	6.533	0.570	6.239	57.1	1.092
52	4.096	0.247	6.585	6.533	0.570	6.986	57.1	1.223
53	4.096	0.243	5.294	6.533	0.570	5.551	57.1	0.972
54	0.681	0.540	2.999	1.763	0.570	3.321	27.0	1.230
55	0.681	0.532	2.847	1.763	0.570	3.136	27.0	1.161
56	1.348	0.534	5.428	2.903	0.570	6.076	36.2	1.678
57	1.348	0.541	5.784	2.903	0.570	6.525	36.2	1.802
58	1.339	0.532	4.627	2.888	0.570	5.092	36.1	1.411
59	1.348	0.529	5.428	2.903	0.570	6.076	36.2	1.678
60	1.339	0.530	4.760	2.888	0.570	5.254	36.1	1.456
61	2.712	0.529	6.851	4.835	0.570	7.454	48.4	1.541
62	2.712	0.538	7.830	4.835	0.570	8.627	48.4	1.784
63	2.712	0.540	7.074	4.835	0.570	7.718	48.4	1.596
64	2.712	0.537	7.118	4.835	0.570	7.771	48.4	1.607
65	4.096	0.529	8.542	6.533	0.570	9.230	57.1	1.616
66	4.096	0.540	8.987	6.533	0.570	9.752	57.1	1.707
67	4.096	0.533	10.144	6.533	0.570	11.129	57.1	1.948
68	0.681	0.765	4.160	1.763	0.570	4.806	27.0	1.780
69	0.681	0.758	4.493	1.763	0.570	5.258	27.0	1.947
70	1.339	0.765	6.985	2.888	0.570	8.102	36.1	2.245
71	1.339	0.753	7.163	2.888	0.570	8.343	36.1	2.311
72	1.282	0.758	6.585	2.797	0.570	7.605	35.4	2.146
73	2.712	0.765	9.387	4.835	0.570	10.556	48.4	2.183
74	2.712	0.759	9.387	4.835	0.570	10.556	48.4	2.183
75	4.096	0.777	11.745	6.533	0.570	13.087	57.1	2.291
76	4.096	0.765	14.059	6.533	0.570	16.025	57.1	2.805
77	0.681	1.164	6.807	1.763	0.570	8.729	27.0	3.232
78	1.339	1.154	10.233	2.888	0.570	12.824	36.1	3.553
79	3.960	0.283	4.671	8.340	4.140	6.082	64.4	0.944
80	3.960	0.426	5.739	8.414	4.232	8.069	64.4	1.253
81	3.960	0.499	5.899	8.310	4.131	8.347	64.5	1.294
82	3.960	0.679	7.875	8.259	4.075	12.878	64.7	1.991
83	3.960	0.793	8.765	8.158	3.892	15.061	64.3	2.342
84	3.960	0.261	4.547	8.338	4.041	5.832	64.1	0.909
85	3.940	0.407	6.318	8.443	4.358	9.375	63.5	1.477
86	3.940	0.530	7.697	8.491	4.434	12.870	63.5	2.027
87	3.940	0.656	8.297	8.212	4.044	14.031	64.0	2.194
88	3.940	0.799	9.031	8.278	4.107	16.365	63.7	2.570
89	3.987	0.400	5.695	8.439	4.195	7.944	64.2	1.237
90	3.987	0.542	7.541	8.645	4.467	12.355	64.1	1.926
91	3.987	0.667	8.231	8.526	4.333	14.150	64.5	2.194
92	3.987	0.770	8.942	8.634	4.460	16.619	64.3	2.584
93	1.397	0.420	3.857	3.968	4.265	6.589	34.5	1.908
94	3.255	0.412	9.298	6.899	0.413	9.847	57.2	1.720

Table - 8.2.1 B (contd.)

No.	L	G	$K_G a$ $\times 10^2$	$k_L a$ $\times 10^3$	H $\times 10^2$	$k_G a$ $\times 10^2$	a_{dy}	k_G $\times 10^3$
	---kg/m^{2}s---		kmol/m^{3}sa	s^{-1}	a/kmol/m^3	kmol/m^{3}sa	m^2/m^3	kmol/m^{2}sa
95	2.102	0.412	7.497	5.014	0.443	8.028	44.6	1.800
96	4.489	0.279	7.029	8.724	0.411	7.270	68.1	1.068
97	4.123	0.557	10.010	8.451	0.469	10.599	64.8	1.635
98	4.123	0.659	11.478	8.702	0.511	12.308	64.6	1.904
99	4.421	0.797	13.258	9.216	0.481	14.243	67.1	2.124
100	5.574	0.411	9.610	10.469	0.465	10.038	76.0	1.321
101	2.929	0.414	7.808	6.638	0.476	8.271	53.7	1.540
102	3.499	0.255	6.206	7.890	0.442	6.430	59.0	1.090
103	1.207	0.412	5.294	4.121	0.510	5.665	30.1	1.885
104	1.031	0.412	4.783	3.818	0.580	5.157	26.6	1.938
105	0.746	0.412	3.604	3.015	0.580	3.872	20.7	1.871
106	3.974	0.509	5.057	9.667	0.424	5.172	62.5	0.828
107	3.974	0.788	7.163	9.436	0.396	7.385	62.9	1.174
108	3.580	0.513	5.561	8.663	0.389	5.704	59.2	0.964
109	3.852	0.717	6.251	10.220	0.510	6.452	60.9	1.060
110	3.580	0.692	2.767	9.827	0.527	2.809	58.3	0.481
111	3.580	0.313	1.869	9.617	0.501	1.887	58.5	0.323
112	3.987	0.380	2.202	10.482	0.510	2.226	62.0	0.359
113	3.987	0.759	3.559	10.526	0.518	3.623	62.0	0.584
114	3.987	1.112	4.582	10.482	0.510	4.687	62.0	0.756
115	3.987	1.214	4.796	10.756	0.545	4.915	61.9	0.794
116	3.987	0.636	1.851	10.897	0.563	1.869	61.8	0.302
117	3.987	1.058	2.607	10.897	0.563	2.643	61.8	0.428
118	3.987	1.492	3.399	10.756	0.545	3.459	61.9	0.559
119	3.987	1.847	4.271	11.129	0.591	4.370	61.7	0.709
120	3.987	0.932	2.184	11.435	0.631	2.211	61.5	0.360
121	3.987	0.434	1.317	11.435	0.631	1.327	61.5	0.216
122	3.987	0.570	1.428	11.674	0.662	1.440	61.4	0.235
123	3.987	1.164	2.122	11.804	0.695	2.149	61.3	0.350
124	3.987	1.682	2.714	11.319	0.611	2.754	61.5	0.448
125	1.111	0.459	2.803	3.432	4.665	4.528	27.9	1.622
126	1.326	0.459	3.181	3.904	4.703	5.157	31.6	1.630
127	1.565	0.459	3.608	4.351	4.594	5.829	35.4	1.645
128	1.086	0.545	2.825	3.376	4.845	4.751	27.5	1.729
129	1.326	0.545	3.426	3.911	4.919	6.019	31.7	1.900
130	1.555	0.545	3.782	4.394	4.919	6.557	35.3	1.859
131	1.086	0.569	2.941	3.542	5.231	5.199	27.2	1.914
132	1.326	0.569	3.581	4.212	5.388	6.609	31.1	2.124
133	1.555	0.569	3.902	4.725	5.360	6.999	34.7	2.016
134	1.118	0.401	2.291	3.842	5.884	3.530	27.4	1.291
135	1.326	0.401	2.838	4.350	5.972	4.651	30.9	1.504
136	1.555	0.401	3.403	4.814	5.799	5.769	34.6	1.666
137	1.111	0.700	2.914	3.388	4.534	4.778	28.0	1.707
138	1.326	0.700	3.786	3.904	4.639	6.882	31.6	2.176
139	1.575	0.700	4.169	4.490	4.675	7.365	35.4	2.079
140	1.257	0.380	2.536	3.350	5.620	4.413	37.4	1.181
141	1.440	0.380	2.634	3.700	5.620	4.390	39.9	1.101
142	1.440	0.444	2.781	3.700	5.620	4.814	39.9	1.208
143	1.440	0.503	2.830	3.752	6.003	5.171	39.8	1.298
144	1.440	0.378	2.776	3.752	5.801	4.864	39.8	1.221

Table – 8.2.1 B (contd.)

No.	L	G	$K_G a$ $\times 10^2$	$k_L a$ $\times 10^3$	H $\times 10^2$	$k_G a$ $\times 10^2$	a_{dy}	k_G $\times 10^3$
	---$kg/m^2 s$---		$kmol/m^3 sa$	s^{-1}	$a/kmol/m^3$	$kmol/m^3 sa$	m^2/m^3	$kmol/m^2 sa$
145	1.208	0.584	2.678	3.214	5.755	5.146	36.7	1.402
146	1.440	0.584	3.048	3.700	5.878	5.908	39.9	1.482
147	1.440	0.413	2.607	3.777	5.801	4.348	39.8	1.092
148	1.208	0.387	2.322	3.214	5.501	3.854	36.7	1.050
149	1.452	0.387	2.741	3.723	5.620	4.675	40.0	1.168
150	1.462	0.308	2.033	2.735	4.963	3.222	34.8	0.926
151	1.240	0.276	1.833	2.330	4.139	2.718	32.6	0.835
152	1.450	0.276	2.064	2.526	3.951	3.049	34.6	0.880
153	1.045	0.350	1.855	1.945	3.861	2.937	30.4	0.966
154	1.262	0.350	2.051	2.194	3.716	3.142	32.8	0.958
155	1.465	0.350	2.394	2.474	3.630	3.689	34.8	1.060
156	1.057	0.393	1.993	1.961	3.861	3.280	30.6	1.074
157	1.230	0.425	2.176	2.255	3.893	3.484	32.5	1.073
158	0.659	0.425	1.490	1.405	3.833	2.511	25.3	0.994
159	0.828	0.425	1.771	1.640	3.745	2.972	27.7	1.073
160	1.235	0.284	1.815	2.453	4.604	2.753	32.6	0.846
161	1.477	0.284	2.024	2.752	4.467	3.015	34.9	0.863
162	0.678	0.678	4.004	2.518	2.230	6.204	26.9	2.305
163	0.678	0.678	4.538	2.518	2.230	7.587	26.9	2.819
164	0.678	0.194	2.211	2.518	2.230	2.750	26.9	1.022
165	0.678	0.467	3.630	2.518	2.230	5.351	26.9	1.988
166	0.678	0.706	4.255	2.518	2.230	6.828	26.9	2.537
167	0.678	1.126	5.570	2.518	2.230	10.992	26.9	4.084
168	0.542	0.678	3.928	2.139	2.230	6.652	24.4	2.728
169	0.659	0.678	4.138	2.466	2.230	6.611	26.6	2.487
170	0.814	0.678	4.569	2.876	2.230	7.075	29.1	2.427
171	1.085	0.678	5.570	3.548	2.230	8.569	33.0	2.597
172	1.423	0.678	6.077	4.325	2.230	8.850	37.0	2.391
173	4.069	0.698	10.273	9.568	2.175	13.403	58.6	2.287
174	2.848	0.705	7.692	7.465	2.230	9.987	50.7	1.970
175	4.069	0.549	8.333	9.685	2.230	10.311	58.6	1.759
176	6.078	1.351	16.550	6.303	0.725	20.442	55.3	3.696
177	2.026	1.351	9.254	3.001	0.880	12.700	36.7	3.464
178	6.078	0.473	7.074	5.907	0.648	7.669	55.4	1.384
179	6.078	0.810	10.099	6.093	0.705	11.435	55.5	2.062
180	6.093	0.270	4.849	5.796	0.629	5.119	55.5	0.922
181	6.078	0.810	8.520	4.952	0.629	9.554	45.1	2.120
182	6.078	1.350	11.923	5.056	0.648	14.072	45.1	3.123
183	2.026	0.810	4.849	2.419	0.725	5.674	30.2	1.879

A typical sample calculation for obtaining the values of k_G from the data bank of k_Ga has been illustrated in Appendix (I) : Sample Calculation (A.1.1). Using this six step procedure the values of k_G were calculated for all the 183 data points mentioned in the data bank of K_Ga reported in Table (5.5 A) and these values of k_G - hence forth referred as "observed values of k_G" - are tabulated in Table (8.2.1 B).

CASE (II) : Values of k_G obtained from k_Ga values (chemical technique) :

Sharma and coworkers (41,53) have used the instantaneous reaction technique to obtain the values of k_Ga for the systems - Cl_2 absorption in 2 M NaOH and SO_2 absorption 2M NaOH. Since these systems are unambiguously gas film controlled, the entire resistance to mass transfer lies in the gas side. Hence the values of K_Ga and k_Ga are expected to be identical.

It has been discussed in chapter - (6) : Mathematical modelling of effective interfacial areas and mass transfer coefficients, that when absorption is accompanied by an instantaneous reaction, the values of effective interfacial area available for mass transfer are equal to a_{dy} [Refer to equation (6.7)].

Hence for the case under consideration also, the values of a_{dy} were obtained by calculating the values of a_w and a_{st} by the generalised correlations [Equations (7.3) and (7.16) respectively] and subtracting the values of a_{st} from the values of a_w. Thus the values of a_w, a_{st}, a_{dy} and k_G were obtained under otherwise identical conditions mentioned for the k_Ga data bank reported in Table (5.5 B). Results obtained for Case (II) under consideration are reported in Table (8.2.1 C) which consists of 59 data points - observed values of k_G.

CASE III : Values of k_G obtained from k_Ga values during vaporization

When a pure solvent is vaporized in a gas stream in a randomly packed bed the values of K_Ga and k_Ga become equal because of absence of liquid film resistance. For the case under consideration the effective interfacial area available for mass transfer (a_v) will be equal to the wetted surface area (a_w). Thus the values of k_G can be obtained conveniently by dividing the values of k_Ga by a_w values.

Therefore, the values of a_w were calculated by using the generalised correlation for a_w [Equation (7.3)] under otherwise identical conditions mentioned for the k_Ga data during vaporization reported in Table (5.5 C). The results obtained for Case (III) under consideration are reported in Table (8.2.1 D) which consists of 60 data points - observed values of k_G.

CASE (IV) : Values of k_G obtained from HTU data on vaporization :-

In order to obtain the values of k_G from HTU data, the methodology listed in Section - (4.1.1) of Chapter - (4) : General Consideration was used. The values of effective interfacial area during vaporization being equal to a_w were estimated by the

Table - 8.2.1 (C)

Observed values of k_G obtained from $k_G a$ data bank inclusive of physical properties.

No	ρ_L kg/m^3	μ_L mNs/m^2	σ mN/m	σ/σ_c	a_w	a_{st} (m^2/m^3)	a_{dy}	$k_G a$ $\times 10^2$ $kmol/m^3\,sa$	k_G $\times 10^3$ $kmol/m^2\,sa$
1	1084.0	1.400	74.2	1.216	55.8	17.6	38.2	4.470	1.171
2	1084.0	1.400	74.2	1.216	69.8	19.7	50.1	6.330	1.264
3	1084.0	1.400	74.2	1.216	90.6	22.5	68.0	12.150	1.786
4	1084.0	1.400	74.2	1.216	69.8	19.7	50.1	10.200	2.037
5	1084.0	1.400	74.2	1.216	69.9	19.8	50.2	12.450	2.482
6	1084.0	1.400	74.2	1.216	57.9	17.9	39.9	3.000	0.751
7	1084.0	1.400	74.2	1.216	88.2	22.2	65.9	5.200	0.789
8	1084.0	1.400	74.2	1.216	101.8	23.9	77.9	7.000	0.899
9	1084.0	1.400	74.2	1.216	116.3	25.6	90.7	7.500	0.827
10	1084.0	1.400	74.2	1.216	57.9	17.9	39.9	4.000	1.002
11	1084.0	1.400	74.2	1.216	72.5	20.1	52.4	5.100	0.973
12	1084.0	1.400	74.2	1.216	88.2	22.2	65.9	6.700	1.016
13	1084.0	1.400	74.2	1.216	101.8	23.9	77.9	8.300	1.066
14	1084.0	1.400	74.2	1.216	108.9	24.7	84.1	8.900	1.058
15	1084.0	1.400	74.2	1.216	116.3	25.6	90.7	9.000	0.992
16	1084.0	1.400	74.2	1.216	57.9	17.9	39.9	4.900	1.227
17	1084.0	1.400	74.2	1.216	88.2	22.2	65.9	7.800	1.183
18	1084.0	1.400	74.2	1.216	101.8	23.9	77.9	9.200	1.181
19	1084.0	1.400	74.2	1.216	116.3	25.6	90.7	10.400	1.146
20	1084.0	1.400	74.2	1.855	48.4	13.3	35.1	3.100	0.883
21	1084.0	1.400	74.2	1.855	60.8	14.9	45.9	3.800	0.828
22	1084.0	1.400	74.2	1.855	69.2	15.9	53.3	4.300	0.807
23	1084.0	1.400	74.2	1.855	74.1	16.5	57.6	5.100	0.885
24	1084.0	1.400	74.2	1.855	44.7	12.7	31.9	4.500	1.409
25	1084.0	1.400	74.2	1.855	61.2	14.9	46.2	5.900	1.277
26	1084.0	1.400	74.2	1.855	70.1	16.0	54.1	7.000	1.294
27	1084.0	1.400	74.2	1.855	75.2	16.6	58.6	8.000	1.365
28	1084.0	1.400	74.2	1.855	47.5	13.1	34.3	6.300	1.835
29	1084.0	1.400	74.2	1.855	58.3	14.6	43.7	7.300	1.669
30	1084.0	1.400	74.2	1.855	68.3	15.8	52.5	9.000	1.713
31	1084.0	1.400	74.2	1.855	75.2	16.6	58.6	10.300	1.758
32	1084.0	1.400	74.2	1.855	46.9	13.1	33.8	7.400	2.188
33	1084.0	1.400	74.2	1.855	61.0	14.9	46.1	9.200	1.996
34	1084.0	1.400	74.2	1.855	68.3	15.8	52.5	12.300	2.342
35	1084.0	1.400	74.2	1.855	78.7	17.0	61.7	14.100	2.284
36	1084.0	1.400	74.2	1.855	46.3	13.0	33.3	10.200	3.062
37	1084.0	1.400	74.2	1.855	61.8	15.0	46.8	13.900	2.973
38	1084.0	1.400	74.2	1.855	68.1	15.8	52.3	16.200	3.099
39	1084.0	1.400	74.2	1.855	76.5	16.7	59.8	18.600	3.112
40	1087.0	1.600	74.0	2.671	44.1	10.3	33.8	3.500	1.035
41	1087.0	1.600	74.0	2.671	52.8	11.3	41.5	4.100	0.987
42	1087.0	1.600	74.0	2.671	60.3	12.0	48.3	5.000	1.036
43	1087.0	1.600	74.0	2.671	64.7	12.5	52.3	5.400	1.033
44	1087.0	1.600	74.0	2.671	41.4	10.0	31.4	4.200	1.337
45	1087.0	1.600	74.0	2.671	53.4	11.3	42.0	5.800	1.380

Table - 8.2.1 C (contd.)

No	ρ_L	μ_L	σ	σ/σ_c	a_w	a_{st}	a_{dy}	$k_G a \times 10^2$	$k_G \times 10^3$
	kg/m^3	mNs/m^2	mN/m		------	m^2/m^3	------	$kmol/m^3 sa$	$kmol/m^2 sa$
46	1087.0	1.600	74.0	2.671	58.2	11.8	46.4	5.800	1.251
47	1087.0	1.600	74.0	2.671	65.5	12.6	52.9	7.000	1.322
48	1087.0	1.600	74.0	2.671	45.3	10.4	34.9	5.600	1.606
49	1087.0	1.600	74.0	2.671	53.4	11.3	42.0	7.200	1.713
50	1087.0	1.600	74.0	2.671	61.4	12.2	49.3	7.500	1.522
51	1087.0	1.600	74.0	2.671	65.2	12.5	52.6	8.900	1.691
52	1084.0	1.400	74.2	1.855	48.4	13.3	35.1	2.800	0.798
53	1084.0	1.400	74.2	1.855	59.4	14.7	44.7	3.500	0.784
54	1084.0	1.400	74.2	1.855	68.3	15.8	52.5	4.300	0.819
55	1084.0	1.400	74.2	1.855	73.6	16.4	57.2	5.000	0.874
56	1084.0	1.400	74.2	1.855	47.2	13.1	34.1	4.500	1.319
57	1084.0	1.400	74.2	1.855	58.9	14.7	44.3	5.400	1.220
58	1084.0	1.400	74.2	1.855	64.8	15.4	49.4	6.200	1.254
59	1084.0	1.400	74.2	1.855	73.6	16.4	57.2	7.300	1.276

Table - 8.2.1 (D)

Observed values of k_G obtained from k_Ga vaporization data bank inclusive of physical properties.

No	ρ_L kg/m^3	μ_L mNs/m^2	σ mN/m	σ/σ_c	a_w m^2/m^3	k_Ga $\times 10^2$ $kmol/m^3 sa$	k_G $\times 10^3$ $kmol/m^2 sa$
1	881.4	0.672	29.2	0.521	113.7	7.741	0.681
2	884.3	0.705	29.6	0.528	112.7	9.298	0.825
3	885.4	0.715	29.7	0.531	112.4	9.031	0.804
4	886.2	0.724	29.8	0.532	112.1	9.387	0.837
5	886.6	0.728	29.9	0.534	111.9	10.678	0.954
6	886.3	0.725	29.8	0.533	112.1	11.923	1.064
7	886.6	0.728	29.9	0.534	111.9	13.480	1.204
8	887.1	0.732	29.9	0.534	111.8	12.991	1.162
9	886.6	0.728	29.9	0.534	111.9	14.103	1.260
10	887.6	0.738	30.0	0.536	111.6	14.548	1.303
11	887.1	0.732	29.9	0.534	111.8	14.415	1.289
12	887.8	0.740	30.0	0.536	111.6	13.925	1.247
13	887.8	0.740	30.0	0.536	111.6	14.993	1.343
14	887.8	0.740	30.0	0.536	111.6	16.105	1.443
15	888.4	0.746	30.1	0.538	111.4	18.107	1.625
16	876.1	0.640	24.2	0.433	127.4	6.896	0.541
17	876.2	0.641	24.3	0.433	127.3	7.830	0.615
18	876.4	0.642	24.3	0.434	127.2	8.142	0.640
19	876.5	0.642	24.3	0.434	127.2	9.165	0.721
20	876.9	0.647	24.3	0.435	127.0	9.832	0.774
21	877.2	0.650	24.4	0.435	127.0	10.945	0.862
22	877.5	0.652	24.4	0.436	126.9	11.034	0.870
23	877.7	0.655	24.4	0.436	126.8	11.745	0.926
24	877.5	0.652	24.4	0.436	126.9	13.258	1.045
25	878.0	0.657	24.4	0.436	126.7	12.413	0.980
26	876.7	0.645	24.3	0.434	127.2	12.101	0.952
27	876.9	0.647	24.3	0.435	127.0	12.813	1.009
28	877.5	0.652	24.4	0.436	126.9	14.548	1.147
29	877.8	0.654	24.4	0.436	126.8	14.815	1.168
30	877.5	0.652	24.4	0.436	126.9	14.415	1.136
31	998.6	1.067	73.1	1.305	55.1	8.142	1.479
32	998.6	1.057	73.0	1.304	66.3	11.478	1.731
33	998.7	1.070	73.1	1.305	68.7	10.411	1.516
34	998.5	1.053	73.0	1.304	69.2	10.767	1.556
35	998.6	1.062	73.1	1.304	71.6	8.275	1.156
36	998.3	1.018	72.8	1.300	48.0	7.608	1.586
37	998.3	1.026	72.8	1.301	55.6	9.165	1.650
38	998.3	1.024	72.8	1.301	55.9	9.432	1.687
39	998.3	1.021	72.8	1.300	62.8	11.567	1.841
40	998.2	1.029	72.8	1.300	70.9	10.233	1.444
41	998.0	0.982	72.6	1.296	41.3	7.875	1.905
42	997.9	0.978	72.6	1.296	49.1	8.587	1.749
43	998.1	0.994	72.7	1.298	57.7	9.743	1.687
44	998.0	0.990	72.6	1.297	60.6	9.788	1.616

Table - 8.2.1 D (contd.)

No	ρ_L kg/m^3	μ_L mNs/m^2	σ mN/m	σ/σ_c	a_w m^2/m^3	k_Ga $\times 10^2$ $kmol/m^3 sa$	k_G $\times 10^3$ $kmol/m^2 sa$
45	998.3	1.024	72.8	1.301	65.7	10.989	1.673
46	997.9	0.978	72.6	1.296	57.8	9.743	1.686
47	997.9	0.977	72.6	1.296	63.0	10.010	1.589
48	997.6	0.947	72.3	1.292	64.1	7.430	1.158
49	996.6	0.945	72.3	1.292	64.1	8.275	1.290
50	998.5	1.043	72.9	1.303	63.8	10.856	1.702
51	998.6	1.060	73.1	1.304	63.7	13.036	2.045
52	998.0	0.989	72.6	1.297	64.0	13.347	2.086
53	998.2	1.003	72.7	1.299	63.9	12.457	1.949
54	998.4	1.031	72.9	1.302	63.8	14.148	2.217
55	998.4	1.031	72.9	1.302	63.8	14.459	2.265
56	998.7	1.074	73.1	1.306	63.7	17.485	2.745
57	998.8	1.088	73.2	1.307	63.7	16.283	2.558
58	998.8	1.084	73.2	1.307	63.7	16.951	2.662
59	998.9	1.101	73.3	1.308	63.6	18.330	2.881
60	998.8	1.088	73.2	1.307	63.7	17.885	2.810

generalised correlation for a_w [Equation (7.3)] under otherwise identical conditions mentioned for the HTU data reported in Table (5.5 D). The results obtained for Case (IV) under consideration are reported in Table (8.2.1 E) which consists of ten data points - observed values of k_G.

8.2.2 Critical analysis of data and Mathematical modelling :

The observed values of k_G obtained for the earlier mentioned four cases consisting of 312 data points are reported in Tables (8.2.1 B), (8.2.1 C), (8.2.1 D) and (8.2.1 E). In totality the k_G data bank incorporates 27 variations including 10 system variations.

(I) <u>Effect of L and G on the values of k_G and k_Ga :-</u>

It is observed that the values of k_G get affected by the gas flow rate (G). The liquid flow rate (L) appears to have no effect on the values of k_G. However, the values of k_Ga get affected by L as well as G. Thus for example in Table (8.2.1 B) the observations (18) and (20) for the system acetone - water, using 25 mm carbon Raschig rings (a_t = 190 m^2/m^3) reveal the following :-

Observation (18) - CASE (A) :

For a fixed value of L = 0.678 kg/m^2-s and G = 0.564 kg/m^2-s the values of a_{dy} (m^2/m^3), k_Ga (k mol/m^2s atm.) and k_G (k mol/m^2s atm) are 27.0, 4.622 x 10^{-2} and 1.714 x 10^{-3} respectively.

Observation (20) - CASE (B) :

For a fixed value of L = 2.712 kg/m^2-s and G = 0.561 kg/m^2-s, the values of a_{dy} (m^2/m^3), k_Ga (k mol/m^2s atm) and k_G

Table - 8.2.1 (E)

Observed values of k_G obtained from HTU data bank inclusive of physical properties.

No.	ρ_G kg/m^3	μ_G x 10^2 mNs/m^2	D_G x 10^5 m^2/s	ρ_L kg/m^3	μ_L mNs/m^2	σ mN/m	σ/σ_C	a_w m^2/m^3	k_Ga x 10^2	k_G x 10^3 kmol/m^2 sa
1	1.144	1.910	2.848	995.2	0.774	71.9	1.179	66.5	28.614	4.300
2	1.156	1.869	2.716	996.1	0.827	71.4	1.171	57.5	10.032	1.743
3	1.156	1.868	2.714	996.1	0.827	71.4	1.171	72.3	10.588	1.464
4	1.156	1.873	2.721	995.9	0.812	71.3	1.169	47.7	7.330	1.537
5	4.685	1.315	1.254	994.3	0.732	70.5	1.156	67.4	14.261	2.117
6	4.669	1.324	1.258	994.3	0.729	70.5	1.155	67.4	17.257	2.561
7	4.765	1.303	1.215	994.9	0.759	70.8	1.160	67.2	3.660	0.545
8	4.792	1.295	1.207	994.6	0.743	70.6	1.158	67.3	5.108	0.759
9	4.565	1.344	1.270	993.9	0.713	70.3	1.152	67.5	10.021	1.485
10	4.685	1.311	1.257	994.4	0.733	70.5	1.156	67.3	12.022	1.785

(k mol/m^2s atm) are 48.4, 9.096 x 10^{-2} and 1.88 x 10^{-3} respectively.

Since the values of k_G for Cases (A) and (B) are comparable under otherwise identical conditions, the liquid flow rate appears to have no effect on the values of k_G. However, since the values of k_Ga are substantially higher for the Case (B) than that for the Case (A) the values of k_Ga do get affected by L. It is already known that with an increase in L, the value of 'a' increases (here it increases from 27.0 to 48.4 m^2/m^3) and hence the value of k_Ga also increases.

Further for example, in Table (8.2.1 B), the observations (1) and (8) for the system ammonia - water, using 25 mm carbon Raschig rings (a_t = 190 m^2/m^3) reveal the following :-

Observation (1) - CASE (A)

For a fixed value of L = 0.679 (kg/m^2-s) and G = 0.244 (kg/m^2-s), the values of a_{dy} (m^2/m^3), k_Ga (k mol/m^3s atm), and k_G (k mol/m^2s atm) are 27.0, 3.589 x 10^{-2} and 1.33 x 10^{-3} respectively.

Observation (8) : CASE (B) :

For a fixed value of L = 0.681 kg/m^2-s and G = 0.825 kg/m^2-s the values of a_{dy} (m^2/m^3), k_Ga (k mol/m^2s atm) and k_G (k mol/m^2s atm) are 27.0, 10.758 x 10^{-2} and 3.984 x 10^{-3} respectively.

Under otherwise identical conditions since the values of a_{dy} for Case (A) and (B) are comparable, the liquid flow rate appears to have no effect on the values of k_Ga. The increase in the value of k_Ga for CASE (B) than for CASE (A) is because of the increase in the value of k_G which is due to an increase in the value of G. Similar observations can be made about the effect of L and G on the observed values of k_G reported in Tables (8.2.1 C) and (8.2.1 D).

(II) Effect of packing size and a_t on k_G :

The values of k_G decrease with an increase in the packing size or with a decrease in the surface area. Thus for the system : Acetone - water, under otherwise similar conditions comparing points (132) and (145) of Table (8.2.1 B), for a fixed value of G = 0.569 - 0.584 kg/m^2-s with an increase in d_p from 13 mm to 19 mm (with decrease in the value of a_t from 370 m^2/m^3 to 243 m^2/m^3), the value of k_G decreases from 2.124 x 10^{-3} to 1.402 x 10^{-3} k mol/m^2s atm. Similar observation can be made about the effect of the packing size on the values of k_G reported in Tables (8.2.1 C), (8.2.1 D) and (8.2.1 E).

(III) Effect of diffusivity of the solute gas (D_G) :

The value of k_G decreases with a decrease in difusivity. Thus for example in Table (8.2.1 B) comparing observations (3) and (16) for systems :- ammonia - water and acetone - water respectively under otherwise identical conditions of [Data from Table (5.5 A)] a_t = 190 m^2/m^3, ρ_L = 996.6 kg/m^3, ρ_G = 1.178 kg/m^3, μ_L = 0.867 mNs/m^2, μ_G = 1.839 x 10^{-2} mNs/m^2, L = 2.712 kg/m^2-s and G = 0.248 - 0.262 kg/m^2-s; with a decrease in the value of D_G from 2.33 x 10^{-5} m^2/s (for ammonia - water) to 1.28 x 10^{-5} m^2/s (acetone - water), the value of k_G decreases from 1.149 x 10^{-3} to 0.94 x 10^{-3} k mol/m^2s atm. Simillar observations can be made about the effect of the diffusivity of gas on the values of k_G reported in Tables (8.2.1 C), (8.2.1 D) and (8.2.1 E).

(IV) <u>Effect of density of gas</u> (ρ_G) <u>on the values of k_G</u> :

The value of k_G decreases with an increase in the value of density (hence corresponding pressure) of gas. Thus for example for the case of absorption of methanol vapour in water, using 13 mm ceramic Raschig rings (a_t = 370 m^2/m^3) the observations (115) and (123) from Table (8.2.1 B) and the corresponding preliminary data from Table (5.5 A) reveal the following :-

Observation (115) : Case A :-

For a fixed value of P = 3.9 atm a, L = 3.987 kg/m^2-s, G = 1.214 kg/m^2-s, μ_G = 1.85 x 10^{-2} mNs/m^2, D_G = 0.4 x 10^{-5} m^2/s and ρ_G = 4.56 kg/m^3, the values of a_{dy} (m^2/m^3), k_Ga (k mol/m^3s atm) and k_G (k mol/m^2s atm) are 61.9, 4.915 x 10^{-2} and 0.794 x 10^{-3} respectively.

Observation (123) : Case B :-

For a fixed value of P = 10.7 atm a, L = 3.987 kg/m^2-s, G = 1.164 kg/m^2-s, μ_G = 1.86 x 10^{-2} mNs/m^2, D_G = 0.15 x 10^{-5} m^2/s and ρ_g = 12.46 kg/m^3, the values of a_{dy} (m^2/m^3), k_Ga (k mol/m^3s atm) and k_G (k mol/m^2s atm) are 61.3, 2.149 x 10^{-2} and 0.35 x 10^{-3} respectively.

Thus, under otherwise identical conditions with an increase in ρ_G from 4.56 kg/m^3 to 12.56 kg/m^3 and decrease of D_G from 0.4 x 10^{-5} to .15 x 10^{-5} m^2/s, the value of k_Ga decreases from 4.915 x 10^{-2} to 2.149 x 10^{-2}. And this decrease in the values of k_Ga is due to the decrease in the value of k_G from 0.794 x 10^{-3} to 0.35 x 10^{-3} as the values of a_{dy} remains practically the same for both Cases (A) and (B). Similarly it is also observed from the data of vaporization of water into air and into Freon - 12 that with an increase in the value of ρ_G, the value of k_G decreases [Table (8.2.1 E)].

Mathematical modelling of k_G data :-

Hence, based on the above discussion in order ot correlate the data for k_G in terms of system parameters and hydrodynamic parameters one can propose the following equation :-

$$k_G = f\ (G,\ D_G,\ \mu_G^{-1},\ \rho_G^{-1},\ a_t^{-1}) \tag{8.8}$$

With the help of dimensional analysis, these parameters can be grouped in terms of different dimensionless numbers and groups as per the following equation :-

$$k_G = C\ (Re_G)^{\alpha}\ (Sc_G)^{m}\ (a_t.d_p)^{n}\ (RT/a_t.D_G)^{-1} \tag{8.9}$$

The dimensionless numbers and groups used in this equation (8.9) are identical with those utilised by Onda et.al [Equation (2.2.6)]. For performing mathematical modelling, one thus requries the knowledge of Re_G, Sc_G, $(a_t.d_p)$ and $(RT/a_t.D_G)$. With the help of data on physical properties and hydrodynamic parameters reported in Tables [(5.5 A) and (8.2.1 B)], [(5.5 B) and (8.2.1 C)], [(5.5 C) and (8.2.1 D)] and [(5.5 D) and (8.2.1 E)], the relevant dimensionless numbers and groups were calculated and all these values along with the corresponding k_G values are tabulated in Table (8.2.2). The observed values of k_G reported in Table (8.2.2.) are totally 312. The category wise split up is as under :-

CASE I : k_G from K_Ga : Total number of data points = 183.

CASE II : k_G from k_Ga (chemical): Total number of data points= 59.

Table – (8.2.2)

Results inclusive of processing parameters for (k_g)

No.	Re_g	Sc_g	$a_t dp$	$R.T/a_t D_g$	(k_g) obs.	(k_g) pred.	% err
				$m^2 s\ a/kmol$ $\times 10^{-3}$	--$kmol/m^2 s\ a$-- $\times 10^{3}$	$\times 10^{3}$	
Observed values of k_g obtained from $K_g a$ data bank. :							
1	69.865	0.670	4.826	5.550	1.331	1.267	4.80
2	73.747	0.670	4.826	5.550	1.404	1.316	6.27
3	71.030	0.670	4.826	5.550	1.150	1.282	-11.51
4	153.700	0.670	4.826	5.550	2.145	2.200	-2.60
5	153.700	0.670	4.826	5.550	2.747	2.200	19.89
6	158.360	0.670	4.826	5.550	2.045	2.247	-9.89
7	189.800	0.670	4.826	5.550	3.140	2.550	18.77
8	235.990	0.670	4.826	5.550	3.988	2.971	25.52
9	228.230	0.670	4.826	5.550	3.649	2.902	20.47
10	219.300	0.670	4.826	5.550	3.631	2.822	22.28
11	204.940	0.670	4.826	5.550	2.632	2.691	-2.25
12	33.768	1.217	4.826	10.081	0.472	0.536	-13.73
13	36.873	1.217	4.826	10.081	0.566	0.570	-0.75
14	70.253	1.217	4.826	10.081	0.871	0.896	-2.85
15	68.313	1.217	4.826	10.081	1.126	0.878	21.99
16	74.911	1.217	4.826	10.081	0.940	0.937	0.36
17	71.418	1.217	4.826	10.081	1.122	0.906	19.21
18	161.470	1.217	4.826	10.081	1.717	1.604	6.59
19	144.390	1.217	4.826	10.081	1.996	1.483	25.71
20	160.690	1.217	4.826	10.081	1.883	1.598	15.11
21	41.143	1.001	4.826	8.293	0.642	0.691	-7.55
22	39.590	1.001	4.826	8.293	0.802	0.672	16.20
23	38.814	1.001	4.826	8.293	0.608	0.663	-9.06
24	72.582	1.001	4.826	8.293	0.852	1.028	-20.61
25	70.641	1.001	4.826	8.293	1.226	1.008	17.72
26	72.582	1.001	4.826	8.293	1.153	1.028	10.84
27	67.925	1.001	4.826	8.293	0.971	0.981	-1.05
28	159.910	1.001	4.826	8.293	1.511	1.787	-18.26
29	158.750	1.001	4.826	8.293	1.903	1.778	6.58
30	159.530	1.001	4.826	8.293	2.120	1.784	15.86
31	166.510	1.001	4.826	8.293	2.112	1.838	12.98
32	229.780	1.001	4.826	8.293	2.252	2.303	-2.27
33	209.980	1.001	4.826	8.293	2.871	2.162	24.70
34	232.880	1.001	4.826	8.293	2.933	2.324	20.75
35	199.890	1.001	4.826	8.293	2.502	2.089	16.53
36	341.180	1.001	4.826	8.293	3.799	3.037	20.06
37	368.340	1.001	4.826	8.293	4.693	3.204	31.72
38	366.020	1.001	4.826	8.293	4.696	3.190	32.08
39	39.978	1.301	4.826	10.773	0.587	0.581	1.10
40	39.978	1.301	4.826	10.773	0.636	0.581	8.70
41	40.367	1.301	4.826	10.773	0.690	0.585	15.34
42	39.590	1.301	4.826	10.773	0.778	0.577	25.92
43	40.367	1.301	4.826	10.773	0.606	0.585	3.51
44	39.978	1.301	4.826	10.773	0.751	0.581	22.74
45	69.865	1.301	4.826	10.773	0.794	0.858	-8.03
46	70.253	1.301	4.826	10.773	1.086	0.861	20.65

Table - 8.2.2 (contd.)

No.	Re_g	Sc_g	$a_t dp$	$R.T/a_t D_g$ $m^2 s$ a/kmol x 10^{-3}	(k_g) obs. --kmol/m^2s a-- x 10^3	(k_g) pred. x 10^3	% err
47	67.925	1.301	4.826	10.773	1.045	0.841	19.49
48	70.253	1.301	4.826	10.773	0.981	0.861	12.21
49	69.865	1.301	4.826	10.773	1.033	0.858	16.90
50	70.253	1.301	4.826	10.773	1.084	0.861	20.56
51	69.477	1.301	4.826	10.773	1.092	0.855	21.74
52	70.641	1.301	4.826	10.773	1.223	0.865	29.29
53	69.477	1.301	4.826	10.773	0.972	0.855	12.04
54	154.480	1.301	4.826	10.773	1.230	1.495	-21.59
55	152.150	1.301	4.826	10.773	1.161	1.480	-27.39
56	152.930	1.301	4.826	10.773	1.678	1.485	11.53
57	154.870	1.301	4.826	10.773	1.803	1.498	16.90
58	152.150	1.301	4.826	10.773	1.411	1.480	-4.87
59	151.370	1.301	4.826	10.773	1.678	1.474	12.16
60	151.760	1.301	4.826	10.773	1.456	1.477	-1.45
61	151.370	1.301	4.826	10.773	1.541	1.474	4.36
62	154.090	1.301	4.826	10.773	1.784	1.493	16.33
63	154.480	1.301	4.826	10.773	1.596	1.495	6.30
64	153.700	1.301	4.826	10.773	1.607	1.490	7.27
65	151.370	1.301	4.826	10.773	1.616	1.474	8.77
66	154.480	1.301	4.826	10.773	1.707	1.495	12.41
67	152.540	1.301	4.826	10.773	1.948	1.482	23.92
68	218.910	1.301	4.826	10.773	1.780	1.909	-7.22
69	216.970	1.301	4.826	10.773	1.947	1.897	2.59
70	218.910	1.301	4.826	10.773	2.245	1.909	14.98
71	215.420	1.301	4.826	10.773	2.312	1.887	18.36
72	216.970	1.301	4.826	10.773	2.146	1.897	11.62
73	218.910	1.301	4.826	10.773	2.183	1.909	12.57
74	217.360	1.301	4.826	10.773	2.183	1.899	13.00
75	222.400	1.301	4.826	10.773	2.291	1.930	15.76
76	218.910	1.301	4.826	10.773	2.806	1.909	31.97
77	333.020	1.301	4.826	10.773	3.234	2.560	20.82
78	330.310	1.301	4.826	10.773	3.554	2.546	28.37
79	41.275	1.218	4.699	5.133	0.944	1.242	-31.51
80	61.878	1.218	4.699	5.123	1.253	1.652	-31.87
81	72.637	1.218	4.699	5.131	1.295	1.846	-42.59
82	98.942	1.219	4.699	5.137	1.992	2.290	-14.93
83	115.970	1.218	4.699	5.151	2.344	2.551	-8.80
84	38.078	1.218	4.699	5.141	0.910	1.172	-28.87
85	59.056	1.217	4.699	5.113	1.478	1.602	-8.41
86	76.846	1.218	4.699	5.109	2.029	1.928	4.95
87	95.843	1.218	4.699	5.148	2.196	2.234	-1.75
88	116.700	1.218	4.699	5.151	2.572	2.562	0.39
89	58.385	1.218	4.699	5.145	1.238	1.580	-27.62
90	78.784	1.218	4.699	5.119	1.928	1.958	-1.58
91	96.904	1.218	4.699	5.119	2.196	2.264	-3.09
92	111.690	1.219	4.699	5.113	2.587	2.504	3.23
93	61.288	1.218	4.699	5.137	1.910	1.637	14.31
94	60.102	1.002	4.699	4.226	1.720	1.811	-5.24
95	59.715	1.003	4.699	4.202	1.801	1.813	-0.70
96	40.727	1.002	4.699	4.228	1.068	1.379	-29.06
97	80.604	1.002	4.699	4.194	1.635	2.241	-37.09
98	94.906	1.002	4.699	4.176	1.904	2.523	-32.49

Table - 8.2.2 (contd.)

No.	Re_g	Sc_g	$a_t dp$	$R.T/a_t D_g$ $m^2 s\ g/kmol$ $\times 10^{-3}$	(k_g) obs. --kmol/m^2 s g-- $\times 10^3$	(k_g) pred. $\times 10^3$	% err
99	115.500	1.002	4.699	4.200	2.124	2.878	-35.52
100	59.423	1.002	4.699	4.194	1.321	1.810	-37.06
101	59.783	1.002	4.699	4.192	1.540	1.819	-18.11
102	37.228	1.002	4.699	4.234	1.090	1.292	-18.53
103	60.199	1.002	4.699	4.234	1.885	1.809	4.00
104	59.811	1.002	4.699	4.206	1.939	1.813	6.47
105	59.811	1.002	4.699	4.206	1.871	1.813	3.08
106	74.275	1.002	4.699	8.254	0.828	1.075	-29.84
107	115.080	1.002	4.699	8.254	1.174	1.461	-24.40
108	74.869	1.002	4.699	8.254	0.964	1.081	-12.19
109	104.920	1.002	4.699	8.265	1.060	1.367	-28.96
110	100.870	1.002	4.699	16.544	0.481	0.665	-38.03
111	45.655	1.002	4.699	16.533	0.323	0.382	-18.31
112	54.983	1.002	4.699	16.431	0.359	0.438	-21.95
113	110.990	1.002	4.699	16.578	0.584	0.709	-21.39
114	162.060	1.002	4.699	16.533	0.756	0.927	-22.66
115	176.890	1.002	4.699	16.533	0.794	0.985	-24.05
116	91.767	1.002	4.699	27.852	0.302	0.370	-22.20
117	152.620	1.002	4.699	27.852	0.428	0.528	-23.37
118	215.540	1.002	4.699	27.891	0.559	0.671	-20.03
119	266.880	1.002	4.699	27.891	0.709	0.779	-9.92
120	136.260	1.002	4.699	45.501	0.360	0.298	17.07
121	62.657	1.002	4.699	44.943	0.216	0.175	18.73
122	82.180	1.002	4.699	44.912	0.235	0.212	9.60
123	168.960	1.002	4.699	45.189	0.350	0.349	0.34
124	244.390	1.002	4.699	45.220	0.448	0.452	-0.89
125	67.177	1.218	4.699	5.163	1.623	1.737	-7.00
126	67.105	1.218	4.699	5.159	1.632	1.737	-6.45
127	67.177	1.218	4.699	5.163	1.646	1.737	-5.51
128	79.550	1.218	4.699	5.145	1.731	1.962	-13.35
129	79.550	1.218	4.699	5.145	1.902	1.962	-3.15
130	79.550	1.218	4.699	5.145	1.861	1.962	-5.44
131	82.873	1.218	4.699	5.133	1.916	2.023	-5.60
132	82.873	1.218	4.699	5.133	2.126	2.023	4.83
133	82.694	1.218	4.699	5.123	2.018	2.024	-0.31
134	58.078	1.218	4.699	5.109	1.292	1.585	-22.74
135	57.985	1.218	4.699	5.102	1.505	1.586	-5.36
136	58.078	1.218	4.699	5.109	1.668	1.585	4.96
137	102.720	1.217	4.699	5.169	1.708	2.335	-36.67
138	102.610	1.218	4.699	5.165	2.178	2.335	-7.20
139	102.720	1.217	4.699	5.169	2.081	2.335	-12.19
140	83.971	1.218	4.617	7.800	1.182	1.365	-15.55
141	83.971	1.218	4.617	7.800	1.102	1.365	-23.86
142	98.155	1.218	4.617	7.800	1.209	1.523	-25.99
143	110.850	1.218	4.617	7.764	1.299	1.666	-28.24
144	83.446	1.218	4.617	7.789	1.222	1.361	-11.37
145	128.800	1.218	4.617	7.774	1.404	1.848	-31.67
146	128.670	1.218	4.617	7.768	1.484	1.849	-24.56
147	91.318	1.218	4.617	7.795	1.093	1.449	-32.56
148	85.850	1.217	4.617	7.806	1.051	1.385	-31.78
149	85.711	1.218	4.617	7.800	1.169	1.385	-18.47
150	112.560	1.218	4.699	12.869	0.926	1.000	-7.95
151	102.020	1.217	4.699	13.031	0.835	0.921	-10.35

Table - 8.2.2 (contd.)

No.	Re_g	Sc_g	$a_t d_p$	$R.T/a_t D_g$ $m^2 s\ a/kmol$ $\times 10^{-3}$	(k_g) obs. --kmol/m^2s a-- $\times 10^3$	(k_g) pred. $\times 10^3$	% err
152	102.070	1.217	4.699	13.040	0.881	0.921	-4.62
153	129.450	1.217	4.699	13.040	0.966	1.088	-12.58
154	129.730	1.217	4.699	13.068	0.959	1.087	-13.42
155	130.090	1.217	4.699	13.104	1.061	1.086	-2.39
156	145.610	1.217	4.699	13.040	1.074	1.181	-9.95
157	157.610	1.217	4.699	13.068	1.074	1.246	-16.05
158	157.610	1.217	4.699	13.068	0.995	1.246	-25.20
159	157.690	1.217	4.699	13.077	1.074	1.246	-15.96
160	104.760	1.217	4.699	12.976	0.846	0.943	-11.40
161	104.880	1.217	4.699	12.994	0.863	0.942	-9.17
162	192.600	0.670	4.826	5.511	2.307	2.596	-12.53
163	192.600	0.670	4.826	5.511	2.821	2.596	7.99
164	55.085	0.670	4.826	5.511	1.022	1.081	-5.76
165	132.740	0.670	4.826	5.511	1.989	2.000	-0.56
166	200.500	0.670	4.826	5.511	2.539	2.670	-5.16
167	319.960	0.670	4.826	5.511	4.089	3.703	9.44
168	192.600	0.670	4.826	5.511	2.730	2.596	4.93
169	192.600	0.670	4.826	5.511	2.489	2.596	-4.28
170	192.600	0.670	4.826	5.511	2.429	2.596	-6.86
171	192.600	0.670	4.826	5.511	2.599	2.596	0.14
172	192.600	0.670	4.826	5.511	2.392	2.596	-8.50
173	198.600	0.670	4.826	5.517	2.288	2.649	-15.80
174	200.310	0.670	4.826	5.510	1.971	2.668	-35.37
175	156.010	0.670	4.826	5.510	1.760	2.240	-27.29
176	595.030	0.776	4.940	9.958	3.696	3.290	10.99
177	590.297	0.772	4.940	9.844	3.464	3.304	4.64
178	209.309	0.776	4.940	10.005	1.384	1.576	-13.92
179	357.476	0.779	4.940	9.980	2.062	2.302	-11.68
180	119.778	0.777	4.940	10.021	0.922	1.065	-15.50
181	491.914	0.776	4.750	13.713	2.120	2.167	-2.23
182	818.882	0.776	4.750	13.691	3.123	3.100	0.74
183	488.813	0.774	4.750	13.611	1.879	2.171	-15.59
Observed values of k_g obtained from $k_g a$ data bank. :							
184	88.192	1.140	4.826	9.353	1.171	1.102	5.94
185	86.211	1.140	4.826	9.353	1.264	1.084	14.20
186	139.720	1.163	4.826	9.544	1.786	1.502	15.87
187	170.770	1.167	4.826	9.580	2.037	1.725	15.29
188	265.240	1.208	4.826	9.916	2.482	2.301	7.29
189	50.868	1.110	4.826	9.113	0.751	0.761	-1.29
190	50.868	1.110	4.826	9.113	0.789	0.761	3.48
191	50.868	1.110	4.826	9.113	0.899	0.761	15.32
192	50.868	1.110	4.826	9.113	0.827	0.761	7.94
193	71.347	1.110	4.826	9.113	1.002	0.964	3.73
194	71.347	1.110	4.826	9.113	0.973	0.964	0.93
195	71.347	1.110	4.826	9.113	1.016	0.964	5.07
196	71.347	1.110	4.826	9.113	1.066	0.964	9.50
197	71.347	1.110	4.826	9.113	1.058	0.964	8.82
198	71.347	1.110	4.826	9.113	0.992	0.964	2.78
199	102.070	1.110	4.826	9.113	1.227	1.239	-0.98
200	102.070	1.110	4.826	9.113	1.183	1.239	-4.77

Table - 8.2.2 (contd.)

No.	Re_g	Sc_g	$a_t dp$	$R.T/a_t D_g$ $m^2 s$ a/kmol $\times 10^{-3}$	(k_g) obs. kmol/m^2 s a $\times 10^3$	(k_g) pred. $\times 10^3$	% err
201	102.070	1.110	4.826	9.113	1.181	1.239	-4.91
202	102.070	1.110	4.826	9.113	1.146	1.239	-8.10
203	49.546	1.110	4.826	9.113	0.883	0.747	15.41
204	49.546	1.110	4.826	9.113	0.828	0.747	9.72
205	49.546	1.110	4.826	9.113	0.807	0.747	7.38
206	49.546	1.110	4.826	9.113	0.885	0.747	15.54
207	99.093	1.110	4.826	9.113	1.409	1.214	13.88
208	99.093	1.110	4.826	9.113	1.277	1.214	4.92
209	99.093	1.110	4.826	9.113	1.294	1.214	6.18
210	99.093	1.110	4.826	9.113	1.365	1.214	11.08
211	148.640	1.110	4.826	9.113	1.836	1.612	12.17
212	148.640	1.110	4.826	9.113	1.669	1.612	3.40
213	148.640	1.110	4.826	9.113	1.713	1.612	5.91
214	148.640	1.110	4.826	9.113	1.758	1.612	8.27
215	214.700	1.110	4.826	9.113	2.188	2.085	4.67
216	214.700	1.110	4.826	9.113	1.996	2.085	-4.49
217	214.700	1.110	4.826	9.113	2.342	2.085	10.94
218	214.700	1.110	4.826	9.113	2.284	2.085	8.70
219	280.760	1.110	4.826	9.113	3.062	2.516	17.81
220	280.760	1.110	4.826	9.113	2.973	2.516	15.35
221	280.760	1.110	4.826	9.113	3.099	2.516	18.80
222	280.760	1.110	4.826	9.113	3.112	2.516	19.15
223	50.135	1.110	4.826	9.158	1.035	0.750	27.60
224	50.135	1.110	4.826	9.158	0.987	0.750	24.08
225	50.135	1.110	4.826	9.158	1.036	0.750	27.66
226	50.135	1.110	4.826	9.158	1.033	0.750	27.47
227	83.558	1.110	4.826	9.158	1.337	1.072	19.81
228	83.558	1.110	4.826	9.158	1.380	1.072	22.32
229	83.558	1.110	4.826	9.158	1.251	1.072	14.32
230	83.558	1.110	4.826	9.158	1.322	1.072	18.95
231	133.690	1.110	4.826	9.158	1.606	1.489	7.28
232	133.690	1.110	4.826	9.158	1.713	1.489	13.05
233	133.690	1.110	4.826	9.158	1.522	1.489	2.17
234	133.690	1.110	4.826	9.158	1.691	1.489	11.93
235	49.546	1.052	4.826	8.632	0.798	0.771	3.31
236	49.546	1.052	4.826	8.632	0.784	0.771	1.58
237	49.546	1.052	4.826	8.632	0.819	0.771	5.77
238	49.546	1.052	4.826	8.632	0.874	0.771	11.71
239	99.093	1.052	4.826	8.632	1.319	1.253	4.97
240	99.093	1.052	4.826	8.632	1.220	1.253	-2.73
241	99.093	1.052	4.826	8.632	1.254	1.253	0.09
242	99.093	1.052	4.826	8.632	1.276	1.253	1.76

Observed values of k_g obtained from $k_g a$ vaporization data bank. :

243	59.158	1.723	4.826	14.310	0.681	0.646	5.17
244	68.110	1.725	4.826	14.328	0.825	0.712	13.70
245	76.966	1.723	4.826	14.364	0.804	0.773	3.78
246	84.713	1.723	4.826	14.419	0.837	0.824	1.60
247	97.940	1.723	4.826	14.401	0.954	0.913	4.27
248	112.040	1.723	4.826	14.401	1.064	1.003	5.71
249	124.630	1.723	4.826	14.364	1.204	1.084	10.00
250	131.630	1.723	4.826	14.401	1.162	1.123	3.32

Table - 8.2.2 (contd.)

No.	Re_g	Sc_g	$a_t d_p$	$R.T/a_t D_g$ m^2 s a/kmol $\times 10^{-3}$	(k_g) obs. --kmol/m^2 s a-- $\times 10^3$	(k_g) pred. $\times 10^3$	% err
251	142.990	1.723	4.826	14.401	1.260	1.190	5.55
252	148.620	1.723	4.826	14.383	1.303	1.224	6.04
253	157.230	1.723	4.826	14.383	1.289	1.274	1.19
254	168.640	1.723	4.826	14.419	1.247	1.334	-6.96
255	172.660	1.723	4.826	14.428	1.343	1.356	-0.93
256	180.800	1.723	4.826	14.392	1.443	1.404	2.71
257	193.920	1.723	4.826	14.401	1.625	1.473	9.38
258	60.550	2.292	4.826	18.983	0.541	0.557	-2.80
259	66.164	2.291	4.826	19.031	0.615	0.591	3.99
260	80.953	2.291	4.826	19.031	0.640	0.680	-6.26
261	89.905	2.291	4.826	19.031	0.721	0.732	-1.58
262	102.080	2.292	4.826	19.055	0.774	0.799	-3.26
263	111.430	2.292	4.826	19.055	0.862	0.850	1.42
264	121.110	2.291	4.826	19.103	0.870	0.898	-3.30
265	128.150	2.291	4.826	19.103	0.926	0.935	-0.90
266	135.960	2.291	4.826	19.103	1.045	0.974	6.79
267	143.230	2.291	4.826	19.079	0.980	1.012	-3.24
268	146.350	2.291	4.826	19.079	0.952	1.027	-7.92
269	159.400	2.291	4.826	19.103	1.009	1.089	-7.96
270	171.510	2.291	4.826	19.103	1.147	1.146	0.06
271	181.860	2.291	4.826	19.079	1.168	1.196	-2.32
272	190.660	2.291	4.826	19.103	1.136	1.234	-8.63
273	79.310	0.603	4.826	5.076	1.479	1.449	2.00
274	78.352	0.603	4.826	5.040	1.731	1.447	16.40
275	79.485	0.603	4.826	5.063	1.516	1.455	4.02
276	78.568	0.603	4.826	5.053	1.556	1.446	7.08
277	78.175	0.603	4.826	5.053	1.156	1.441	-24.63
278	78.961	0.603	4.826	5.053	1.586	1.451	8.46
279	79.659	0.603	4.826	5.050	1.650	1.461	11.40
280	79.223	0.603	4.826	5.047	1.687	1.457	13.65
281	77.961	0.603	4.826	5.040	1.841	1.442	21.65
282	79.136	0.603	4.826	5.040	1.444	1.457	-0.93
283	78.395	0.603	4.826	5.043	1.905	1.447	24.04
284	78.352	0.603	4.826	5.040	1.749	1.447	17.26
285	78.223	0.603	4.826	5.034	1.687	1.448	14.20
286	78.223	0.603	4.826	5.034	1.616	1.448	10.41
287	78.438	0.603	4.826	5.047	1.673	1.447	13.55
288	76.628	0.604	4.826	4.934	1.686	1.456	13.62
289	76.710	0.604	4.826	4.940	1.589	1.455	8.41
290	55.936	0.603	4.826	5.034	1.158	1.145	1.19
291	59.963	0.603	4.826	5.012	1.290	1.207	6.43
292	90.442	0.603	4.826	5.018	1.702	1.608	5.53
293	107.850	0.603	4.826	5.047	2.045	1.808	11.61
294	113.800	0.603	4.826	4.984	2.086	1.901	8.87
295	116.970	0.603	4.826	5.002	1.949	1.931	0.93
296	126.710	0.603	4.826	5.018	2.217	2.035	8.17
297	135.590	0.603	4.826	5.015	2.265	2.136	5.73
298	145.300	0.603	4.826	5.053	2.745	2.224	18.97
299	165.050	0.603	4.826	5.056	2.558	2.430	4.99
300	173.270	0.603	4.826	5.012	2.662	2.537	4.70
301	181.850	0.606	4.826	5.060	2.881	2.605	9.58
302	185.460	0.603	4.826	5.015	2.810	2.659	5.35

Table – 8.2.2 (contd.)

No.	Re_a	Sc_a	$a_t d_p$	$R.T/a_t D_a$ $m^2 s\ a/kmol$ $\times 10^{-3}$	(k_a) obs. $\times 10^3$	(k_a) pred. $\times 10^3$	% err
					--kmol/m^2 s a--		
Observed values of k_a obtained from HTU data bank. :							
303	349.470	0.586	4.826	4.760	4.300	4.314	-0.33
304	97.502	0.595	4.826	4.858	1.743	1.741	0.14
305	97.554	0.595	4.826	4.860	1.464	1.741	-18.89
306	97.108	0.595	4.826	4.861	1.537	1.735	-12.89
307	821.810	0.224	4.826	10.826	2.117	2.320	-9.58
308	940.760	0.225	4.826	10.812	2.561	2.561	0.00
309	111.640	0.225	4.826	10.970	0.545	0.567	-4.19
310	181.560	0.224	4.826	11.008	0.759	0.793	-4.50
311	464.280	0.232	4.826	10.736	1.485	1.591	-7.17
312	662.070	0.223	4.826	10.784	1.785	1.998	-11.91

CASE III : k_G from vaporization : Total number of data points = 60.

CASE IV : k_G from HTU data : Total number of data points = 10.

8.2.3 Statistical analysis for different correlations :-

For processing the data of k_G reported in Table (8.2.2), the flexible and robust algorithm - the modified simplex method of Nelder and Mead was utilised. The results of various regression steps are reported in Table (8.2.3) and are discussed herewith.

In step (1), all the groups viz. Re_G, Sc_G, $(a_t.d_p)$ and the proportionality constant (C) were regressed. The base values of guesses and ranges of perturbation were based on Onda's correlation [Equation (2.2.6)]. The regression of the k_G data yielded the following correlation :-

$$k_G = 1.024\ (Re_G)^{0.69}\ (Sc_G)^{0.408}\ (a_t.d_p)^{-1.02}\ (RT/a_t.D_G)^{-1} \qquad (8.10)$$

The values of % E_{avg}, % E_{abs} and % S_{dev} were 2.11, 12.37 and 0.031 respectively.

Further, by fixing the values of some indices inclusive of proportionality constant and performing regression of the data as per steps (2) and (3) yielded the following correlation :-

$$k_G = 1.75\ (Re_G)^{0.7}\ (Sc_G)^{0.4125}\ (a_t.d_p)^{-0.9}\ (RT/a_t.D_G)^{-1} \qquad (8.11)$$

The values of % E_{avg}, % E_{abs} and % S_{dev} were 0.76, 12.17 and 0.030 respectively.

Table - (8.2.3)

Statistical analysis for different correlations of k_G

Correlation Structure : $k_G = C \cdot Re_G^{\alpha} \cdot Sc_G^{m} \cdot (a_t dp)^{n} \cdot (R\,T / a_t D_G)^{-1}$

No.	C	α	m	n	% E_{avg}	% E_{abs}	% S_{dev}
Optimisation by the Modified Simplex algorithm of Nelder and Mead							
All parameters are iterated, base values of guesses and ranges of perturbation were as follows :- for α 1.1 <u>0.7</u> 0.3, for m 0.33 <u>0.5</u> 0.66, for n -0.5 -<u>1.0</u> -2.0 and for C 3.0 <u>2.0</u> 1.0.							
1	1.024	0.69	0.4083	-1.024	2.108	12.368	0.031.
α value fixed as 0.7. Other parameters iterated as in step 1.							
2	1.75	0.70	0.4068	-0.896	0.535	12.540	0.0304.
Values of α, n and C fixed as 0.7, -0.9, and 1.75 respectively. Only the indice m was iterated.							
3*	1.75	0.70	0.4125	-0.9	0.76	12.17	0.030.

Note : The values of indices in the finalised generalised correlation are as per regression step marked by (*)

The values of % E_{abs} for regression steps (1) and (3) are practically the same being 12.37 and 12.17 respectively. However the values of % E_{avg} for regression steps (1) and (3) do differ to some extent, being 2.11 and 0.76 respectively. Therefore the appropriate correlation for predicting the values of k_G appears to be equation (8.11) in comparison with equation (8.10).

The values of indices of all dimensionless numbers inclusive of proportionality constant in equation (8.11) are therefore, such that the correlation predicts the values of k_G with the least amount of error.

8.2.4 Comparison between the observed values and the predicted values of k_G :

The observed values of k_G obtained by utilising the various processing steps discussed earlier and the values of k_G predicted by using the generalised correlation [Equation (8.11)] developed in this investigation are tabulated in Table (8.2.4) and are plotted in Figure (8.2). The detailed statistical analysis of the correlation [Equation (8.11)] can be described as follows :

(i) The total number of data points used in the correlation is 312 belonging to four different cases comprising of 27 variations inclusive 10 systems - variations.

(ii) The values of % E_{avg}, % E_{abs} and % S_{dev} were 0.76, 12.17 and 0.030 respectively.

Table (8.2.4)

Comparison between observed values based on data bank and predicted values of k_G.

No.	k_G kmol/m^{2}sa $\times 10^3$ exp	k_G kmol/m^{2}sa $\times 10^3$ This Work	% err This Work	k_G kmol/m^{2}sa $\times 10^3$ Onda et al.	% err Onda et al.
1	1.331	1.267	4.80	0.693	47.94
2	1.404	1.316	6.27	0.720	48.75
3	1.150	1.282	-11.51	0.701	39.02
4	2.145	2.200	-2.60	1.203	43.90
5	2.747	2.200	19.89	1.203	56.19
6	2.045	2.247	-9.89	1.229	39.91
7	3.140	2.550	18.77	1.395	55.58
8	3.988	2.971	25.52	1.624	59.27
9	3.649	2.902	20.47	1.587	56.51
10	3.631	2.822	22.28	1.543	57.50
11	2.632	2.691	-2.25	1.472	44.08
12	0.472	0.536	-13.73	0.279	40.79
13	0.566	0.570	-0.75	0.297	47.55
14	0.871	0.896	-2.85	0.466	46.46
15	1.126	0.878	21.99	0.457	59.39
16	0.940	0.937	0.36	0.488	48.13
17	1.122	0.906	19.21	0.472	57.94
18	1.717	1.604	6.59	0.835	51.37
19	1.996	1.483	25.71	0.772	61.33
20	1.883	1.598	15.11	0.832	55.81
21	0.642	0.691	-7.55	0.365	43.10
22	0.802	0.672	16.20	0.356	55.67
23	0.608	0.663	-9.06	0.351	42.31
24	0.852	1.028	-20.61	0.544	36.19
25	1.226	1.008	17.72	0.533	56.47
26	1.153	1.028	10.84	0.544	52.83
27	0.971	0.981	-1.05	0.519	46.54
28	1.511	1.787	-18.26	0.945	37.44
29	1.903	1.778	6.58	0.940	50.58
30	2.120	1.784	15.86	0.944	55.49
31	2.112	1.838	12.98	0.972	53.96
32	2.252	2.303	-2.27	1.218	45.90
33	2.871	2.162	24.70	1.144	60.16
34	2.933	2.324	20.75	1.230	58.08
35	2.502	2.089	16.53	1.105	55.84
36	3.799	3.037	20.06	1.606	57.71
37	4.693	3.204	31.72	1.695	63.88
38	4.696	3.190	32.08	1.688	64.07
39	0.587	0.581	1.10	0.301	48.80
40	0.636	0.581	8.70	0.301	52.73
41	0.690	0.585	15.34	0.303	56.17
42	0.778	0.577	25.92	0.299	61.65
43	0.606	0.585	3.51	0.303	50.05
44	0.751	0.581	22.74	0.301	60.00
45	0.794	0.858	-8.03	0.444	44.07
46	1.086	0.861	20.65	0.446	58.92
47	1.045	0.841	19.49	0.436	58.32
48	0.981	0.861	12.21	0.446	54.55
49	1.033	0.858	16.90	0.444	56.98

Table - 8.2.4 (contd.)

No.	k_a --kmol/m^{2}sa-- x 10^3 exp	k_a x 10^3 This Work	% err	k_a kmol/m^{2}sa x 10^3 Onda et al.	% err
50	1.084	0.861	20.56	0.446	58.87
51	1.092	0.855	21.74	0.443	59.49
52	1.223	0.865	29.29	0.448	63.39
53	0.972	0.855	12.04	0.443	54.46
54	1.230	1.495	-21.59	0.774	37.05
55	1.161	1.480	-27.39	0.766	34.05
56	1.678	1.485	11.53	0.769	54.20
57	1.803	1.498	16.90	0.776	56.97
58	1.411	1.480	-4.87	0.766	45.71
59	1.678	1.474	12.16	0.763	54.52
60	1.456	1.477	-1.45	0.765	47.48
61	1.541	1.474	4.36	0.763	50.48
62	1.784	1.493	16.33	0.773	56.68
63	1.596	1.495	6.30	0.774	51.49
64	1.607	1.490	7.27	0.772	51.99
65	1.616	1.474	8.77	0.763	52.77
66	1.707	1.495	12.41	0.774	54.65
67	1.948	1.482	23.92	0.767	60.61
68	1.780	1.909	-7.22	0.988	44.49
69	1.947	1.897	2.59	0.982	49.57
70	2.245	1.909	14.98	0.988	55.99
71	2.312	1.887	18.36	0.977	57.73
72	2.146	1.897	11.62	0.982	54.25
73	2.183	1.909	12.57	0.988	54.73
74	2.183	1.899	13.00	0.983	54.96
75	2.291	1.930	15.76	0.999	56.39
76	2.806	1.909	31.97	0.988	64.78
77	3.234	2.560	20.82	1.326	59.01
78	3.554	2.546	28.37	1.318	62.91
79	0.944	1.242	-31.51	0.666	29.50
80	1.253	1.652	-31.87	0.886	29.31
81	1.295	1.846	-42.59	0.989	23.57
82	1.992	2.290	-14.93	1.227	38.40
83	2.344	2.551	-8.80	1.367	41.68
84	0.910	1.172	-28.87	0.628	30.92
85	1.478	1.602	-8.41	0.859	41.89
86	2.029	1.928	4.95	1.034	49.05
87	2.196	2.234	-1.75	1.197	45.46
88	2.572	2.562	0.39	1.374	46.60
89	1.238	1.580	-27.62	0.847	31.59
90	1.928	1.958	-1.58	1.050	45.55
91	2.196	2.264	-3.09	1.213	44.74
92	2.587	2.504	3.23	1.342	48.13
93	1.910	1.637	14.31	0.877	54.06
94	1.720	1.811	-5.24	0.986	42.67
95	1.801	1.813	-0.70	0.988	45.15
96	1.068	1.379	-29.06	0.751	29.70
97	1.635	2.241	-37.09	1.221	25.32
98	1.904	2.523	-32.49	1.374	27.83
99	2.124	2.878	-35.52	1.568	26.18
100	1.321	1.810	-37.06	0.986	25.34
101	1.540	1.819	-18.11	0.991	35.66
102	1.090	1.292	-18.53	0.704	35.43

Table - 8.2.4 (contd.)

No.	k_a --kmol/m^{2}sa-- x 10^3 exp	k_a x 10^3 This Work	% err	k_a kmol/m^{2}sa x 10^3 Onda et al.	% err
103	1.885	1.809	4.00	0.986	47.71
104	1.939	1.813	6.47	0.988	49.05
105	1.871	1.813	3.08	0.988	47.20
106	0.828	1.075	-29.84	0.586	29.27
107	1.174	1.461	-24.40	0.796	32.23
108	0.964	1.081	-12.19	0.589	38.89
109	1.060	1.367	-28.96	0.745	29.75
110	0.481	0.665	-38.03	0.362	24.81
111	0.323	0.382	-18.31	0.208	35.55
112	0.359	0.438	-21.95	0.238	33.57
113	0.584	0.709	-21.39	0.386	33.87
114	0.756	0.927	-22.66	0.505	33.18
115	0.794	0.985	-24.05	0.537	32.43
116	0.302	0.370	-22.20	0.201	33.43
117	0.428	0.528	-23.37	0.287	32.80
118	0.559	0.671	-20.03	0.365	34.62
119	0.709	0.779	-9.92	0.424	40.13
120	0.360	0.298	17.07	0.162	54.82
121	0.216	0.175	18.73	0.096	55.73
122	0.235	0.212	9.60	0.116	50.76
123	0.350	0.349	0.34	0.190	45.71
124	0.448	0.452	-0.89	0.246	45.04
125	1.623	1.737	-7.00	0.931	42.64
126	1.632	1.737	-6.45	0.931	42.94
127	1.646	1.737	-5.51	0.931	43.44
128	1.731	1.962	-13.35	1.052	39.24
129	1.902	1.962	-3.15	1.052	44.71
130	1.861	1.962	-5.44	1.052	43.48
131	1.916	2.023	-5.60	1.085	43.40
132	2.126	2.023	4.83	1.085	48.98
133	2.018	2.024	-0.31	1.085	46.23
134	1.292	1.585	-22.74	0.850	34.21
135	1.505	1.586	-5.36	0.850	43.53
136	1.668	1.585	4.96	0.850	49.06
137	1.708	2.335	-36.67	1.251	26.74
138	2.178	2.335	-7.20	1.252	42.54
139	2.081	2.335	-12.19	1.251	39.86
140	1.182	1.365	-15.55	0.746	36.85
141	1.102	1.365	-23.86	0.746	32.31
142	1.209	1.523	-25.99	0.832	31.15
143	1.299	1.666	-28.24	0.911	29.92
144	1.222	1.361	-11.37	0.744	39.13
145	1.404	1.848	-31.67	1.010	28.04
146	1.484	1.849	-24.56	1.010	31.93
147	1.093	1.449	-32.56	0.792	27.55
148	1.051	1.385	-31.78	0.757	27.98
149	1.169	1.385	-18.47	0.757	35.25
150	0.926	1.000	-7.95	0.536	42.14
151	0.835	0.921	-10.35	0.494	40.84
152	0.881	0.921	-4.62	0.494	43.92
153	0.966	1.088	-12.58	0.583	39.65
154	0.959	1.087	-13.42	0.583	39.20
155	1.061	1.086	-2.39	0.582	45.11

Table - 8.2.4 (contd.)

No.	k_G $x 10^3$ exp	k_G $x 10^3$ This Work	% err	k_G kmol/m^{2}sa $x 10^3$ Onda et al.	% err
	--kmol/m^{2}sa--				
156	1.074	1.181	-9.95	0.633	41.06
157	1.074	1.246	-16.05	0.668	37.79
158	0.995	1.246	-25.20	0.668	32.88
159	1.074	1.246	-15.96	0.668	37.84
160	0.846	0.943	-11.40	0.505	40.28
161	0.863	0.942	-9.17	0.505	-41.48
162	2.307	2.596	-12.53	1.419	38.47
163	2.821	2.596	7.99	1.419	49.69
164	1.022	1.081	-5.76	0.591	42.17
165	1.989	2.000	-0.56	1.094	45.01
166	2.539	2.670	-5.16	1.460	42.50
167	4.089	3.703	9.44	2.025	50.48
168	2.730	2.596	4.93	1.419	48.01
169	2.489	2.596	-4.28	1.419	42.98
170	2.429	2.596	-6.86	1.419	41.57
171	2.599	2.596	0.14	1.419	45.39
172	2.392	2.596	-8.50	1.419	40.67
173	2.288	2.649	-15.80	1.449	36.68
174	1.971	2.668	-35.37	1.459	25.97
175	1.760	2.240	-27.29	1.225	30.39
176	3.696	3.290	10.99	1.733	53.13
177	3.464	3.304	4.64	1.740	49.77
178	1.384	1.576	-13.92	0.830	40.01
179	2.062	2.302	-11.68	1.212	41.21
180	0.922	1.065	-15.50	0.561	39.19
181	2.120	2.167	-2.23	1.191	43.80
182	3.123	3.100	0.74	1.704	45.43
183	1.878	2.171	-15.59	1.194	36.44
184	1.171	1.102	5.94	0.577	50.77
185	1.264	1.084	14.20	0.568	55.09
186	1.786	1.502	15.87	0.785	56.04
187	2.037	1.725	15.29	0.901	55.75
188	2.482	2.301	7.29	1.199	51.71
189	0.751	0.761	-1.29	0.399	46.87
190	0.789	0.761	3.48	0.399	49.37
191	0.899	0.761	15.32	0.399	55.58
192	0.827	0.761	7.94	0.399	51.71
193	1.002	0.964	3.73	0.506	49.50
194	0.973	0.964	0.93	0.506	48.03
195	1.016	0.964	5.07	0.506	50.21
196	1.066	0.964	9.50	0.506	52.53
197	1.058	0.964	8.82	0.506	52.18
198	0.992	0.964	2.78	0.506	49.01
199	1.227	1.239	-0.98	0.650	47.03
200	1.183	1.239	-4.77	0.650	45.05
201	1.181	1.239	-4.91	0.650	44.97
202	1.146	1.239	-8.10	0.650	43.30
203	0.883	0.747	15.41	0.392	55.63
204	0.828	0.747	9.72	0.392	52.65
205	0.807	0.747	7.38	0.392	51.42
206	0.885	0.747	15.54	0.392	55.70
207	1.409	1.214	13.88	0.637	54.83
208	1.277	1.214	4.92	0.637	50.13

Table - 8.2.4 (contd.)

No.	k_a --kmol/m² sa-- x 10³ exp	k_a x 10³ This Work	% err	k_a kmol/m² sa x 10³ Onda et al.	% err
209	1.294	1.214	6.18	0.637	50.79
210	1.365	1.214	11.08	0.637	53.36
211	1.836	1.612	12.17	0.846	53.93
212	1.669	1.612	3.40	0.846	49.33
213	1.713	1.612	5.91	0.846	50.65
214	1.758	1.612	8.27	0.846	51.89
215	2.188	2.085	4.67	1.094	50.00
216	1.996	2.085	-4.49	1.094	45.19
217	2.342	2.085	10.94	1.094	53.29
218	2.284	2.085	8.70	1.094	52.11
219	3.062	2.516	17.81	1.320	56.89
220	2.973	2.516	15.35	1.320	55.60
221	3.099	2.516	18.80	1.320	57.41
222	3.112	2.516	19.15	1.320	57.59
223	1.035	0.750	27.60	0.393	62.02
224	0.987	0.750	24.08	0.393	60.18
225	1.036	0.750	27.66	0.393	62.06
226	1.033	0.750	27.47	0.393	61.96
227	1.337	1.072	19.81	0.562	57.94
228	1.380	1.072	22.32	0.562	59.26
229	1.251	1.072	14.32	0.562	55.06
230	1.322	1.072	18.95	0.562	57.49
231	1.606	1.489	7.28	0.781	51.36
232	1.713	1.489	13.05	0.781	54.39
233	1.522	1.489	2.17	0.781	48.68
234	1.691	1.489	11.93	0.781	53.81
235	0.798	0.771	3.31	0.406	49.06
236	0.784	0.771	1.58	0.406	48.14
237	0.819	0.771	5.77	0.406	50.35
238	0.874	0.771	11.71	0.406	53.48
239	1.319	1.253	4.97	0.660	49.93
240	1.220	1.253	-2.73	0.660	45.87
241	1.254	1.253	0.09	0.660	47.36
242	1.276	1.253	1.76	0.660	48.24
243	0.681	0.646	5.17	0.327	52.03
244	0.825	0.712	13.70	0.360	56.35
245	0.804	0.773	3.78	0.391	51.33
246	0.837	0.824	1.60	0.417	50.22
247	0.954	0.913	4.27	0.462	51.57
248	1.064	1.003	5.71	0.508	52.30
249	1.204	1.084	10.00	0.548	54.47
250	1.162	1.123	3.32	0.568	51.09
251	1.260	1.190	5.55	0.602	52.22
252	1.303	1.224	6.04	0.619	52.47
253	1.289	1.274	1.19	0.644	50.02
254	1.247	1.334	-6.96	0.675	45.89
255	1.343	1.356	-0.93	0.686	48.94
256	1.443	1.404	2.71	0.710	50.78
257	1.625	1.473	9.38	0.745	54.16
258	0.541	0.557	-2.80	0.275	49.21
259	0.615	0.591	3.99	0.292	52.56
260	0.640	0.680	-6.26	0.336	47.50

Table - 8.2.4 (contd.)

No.	k_a --kmol/m^{2}sa-- x 10^3 exp	k_a x 10^3 This Work	% err	k_a kmol/m^{2}sa x 10^3 Onda et al.	% err
261	0.721	0.732	-1.58	0.362	49.81
262	0.774	0.799	-3.26	0.395	48.98
263	0.862	0.850	1.42	0.420	51.30
264	0.870	0.898	-3.30	0.444	48.96
265	0.926	0.935	-0.90	0.462	50.15
266	1.045	0.974	6.79	0.481	53.94
267	0.980	1.012	-3.24	0.500	48.99
268	0.952	1.027	-7.92	0.507	46.68
269	1.009	1.089	-7.96	0.538	46.66
270	1.147	1.146	0.06	0.566	50.62
271	1.168	1.196	-2.32	0.591	49.44
272	1.136	1.234	-8.63	0.610	46.32
273	1.479	1.449	2.00	0.800	45.94
274	1.731	1.447	16.40	0.798	53.88
275	1.516	1.455	4.02	0.803	47.05
276	1.556	1.446	7.08	0.798	48.74
277	1.156	1.441	-24.63	0.795	31.25
278	1.586	1.451	8.46	0.801	49.51
279	1.650	1.461	11.40	0.806	51.13
280	1.687	1.457	13.65	0.804	52.37
281	1.841	1.442	21.65	0.796	56.78
282	1.444	1.457	-0.93	0.804	44.32
283	1.905	1.447	24.04	0.798	58.10
284	1.749	1.447	17.26	0.798	54.36
285	1.687	1.448	14.20	0.799	52.67
286	1.616	1.448	10.41	0.799	50.58
287	1.673	1.447	13.55	0.798	52.31
288	1.686	1.456	13.62	0.803	52.36
289	1.589	1.455	8.41	0.803	49.48
290	1.158	1.145	1.19	0.631	45.50
291	1.290	1.207	6.43	0.666	48.38
292	1.702	1.608	5.53	0.887	47.89
293	2.045	1.808	11.61	0.997	51.24
294	2.086	1.901	8.87	1.049	49.73
295	1.949	1.931	0.93	1.065	45.35
296	2.217	2.035	8.17	1.123	49.35
297	2.265	2.136	5.73	1.178	48.00
298	2.745	2.224	18.97	1.227	55.30
299	2.558	2.430	4.99	1.341	47.59
300	2.662	2.537	4.70	1.400	47.43
301	2.881	2.605	9.58	1.436	50.14
302	2.810	2.659	5.35	1.467	47.79
303	4.300	4.314	-0.33	2.385	44.53
304	1.743	1.741	0.14	0.961	44.86
305	1.464	1.741	-18.89	0.961	34.35
306	1.537	1.735	-12.89	0.958	37.66
307	2.117	2.320	-9.58	1.389	34.40
308	2.561	2.561	0.00	1.532	40.18
309	0.545	0.567	-4.19	0.340	37.66
310	0.759	0.793	-4.50	0.475	37.45
311	1.485	1.591	-7.17	0.950	36.03
312	1.785	1.998	-11.91	1.196	32.98

(iii) From the 312 data points, 80% of the predicted values of k_G were within ± 20% of the observed data values ; 67 % were within ± 15 % and 50 % were within ± 10 %.

Figure (8.2) shows a parity plot of equation (8.11) wherein the values of $(k_G)_{pred.}$ have been plotted versus $(k_G)_{obs}$. The satisfactory correlation data fit clearly reflects that equation (8.11) can correlate satisfactorily all the data obtained from the various sources covering wide range of variables as mentioned earlier.

Out of the various correlations reported in literature, the correlation proposed by Onda et al. [Equation (2.2.6)] appears to be more generalised in nature and has been proposed based on a large data bank of k_G. Hence the values of $(k_G)_{pred.}$ obtained by using the correlation of Onda et al. are also reported in Table (8.2.4) for the purpose of comparison. The detailed statistical analysis of the correlation by Onda et al. can be described as follows :-

(i) The values of % E_{avg}, % E_{abs}, and % S_{dev} were 47.11, 47.11 and 0.048 respectively.

(ii) Out of 312 data points none of the predicted values were within ± 20 % of the observed values. The predicted values of k_G were consistently less than the observed values of k_G.

The comparison of the detailed statistical analysis for both these correlations under consideration reveals that the values of % E_{abs} for the correlation of Onda and for the correlation developed

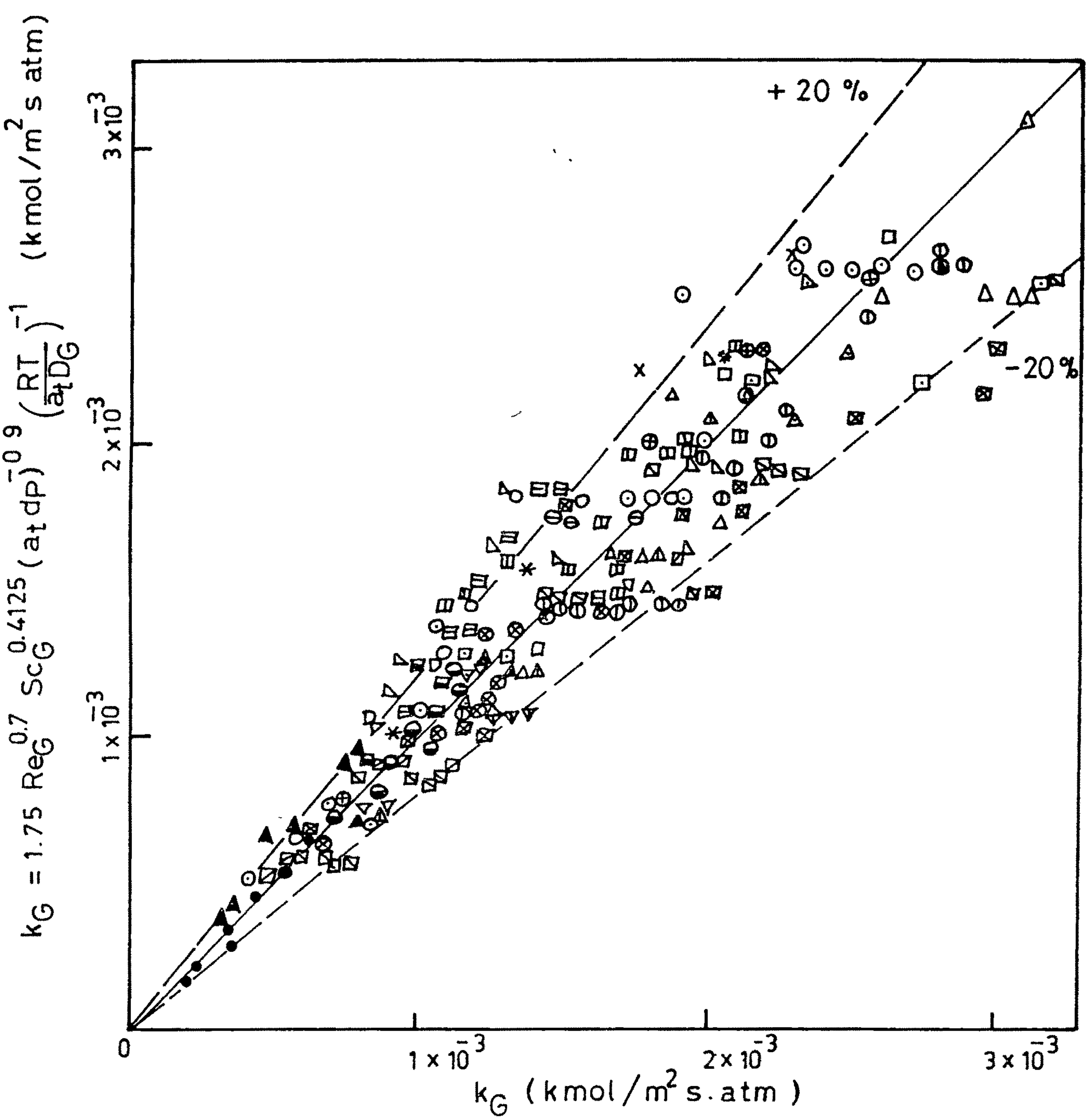

Fig. 8.2 TRUE GAS SIDE MASS TRANSFER COEFFICIENT. COMPARISON OF PREDICTED vs. EXPERIMENTAL (Lit.) DATA.

LEGENDS FOR FIG. 8.2

Data No.	Relevant Information	Symbol
1-11	Houston (47), Carbon R.R., 25mm. Ammonia-Water.	□
12-20	Houston (47), Carbon R.R., 25mm. Acetone-Water.	⧄
21-38	Houston (47), Carbon R.R., 25mm. Methanol-Water.	⊠
39-78	Houston (47), Carbon R.R., 25mm. Ethanol-Water.	⧅
79-93	Zabban (48), C.R.R., 13mm, Acetone-Water.	◺
94-124	Zabban (48), C.R.R., 13mm, Methanol-Water, at pressures in atm a 1.00, 1.95, 3.90, 6.70 and 10.70.	○ D ◗ ◖ ●
125-161	Hutchings (49), Acetone-Water. C.R.R., 13mm, 19mm, 31.7mm.	◫ ⊟ ⬓
162-172	Dyer (50), Ammonia-Water; Carbon R.R., 25mm.	○
173-175	Molstad (51), Ammonia-Water, C.R.R., 25mm.	x
176-183	Fellinger (52), Ammonia-Water, C.R.R., 38mm, 50mm.	✶ ⊗
184-188	Vidwans (53), SO_2-NaOH, C.R.R., 25mm.	Δ
189-234	Sahay(41), dp=25mm, Cl_2-NaOH, C.R.R., PVC. R.R. Polypropylene .R.R.	∇ ⟁ ⏄
235-242	Sahay(41), dp=25mm, SO_2-NaOH, PVC. R.R.,	▲
243-257	Surosky (54), Carbon. R.R., 25mm, Benzene vaporization.	⊗
258-272	Surosky (54), Carbon. R.R., 25mm, Ethylbutyrate vaporsation.	○
273-302	Surosky (54), Carbon. R.R., 25mm, Water vaporization.	⦶
303-312	Lynch (55), C.R.R, 25mm, Water vaporization in air, water vaporization in Freon 12.	⊖ ⊕

in this investigation are 47 % and 12 % respectively. Further Onda's correlation predicts k_G values which are consistently lower than the observed values. This is expected for the cases where the k_G values were obtained from either K_Ga or from k_Ga (chemical technique) by dividing the values of a_w instead of a_{dy}. However, it is rather surprising that also for the cases wherein the values of k_G were obtained from vaporization data (wherein a_w values were used in this investigation as well as Onda's correlation) the data fit is highly inferior.

Thus, it can be concluded that the correlation developed in this investigation appears to be more appropriate and sound than the correlation of Onda and coworkers.

8.3.0 RESULTS AND DISCUSSION FOR TRUE LIQUID SIDE MASS TRANSFER COEFFICIENT (k_L) :

When gas absorption is accompanied by a chemical reaction knowledge of the true liquid side mass transfer coefficient (k_L) and the effective interfacial area (a_c) separately is essential for the design of packed column.

The existing correlations available in the literature (listed in Table 2.2 : Chapter 2) for predicting the values of k_L are mostly developed based on the values of k_L obtained by dividing the experimentally obtained k_La values for physical absorption by the corresponding values of wetted surface area (a_w). Thus, the values of k_L predicted using these generalised correlations are also expected to involve considerable amount of error. Further, the data on k_L obtained by different investigators (22, 36, 37, 56) using chemical technique cannot be correlated satisfactorily by these correlations.

Hence, it was thought desirable to reobtain the values of k_L from the data bank of k_La by dividing these values by the appropriate values of 'a'. It was also thought desirable to reanalyse both these data banks (k_L values obtained from k_La data bank and k_L values obtained by using chemical technique) and to develop a generalised correlation by mathematical modelling for predicting the values of k_L.

8.3.1 Results for true liquid side mass transfer coefficient (k_L)

As has already been discussed in Chapter 6, during physical absorption the effective interfacial area avaliable for mass transfer is the dynamic area (a_{dy}). Under these conditions the interrelationship between volumetric mass transfer coefficient (k_La), the true mass transfer coefficient (k_L), the dynamic area (a_{dy}), static area (a_{st}) and the wetted surface area (a_w) is given by the following equation :-

$$[k_La]_{phy.} = k_La_p = k_La_{dy} = k_L(a_w - a_{st}) \qquad (8.12)$$

Therefore the values of k_L can be obtained by using the following equations :-

$$k_L = [k_La]_{phy.}/(a_w - a_{st}) \quad (8.13)$$

$$= [k_La]_{phy.}/(a_{dy}) \quad (8.14)$$

The existing literature data on k_La reported in Table (5.4) incorporating 34 variations including system variations such as CO_2-water, CO_2 - aqueous electrolyte solutions, CO_2 - glycerol solutions, H_2 - water etc. and packings of different wettabilities was used initially to obtain the values of a_{dy}. The values of a_{dy} were obtained under otherwise identical conditions mentioned for the k_La data bank reported in Table (5.4) by calculating the values of a_w and a_{st} using the generalised correlations developed in this investigation [Equations (7.3) and (7.16) respectively] and subtracting the values of a_{st} from the values of a_w. The values of k_L were then calculated by using equation (8.14). These values of k_L obtained by this two step procedure were reffered to as the observed values of k_L.

The k_L values obtained using the k_La data bank [Table (5.4) : observations 1 to 187] are reported in Table (8.3.1). This table also contains the relevant processing parameters like Re, Sc etc. required for the mathematical modelling of the k_L data. The experimental values of k_L obtained by Danckwerts plot reported in Data Table (5.6) have been merged as observation numbers (188) to (217) along with the observed values of k_L (observation numbers upto 187) in Table (8.3.1). Thus, Table (8.3.1) consists of totally 217 data points covering 37 variations inclusive of system variations as CO_2 - water, CO_2 - electrolyte solutions, CO_2 - isopropanol, CO_2 -

Table - (8.3.1)

Results inclusive of processing parameters for true liquid side mass transfer coefficient (k_L)

No.	L $kg/m^2 s$	$k_L a$ $\times 10^3$ s^{-1}	Re	Sc $\times 10^{-2}$	mf $\times 10^2$	a_{dy} m^2/m^3	k_L $\times 10^4$ m/s obs.	k_L $\times 10^4$ m/s pred.	% err
Observed values of k_L obtained from $k_L a$ data bank :-									
1	0.472	2.278	1.601	4.55	2.07	18.2	1.251	1.060	15.25
2	0.694	3.056	2.354	4.55	2.07	23.9	1.279	1.140	10.91
3	1.000	4.444	3.390	4.55	2.07	30.2	1.473	1.220	17.16
4	1.222	5.278	4.143	4.55	2.07	34.1	1.549	1.267	18.23
5	1.444	6.111	4.896	4.55	2.07	37.6	1.627	1.307	19.67
6	1.917	6.944	6.497	4.55	2.07	44.0	1.577	1.378	12.61
7	2.778	9.167	9.416	4.55	2.07	53.8	1.705	1.477	13.40
8	4.167	12.222	14.123	4.55	2.07	66.1	1.848	1.593	13.80
9	8.889	23.889	30.130	4.55	2.07	95.2	2.509	1.836	26.83
10	12.222	26.944	41.428	4.55	2.07	110.2	2.444	1.948	20.30
11	0.667	2.778	3.824	4.55	2.07	27.7	1.003	1.248	-24.38
12	3.056	8.889	17.528	4.55	2.07	52.9	1.679	1.659	1.23
13	13.056	26.111	74.892	4.55	2.07	94.4	2.766	2.176	21.30
14	1.498	6.400	4.529	4.55	2.07	34.8	1.838	1.288	29.92
15	1.600	4.555	3.089	8.96	2.33	40.3	1.130	0.960	15.00
16	0.770	3.250	1.928	6.19	2.16	25.2	1.287	0.979	23.94
17	1.551	4.860	3.881	6.19	2.16	39.8	1.222	1.116	8.71
18	2.311	6.830	5.784	6.19	2.16	50.1	1.363	1.202	11.77
19	3.103	8.230	7.765	6.19	2.16	58.9	1.397	1.270	9.05
20	3.873	9.810	9.692	6.19	2.16	66.3	1.481	1.324	10.56
21	3.153	5.647	19.879	7.39	2.24	43.0	1.312	1.443	-9.91
22	4.407	8.000	27.790	7.39	2.24	48.8	1.641	1.536	6.39
23	5.015	8.823	31.617	7.39	2.24	51.2	1.725	1.573	8.77
24	6.465	10.924	40.763	7.39	2.24	56.2	1.943	1.650	15.10
25	1.263	3.950	3.543	5.38	2.16	36.1	1.094	1.177	-7.57
26	3.122	8.330	8.759	5.38	2.16	58.2	1.430	1.394	2.53
27	7.741	16.660	21.720	5.38	2.16	89.9	1.852	1.652	10.80
28	15.596	29.160	43.760	5.38	2.16	123.1	2.368	1.884	20.46
29	0.857	3.600	2.822	3.85	2.02	22.8	1.582	1.249	21.07
30	1.713	6.000	5.720	3.74	2.01	36.9	1.625	1.439	11.40
31	2.719	8.100	9.111	3.72	2.01	49.0	1.652	1.575	4.68
32	3.524	10.100	12.139	3.50	1.99	56.6	1.786	1.695	5.06
33	4.439	12.900	15.448	3.42	1.98	64.2	2.010	1.788	11.04
34	5.444	14.500	19.139	3.35	1.98	71.5	2.029	1.874	7.61
35	7.117	17.400	24.766	3.43	1.98	82.4	2.111	1.952	7.55
36	11.196	24.300	39.202	3.38	1.98	103.3	2.351	2.137	9.12
37	14.778	28.600	51.957	3.35	1.98	118.1	2.421	2.259	6.69
38	4.282	9.400	27.551	3.76	2.01	59.6	1.577	1.928	-22.28
39	6.712	12.500	43.452	3.72	2.01	71.4	1.752	2.109	-20.40
40	8.017	15.200	51.583	3.76	2.01	76.5	1.986	2.168	-9.17
41	10.706	18.400	69.053	3.74	2.01	85.7	2.147	2.293	-6.84
42	13.694	23.100	88.110	3.76	2.01	94.4	2.448	2.396	2.12
43	15.736	25.800	101.248	3.76	2.01	99.6	2.591	2.459	5.09
44	0.856	3.500	2:770	3.99	2.03	24.8	1.410	1.231	12.69
45	2.875	8.500	9.410	3.90	2.02	54.0	1.573	1.560	0.86

Table – 8.3.1 (contd.)

No.	L kg/m²s	k_La × 10^3 s^{-1}	Re	Sc × 10^{-2}	mf × 10^2	a_{dy} m^2/m^3	k_L × 10^4 m/s obs.	k_L × 10^4 m/s pred.	% err
46	5.401	14.700	18.079	3.71	2.01	75.8	1.940	1.792	7.63
47	7.399	17.600	25.023	3.63	2.00	88.9	1.980	1.919	3.10
48	13.673	28.400	47.005	3.51	1.99	119.7	2.373	2.185	7.91
49	0.845	3.400	2.676	4.17	2.05	28.0	1.213	1.205	0.62
50	2.871	9.400	9.340	3.94	2.03	59.3	1.586	1.553	2.13
51	5.403	16.000	17.806	3.83	2.02	82.6	1.937	1.769	8.68
52	6.952	17.700	23.103	3.77	2.02	93.6	1.890	1.868	1.16
53	13.702	31.400	46.299	3.65	2.00	129.4	2.426	2.151	11.36
54	0.833	3.600	2.563	4.42	2.07	30.6	1.178	1.174	0.35
55	2.847	9.900	9.046	4.12	2.05	63.3	1.565	1.522	2.75
56	5.436	14.900	17.272	4.12	2.05	88.5	1.684	1.718	-2.00
57	7.408	20.600	23.865	4.00	2.04	102.8	2.004	1.844	7.99
58	14.080	30.900	45.936	3.89	2.03	138.9	2.225	2.104	5.45
59	0.843	4.000	2.488	4.81	2.10	33.7	1.188	1.134	4.48
60	2.863	11.200	8.770	4.45	2.07	67.8	1.651	1.475	10.68
61	5.229	15.300	16.050	4.43	2.07	92.2	1.660	1.655	0.30
62	6.734	20.100	20.882	4.33	2.06	104.1	1.931	1.752	9.29
63	14.111	35.000	44.033	4.27	2.06	146.9	2.383	2.023	15.12
64	0.840	3.800	2.388	5.18	2.13	37.7	1.008	1.099	-9.11
65	2.836	10.200	8.299	4.86	2.11	74.0	1.379	1.418	-2.89
66	5.416	17.100	15.782	4.91	2.11	102.1	1.676	1.595	4.83
67	6.720	18.700	19.794	4.80	2.10	112.9	1.656	1.677	-1.25
68	13.635	29.600	40.577	4.69	2.09	156.0	1.898	1.933	-1.83
69	2.804	9.400	7.412	5.98	2.18	83.1	1.132	1.298	-14.66
70	5.264	14.900	14.062	5.84	2.17	112.3	1.327	1.474	-11.09
71	7.998	19.800	21.514	5.76	2.17	136.0	1.456	1.605	-10.18
72	14.952	31.100	40.619	5.64	2.16	179.2	1.735	1.821	-4.92
73	0.896	3.600	3.052	3.59	2.00	25.2	1.431	1.299	9.26
74	1.752	6.000	5.968	3.59	2.00	37.5	1.599	1.472	7.91
75	2.688	8.500	9.155	3.59	2.00	47.4	1.794	1.595	11.10
76	4.012	11.100	13.665	3.59	2.00	58.3	1.906	1.719	9.79
77	5.247	13.400	17.871	3.59	2.00	66.6	2.013	1.807	10.22
78	7.318	15.400	24.925	3.59	2.00	78.1	1.971	1.923	2.40
79	9.458	17.200	32.214	3.59	2.00	88.1	1.951	2.018	-3.41
80	12.940	21.000	44.074	3.59	2.00	101.8	2.063	2.140	-3.71
81	3.848	6.900	22.654	4.55	2.07	50.0	1.381	1.740	-26.04
82	5.264	9.100	30.990	4.55	2.07	56.5	1.611	1.845	-14.56
83	6.630	11.800	39.034	4.55	2.07	61.8	1.910	1.927	-0.86
84	7.936	13.000	46.721	4.55	2.07	66.2	1.964	1.993	-1.47
85	10.668	17.200	62.805	4.55	2.07	74.1	2.320	2.106	9.22
86	13.360	20.000	78.653	4.55	2.07	80.8	2.476	2.196	11.29
87	15.850	22.000	93.312	4.55	2.07	86.2	2.553	2.268	11.17
88	0.925	3.500	2.951	4.12	2.04	27.7	1.263	1.232	2.47
89	1.732	6.300	5.605	3.99	2.03	39.6	1.589	1.404	11.65
90	2.666	9.000	8.668	3.95	2.03	49.9	1.805	1.528	15.32
91	4.029	12.900	13.187	3.90	2.02	61.4	2.101	1.661	20.92
92	5.073	14.600	16.790	3.80	2.02	68.6	2.127	1.752	17.62
93	7.062	16.400	23.624	3.72	2.01	80.3	2.043	1.883	7.86
94	10.344	21.300	34.604	3.72	2.01	95.8	2.223	2.022	9.05
95	13.526	23.200	45.484	3.68	2.01	108.1	2.146	2.137	0.44

Table - 8.3.1 (contd.)

No.	L kg/m^2s	k_La $\times 10^3$ s^{-1}	Re	Sc $\times 10^{-2}$	mf $\times 10^2$	a_{dy} m^2/m^3	k_L obs. $\times 10^4$ m/s	k_L pred. $\times 10^4$ m/s	% err
96	0.864	4.200	2.739	4.17	2.05	29.8	1.409	1.210	14.13
97	1.709	7.700	5.414	4.17	2.05	43.7	1.763	1.375	22.01
98	4.063	14.400	12.873	4.17	2.05	67.7	2.126	1.616	23.97
99	5.097	15.600	16.149	4.17	2.05	75.5	2.067	1.686	18.39
100	6.955	19.200	22.037	4.17	2.05	87.3	2.200	1.787	18.74
101	9.786	26.400	31.348	4.07	2.04	101.8	2.592	1.925	25.74
102	13.263	32.000	42.486	4.07	2.04	116.6	2.744	2.038	25.74
103	0.913	3.700	2.717	4.74	2.09	34.2	1.082	1.158	-6.97
104	1.737	6.000	5.169	4.74	2.09	48.3	1.242	1.306	-5.17
105	2.680	8.700	8.026	4.68	2.09	60.0	1.449	1.425	1.67
106	4.020	12.700	12.093	4.63	2.08	73.0	1.740	1.543	11.33
107	5.062	15.100	15.227	4.63	2.08	81.3	1.857	1.611	13.25
108	7.167	18.200	21.800	4.52	2.08	95.2	1.911	1.737	9.11
109	10.373	23.000	31.552	4.52	2.08	112.3	2.047	1.862	9.08
110	13.302	25.600	40.461	4.48	2.08	125.3	2.044	1.959	4.12
111	0.879	3.400	2.656	4.55	2.08	36.0	0.945	1.170	-23.81
112	1.729	5.600	5.223	4.55	2.08	51.5	1.088	1.327	-22.00
113	2.647	8.500	8.074	4.50	2.08	63.4	1.341	1.448	-7.98
114	4.050	12.000	12.354	4.50	2.08	77.7	1.545	1.568	-1.45
115	5.038	14.700	15.367	4.50	2.08	85.9	1.711	1.633	4.54
116	7.457	17.400	22.980	4.40	2.07	102.5	1.697	1.774	-4.54
117	9.976	20.300	30.743	4.40	2.07	116.6	1.741	1.873	-7.63
118	12.938	24.000	40.285	4.30	2.06	130.5	1.839	1.986	-7.96
119	0.861	3.900	2.542	4.80	2.10	38.3	1.018	1.140	-12.03
120	1.692	6.000	4.997	4.80	2.10	54.5	1.102	1.294	-17.42
121	2.651	9.200	7.919	4.69	2.09	67.7	1.359	1.422	-4.62
122	4.016	12.900	11.996	4.69	2.09	82.3	1.568	1.536	1.98
123	4.995	16.400	14.920	4.69	2.09	90.9	1.803	1.600	11.26
124	6.973	17.000	21.041	4.59	2.08	105.5	1.611	1.720	-6.72
125	9.673	22.300	29.188	4.59	2.08	121.8	1.831	1.828	0.13
126	13.203	26.500	40.255	4.49	2.08	139.2	1.904	1.957	-2.76
127	0.860	3.900	2.478	5.06	2.12	39.8	0.981	1.115	-13.69
128	1.710	7.000	4.927	5.06	2.12	56.6	1.236	1.268	-2.54
129	2.649	9.200	7.632	5.06	2.12	70.0	1.315	1.376	-4.64
130	4.022	12.500	11.590	5.06	2.12	85.0	1.471	1.488	-1.16
131	5.044	13.800	14.535	5.06	2.12	94.2	1.465	1.552	-5.94
132	7.055	19.400	20.558	4.94	2.11	109.2	1.776	1.670	5.97
133	9.732	21.400	28.680	4.82	2.10	125.5	1.705	1.792	-5.14
134	13.258	26.900	39.071	4.82	2.10	143.3	1.877	1.899	-1.18
135	5.727	9.600	36.448	3.85	2.02	50.8	1.888	2.015	-6.71
136	7.172	10.100	45.644	3.85	2.02	55.4	1.823	2.102	-15.26
137	8.815	12.800	56.100	3.85	2.02	59.9	2.137	2.184	-2.21
138	11.256	15.900	71.635	3.85	2.02	65.7	2.421	2.286	5.54
139	1.851	4.000	3.565	8.55	2.29	44.1	0.906	1.014	-11.89
140	2.504	5.498	4.823	8.55	2.29	52.1	1.056	1.073	-1.60
141	2.892	6.356	5.569	8.55	2.29	56.2	1.131	1.102	2.57
142	3.654	7.036	7.036	8.55	2.29	63.4	1.110	1.152	-3.77
143	4.534	8.621	8.731	8.55	2.29	70.7	1.220	1.199	1.69
144	5.648	9.000	10.876	8.55	2.29	78.8	1.143	1.249	-9.33
145	6.713	10.980	12.927	8.55	2.29	85.6	1.283	1.290	-0.61

Table - 8.3.1 (contd.)

No.	L kg/m^2s	k_La $\times 10^3$ s^{-1}	Re	Sc $\times 10^{-2}$	mf $\times 10^2$	a_{dy} m^2/m^3	k_L $\times 10^4$ m/s obs.	k_L $\times 10^4$ m/s pred.	% err
146	7.470	11.600	14.386	8.55	2.29	90.1	1.288	1.316	-2.24
147	2.610	3.924	3.445	14.49	2.54	57.0	0.689	0.849	-23.24
148	3.727	5.233	4.919	14.49	2.54	67.9	0.771	0.907	-17.68
149	4.848	6.000	6.399	14.49	2.54	77.0	0.780	0.953	-22.22
150	6.138	7.445	8.102	14.49	2.54	85.9	0.867	0.996	-14.93
151	7.291	8.000	9.624	14.49	2.54	93.0	0.860	1.029	-19.55
152	8.715	9.074	11.503	14.49	2.54	100.8	0.900	1.063	-18.15
153	2.777	5.555	6.753	4.55	2.07	41.7	1.333	1.388	-4.13
154	4.372	8.330	10.630	4.55	2.07	52.4	1.589	1.511	4.93
155	6.549	11.110	15.925	4.55	2.07	63.7	1.743	1.629	6.53
156	8.614	13.492	20.946	4.55	2.07	72.5	1.862	1.715	7.88
157	10.791	15.897	26.240	4.55	2.07	80.4	1.978	1.789	9.55
158	13.036	18.370	31.699	4.55	2.07	87.6	2.098	1.853	11.67
159	6.444	14.470	15.670	4.55	2.07	68.4	2.114	1.624	23.16
160	8.527	18.020	20.735	4.55	2.07	82.5	2.184	1.712	21.61
161	10.777	21.750	26.206	4.55	2.07	95.6	2.275	1.788	21.37
162	13.111	24.800	31.882	4.55	2.07	107.6	2.305	1.855	19.50
163	4.403	11.110	10.754	4.54	2.07	51.5	2.156	1.512	29.85
164	6.447	14.870	15.746	4.54	2.07	68.2	2.182	1.624	25.58
165	8.491	18.510	20.739	4.54	2.07	81.9	2.259	1.710	24.32
166	10.786	22.100	26.346	4.54	2.07	95.3	2.320	1.788	22.92
167	13.050	25.230	31.876	4.54	2.07	106.9	2.360	1.853	21.51
168	5.707	7.894	4.308	37.21	2.97	92.8	0.851	0.640	24.85
169	9.025	10.233	6.812	37.21	2.97	117.8	0.869	0.697	19.79
170	12.138	14.238	9.162	37.21	2.97	136.6	1.042	0.736	29.35
171	2.169	2.456	0.850	98.23	3.65	65.3	0.376	0.357	4.98
172	4.497	3.918	1.761	98.23	3.65	95.7	0.409	0.409	0.00
173	7.295	5.263	2.857	98.23	3.65	121.2	0.434	0.448	-3.20
174	10.692	6.608	4.188	98.23	3.65	145.0	0.456	0.481	-5.65
175	13.993	9.824	5.481	98.23	3.65	164.0	0.599	0.506	15.49
176	1.981	1.578	0.399	290.95	4.52	72.8	0.217	0.223	-2.78
177	4.119	2.280	0.829	290.95	4.52	103.7	0.220	0.256	-16.28
178	5.031	2.836	1.013	290.95	4.52	113.8	0.249	0.265	-6.49
179	9.434	3.450	1.899	290.95	4.52	151.0	0.228	0.298	-30.66
180	12.453	4.327	2.507	290.95	4.52	170.5	0.254	0.314	-23.88
181	15.723	5.877	3.165	290.95	4.52	188.5	0.312	0.328	-5.33
182	18.805	7.602	3.785	290.95	4.52	203.4	0.374	0.340	9.14
183	3.396	1.695	0.459	509.65	5.14	100.9	0.168	0.197	-17.21
184	5.660	1.988	0.764	509.65	5.14	127.0	0.157	0.217	-38.36
185	8.207	2.397	1.108	509.65	5.14	149.3	0.161	0.232	-44.70
186	13.679	4.093	1.847	509.65	5.14	185.7	0.220	0.256	-15.91
187	16.714	4.385	2.257	509.65	5.14	201.9	0.217	0.265	-22.14

Observed values of k_L obtained from Danckwerts plots :-

188	6.595	-----	41.579	7.51	2.25	---	1.315	1.652	-25.59
189	8.720	-----	54.981	7.51	2.25	---	1.570	1.740	-10.84
190	9.538	-----	60.136	7.51	2.25	---	1.720	1.770	-2.88
191	13.080	-----	82.472	7.51	2.25	---	1.903	1.877	1.36
192	17.440	-----	109.962	7.51	2.25	---	2.129	1.981	6.95
193	1.589	-----	3.905	8.21	2.29	---	1.036	1.032	0.43

Table - 8.3.1 (contd.)

No.	L kg/m^2s	k_La $\times 10^3$ s^{-1}	Re	Sc $\times 10^{-2}$	mf $\times 10^2$	a_{dy} m^2/m^3	k_L obs.	k_L pred.	% err
							-- $\times 10^4$ -- -- m/s --		
194	3.132	-----	7.695	8.21	2.29	---	1.124	1.171	-4.19
195	4.884	-----	11.999	8.21	2.29	---	1.200	1.273	-6.05
196	6.102	-----	14.991	8.21	2.29	---	1.280	1.327	-3.64
197	5.970	-----	12.683	6.49	2.17	---	1.178	1.371	-16.46
198	3.498	-----	7.432	6.49	2.17	---	1.158	1.241	-7.15
199	1.306	-----	2.774	6.49	2.17	---	0.996	1.032	-3.64
200	10.683	-----	19.768	8.08	2.27	---	1.386	1.395	-0.65
201	8.570	-----	15.858	8.08	2.27	---	1.353	1.339	1.08
202	6.105	-----	11.296	8.08	2.27	---	1.268	1.256	0.91
203	3.757	-----	6.952	8.08	2.27	---	1.180	1.147	2.77
204	2.055	-----	3.802	8.08	2.27	---	1.190	1.025	13.87
205	9.643	-----	16.175	9.49	2.34	---	1.432	1.281	10.56
207	8.350	-----	14.005	9.49	2.34	---	1.415	1.247	11.89
207	6.468	-----	10.849	9.49	2.34	---	1.304	1.189	8.85
208	3.528	-----	5.918	9.49	2.34	---	1.326	1.061	19.97
209	1.999	-----	3.353	9.49	2.34	---	1.315	0.954	27.43
210	10.680	-----	14.727	12.81	2.49	---	1.273	1.149	9.78
211	8.520	-----	11.748	12.81	2.49	---	1.218	1.101	9.61
212	5.160	-----	7.115	12.81	2.49	---	1.140	1.002	12.07
213	3.600	-----	4.964	12.81	2.49	---	1.137	0.937	17.57
214	2.280	-----	3.144	12.81	2.49	---	1.112	0.860	22.62
215	2.941	-----	4.171	8.80	2.31	---	1.490	1.016	31.79
216	3.922	-----	5.561	8.80	2.31	---	1.550	1.073	30.80
217	4.902	-----	6.951	8.80	2.31	---	1.580	1.118	29.22

Note : mf = $(\rho_L / \mu_L g)^{-1/3}$

aqueous glycerol, CO_2 - pottasium carbonate-bicarbonate-arsenite buffer solutions etc.

8.3.2 Critical analysis of data and mathematical modelling :

The observed values of k_L along with some values of k_L obtained by chemical technique reported in Table (8.3.1) can be used conveniently for analysing the effect of different parameters/variables on the values of k_L.

Critical analysis of the k_L data reported in Table (8.3.1) alongwith the relevant data of physical properties etc. reported in Table (5.4) and (5.6) reveals the following :-

(i) Effect of liquid flow rate (L) :-

Under otherwise identical conditions with an increase in L the value of k_L increases. Thus for example for observation numbers (1) and (8) for CO_2 - water system, under otherwise identical conditions of a_t = 330 m^2/m^3, σ = 71.3 mN/m, ρ_L = 997.1 kg/m^3 μ_L = 0.89 mNs/m^2 & D_L = 1.97 x 10^{-9} m/s, with increase in the value of L from 0.47 to 4.17 kg/m^2s, the value of k_L increases from 1.25 x 10^{-4} to 1.848 x 10^{-4} m/s. Also for the k_L data ootained by chemical technique for observation numbers (193) and (196) for the system : CO_2 - pottasium carbonate bicarbonate buffer under otherwise identical conditions [Data from Table (5.6) corresponding observations being (6) and (10)] of a_t = 290 m^2/m^3, σ = 75.6 mN/m

ρ_L = 1156.5 kg/m^3, μ_L = 1.4 mNs/m^2 & D_L = 1.478 x 10^{-9} m^2/s, with an increase in the value of L from 1.589 to 6.102 kg/m^{2}s, the value of k_L increases from 1.036 x 10^{-4} to 1.28 x 10^{-4} m/s. Also for other systems/variations under consideration similar conclusions can be drawn.

(ii) Effect of packing size (d_p) and dry surface area (a_t) :-

With a decrease in packing size ; hence an increase in its dry surface area, the value of k_L decreases under otherwise identical conditions. This effect is illustrated by comparing observation number (31) and (153) under similar conditions of ρ_L = 996 - 997 kg/m^3, μ_L = 0.813 - 0.894 mNs/m^2, σ = 71.6 - 72 mN/m, D_L = 2.198 x 10^{-9} - 1.97 x 10^{-9} m^2/s and L = 2.719 - 2.777 kg/m^2-s. With an increase in a_t value from 367 to 460 m^2/m^3 (with a decrease in packing size from 0.013 to 0.01m) the value of k_L decreases from 1.652 x 10^{-4} m/s to 1.33 x 10^{-4} m/s. Similar trend is observed for all the other systems/variations under consideration.

(iii) Effect of physical properties ρ_L, μ_L and D_L :-

Under otherwise similar conditions, with an increase in ρ_L the values of k_L decrease. Thus, comparing observation numbers (4) and (25) under comparable conditions of a_t = 330 m^2/m^3, μ_L = 0.89 - 1.08 mNs/m^2, D_L = 1.97 x 10^{-9} - 1.88 x 10^{-9} m^2/s & L = 1.22 - 1.26 kg/m^2-s, with an increase in the value of ρ_L from 997 kg/m^3 to 1070 kg/m^3 the value of k_L decreases from 1.549 x 10^{-4} to 1.09 x 10^{-4} m/s.

With an increase in viscosity and with a decrease in diffusivity, the value of k_L decreases. Thus, for observation numbers

(163) and (172) under otherwise similar conditions of a_t = 460 m^2/m^3, ρ_L = 1000 - 1130 kg/m^3 & L = 4.40 - 4.50 kg/m^2-s, as μ_L increases from 0.89 to 5.5 mNs/m^2 and D_L decreases from 1.97 x 10^{-9} m^2/s to 0.5 x 10^{-9} m^2/s, the value of k_L decreases from 2.156 x 10^{-4} to 0.409 x 10^{-4} m/s. Similar conclusions can be drawn for the other systems/variations under consideration.

(iv) Mathematical modelling of k_L data :-

Hence, based on the above discussion in order to correlate the data for k_L in terms of system parameters and hydrodynamic parameters, one can propose the following equation :-

$$k_L = f(L,\ a_t^{-1},\ \rho_L^{-1},\ \mu_L^{-1},\ D_L) \qquad (8.15)$$

With the help of dimensional analysis, these parameters can be grouped in terms of different dimensionless numbers and groups as per following equation :-

$$k_L = c\ (Re)^{\alpha}\ (Sc)\ \ (\rho_L / \mu_L g)^{-1/3} \qquad (8.16)$$

The dimensionless numbers and groups used in this equation (8.16) are identical with those utilised by Onda et al. [Equation (2.2.3)].

Thus, for performing "mathematical modelling" of the k_L data one requires the knowledge of (Re), (Sc), ($\rho_L / \mu_L g$). With the help of data on physical properties and hydrodynamic properties reported in Tables (5.4) and (5.6), the relevant dimensionless numbers and groups were calculated and all these values along with the corresponding k_L values are tabulated in Table (8.3.1).

8.3.3 Statistical analysis for different correlations :-

Processing of the data on k_L values reported in Table (8.3.1) was done by the modified simplex algorithm of Nelder and Mead. The results obtained for the various regression steps are reported in Table (8.3.2) and are discussed herewith.

In step - (1), all the groups viz. Reynolds number (Re) Schmidt number (Sc), and the proportionality constant (C) were regressed. The regression of the data yielded the following correlation :-

$$k_L = 0.1075\ (Re)^{0.201}\ (Sc)^{-0.513}\ (\rho_L / \mu_L g)^{-1/3} \qquad (8.17)$$

The values of % E_{avg}, % E_{abs} and % S_{dev} were 2.44, 10.75 and 0.002 respectively.

However, taking into consideration the indices of Re, Sc in the generalised correlation k_La [Equation (8.6)] and that of Re in the generalised correlation of a_p [Equation (7.7)], the indices of Re and Sc in the correlation under consideration should be 0.187 for Re and -0.5 for Sc.

Hence, the values of indices of Re, Sc were fixed as α = 0.187 and m = -0.5. When the data on k_L was regressed as per step (4), the mathematical modelling of the data yielded the following correlation :-

$$k_L = 0.0999\ Re^{0.187}\ Sc^{-0.5}\ (\rho_L / \mu_L g)^{-1/3} \qquad (8.18)$$

Table - (8.3.2)

Statistical analysis for different correlations of k_L

Correlation Structure : $k_L = C \cdot Re^{\alpha} \cdot Sc^{m} \cdot (\rho_L / \mu_L g)^{-1/3}$.

No.	C	α	m	% E_{avg}	% E_{abs}	% S_{dev}
Optimisation by the Modified Simplex algorithm of Nelder and Mead						
All parameters are iterated, base values of guesses and ranges of perturbation were as follows :- for α 0.1 <u>0.2</u> 0.4, for m −0.3 −<u>0.5</u> −0.7 and for C 0.05 <u>0.1</u> 0.2.						
1	0.1075	0.201	−0.513	1.44	10.75	0.00207.
m value (i.e indice of Sc) fixed as −<u>0.50</u> in concordance with the penetration theory. C and α were iterated as in step 1.						
2	0.0956	0.208	−0.50	2.83	11.06	0.00209.
α value fixed as 0.187 (This value of α is arrived at by taking the difference of α values obtained in the selected $k_L a$ and a_p/a_t correlations which were 0.286 and 0.099 respectively.) C and m were iterated as in step 1.						
3	0.1149	0.187	−0.517	0.70	10.83	0.00206.
The values of α and m were fixed as <u>0.187</u> and <u>−0.5</u> respectively. Only C was determined by iteration.						
4*	0.0999	0.187	−0.50	3.39	11.32	0.00209.

Note : The values of indices in the finalised generalised correlation are as per regression step marked by (*)

The statistical analysis of correlation [Equation (8.18)] was as under :-

The values of % E_{avg}, % E_{abs} and % S_{dev} were 3.39, 11.32 and 0.002 respectively.

The statistical analysis of the correlation [Equation (8.18)] although slightly inferior, it is not very much different from the previous correlation [Equation (8.17)]. Hence this correlation can be considered as an appropriate equation which could be used conveniently for predicting most of the values of k_L within ± 20 % error range.

8.3.4 Comparison between observed values and predicted values of k_L :-

The observed values of k_L obtained from k_La data bank along with the k_L values obtained by chemical technique and the values of k_L predicted by the generalised correlation [Equation (8.18)] developed in this investigation are tabulated in Table (8.3.3) and are plotted in Figure (8.3).

The detailed statistical analysis of the correlation [Equation (8.18)] can be described as follows :-

(i) The total number of data points used in the correlation is 217 with 37 different variations/systems included.

Table - (8.3.3)

Comparison between observed values based on data bank and predicted values of k_L

No.	$k_L \times 10^4$ m/s obs.	$k_L \times 10^4$ m/s This work	% err	$k_L \times 10^4$ m/s Onda.	% err	$k_L \times 10^4$ m/s Mersmann.	% err	$k_L \times 10^4$ m/s Billet.	% err
1	1.251	1.060	15.25	0.358	71.39	2.038	-62.9	0.336	73.11
2	1.279	1.140	10.91	0.423	66.93	2.172	-69.8	0.382	70.10
3	1.473	1.220	17.16	0.496	66.30	2.308	-56.7	0.432	70.67
4	1.549	1.267	18.23	0.542	64.99	2.386	-54.0	0.462	70.20
5	1.627	1.307	19.67	0.584	64.09	2.453	-50.8	0.488	70.00
6	1.577	1.378	12.61	0.663	57.92	2.571	-63.1	0.536	65.98
7	1.705	1.477	13.40	0.786	53.93	2.735	-60.3	0.607	64.41
8	1.848	1.593	13.80	0.948	48.69	2.925	-58.3	0.695	62.42
9	2.509	1.836	26.83	1.364	45.64	3.317	-32.2	0.894	64.37
10	2.444	1.948	20.30	1.597	34.68	3.497	-43.1	0.994	59.34
11	1.003	1.248	-24.38	0.528	47.37	1.561	-55.6	0.331	66.98
12	1.679	1.659	1.23	1.057	37.06	2.010	-19.7	0.550	67.25
13	2.766	2.176	21.30	2.168	21.60	2.557	7.5	0.892	67.74
14	1.838	1.288	29.92	0.556	69.74	2.703	-47.0	0.519	71.75
15	1.130	0.960	15.00	0.360	68.11	2.266	-100.6	0.411	63.58
16	1.287	0.979	23.94	0.328	74.52	2.147	-66.8	0.362	71.85
17	1.222	1.116	8.71	0.446	63.49	2.412	-97.3	0.458	62.57
18	1.363	1.202	11.77	0.534	60.82	2.577	-89.1	0.522	61.66
19	1.397	1.270	9.05	0.611	56.28	2.706	-93.7	0.576	58.74
20	1.481	1.324	10.56	0.677	54.30	2.807	-89.6	0.621	58.09
21	1.312	1.443	-9.91	0.945	27.97	1.346	-2.6	0.449	65.76
22	1.641	1.536	6.39	1.111	32.26	1.423	13.3	0.502	69.38
23	1.724	1.573	8.76	1.184	31.34	1.454	15.7	0.524	69.59
24	1.943	1.650	15.10	1.343	30.89	1.517	22.0	0.571	70.63
25	1.094	1.177	-7.57	0.478	56.34	2.299	-110.1	0.436	60.13
26	1.430	1.394	2.53	0.718	49.78	2.672	-86.8	0.590	58.77
27	1.852	1.652	10.80	1.101	40.56	3.107	-67.7	0.798	56.92
28	2.368	1.884	20.46	1.555	34.33	3.490	-47.4	1.008	57.44
29	1.582	1.249	21.07	0.484	69.40	2.579	-63.0	0.456	71.18
30	1.625	1.439	11.40	0.670	58.76	2.916	-79.5	0.580	64.29
31	1.652	1.575	4.68	0.830	49.76	3.155	-91.0	0.678	58.93
32	1.786	1.695	5.06	0.971	45.65	3.346	-87.4	0.755	57.73
33	2.010	1.788	11.04	1.096	45.44	3.495	-73.9	0.821	59.14
34	2.029	1.874	7.61	1.224	39.69	3.640	-79.4	0.886	56.33
35	2.111	1.952	7.55	1.371	35.05	3.783	-79.2	0.961	54.47
36	2.351	2.137	9.12	1.725	26.62	4.093	-74.1	1.123	52.24
37	2.421	2.259	6.69	1.993	17.67	4.296	-77.4	1.235	48.97
38	1.577	1.928	-22.28	1.406	10.83	2.238	-42.0	0.655	58.48
39	1.752	2.109	-20.40	1.767	-0.87	2.420	-38.2	0.764	56.40
40	1.986	2.168	-9.17	1.915	3.54	2.484	-25.1	0.807	59.38
41	2.147	2.293	-6.84	2.226	-3.71	2.610	-21.6	0.890	58.55
42	2.448	2.396	2.12	2.521	-2.96	2.714	-10.9	0.964	60.62
43	2.591	2.459	5.09	2.712	-4.65	2.778	-7.2	1.010	61.03
44	1.410	1.231	12.69	0.461	67.31	2.539	-80.1	0.451	68.01
45	1.573	1.560	0.86	0.806	48.76	3.125	-98.6	0.681	56.73
46	1.940	1.792	7.63	1.117	42.42	3.515	-81.2	0.854	55.98

Table - 8.3.3 (contd.)

No.	k_L x 10^4 m/s obs.	k_L x 10^4 m/s This work	% err	k_L x 10^4 m/s Onda.	% err	k_L x 10^4 m/s Mersmann.	% err	k_L x 10^4 m/s Billet.	% err
47	1.980	1.919	3.10	1.318	33.44	3.726	-88.2	0.956	51.74
48	2.373	2.185	7.91	1.827	23.00	4.165	-75.5	1.187	49.99
49	1.213	1.205	0.62	0.427	64.82	2.477	-104.3	0.443	63.49
50	1.586	1.553	2.13	0.769	51.50	3.082	-94.3	0.679	57.22
51	1.937	1.769	8.68	1.056	45.45	3.449	-78.1	0.846	56.33
52	1.890	1.868	1.16	1.208	36.11	3.614	-91.2	0.926	51.03
53	2.426	2.151	11.36	1.733	28.58	4.078	-68.1	1.173	51.66
54	1.178	1.174	0.35	0.396	66.35	2.419	-105.4	0.433	63.24
55	1.565	1.522	2.75	0.724	53.72	3.023	-93.1	0.668	57.34
56	1.684	1.718	-2.00	0.986	41.44	3.365	-99.8	0.828	50.82
57	2.004	1.844	7.99	1.170	41.61	3.572	-78.2	0.928	53.71
58	2.225	2.104	5.45	1.649	25.90	4.003	-79.9	1.160	47.87
59	1.188	1.134	4.48	0.367	69.13	2.354	-98.2	0.423	64.41
60	1.651	1.475	10.68	0.674	59.16	2.944	-78.3	0.652	60.49
61	1.660	1.655	0.30	0.903	45.57	3.260	-96.4	0.799	51.87
62	1.931	1.752	9.29	1.038	46.25	3.420	-77.1	0.876	54.64
63	2.383	2.023	15.12	1.526	35.97	3.880	-62.8	1.125	52.77
64	1.008	1.099	-9.11	0.335	66.74	2.287	-127.0	0.413	59.05
65	1.379	1.418	-2.89	0.611	55.65	2.848	-106.6	0.632	54.12
66	1.676	1.595	4.83	0.832	50.33	3.162	-88.7	0.782	53.33
67	1.656	1.677	-1.25	0.941	43.20	3.299	-99.1	0.847	48.86
68	1.898	1.933	-1.83	1.374	27.61	3.732	-96.6	1.080	43.08
69	1.132	1.298	-14.66	0.509	54.99	2.665	-135.5	0.590	47.90
70	1.327	1.474	-11.09	0.705	46.92	2.977	-124.3	0.733	44.77
71	1.456	1.605	-10.18	0.880	39.57	3.204	-120.0	0.847	41.85
72	1.735	1.821	-4.92	1.242	28.40	3.575	-106.1	1.051	39.44
73	1.431	1.299	9.26	0.621	56.60	2.648	-85.0	0.474	66.85
74	1.599	1.472	7.91	0.830	48.10	2.960	-85.2	0.593	62.90
75	1.794	1.595	11.10	1.001	44.18	3.178	-77.2	0.684	61.87
76	1.906	1.719	9.79	1.197	37.17	3.397	-78.3	0.782	58.98
77	2.013	1.807	10.22	1.352	32.86	3.551	-76.4	0.855	57.55
78	1.971	1.923	2.40	1.574	20.12	3.753	-90.4	0.955	51.55
79	1.951	2.018	-3.41	1.774	9.11	3.916	-100.7	1.040	46.71
80	2.063	2.140	-3.71	2.056	0.33	4.126	-99.9	1.154	44.05
81	1.381	1.740	-26.04	1.382	-0.07	2.088	-51.2	0.591	57.17
82	1.611	1.845	-14.56	1.597	0.82	2.199	-36.5	0.656	59.25
83	1.910	1.927	-0.86	1.781	6.78	2.285	-19.6	0.709	62.90
84	1.964	1.993	-1.47	1.940	1.22	2.355	-19.9	0.753	61.68
85	2.320	2.106	9.22	2.237	3.56	2.473	-6.6	0.830	64.20
86	2.476	2.196	11.29	2.498	-0.88	2.567	-3.7	0.895	63.85
87	2.553	2.268	11.17	2.719	-6.50	2.641	-3.5	0.947	62.89
88	1.263	1.232	2.47	0.563	55.40	2.554	-102.2	0.458	63.75
89	1.589	1.404	11.65	0.754	52.56	2.857	-79.8	0.570	64.12
90	1.805	1.528	15.32	0.917	49.18	3.077	-70.5	0.661	63.40
91	2.101	1.661	20.92	1.113	47.00	3.308	-57.5	0.762	63.74
92	2.127	1.752	17.62	1.255	41.01	3.459	-62.6	0.829	61.02
93	2.043	1.883	7.86	1.482	27.46	3.677	-79.9	0.933	54.33
94	2.223	2.022	9.05	1.772	20.30	3.918	-76.2	1.060	52.34
95	2.146	2.137	0.44	2.028	5.50	4.109	-91.5	1.163	45.80
96	1.409	1.210	14.13	0.516	63.41	2.485	-76.3	0.446	68.35

Table – 8.3.3 (contd.)

No.	$k_L \times 10^4$ m/s obs.	$k_L \times 10^4$ m/s This work	% err	$k_L \times 10^4$ m/s Onda.	% err	$k_L \times 10^4$ m/s Mersmann.	% err	$k_L \times 10^4$ m/s Billet.	% err
97	1.763	1.375	22.01	0.694	60.64	2.783	-57.9	0.560	68.24
98	2.126	1.616	23.97	1.022	51.91	3.213	-51.1	0.747	64.87
99	2.067	1.686	18.39	1.134	45.11	3.336	-61.5	0.806	61.02
100	2.200	1.787	18.74	1.310	40.43	3.513	-59.7	0.893	59.38
101	2.592	1.925	25.74	1.563	39.71	3.742	-44.4	1.009	61.07
102	2.744	2.038	25.74	1.809	34.07	3.936	-43.4	1.117	59.30
103	1.082	1.158	-6.97	0.467	56.88	2.402	-121.9	0.435	59.76
104	1.242	1.306	-5.17	0.619	50.17	2.672	-115.2	0.539	56.55
105	1.449	1.425	1.67	0.758	47.71	2.882	-98.9	0.626	56.77
106	1.740	1.543	11.33	0.916	47.34	3.091	-77.6	0.719	58.67
107	1.857	1.611	13.25	1.019	45.11	3.212	-72.9	0.777	58.19
108	1.911	1.737	9.11	1.218	36.27	3.424	-79.2	0.879	54.00
109	2.047	1.862	9.08	1.453	29.01	3.641	-77.8	0.994	51.44
110	2.044	1.959	4.12	1.648	19.35	3.813	-86.6	1.085	46.89
111	0.945	1.170	-23.81	0.453	52.00	2.385	-152.5	0.435	53.90
112	1.088	1.327	-22.00	0.611	43.87	2.668	-145.3	0.545	49.87
113	1.341	1.448	-7.98	0.748	44.24	2.889	-115.5	0.634	52.70
114	1.545	1.568	-1.45	0.909	41.21	3.100	-100.6	0.731	52.72
115	1.711	1.633	4.54	1.006	41.21	3.215	-87.9	0.786	54.07
116	1.697	1.774	-4.54	1.228	27.66	3.452	-103.4	0.902	46.84
117	1.741	1.873	-7.63	1.413	18.82	3.623	-108.1	0.994	42.89
118	1.839	1.986	-7.96	1.628	11.49	3.805	-106.9	1.092	40.61
119	1.018	1.140	-12.03	0.420	58.71	2.332	-129.1	0.426	58.12
120	1.102	1.294	-17.42	0.567	48.57	2.608	-136.8	0.534	51.55
121	1.359	1.422	-4.62	0.705	48.14	2.828	-108.1	0.625	54.01
122	1.568	1.536	1.98	0.854	45.54	3.030	-93.3	0.718	54.21
123	1.803	1.600	11.26	0.946	47.57	3.142	-74.2	0.772	57.20
124	1.611	1.720	-6.72	1.124	30.26	3.340	-107.3	0.869	46.07
125	1.831	1.828	0.13	1.317	28.04	3.527	-92.7	0.969	47.06
126	1.904	1.957	-2.76	1.559	18.14	3.737	-96.3	1.083	43.11
127	0.981	1.115	-13.69	0.400	59.22	2.291	-133.6	0.419	57.29
128	1.236	1.268	-2.54	0.543	56.12	2.568	-107.7	0.527	57.42
129	1.315	1.376	-4.64	0.662	49.68	2.762	-110.0	0.609	53.68
130	1.471	1.488	-1.16	0.803	45.42	2.960	-101.2	0.700	52.40
131	1.465	1.552	-5.94	0.893	39.04	3.073	-109.8	0.755	48.47
132	1.776	1.670	5.97	1.064	40.06	3.270	-84.1	0.851	52.07
133	1.705	1.792	-5.14	1.264	25.82	3.472	-103.7	0.955	43.95
134	1.877	1.899	-1.18	1.475	21.41	3.655	-94.8	1.059	43.57
135	1.888	2.015	-6.71	2.132	-12.88	2.335	-23.7	0.715	62.12
136	1.823	2.102	-15.26	2.362	-29.54	2.424	-32.9	0.771	57.72
137	2.137	2.184	-2.21	2.598	-21.56	2.508	-17.4	0.826	61.36
138	2.421	2.286	5.54	2.911	-20.27	2.612	-7.9	0.896	63.00
139	0.906	1.015	-12.04	0.398	56.11	2.332	-157.5	0.437	51.80
140	1.056	1.074	-1.72	0.455	56.89	2.452	-132.3	0.483	54.27
141	1.131	1.103	2.46	0.485	57.07	2.511	-122.1	0.506	55.21
142	1.109	1.152	-3.88	0.540	51.32	2.611	-135.4	0.547	50.65
143	1.219	1.200	1.59	0.596	51.09	2.706	-121.9	0.588	51.75
144	1.142	1.250	-9.43	0.660	42.20	2.806	-145.7	0.633	44.60
145	1.282	1.291	-0.70	0.716	44.15	2.888	-125.3	0.670	47.72
146	1.287	1.317	-2.32	0.753	41.49	2.940	-128.4	0.695	46.04

Table - 8.3.3 (contd.)

No.	k_L x 10^4 m/s obs.	k_L x 10^4 m/s This work	% err	k_L x 10^4 m/s Onda.	% err	k_L x 10^4 m/s Mersmann.	% err	k_L x 10^4 m/s Billet.	% err
147	0.689	0.849	-23.24	0.313	54.49	2.149	-212.0	0.403	41.47
148	0.771	0.907	-17.68	0.368	52.26	2.280	-195.7	0.454	41.13
149	0.780	0.953	-22.22	0.415	46.77	2.381	-205.4	0.495	36.47
150	0.867	0.996	-14.93	0.463	46.58	2.476	-185.8	0.536	38.16
151	0.860	1.029	-19.55	0.502	41.68	2.548	-196.2	0.568	34.04
152	0.900	1.063	-18.15	0.546	39.36	2.625	-191.6	0.602	33.09
153	1.333	1.388	-4.13	1.107	16.94	3.541	-165.7	0.641	51.87
154	1.589	1.511	4.93	1.342	15.55	3.818	-140.3	0.746	53.05
155	1.743	1.629	6.53	1.596	8.47	4.083	-134.3	0.854	51.04
156	1.862	1.715	7.88	1.796	3.50	4.274	-129.6	0.935	49.77
157	1.978	1.789	9.55	1.982	-0.20	4.436	-124.3	1.008	49.03
158	2.098	1.853	11.67	2.153	-2.62	4.578	-118.2	1.073	48.84
159	2.114	1.624	23.16	0.904	57.22	4.073	-92.7	0.849	59.84
160	2.184	1.712	21.61	1.036	52.56	4.266	-95.4	0.932	57.32
161	2.275	1.788	21.37	1.163	48.87	4.435	-95.0	1.008	55.70
162	2.305	1.855	19.50	1.283	44.34	4.582	-98.8	1.075	53.33
163	2.156	1.512	29.85	0.757	64.90	3.812	-76.8	0.746	65.39
164	2.182	1.624	25.58	0.907	58.42	4.061	-86.1	0.847	61.18
165	2.259	1.710	24.32	1.037	54.10	4.251	-88.2	0.928	58.90
166	2.320	1.788	22.92	1.167	49.70	4.423	-90.7	1.005	56.65
167	2.360	1.853	21.51	1.283	45.63	4.565	-93.4	1.071	54.61
168	0.851	0.640	24.85	0.207	75.66	2.325	-173.2	0.397	53.34
169	0.869	0.697	19.79	0.258	70.34	2.509	-188.8	0.463	46.74
170	1.042	0.736	29.35	0.298	71.44	2.635	-152.8	0.511	51.02
171	0.376	0.357	4.98	0.067	82.27	1.637	-335.6	0.215	42.74
172	0.409	0.409	0.02	0.093	77.33	1.848	-351.4	0.274	32.98
173	0.434	0.448	-3.20	0.116	73.19	2.003	-361.2	0.322	25.76
174	0.456	0.481	-5.65	0.140	69.32	2.134	-368.4	0.366	19.64
175	0.599	0.506	15.49	0.159	73.38	2.231	-272.6	0.400	33.14
176	0.217	0.223	-2.78	0.030	85.98	1.276	-488.5	0.149	31.33
177	0.220	0.256	-16.28	0.042	80.77	1.441	-555.6	0.190	13.54
178	0.249	0.265	-6.49	0.046	81.40	1.490	-497.9	0.203	18.48
179	0.228	0.298	-30.66	0.062	72.75	1.654	-624.0	0.250	-9.64
180	0.254	0.314	-23.88	0.071	71.97	1.732	-582.4	0.275	-8.25
181	0.312	0.328	-5.33	0.080	74.43	1.800	-477.4	0.297	4.77
182	0.374	0.340	9.14	0.087	76.70	1.855	-396.2	0.315	15.68
183	0.168	0.197	-17.21	0.026	84.53	1.277	-660.1	0.153	8.93
184	0.157	0.217	-38.36	0.033	79.04	1.390	-787.7	0.181	-15.83
185	0.161	0.232	-44.70	0.039	75.68	1.478	-821.1	0.205	-27.88
186	0.220	0.256	-15.91	0.050	77.40	1.609	-630.0	0.243	-10.37
187	0.217	0.265	-22.14	0.055	74.70	1.664	-666.0	0.260	-19.76
188	1.315	1.652	-25.59	1.352	-2.79	1.529	-16.3	0.576	56.20
189	1.570	1.740	-10.84	1.557	0.83	1.602	-2.0	0.632	59.73
190	1.720	1.770	-2.88	1.630	5.23	1.626	5.5	0.651	62.13
191	1.903	1.877	1.36	1.921	-0.95	1.713	10.0	0.724	61.98
192	2.129	1.981	6.95	2.239	-5.15	1.797	15.6	0.796	62.60
193	1.036	1.031	0.43	0.535	48.40	1.995	-92.6	0.387	62.68
194	1.124	1.171	-4.18	0.717	36.19	2.233	-98.7	0.485	56.88
195	1.200	1.272	-6.04	0.873	27.29	2.404	-100.3	0.562	53,17
196	1.280	1.327	-3.64	0.964	24.70	2.495	-94.9	0.605	52.72

Table - 8.3.3 (contd.)

No.	k_L x 10^4 m/s obs.	k_L x 10^4 m/s This work	% err	k_L x 10^4 m/s Onda.	% err	k_L x 10^4 m/s Mersmann.	% err	k_L x 10^4 m/s Billet.	% err
197	1.178	1.371	-16.46	0.671	42.99	3.478	-195.3	0.671	42.99
198	1.158	1.241	-7.15	0.522	54.88	3.182	-174.8	0.562	51.49
199	0.996	1.032	-3.64	0.335	66.40	2.702	-171.4	0.405	59.36
200	1.386	1.395	-0.65	0.764	44.84	3.658	-163.9	0.761	45.08
201	1.353	1.339	1.08	0.687	49.27	3.527	-160.6	0.707	47.73
202	1.268	1.256	0.91	0.583	53.99	3.333	-162.9	0.632	50.17
203	1.180	1.147	2.77	0.465	60.63	3.075	-160.6	0.537	54.45
204	1.190	1.025	13.87	0.353	70.37	2.782	-133.8	0.440	63.06
205	1.432	1.281	10.56	0.652	54.47	3.482	-143.1	0.701	51.05
206	1.415	1.247	11.89	0.608	57.03	3.400	-140.3	0.668	52.78
207	1.304	1.189	8.85	0.538	58.75	3.258	-149.9	0.614	52.94
208	1.326	1.061	19.97	0.405	69.46	2.947	-122.2	0.501	62.18
209	1.315	0.954	27.43	0.313	76.22	2.681	-103.9	0.415	68.44
210	1.273	1.149	9.78	0.554	56.46	3.307	-159.8	0.658	48.35
211	1.218	1.101	9.61	0.497	59.22	3.185	-161.5	0.610	49.93
212	1.140	1.002	12.07	0.391	65.67	2.931	-157.1	0.516	54.73
213	1.137	0.937	17.57	0.331	70.88	2.761	-142.8	0.458	59.74
214	1.112	0.860	22.62	0.269	75.82	2.559	-130.1	0.393	64.64
215	1.490	1.016	31.79	0.378	74.65	2.863	-92.1	0.490	67.11
216	1.550	1.073	30.80	0.431	72.21	3.003	-93.7	0.539	65.21
217	1.580	1.118	29.22	0.478	69.78	3.116	-97.2	0.581	63.23

(ii) The values of % E_{avg}, % E_{abs} and % S_{dev} were 3.39, 11.32 and 0.002 respectively.

(iii) From the 217 data points, 81 % of the predicted values of k_L were within ± 20 % of the observed data values, 69.5 % were within ± 15 % and 54 % were within ± 10 %.

(iv) 19 % of the points registered deviations greater than ± 20 % with the values of maximum deviation being ± 31 %.

Figure (8.3) shows a parity plot of equation (8.18) wherein the values of $(k_L)_{pred.}$ have been plotted versus $(k_L)_{obs}$. The satisfactory correlation fit in Figure (8.3) clearly reflects that equation (8.18) can correlate satisfactorily all the data obtained from various sources covering a wide range of variables as mentioned earlier.

Out of various correlation reported in literature, the correlation proposed by Onda and coworkers (97) appears to be more generalised in nature and has been proposed based on a large data bank of k_L. The values of k_L were predicted by using Onda's correlation [Equation (2.2.3)] and are also tabulated in Table (8.3.3). The detailed statistical analysis of the Onda's correlation [Equation (2.2.3)] can be described as follows :-

(i) The values of % E_{avg}, % E_{abs} and % S_{dev} were 43.3, 44.4 and 0.354 respectively.

(ii) Out of 217 data points only 15 % (i.e. 32 points) of the predicted values of k_L were within ± 20 % of the observed data values.

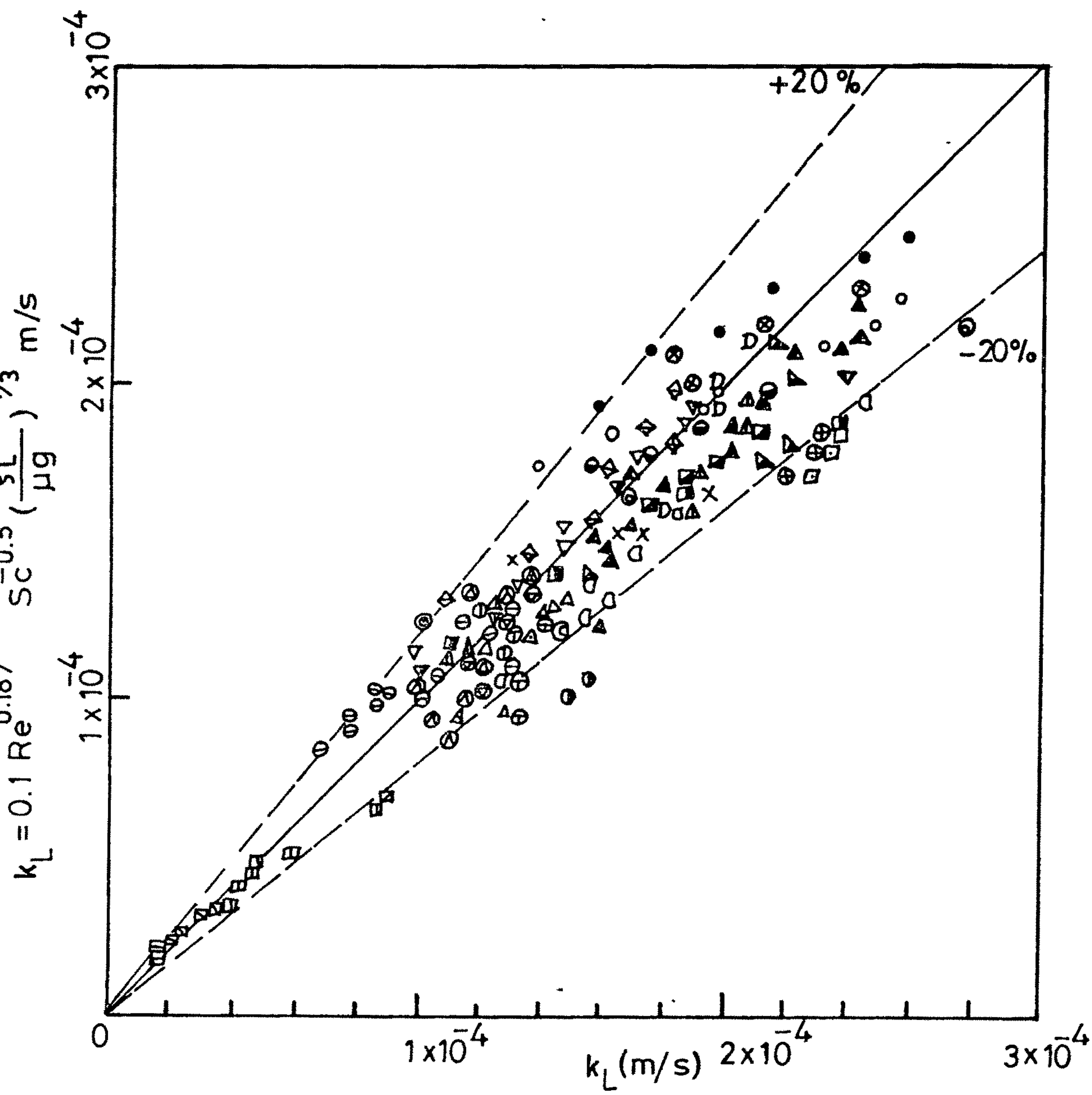

Fig 8.3 TRUE LIQUID SIDE MASS TRANSFER COEFFICIENT COMPARISON OF THE PREDICTED vs. EXPERIMENTAL (LIT.) DATA.

LEGENDS FOR FIG. 8.3

Data No.	Relevant Information	Symbol
1-13	Hikita (40), CO_2- H_2O, C.R.R., 15mm, 25mm.	◐ ⊙
14-15	Danckwerts (19), C.R.R., 13mm, CO_2- H_2O;	◿
	CO_2- aq. Na_2SO_4.	◿
16-20	Richards (21), CO_2-1.8 M NaCl, C.R.R., 13mm.	△
21-24	Danckwerts (22), CO_2- aq. Na_2SO_4, C.R.R., 38mm.	X
25-28	Onda (28), O_2- aq. Na_2SO_3, C.R.R., 15mm.	◨
29-43	Sahay (41), CO_2-H_2O, C.R.R., 13mm, 25mm.	▲ ●
44-72	Sahay (41), CO_2- aq. isopropanol, C.R.R., 13mm,	
	σ = 62.8, 59.2, 56.0 mN/m.	◬ ◭ ▼
	σ = 52.0, 47.0 mN/m.	⧩ ▽
73-87	Sahay (41), CO_2-H_2O, PVC.R.R., 13mm, 25mm.	D O
88-134	Sahay (41), CO_2- aq. isopropanol PVC.R.R., 13mm,	
	σ= 68.5, 58.0, 54.0 mN/m.	◣ ◬ ⊖
	σ = 51.0, 49.0 mN/m.	⊕ ▽
135-138	Sahay (41), CO_2-H_2O, Polypropylene R.R., 25mm.	⊗
139-152	Joosten (42), CO_2- aq. $NaNO_3$, C.R.R., 13mm.	◩
153-162	Mangers (43), CO_2-H_2O, dp = 10mm,	
	PTFE R.R., Glass R.R.	⊖ ⊕
163-187	Mangers (44), CO_2-H_2O, aq.Glycerol, Glass R.R.,	
	d_p = 10mm, μ_L = 0.90, 2.88, 5.50 mNs/m^2.	□ ⊠ ◫
	μ_L = 10.8, 16.0 mNs/m^2.	⧅ ⊟
188-192	Danckwerts (22), CO_2-K.Buffer, C.R.R., 38mm.	◒
193-196	Alper (36), CO_2-K.Buffer, Polyethylene R.R., 16mm.	⊘
197-214	Rizzuti (37), CO_2-K.Buffer, Glass R.R., 10mm,	
	μ_L = 1.2, 1.4, 1.5 and 1.9 mNs/m^2.	◬ ⊽ ⊕ ⊘
215-217	Rizzuti (56), CO_2-K.Buffer, Glass R.R., 10mm.	◑

(iii) Most of the predicted values were nearly 30 to 70 % less than the observed values. The values of maximum deviation was 85 %.

The theoreticl correlation based on hydrodynamics of rivulets of Zech & Mersmann (104) [equation (2.2.4)] was also used to predict the values of k_L. The predicted values are also tabulated in Table (8.3.3). The detailed statistical analysis can be described as follows :-

(i) The values of % E_{avg}, % E_{abs} and % S_{dev} were -12.4, 125.0 and 0.566 respectively.

(ii) Out of the 217 data points only 9 % (i.e 18 points) of the predicted values of k_L were within ± 20 % of the observed data values.

(iii) Most of the predicted values were consistently substantially greater than the observed values. The value of maximum deviation obtained was -821.0 %.

The recently proposed correlation by Billet and Schultes (105) [Equation (2.2.5)] also appears to be a generalised correlation. The values of k_L obtained by Billet and Schultes correlation are also reported in Table (8.3.3). The detailed statistical analysis of k_L values obtained by the correlation of Billet and Schultes can be described as follows :

(i) The values of % E_{avg}, % E_{abs} and % S_{dev} were 51.79, 52.8 and 0.368 respectively.

(ii) Out of 217 data points only 4 % of the predicted values of k_L were within ± 20 % of the observed values.

(iii) Most of the data points were consistently falling short by 40 to 70% from the observed values. - The value of maximum deviation was 68 %.

The comparison of the detailed statistical analysis for all the four correlations under consideration reveals that the values of % E_{abs} for the correlation of Onda, Mersmann, Billet and that developed in this Investigation are 44.4, 125.0, 52.8 and 11.3 respectively. The values of k_L obtained by chemical technique being more representative can be considered as the real values of k_L, and that obtained from k_La data can be considered as the apparent values of k_L. As expected, it can be seen from % E_{abs} values that the data for k_L obtained by chemical technique as well as that obtained from k_La values cannot be correlated satisfactorily by any of existing generalised correlations. However, the generalised correlation developed in this investigation correlates both the data sets of k_L values quite satisfactorily with ± 20 %.

Hence it can be concluded that the generalised correlation developed in this investigation is expected to be superior than the existing generalised correlations of Onda et al., Mersmann et al. and Billet et al.

8.4.0 RESULTS AND DISCUSSION FOR VOLUMETRIC LIQUID SIDE MASS TRANSFER COEFFICIENT WITH CHEMICAL REACTION ($k_L'a$) :

Data bank for the overall gas side mass transfer coefficient during chemical absorption can be used to obtain the values of $k_L'a$ by using the methodology discussed in Chapter - (4) : General Considerations. Such observed values of $k_L'a$ can then be compared with the predicted values of $k_L'a$ obtained by utilising "the mass transfer coefficient model" proposed in Chapter - (6). No such study has been reported in the literature which establishes relationship between $(k_L a)_{phy.}$ and $(k_L'a)_{chem.}$

8.4.1 Results for observed values of volumetric liquid side mass transfer coefficients with chemical reaction ($k_L'a$) :

The observed values of $k_L'a$ were obtained utilising the two data banks for overall gas side mass transfer coefficient during chemical absorption [K_Ga - chemical] reported in Tables - (5.7) and (5.8). The data bank - (I) (Table - 5.7) for K_Ga consists of 162 data points for the systems such as CO_2 - NaOH, CO_2 -monoethanolamine, CO_2 - diethanolamine, CO_2 - aqueous ammonia solution and CO_2 - KOH solution inclusive 15 variations. In this data bank - (I) the systems/data points falling under the category of very low concentration of reactive species are excluded. The Data bank - (II) (Table - 5.8) for K_Ga consists of 24 data points for systems such as CO_2-NaOH, CO_2-KOH etc. wherein the concentration of reactive species was very low.

The observed values of $k_L^{'}a$ using data bank - (I) [Table - 5.7] :-

In order to obtain the observed values of $k_L^{'}a$ the methodology listed in section (4.2) of Chapter - (4) : General Considerations was used. The values of true gas side mass transfer coefficient (k_G) and the effective interfacial area during chemical absorption (a_c) were estimated under otherwise identical conditions mentioned for the K_Ga data bank (I) reported in Table (5.7) by using the generalised correlations for k_G and a_c [Equations (8.11) and (7.10) respectively] developed in this investigation. The values of Henry's law constant (H') for absorption of gas in electrolyte/reactive solutions were estimated by using appropriate equations and methodology mentioned in section - (4.3.1) of Chapter - (4). Thus knowing the values of k_G, a_c and H', the observed values of $k_L^{'}a$ were obtained by using equation (4.5).

A typical sample calculation for obtaining the values of $k_L^{'}a$ from the data bank of K_Ga for the system CO_2-NaOH which followed second order reaction kinetics and also for the system CO_2 - diethanolamine which followed third order kinetics, has been illustrated in Appendix - (1) :- Sample Calculations - (A 1.2) and (A 1.3) respectively for the two systems mentioned above.

The physical properties of the absorption media and the gas phase necessary for the calculation of parameters - a_c and k_G under otherwise identical conditions mentioned for the K_Ga data bank - (I) [reported in Table (5.7)] are recorded in Table (8.4.1 A) for all the 162 data points under consideration. The calculated values of k_G, a_c, H' and k_Ga_c using the relevant data reported in Table (8.4.1 A)

Table – (8.4.1 A)

Physical properties of liquids and gases required for obtaining liquid side mass transfer coefficient with chemical reaction (k_L'a) based on K_Ga data bank (I).

No.	ρ_L kg/m^3	μ_L mNs/m^2	σ mN/m	σ/σ_c	$D_L \times 10^9$ m^2/s	ρ_G kg/m^3	$\mu_G \times 10^2$ mNs/m^2	$D_G \times 10^5$ m^2/s
1	1061.0	1.189	72.7	1.192	1.5111	1.161	1.856	1.6005
2	1061.0	1.189	72.7	1.192	1.5111	1.161	1.856	1.5985
3	1060.5	1.189	72.7	1.192	1.5150	1.158	1.856	1.5938
4	1060.8	1.189	72.7	1.192	1.5135	1.159	1.856	1.5891
5	1060.8	1.189	72.7	1.192	1.5135	1.159	1.856	1.5811
6	1061.0	1.189	72.7	1.192	1.5111	1.161	1.856	1.5688
7	1060.3	1.189	72.7	1.192	1.5160	1.157	1.856	1.5837
8	1060.8	1.189	72.7	1.192	1.5135	1.159	1.856	1.5772
9	1061.0	1.189	72.7	1.192	1.5111	1.161	1.856	1.5668
10	1059.0	1.260	72.9	1.303	1.3990	1.184	1.832	1.6087
11	1043.5	1.249	72.3	1.291	1.3956	1.190	1.825	1.5955
12	1083.0	1.174	72.7	1.299	1.5365	1.173	1.845	1.6350
13	1065.0	1.220	73.4	1.311	1.4561	1.183	1.833	1.6112
14	1056.0	1.020	72.7	1.299	1.7765	1.161	1.861	1.6668
15	1062.0	1.218	72.7	1.299	1.4477	1.180	1.837	1.6191
16	1063.0	1.218	72.7	1.299	1.4477	1.183	1.833	1.6112
17	1071.0	1.227	73.4	1.311	1.4367	1.183	1.833	1.6112
18	1071.0	1.227	73.4	1.311	1.4367	1.182	1.834	1.6134
19	1045.0	1.220	72.7	1.299	1.4460	1.177	1.841	1.6271
20	1101.0	1.510	74.5	1.330	1.1815	1.176	1.843	1.6295
21	1090.6	1.148	74.1	1.323	1.5470	1.178	1.840	1.6238
22	1074.0	1.105	73.8	1.318	1.5976	1.173	1.845	1.6350
23	1032.0	1.160	72.3	1.291	1.5196	1.194	1.820	1.5851
24	1032.0	1.160	72.3	1.291	1.5208	1.181	1.836	1.6160
25	1032.0	1.160	72.3	1.291	1.5196	1.180	1.837	1.6191
26	1032.0	1.160	72.3	1.291	1.5196	1.179	1.839	1.6218
27	1008.0	1.104	72.1	1.182	1.6006	1.180	1.837	1.6182
28	1071.0	1.425	74.0	1.213	1.2451	1.176	1.843	1.6297
29	1072.0	1.480	74.0	1.213	1.1788	1.196	1.819	1.5823
30	1064.0	1.420	74.0	1.213	1.2286	1.196	1.819	1.5823
31	1064.0	1.420	74.0	1.213	1.2286	1.196	1.819	1.5823
32	1060.0	1.380	73.0	1.197	1.2642	1.196	1.819	1.5823
33	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
34	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
35	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
36	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
37	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
38	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
39	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
40	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
41	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
42	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
43	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
44	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139

Table - 8.4.1 A (contd.)

No.	ρ_L kg/m^3	μ_L mNs/m^2	σ mN/m	σ/σ_c	$D_L \times 10^9$ m^2/s	ρ_G kg/m^3	$\mu_G \times 10^2$ mNs/m^2	$D_G \times 10^5$ m^2/s
45	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
46	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
47	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
48	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
49	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
50	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
51	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
52	1036.0	1.157	72.6	1.190	1.5243	1.182	1.832	1.6139
53	1036.0	1.157	72.6	0.968	1.5243	1.182	1.832	1.6139
54	1036.0	1.157	72.6	0.968	1.5243	1.182	1.832	1.6139
55	1036.0	1.157	72.6	0.968	1.5243	1.182	1.832	1.6139
56	1036.0	1.157	72.6	0.968	1.5243	1.182	1.832	1.6139
57	1036.0	1.157	72.6	0.968	1.5243	1.182	1.832	1.6139
58	1036.0	1.157	72.6	0.968	1.5243	1.182	1.832	1.6139
59	995.7	1.045	56.0	0.747	1.5982	1.104	1.935	1.8183
60	995.7	1.045	56.0	0.747	1.5982	1.104	1.935	1.8183
61	995.7	1.075	56.0	0.747	1.5657	1.108	1.930	1.8073
62	995.7	1.025	56.0	0.747	1.6179	1.102	1.938	1.8242
63	995.7	1.075	56.0	0.747	1.5657	1.108	1.930	1.8073
64	995.7	1.045	56.0	0.747	1.5982	1.104	1.935	1.8183
65	995.7	1.075	56.0	0.747	1.5657	1.108	1.930	1.8073
66	997.0	1.134	56.0	0.747	1.4967	1.116	1.920	1.7855
67	994.5	1.000	56.0	0.747	1.6695	1.097	1.945	1.8402
68	995.7	1.045	56.0	0.747	1.5982	1.104	1.935	1.8183
69	995.7	1.075	56.0	0.747	1.5657	1.108	1.930	1.8073
70	995.7	1.045	56.0	0.747	1.5982	1.104	1.935	1.8183
71	995.7	1.065	56.0	0.747	1.5957	1.106	1.933	1.8133
72	997.0	1.134	56.0	0.747	1.4967	1.116	1.920	1.7855
73	991.9	0.765	70.1	1.150	2.3592	1.155	1.868	1.6802
74	989.4	0.768	69.5	1.139	2.3498	1.155	1.868	1.6802
75	986.6	0.775	68.8	1.127	2.3291	1.155	1.868	1.6802
76	982.7	0.791	67.4	1.105	2.2821	1.155	1.868	1.6802
77	980.9	0.796	67.2	1.101	2.2669	1.155	1.868	1.6802
78	974.0	0.812	65.9	1.080	2.2223	1.155	1.868	1.6802
79	991.9	0.765	70.1	1.150	2.3592	1.155	1.868	1.6802
80	991.7	0.768	69.6	1.140	2.3498	1.155	1.868	1.6802
81	987.4	0.775	68.5	1.123	2.3291	1.155	1.868	1.6802
82	980.9	0.796	67.1	1.100	2.2669	1.155	1.868	1.6802
83	973.7	0.812	65.9	1.080	2.2223	1.155	1.868	1.6802
84	991.9	0.765	70.1	1.150	2.3592	1.155	1.868	1.6802
85	991.7	0.768	69.6	1.140	2.3498	1.155	1.868	1.6802
86	987.3	0.775	68.5	1.123	2.3291	1.155	1.868	1.6802
87	980.9	0.796	67.1	1.100	2.2669	1.155	1.868	1.6802
88	973.7	0.812	65.9	1.080	2.2223	1.155	1.868	1.6802
89	991.9	0.765	70.1	1.150	2.3592	1.155	1.868	1.6802
90	987.7	0.775	68.5	1.123	2.3291	1.155	1.868	1.6802
91	987.9	0.775	68.6	1.124	2.3291	1.155	1.868	1.6802
92	980.4	0.796	67.2	1.101	2.2669	1.155	1.868	1.6802
93	974.0	0.812	65.9	1.080	2.2223	1.155	1.868	1.6802
94	991.9	0.765	70.1	1.150	2.3592	1.155	1.868	1.6802
95	991.7	0.768	69.6	1.140	2.3498	1.155	1.868	1.6802

Table - 8.4.1 A (contd.)

No.	ρ_L kg/m^3	μ_L mNs/m^2	σ mN/m	σ/σ_c	D_L x 10^9 m^2/s	ρ_G kg/m^3	μ_G x 10^2 mNs/m^2	D_G x 10^5 m^2/s
96	985.5	0.775	68.5	1.123	2.3291	1.155	1.868	1.6802
97	980.4	0.796	67.0	1.098	2.2669	1.155	1.868	1.6802
98	973.7	0.812	65.9	1.080	2.2223	1.155	1.868	1.6802
99	1016.0	1.370	74.0	1.213	1.2251	1.247	1.759	1.4697
100	1007.0	1.320	74.0	1.213	1.2783	1.243	1.763	1.4779
101	1006.0	1.370	74.0	1.213	1.2226	1.242	1.765	1.4806
102	1003.0	1.340	74.0	1.213	1.2548	1.241	1.766	1.4824
103	1003.0	1.300	74.0	1.213	1.2961	1.239	1.768	1.4861
104	1002.0	1.250	74.0	1.213	1.3532	1.237	1.770	1.4897
105	1014.0	1.330	74.0	1.213	1.2691	1.235	1.773	1.4961
106	1007.0	1.200	74.0	1.213	1.4159	1.230	1.779	1.5062
107	1003.0	1.270	74.0	1.213	1.3253	1.240	1.767	1.4852
108	1002.0	1.270	74.0	1.213	1.3281	1.238	1.769	1.4888
109	1004.0	1.300	74.0	1.213	1.2957	1.240	1.767	1.4842
110	1001.0	1.270	74.0	1.213	1.3230	1.243	1.763	1.4779
111	1005.0	1.270	74.0	1.213	1.3291	1.236	1.772	1.4934
112	1010.0	1.288	60.2	0.987	1.2762	1.188	1.827	1.5993
113	1010.0	1.288	60.2	0.987	1.2762	1.188	1.827	1.5993
114	1011.0	1.408	60.2	0.987	1.1760	1.201	1.813	1.5711
115	1011.0	1.408	60.2	0.987	1.1760	1.201	1.813	1.5711
116	1011.0	1.367	60.2	0.987	1.2095	1.196	1.818	1.5805
117	1011.0	1.506	60.2	0.987	1.1115	1.209	1.803	1.5524
118	1010.0	1.288	60.2	0.987	1.2762	1.188	1.827	1.5993
119	1009.0	1.510	60.2	0.987	1.2762	1.188	1.827	1.5993
120	1023.0	2.000	57.5	0.943	1.1150	1.184	1.832	1.6087
121	1037.0	0.969	72.5	1.189	1.8380	1.165	1.856	1.6562
122	1037.0	0.969	72.5	1.189	1.8380	1.165	1.856	1.6562
123	1037.0	0.969	72.5	1.189	1.8380	1.165	1.856	1.6562
124	1037.0	0.969	72.5	1.189	1.8380	1.165	1.856	1.6562
125	1037.0	0.969	72.5	1.189	1.8380	1.165	1.856	1.6562
126	1037.0	0.969	72.5	1.189	1.8380	1.165	1.856	1.6562
127	1037.0	0.969	72.5	1.189	1.8380	1.165	1.856	1.6562
128	1037.0	0.969	72.5	1.189	1.8380	1.165	1.856	1.6562
129	1037.0	0.969	72.5	1.189	1.8380	1.165	1.856	1.6562
130	1037.0	0.969	72.5	1.189	1.8380	1.165	1.856	1.6562
131	1037.0	0.969	72.5	1.189	1.8380	1.165	1.856	1.6562
132	1037.0	0.969	72.5	1.189	1.8380	1.165	1.856	1.6562
133	1019.0	0.897	71.9	1.179	1.9800	1.165	1.856	1.6562
134	1019.0	0.897	71.9	1.179	1.9800	1.165	1.856	1.6562
135	1019.0	0.897	71.9	1.179	1.9800	1.165	1.856	1.6562
136	1019.0	0.897	71.9	1.179	1.9800	1.165	1.856	1.6562
137	1019.0	0.897	71.9	1.179	1.9800	1.165	1.856	1.6562
138	1019.0	0.897	71.9	1.179	1.9800	1.165	1.856	1.6562
139	1019.0	0.897	71.9	1.179	1.9800	1.165	1.856	1.6562
140	1019.0	0.897	71.9	1.179	1.9800	1.165	1.856	1.6562
141	1007.0	0.853	71.6	1.174	2.0800	1.165	1.856	1.6562
142	1007.0	0.853	71.6	1.174	2.0800	1.165	1.856	1.6562
143	1007.0	0.853	71.6	1.174	2.0800	1.165	1.856	1.6562
144	1007.0	0.853	71.6	1.174	2.0800	1.165	1.856	1.6562
145	1004.0	0.828	71.4	1.170	2.1305	1.165	1.856	1.6562
146	1004.0	0.828	71.4	1.170	2.1305	1.165	1.856	1.6562

Table - 8.4.1 A (contd.)

No.	ρ_L kg/m^3	μ_L mNs/m^2	σ mN/m	σ/σ_c	$D_L \times 10^9$ m^2/s	ρ_G kg/m^3	$\mu_G \times 10^2$ mNs/m^2	$D_G \times 10^5$ m^2/s
147	1006.7	0.860	71.0	1.164	2.0816	1.166	1.855	1.6534
148	1006.7	0.860	71.0	1.164	2.0816	1.166	1.855	1.6534
149	1004.0	0.860	71.0	1.164	2.0822	1.166	1.855	1.6543
150	1002.5	0.860	71.0	1.164	2.0822	1.166	1.855	1.6543
151	1002.5	0.860	71.0	1.164	2.0822	1.166	1.855	1.6543
152	1002.5	0.860	71.0	1.164	2.0816	1.166	1.855	1.6543
153	1002.5	0.860	71.0	1.164	2.0829	1.165	1.855	1.6553
154	1002.5	0.860	71.0	1.164	2.0829	1.165	1.855	1.6553
155	1002.5	0.860	71.0	1.164	2.0822	1.166	1.855	1.6543
156	1002.5	0.860	71.0	1.164	2.0822	1.166	1.855	1.6543
157	1002.5	0.860	71.0	1.164	2.0829	1.165	1.855	1.6553
158	1001.4	0.860	71.0	1.164	2.0829	1.164	1.857	1.6572
159	1001.4	0.860	71.0	1.164	2.0829	1.165	1.856	1.6562
160	998.2	0.860	71.0	1.164	2.0822	1.165	1.856	1.6562
161	998.2	0.860	71.0	1.164	2.0822	1.165	1.855	1.6553
162	998.2	0.860	71.0	1.164	2.0822	1.166	1.855	1.6543

along with the observed values of $k_L^{'}a$ are reported in Table (8.4.1 B).

<u>The observed values of $k_L^{'}a$ using data bank - (II) [Table - 5.8] :-</u>

As has been discussed in Chapter - (6) under the conditions where the concentration of reactive species is very low, the effective interfacial area available for mass transfer during chemical absorption is equal to the effective interfacial area available for mass transfer during physical absorption.

Hence, while calculating the observed value of $k_L^{'}a$ from K_Ga data bank - (II) [Table (5.8)], the generalised correlation for predicting the values of a_p [Equation (7.7)] was utilised. Except this modification, the rest of the methodology for calculating the values of $k_L^{'}a$ was practically identical with that already cited for the data bank - (I) of K_Ga values. Hence, the physical properties of absorption media of the gas phase reported in Table (8.5.1 A) under otherwise identical conditions mentioned for the K_Ga data bank - (II), were utilised to calculate the values of k_G, a_p and H'. Accordingly the values of $k_L^{'}a$ were estimated by using the same equation (4.5) and are reported as the observed values of $k_L^{'}a$ in Table (8.5.1 B).

8.4.2 Results for the predicted values of volumetric liquid side mass transfer coefficient with chemical reaction $(k_L^{'}a)_{predicted}$:-

"The mass transfer coefficient model" proposed in this investigation in Chapter - (6) : Mathematical modelling of effective

Table - (8.4.1 B)

Observed values of k_L'a obtained from K_Ga data bank (I) for chemical absorption inclusive of processing parameters.

No.	a_c (m^2/m^3)	a_{st} (m^2/m^3)	k_La $\times 10^3$ s^{-1}	k_L $\times 10^4$ m/s	k_G $\times 10^3$ $kmol/m^2 s$ a	$k_G.a_c$ $kmol/m^3 s$ a	H' a /$kmol/m^3$	k_L'a s^{-1}
1	153.0	109.0	7.097	1.107	1.939	0.297	62.17	1.0237
2	176.6	117.0	9.619	1.196	1.937	0.342	62.17	1.1535
3	122.6	97.6	4.449	0.984	1.927	0.236	63.51	0.7257
4	155.2	109.7	7.319	1.116	1.927	0.299	63.00	1.0440
5	178.9	117.8	9.891	1.206	1.921	0.344	63.00	1.1757
6	195.6	123.1	11.936	1.264	1.916	0.375	62.17	1.2030
7	63.1	18.5	2.754	1.156	1.263	0.080	63.84	0.3846
8	79.7	20.8	4.515	1.311	1.263	0.101	63.00	0.5438
9	102.6	23.6	7.703	1.501	1.261	0.129	62.17	0.7697
10	82.1	56.4	2.731	0.902	1.273	0.105	47.71	0.3571
11	82.7	56.9	2.720	0.898	1.281	0.106	38.43	0.2582
12	84.5	56.8	3.027	0.978	1.280	0.108	71.12	0.9052
13	82.3	56.6	2.832	0.933	1.283	0.106	52.76	0.5070
14	87.6	59.0	3.487	1.102	1.302	0.114	58.96	0.8113
15	83.9	57.0	2.890	0.934	1.307	0.110	47.05	0.5335
16	105.6	63.9	4.700	1.057	1.302	0.137	47.88	0.6328
17	83.0	56.6	2.864	0.930	1.306	0.108	53.09	0.5798
18	105.0	63.7	4.712	1.056	1.307	0.137	53.08	0.6453
19	127.8	70.8	7.024	1.167	1.303	0.167	46.57	0.7473
20	100.0	60.9	3.982	0.902	1.294	0.129	69.85	0.7143
21	84.0	56.9	3.098	0.996	1.298	0.109	67.72	0.8575
22	106.0	64.4	5.106	1.152	2.095	0.222	60.78	0.8051
23	108.5	65.7	5.033	1.101	0.805	0.087	42.90	0.7159
24	107.5	65.4	4.939	1.096	0.942	0.101	43.54	0.5367
25	151.9	77.7	10.245	1.320	1.298	0.197	42.48	0.6916
26	182.0	85.0	15.019	1.455	1.288	0.234	42.38	0.7590
27	153.6	112.0	7.209	1.144	2.099	0.322	46.64	0.5329
28	141.0	103.7	5.624	0.934	2.269	0.320	64.63	1.0198
29	140.7	103.3	5.452	0.900	1.904	0.268	54.58	0.5381
30	121.5	68.0	5.208	0.982	1.606	0.195	47.17	0.4077
31	100.2	61.7	3.465	0.885	1.606	0.161	47.34	0.3273
32	88.4	57.9	2.624	0.837	1.606	0.142	44.29	0.3428
33	99.2	72.7	3.256	0.952	2.241	0.222	35.16	0.3566
34	130.6	83.4	5.828	1.104	2.241	0.293	35.07	0.4682
35	159.7	92.2	8.920	1.231	2.241	0.358	35.02	0.5838
36	98.1	40.2	4.785	1.190	2.024	0.198	35.14	0.2260
37	74.5	35.0	2.673	1.026	2.024	0.151	35.14	0.1761
38	119.9	44.4	7.323	1.326	2.024	0.243	35.14	0.3297
39	58.6	31.1	1.607	0.901	2.024	0.119	35.14	0.1625
40	58.6	31.1	1.607	0.901	1.207	0.071	35.14	0.1651
41	58.6	31.1	1.607	0.901	1.207	0.071	35.14	0.2705
42	98.1	40.2	4.785	1.190	2.024	0.198	35.14	0.2645
43	74.5	35.0	2.673	1.026	2.024	0.151	35.14	0.2131
44	58.6	31.1	1.607	0.901	2.024	0.119	35.14	0.1879
45	119.9	44.4	7.323	1.326	2.024	0.243	35.14	0.3584

Table - 8.4.1 B (contd.)

No.	a_c	a_{st}	$k_L a \times 10^3$	$k_L \times 10^4$	$k_G \times 10^3$	$k_G . a_c$ kmol/m³ s a	H'	k_L'a
	--- m^2/m^3	---	s^{-1}	m/s	kmol/m² s a		a /kmol/m³	s^{-1}
46	78.9	23.1	4.118	1.260	1.870	0.148	35.03	0.2967
47	98.7	25.8	6.609	1.421	1.870	0.184	35.00	0.3984
48	59.9	20.1	2.301	1.086	1.870	0.112	35.09	0.2209
49	78.9	23.1	4.118	1.260	1.870	0.148	35.24	0.2757
50	47.1	17.9	1.383	0.954	1.870	0.088	35.38	0.1415
51	98.7	25.8	6.609	1.421	1.870	0.184	35.19	0.3672
52	78.9	23.1	4.118	1.260	1.870	0.148	35.37	0.2231
53	92.4	22.4	4.298	1.283	1.983	0.183	35.24	0.2004
54	70.1	19.5	2.401	1.106	1.952	0.137	35.24	0.1587
55	115.5	25.0	6.898	1.447	1.952	0.226	35.24	0.2757
56	92.4	22.4	4.298	1.283	1.952	0.180	35.28	0.1941
57	92.4	22.4	4.298	1.283	1.183	0.109	35.27	0.2102
58	92.4	22.4	4.298	1.283	2.648	0.245	35.30	0.2108
59	115.3	24.0	4.322	1.267	2.608	0.301	53.02	0.4362
60	124.6	24.9	5.091	1.321	2.608	0.325	52.74	0.5322
61	142.5	26.6	6.699	1.396	2.606	0.371	48.69	0.6508
62	147.3	27.1	7.296	1.461	2.609	0.384	49.92	0.6664
63	150.3	27.3	7.502	1.437	2.606	0.392	46.66	0.7566
64	158.4	28.1	8.468	1.503	2.608	0.413	52.17	0.7693
65	180.2	29.9	11.006	1.584	2.606	0.469	44.98	0.9625
66	181.0	29.8	10.890	1.534	2.602	0.471	43.00	0.8991
67	198.1	31.5	13.869	1.751	2.612	0.517	46.84	1.1115
68	128.8	25.3	5.460	1.344	3.411	0.439	57.83	0.5789
69	142.5	26.6	6.699	1.396	3.408	0.486	54.51	0.7481
70	158.4	28.1	8.468	1.503	3.411	0.540	56.15	0.9533
71	170.5	29.1	9.881	1.556	3.410	0.581	53.81	1.0389
72	180.4	29.8	10.804	1.531	3.403	0.614	47.07	1.0640
73	113.5	69.1	5.550	1.443	0.908	0.103	37.58	0.0546
74	114.6	69.3	5.563	1.437	0.908	0.104	38.43	0.0866
75	115.9	69.4	5.557	1.426	0.908	0.105	39.37	0.1340
76	118.0	69.7	5.523	1.400	0.908	0.107	41.79	0.2163
77	118.4	69.7	5.502	1.392	0.908	0.107	42.27	0.2354
78	120.6	70.0	5.470	1.367	0.908	0.109	45.19	0.3303
79	144.4	77.9	9.230	1.643	0.908	0.131	37.62	0.0684
80	145.6	78.0	9.246	1.637	0.908	0.132	38.28	0.1059
81	147.9	78.3	9.262	1.624	0.908	0.134	39.61	0.1654
82	150.6	78.6	9.154	1.585	0.908	0.137	42.30	0.2534
83	153.3	78.9	9.099	1.556	0.908	0.139	45.38	0.3427
84	166.2	83.5	12.430	1.772	0.908	0.151	37.62	0.0831
85	167.6	83.6	12.452	1.766	0.908	0.152	38.26	0.1133
86	170.3	84.0	12.476	1.751	0.908	0.155	39.79	0.1768
87	173.4	84.3	12.327	1.710	0.908	0.157	42.23	0.2738
88	176.5	84.6	12.253	1.679	0.908	0.160	45.32	0.3686
89	183.6	87.8	15.353	1.870	0.908	0.167	37.64	0.0874
90	188.1	88.2	15.404	1.848	0.908	0.171	39.67	0.1943
91	188.0	88.2	15.396	1.848	0.908	0.171	39.54	0.1862
92	191.1	88.5	15.164	1.802	0.908	0.174	42.42	0.2680
93	194.4	88.8	15.027	1.768	0.908	0.176	45.28	0.3666
94	198.4	91.2	18.085	1.950	0.908	0.180	37.65	0.0927
95	200.2	91.4	18.116	1.943	0.908	0.182	38.28	0.1342
96	203.4	91.8	18.153	1.926	0.908	0.185	39.81	0.1983

Table – 8.4.1 B (contd.)

No.	a_c (m^2/m^3)	a_{st} (m^2/m^3)	$k_L a$ $\times 10^3$ s^{-1}	k_L $\times 10^4$ m/s	k_G $\times 10^3$ kmol/m^2 s a	$k_G a_c$ $\times 10^3$ kmol/m^3 s a	H' a /kmol/m^3	$k_L' a$ s^{-1}
97	207.2	92.0	17.907	1.879	0.908	0.188	42.43	0.2733
98	210.2	92.3	17.726	1.844	0.908	0.191	45.48	0.4112
99	99.6	23.7	6.721	1.290	1.613	0.161	21.75	0.1122
100	101.3	24.0	7.102	1.338	1.614	0.164	22.25	0.0971
101	102.2	24.1	7.090	1.304	1.555	0.159	20.01	0.0652
102	102.9	24.2	7.275	1.332	1.555	0.160	20.53	0.0551
103	103.5	24.3	7.480	1.367	1.555	0.161	20.80	0.0567
104	106.0	24.7	8.031	1.428	1.519	0.161	21.17	0.0575
105	85.2	21.9	4.913	1.215	1.509	0.129	22.43	0.0656
106	87.8	22.5	5.504	1.333	1.500	0.132	23.09	0.0722
107	85.8	22.2	5.084	1.256	1.501	0.129	20.48	0.0457
108	86.3	22.3	5.155	1.262	1.488	0.128	20.66	0.0378
109	71.3	20.2	3.398	1.118	1.501	0.107	20.49	0.0301
110	48.6	16.7	1.524	0.923	1.480	0.072	19.81	0.0161
111	39.8	15.1	1.004	0.832	1.502	0.060	21.42	0.0220
112	90.2	30.1	2.989	0.967	1.099	0.099	32.19	0.0436
113	90.2	30.1	2.989	0.967	1.016	0.092	32.29	0.0467
114	88.3	29.6	2.756	0.899	0.980	0.087	29.50	0.0386
115	88.3	29.6	2.756	0.899	0.932	0.082	29.59	0.0347
116	88.9	29.7	2.832	0.922	0.833	0.074	30.53	0.0642
117	104.0	32.0	3.792	0.940	1.610	0.167	28.40	0.0485
118	97.3	31.2	3.511	1.007	1.581	0.154	32.15	0.0491
119	119.7	34.3	5.466	1.085	1.193	0.143	33.04	0.0580
120	118.3	32.8	4.634	0.921	1.418	0.168	39.21	0.1317
121	104.5	54.8	4.956	1.269	1.060	0.111	44.25	0.3605
122	90.8	51.1	3.680	1.176	1.060	0.096	44.25	0.3258
123	97.4	52.9	4.271	1.222	1.060	0.103	44.25	0.3481
124	63.3	42.7	1.716	0.968	1.060	0.067	44.25	0.2306
125	53.1	39.1	1.183	0.881	1.060	0.056	44.25	0.1948
126	64.1	42.9	1.760	0.975	1.060	0.068	44.25	0.2335
127	70.0	44.9	2.125	1.023	1.060	0.074	44.25	0.2657
128	79.4	47.8	2.775	1.094	1.060	0.084	44.25	0.2301
129	89.5	50.7	3.569	1.167	1.060	0.095	44.25	0.3054
130	95.0	52.2	4.047	1.205	1.060	0.101	44.25	0.3561
131	109.2	56.0	5.435	1.299	1.060	0.116	44.25	0.3525
132	134.1	62.0	8.400	1.451	1.060	0.142	44.25	0.4321
133	107.5	56.1	5.362	1.349	1.060	0.114	39.37	0.2138
134	93.4	52.3	3.982	1.251	1.060	0.099	39.37	0.1795
135	100.2	54.2	4.621	1.299	1.060	0.106	39.37	0.1956
136	66.1	44.0	1.914	1.038	1.060	0.070	39.37	0.1499
137	104.1	55.2	5.009	1.326	1.060	0.110	39.37	0.2154
138	112.3	57.3	5.880	1.382	1.060	0.119	39.37	0.2294
139	117.9	58.7	6.521	1.418	1.060	0.125	39.37	0.2593
140	138.3	63.6	9.134	1.546	1.060	0.147	39.37	0.2958
141	109.4	57.0	5.643	1.405	1.060	0.116	36.90	0.1500
142	104.1	55.6	5.085	1.369	1.060	0.110	36.90	0.1471
143	126.5	61.3	7.679	1.520	1.060	0.134	36.90	0.1799
144	138.7	64.1	9.324	1.597	1.060	0.147	36.90	0.1983
145	117.4	59.1	6.590	1.484	1.060	0.124	35.21	0.1247
146	142.1	65.1	9.881	1.645	1.060	0.151	35.21	0.1414

Table – 8.4.1 B (contd.)

No.	a_c	a_{st}	$k_L a$ $\times 10^3$	k_L $\times 10^4$	k_G $\times 10^3$	$k_G . a_c$ $kmol/m^3 s$ a	H'	k_L 'a
	--- m^2/m^3	---	s^{-1}	m/s	$kmol/m^2 s$ a		a /kmol/m^3	s^{-1}
147	127.3	27.2	13.477	2.078	1.716	0.218	36.58	0.8548
148	127.3	27.2	13.477	2.078	1.716	0.218	36.50	0.6502
149	127.3	27.2	13.481	2.078	1.716	0.218	36.49	0.7594
150	127.6	27.3	13.551	2.080	1.716	0.219	36.36	0.5785
151	127.6	27.3	13.551	2.080	1.716	0.219	36.26	0.5447
152	127.6	27.3	13.550	2.080	1.729	0.221	36.04	0.6357
153	127.6	27.3	13.554	2.080	1.730	0.221	36.14	0.4373
154	128.1	27.3	13.658	2.084	1.730	0.222	36.02	0.4918
155	128.1	27.3	13.656	2.084	1.729	0.221	35.82	0.3599
156	128.1	27.3	13.656	2.084	1.769	0.226	35.75	0.4641
157	128.1	27.3	13.658	2.084	1.769	0.227	35.79	0.3614
158	128.5	27.4	13.763	2.088	1.769	0.227	35.67	0.3774
159	128.5	27.4	13.763	2.088	1.769	0.227	35.57	0.3591
160	128.6	27.4	13.763	2.086	1.769	0.227	35.41	0.2547
161	128.6	27.4	13.763	2.086	1.749	0.225	35.29	0.3065
162	128.7	27.5	13.798	2.088	1.749	0.225	35.18	0.2169

Table - (8.5.1 A)

Physical properties of liquids and gases required for obtaining liquid side mass transfer coefficient with chemical reaction. based on K_Ga data bank (II)

No.	ρ_L kg/m^3	μ_L mNs/m^2	σ mN/m	σ/σ_c	D_L $\times 10^9$ m^2/s	ρ_G kg/m^3	μ_G $\times 10^2$ mNs/m^2	D_G $\times 10^5$ m^2/s
1	1001.0	1.000	72.1	1.182	1.7511	1.191	1.824	1.5927
2	1000.0	0.960	72.1	1.182	1.8444	1.178	1.840	1.6238
3	1000.0	0.960	72.1	1.182	1.8444	1.178	1.840	1.6238
4	1000.0	0.980	72.1	1.182	1.7971	1.184	1.832	1.6087
5	1001.0	1.000	72.1	1.182	1.7541	1.189	1.826	1.5974
6	1001.0	1.000	72.1	1.182	1.7546	1.189	1.827	1.5981
7	1000.0	0.960	72.1	1.182	1.8448	1.178	1.840	1.6244
8	1000.0	0.960	72.1	1.182	1.8489	1.175	1.843	1.6308
9	1000.0	0.960	72.1	1.182	1.8516	1.173	1.845	1.6350
10	1003.0	1.270	74.0	1.213	1.3267	1.239	1.768	1.4870
11	1003.0	1.270	74.0	1.213	1.3207	1.244	1.762	1.4760
12	1001.0	1.270	74.0	1.213	1.3193	1.246	1.760	1.4724
13	1001.0	1.270	74.0	1.213	1.3183	1.247	1.759	1.4697
14	1001.0	0.813	71.3	1.169	2.1690	1.165	1.856	1.6562
15	1001.0	0.813	71.3	1.169	2.1690	1.165	1.856	1.6562
16	1001.0	0.813	71.3	1.169	2.1690	1.165	1.856	1.6562
17	1001.0	0.813	71.3	1.169	2.1690	1.165	1.856	1.6562
18	1001.0	0.813	71.3	1.169	2.1690	1.165	1.856	1.6562
19	1001.0	0.813	71.3	1.169	2.1690	1.165	1.856	1.6562
20	1001.0	0.813	71.3	1.169	2.1690	1.165	1.856	1.6562
21	1001.0	0.813	71.3	1.169	2.1690	1.165	1.856	1.6562
22	998.2	0.860	71.0	1.164	2.0822	1.166	1.855	1.6543
23	998.2	0.860	71.0	1.164	2.0829	1.165	1.855	1.6553
24	997.2	0.860	71.0	1.164	2.0816	1.166	1.855	1.6534

Table - (8.5.1 B)

Observed values of $k_L'a$ obtained from K_Ga data bank (II) for chemical absorption inclusive of processing parameters.

No.	a_p	a_{st}	$k_La \times 10^3$	$k_L \times 10^4$	$k_G \times 10^3$	$k_Ga\ p_a$	H'	$k_L'a$
	--- m^2/m^3	---	s^{-1}	m/s	$kmol/m^2\,s\,a$	$kmol/m^3\,s\,a$	$a\ /kmol/m^3$	s^{-1}
1	46.1	94.4	3.498	1.006	1.876	0.086	31.76	0.0416
2	75.9	111.3	7.135	1.241	1.697	0.129	32.26	0.0376
3	76.8	111.7	7.255	1.247	1.697	0.130	32.26	0.0391
4	38.5	89.4	2.794	0.963	1.617	0.062	30.79	0.0180
5	56.5	100.7	4.615	1.080	1.862	0.105	32.22	0.0524
6	98.6	120.2	9.788	1.308	1.862	0.184	31.98	0.1101
7	66.9	106.9	6.020	1.189	1.697	0.114	32.21	0.0523
8	76.7	76.0	8.038	1.380	1.715	0.132	33.15	0.0568
9	75.0	75.4	7.796	1.370	1.340	0.100	33.57	0.0531
10	119.3	83.9	11.386	1.253	1.755	0.209	20.36	0.0425
11	85.0	75.3	7.179	1.112	1.812	0.154	19.50	0.0287
12	63.1	68.6	4.799	1.003	1.845	0.116	19.11	0.0162
13	63.1	68.6	4.798	1.003	1.845	0.116	18.95	0.0140
14	53.5	57.7	5.907	1.458	1.060	0.057	34.36	0.0557
15	42.9	53.8	4.386	1.352	1.060	0.046	34.36	0.0419
16	47.9	55.7	5.090	1.404	1.060	0.051	34.36	0.0480
17	24.4	44.9	2.045	1.113	1.060	0.026	34.36	0.0195
18	24.6	45.0	2.062	1.115	1.060	0.026	34.36	0.0183
19	34.5	50.2	3.262	1.253	1.060	0.037	34.36	0.0302
20	61.1	60.2	7.066	1.526	1.060	0.065	34.36	0.0662
21	80.8	65.8	10.322	1.681	1.060	0.086	34.36	0.0858
22	136.0	92.7	19.081	1.841	2.111	0.287	35.23	0.2858
23	136.0	92.7	19.085	1.841	2.111	0.287	35.23	0.2497
24	136.0	92.7	19.080	1.840	2.110	0.287	34.90	0.2068

interfacial areas and mass transfer coefficients can be utilised conveniently to predict the values of $k_L^{'}a$. This model is based on the assumption that the interface consists of two parts, that is the moving part and the semistagnant part. Then the volumetric mass transfer coefficient for chemical absorption can also be splitted in two parts. The interrelationship between the two volumetric mass transfer coefficients - $(k_L^{'}a)_{chem.}$ and $(k_La)_{phy.}$ - expressed by equation (6.30) could be thus utilised for predicting the values of $k_L^{'}a$. The proposed model correlation [Equation (6.30)] to be utilised for predicting the values of $k_L^{'}a$ requires the knowledge of the following model parameters :-

(i) The value of volumetric mass transfer coefficient for physical absorption $(k_La)_{phy}$.

(ii) The value of static area during mass transfer (a_{st}).

(iii) The true liquid side mass transfer coefficient (k_L).

(iv) The parameter - $\sqrt{D_LK_2[B]}$ to be calculated using the values of D_L, k_2 and [B].

(v) The reaction factor (β) to be calculated using the factor γ

Estimation of different model parameters :

(I) <u>Estimation of $(K_La)_{phy}$</u> :

The generalised correlation developed in this investigation [Equation - (8.6)] was utilised for estimating the values of

$(k_La)_{phy}$. Based on the values of L, a_t, ρ_L, μ_L, σ, (σ / σ_c) and D_L reported in Tables (5.7) and (8.4.1 A), the values of $(k_La)_{phy}$. were calculated under otnerwise identical conditions for all the 162 data points under consideration [Data bank - (I)] and are reported in Table - (8.4.1 B).

(II) Estimation of a_{st} :-

The generalised correlation developed in this investigation [Equation (7.16)] based on the static area model was utilised for estimating the values of a_{st}. Based on the values of L, a_t, ρ_L μ_L, σ, (σ / σ_c) reported in Tables (5.7) and (8.4.1 A), the values of a_{st} were calculated under otherwise identical conditions for all the 162 data points under consideration and are also reported in Table (8.4.1 B).

(III) Estimation of true liquid side mass transfer coefficient (k_L) :-

The generalised correlation developed in this investigation [Equation (8.18)] was utilised for estimating the values of k_L. Based on the values of L, a_t, ρ_L, μ_L and D_L reported in Tables (5.7) and (8.4.1 A), the values of k_L were calculated under otnerwise identical conditions for all the 162 data points under consideration and are also reported in Table (8.4.1 B).

(IV) Estimation of parameter $\sqrt{D_Lk_2[B]}$:

Using the values of [B] and k_2 reported in Table (5.7) and the value of D_L reported in Table (8.4.1 A), the values of $\sqrt{D_Lk_2[B]}$

were estimated for all the 162 data points under consideration excluding data points 112-120. For these data points 112-120 wherein the system was CO_2 - diethanolamine and which followed third order reaction kinetics, the values of $\sqrt{D_L k_3 [B]^2}$ were estimated. All the relevant values of $\sqrt{D_L k_2 [B]}$ or $\sqrt{D_L k_3 [B]^2}$ so obtained are reported in Table (8.4.2).

(V) Estimation of reaction factor (β) :-

Using the values of $\sqrt{D_L k_2 [B]}$ and k_L already estimated the value of γ were calculated by using equation (6.28). Further the values of β which were then calculated using equation (6.27) are reported in Table (8.4.2) for all the 162 data points under consideration.

Prediction of $k_L^{'}a$ using "the mass transfer coefficient model" for Data bank - (I) :-

Knowing the model parameter - β ,$(k_L a)_{phy}$, $\sqrt{D_L k_2 [B]}$ and a_{st} the values of $(k_L^{'} a)_{chem}$ were predicted using the correlation for [Equation (6.30)] proposed in this investigation. The relevant values of $[k_L a]_{phy}$, $\sqrt{D_L k_2 [B]}$ (a_{st}), and $k_L^{'} a_{pred.}$ are reported in Table (8.4.2) for all the 162 data points under consideration [Data bank - (I) from Table (5.7)].

Prediction of $k_L^{'}a$ by using "the mass transfer coefficient model" for Data bank - (II) :-

When the concentration of reactive species is very low the values of a_{st} are likely to be practically ineffective during mass

Table - (8.4.2)

Results inclusive of processing parameters for $k_L'a$ based on K_Ga data bank (I)

No.	$\sqrt{D_L k_2[B]}$ x 10^3	γ	β	$\sqrt{D_L k_2[B]}.a_{st}$	$\beta.k_La$	$k_L'a$ s^{-1} pred.	$k_L'a$ s^{-1} obs.	% err
1	6.5342	59.02	59.02	0.7119	0.4188	1.1308	1.0237	-10.46
2	6.5342	54.62	54.62	0.7647	0.5254	1.2901	1.1535	-11.84
3	6.7336	68.44	68.44	0.6573	0.3045	0.9618	0.7257	-32.53
4	6.6581	59.63	59.63	0.7306	0.4364	1.1670	1.0440	-11.79
5	6.6581	55.23	55.23	0.7842	0.5463	1.3305	1.1757	-13.16
6	6.5342	51.70	51.70	0.8045	0.6170	1.4215	1.2030	-18.17
7	6.7843	58.68	58.68	0.1256	0.1616	0.2872	0.3846	25.32
8	6.6581	50.80	50.80	0.1384	0.2294	0.3678	0.5438	32.37
9	6.5342	43.54	43.54	0.1541	0.3354	0.4894	0.7697	36.41
10	3.8862	43.10	43.10	0.2192	0.1177	0.3370	0.3571	5.64
11	2.6442	29.45	29.45	0.1503	0.0801	0.2305	0.2582	10.73
12	7.1451	73.05	73.05	0.4060	0.2211	0.6271	0.9052	30.73
13	4.5978	49.29	49.29	0.2601	0.1396	0.3997	0.5070	21.17
14	6.7005	60.81	60.81	0.3954	0.2120	0.6074	0.8113	25.14
15	4.4546	47.69	47.69	0.2539	0.1379	0.3918	0.5335	26.56
16	4.5771	43.29	43.29	0.2924	0.2034	0.4958	0.6328	21.64
17	4.5159	48.54	48.54	0.2558	0.1390	0.3948	0.5798	31.91
18	4.6033	43.58	43.58	0.2931	0.2053	0.4984	0.6453	22.76
19	4.5436	38.95	38.95	0.3217	0.2736	0.5952	0.7473	20.35
20	4.7502	52.66	52.66	0.2892	0.2097	0.4989	0.7143	30.16
21	7.2556	72.84	72.84	0.4129	0.2256	0.6385	0.8575	25.55
22	6.5166	56.59	56.59	0.4197	0.2889	0.7087	0.8051	11.98
23	4.1467	37.65	37.65	0.2725	0.1895	0.4620	0.7159	35.46
24	4.0508	36.95	36.95	0.2650	0.1825	0.4475	0.5367	16.62
25	3.9820	30.17	30.17	0.3093	0.3091	0.6184	0.6916	10.59
26	3.8933	26.76	26.76	0.3309	0.4019	0.7327	0.7590	3.46
27	3.7001	32.36	32.36	0.4143	0.2333	0.6476	0.5329	-21.52
28	5.3317	57.08	57.08	0.5528	0.3210	0.8738	1.0198	14.32
29	4.4276	49.19	49.19	0.4573	0.2682	0.7255	0.5381	-34.81
30	3.8186	38.89	38.89	0.2595	0.2025	0.4620	0.4077	-13.34
31	3.7662	42.55	42.55	0.2325	0.1474	0.3800	0.3273	-16.09
32	3.0647	36.63	36.63	0.1775	0.0961	0.2736	0.3428	20.19
33	3.6619	38.46	38.46	0.2662	0.1252	0.3915	0.3566	-9.78
34	3.7897	34.31	34.31	0.3160	0.2000	0.5160	0.4682	-10.20
35	3.8439	31.23	31.23	0.3542	0.2786	0.6328	0.5838	-8.39
36	3.6864	30.98	30.98	0.1481	0.1482	0.2964	0.2260	-31.14
37	3.6864	35.93	35.93	0.1292	0.0960	0.2252	0.1761	-27.91
38	3.6864	27.79	27.79	0.1637	0.2035	0.3673	0.3297	-11.41
39	3.6864	40.90	40.90	0.1146	0.0657	0.1804	0.1625	-11.02
40	3.6864	40.90	40.90	0.1146	0.0657	0.1804	0.1651	-9.25
41	3.6864	40.90	40.90	0.1146	0.0657	0.1804	0.2705	33.32
42	3.6864	30.98	30.98	0.1481	0.1482	0.2964	0.2645	-12.04
43	3.6864	35.93	35.93	0.1292	0.0960	0.2252	0.2131	-5.71
44	3.6864	40.90	40.90	0.1146	0.0657	0.1804	0.1879	4.03
45	3.6864	27.79	27.79	0.1637	0.2035	0.3673	0.3584	-2.47
46	3.8318	30.42	30.42	0.0884	0.1253	0.2137	0.2967	27.96

Table - 8.4.2 (contd.)

No.	$\sqrt{D_L k_2 [B]}$ $\times 10^3$	γ	β	$\sqrt{D_L k_2 [B]} \cdot a_{sl}$	$\beta \cdot k_L a$	$k_L'a$ s^{-1} pred.	$k_L'a$ s^{-1} obs.	% err
47	3.8797	27.31	27.31	0.1001	0.1805	0.2805	0.3984	29.59
48	3.7594	34.62	34.62	0.0757	0.0796	0.1553	0.2209	29.71
49	3.5630	28.29	28.29	0.0822	0.1165	0.1987	0.2757	27.92
50	3.3739	35.37	35.37	0.0602	0.0489	0.1092	0.1415	22.85
51	3.6250	25.51	25.51	0.0935	0.1686	0.2621	0.3672	28.63
52	3.3866	26.89	26.89	0.0781	0.1107	0.1889	0.2231	15.35
53	3.5630	27.77	27.77	0.0798	0.1194	0.1992	0.2004	0.62
54	3.5630	32.21	32.21	0.0696	0.0774	0.1469	0.1587	7.39
55	3.5630	24.62	24.62	0.0892	0.1698	0.2590	0.2757	6.07
56	3.5006	27.29	27.29	0.0784	0.1173	0.1957	0.1941	-0.81
57	3.5131	27.38	27.38	0.0787	0.1177	0.1964	0.2102	6.56
58	3.4754	27.09	27.09	0.0778	0.1164	0.1943	0.2108	7.82
59	8.1786	64.57	64.57	0.1959	0.2790	0.4750	0.4362	-8.89
60	8.2127	62.19	62.19	0.2045	0.3166	0.5211	0.5322	2.09
61	8.1400	58.30	58.30	0.2163	0.3906	0.6069	0.6508	6.74
62	8.8072	60.29	60.29	0.2386	0.4399	0.6785	0.6664	-1.81
63	8.3933	58.41	58.41	0.2291	0.4382	0.6672	0.7566	11.82
64	8.2806	55.08	55.08	0.2324	0.4664	0.6987	0.7693	9.17
65	8.6098	54.34	54.34	0.2571	0.5981	0.8552	0.9625	11.15
66	8.0443	52.43	52.43	0.2399	0.5710	0.8109	0.8991	9.82
67	10.0929	57.65	57.65	0.3176	0.7995	1.1171	1.1115	-0.50
68	7.6206	56.68	56.68	0.1929	0.3095	0.5024	0.5789	13.23
69	7.4563	53.41	53.41	0.1981	0.3578	0.5559	0.7481	25.69
70	7.8110	51.95	51.95	0.2192	0.4399	0.6591	0.9533	30.86
71	7.8883	50.70	50.70	0.2293	0.5010	0.7303	1.0389	29.71
72	7.5397	49.24	49.24	0.2244	0.5320	0.7564	1.0640	28.91
73	0.5926	4.11	4.11	0.0410	0.0228	0.0638	0.0546	-16.78
74	0.9311	6.48	6.48	0.0645	0.0360	0.1005	0.0866	-16.06
75	1.1912	8.35	8.35	0.0827	0.0464	0.1291	0.1340	3.63
76	1.6524	11.80	11.80	0.1151	0.0652	0.1803	0.2163	16.68
77	1.7233	12.38	12.38	0.1201	0.0681	0.1882	0.2354	20.04
78	2.0916	15.30	15.30	0.1464	0.0837	0.2301	0.3303	30.33
79	0.6147	3.74	3.75	0.0479	0.0346	0.0825	0.0684	-20.56
80	0.8832	5.39	5.40	0.0689	0.0499	0.1188	0.1059	-12.15
81	1.2481	7.69	7.69	0.0977	0.0712	0.1689	0.1654	-2.15
82	1.7273	10.90	10.90	0.1357	0.0998	0.2355	0.2534	7.08
83	2.1131	13.58	13.58	0.1667	0.1236	0.2903	0.3427	15.28
84	0.6147	3.47	3.48	0.0513	0.0432	0.0945	0.0831	-13.84
85	0.8766	4.96	4.96	0.0733	0.0618	0.1351	0.1133	-19.24
86	1.2883	7.36	7.36	0.1082	0.0918	0.2000	0.1768	-13.08
87	1.7159	10.04	10.04	0.1446	0.1237	0.2683	0.2738	2.03
88	2.1060	12.55	12.55	0.1782	0.1537	0.3320	0.3686	9.94
89	0.6227	3.33	3.34	0.0547	0.0513	0.1059	0.0874	-21.14
90	1.2609	6.82	6.82	0.1113	0.1051	0.2163	0.1943	-11.37
91	1.2312	6.66	6.66	0.1086	0.1026	0.2112	0.1862	-13.41
92	1.7452	9.68	9.68	0.1544	0.1468	0.3013	0.2680	-12.43
93	2.1016	11.88	11.88	0.1866	0.1786	0.3652	0.3666	0.39
94	0.6294	3.23	3.24	0.0574	0.0586	0.1160	0.0927	-25.10
95	0.8827	4.54	4.54	0.0806	0.0823	0.1630	0.1342	-21.43
96	1.2933	6.71	6.71	0.1187	0.1219	0.2406	0.1983	-21.36

Table – 8.4.2 (contd.)

No.	$\sqrt{D_L k_2 [B]}$ $\times 10^3$	γ	β	$\sqrt{D_L k_2 [B]}.a_{st}$	$\beta.k_L a$	$k_L'a$ s^{-1} pred.	$k_L'a$ s^{-1} obs.	% err
97	1.7468	9.29	9.29	0.1607	0.1664	0.3272	0.2733	-19.71
98	2.1249	11.52	11.52	0.1962	0.2042	0.4004	0.4112	2.62
99	1.1206	8.69	8.69	0.0265	0.0584	0.0849	0.1122	24.35
100	1.0709	8.00	8.00	0.0257	0.0568	0.0825	0.0971	15.00
101	0.7301	5.60	5.60	0.0176	0.0397	0.0573	0.0652	12.19
102	0.6990	5.25	5.25	0.0169	0.0382	0.0551	0.0551	0.00
103	0.6725	4.92	4.92	0.0164	0.0368	0.0532	0.0567	6.25
104	0.5269	3.69	3.69	0.0130	0.0297	0.0427	0.0575	25.82
105	1.1020	9.07	9.07	0.0242	0.0446	0.0688	0.0656	-4.76
106	1.0230	7.68	7.68	0.0230	0.0422	0.0652	0.0722	9.67
107	0.6185	4.92	4.92	0.0137	0.0250	0.0388	0.0457	15.14
108	0.5184	4.11	4.11	0.0115	0.0212	0.0327	0.0378	13.33
109	0.5575	4.98	4.99	0.0113	0.0169	0.0282	0.0301	6.21
110	0.4155	4.50	4.50	0.0070	0.0069	0.0138	0.0161	14.41
111*	0.8083	9.71	9.71	0.0122	0.0098	0.0220	0.0220	0.00
112*	0.7667	7.93	7.93	0.0230	0.0237	0.0468	0.0436	-7.35
113*	0.7547	7.81	7.81	0.0227	0.0233	0.0460	0.0467	1.45
114*	0.6543	7.28	7.28	0.0194	0.0200	0.0394	0.0386	-1.99
115*	0.6439	7.16	7.16	0.0191	0.0197	0.0388	0.0347	-11.73
116*	0.6721	7.29	7.29	0.0200	0.0207	0.0406	0.0642	36.75
117*	0.5202	5.53	5.53	0.0166	0.0210	0.0376	0.0485	22.46
118*	0.7728	7.67	7.67	0.0241	0.0269	0.0511	0.0491	-3.97
119*	0.7569	6.97	6.97	0.0260	0.0381	0.0641	0.0580	-10.43
120*	1.3776	14.97	14.97	0.0452	0.0693	0.1145	0.1317	13.02
121	3.8660	30.47	30.47	0.2117	0.1510	0.3628	0.3605	-0.64
122	3.8660	32.87	32.87	0.1974	0.1210	0.3184	0.3258	2.26
123	3.8660	31.65	31.65	0.2045	0.1352	0.3396	0.3481	2.45
124	3.8660	39.92	39.92	0.1650	0.0685	0.2335	0.2306	-1.25
125	3.8660	43.90	43.90	0.1512	0.0519	0.2031	0.1948	-4.27
126	3.8660	39.67	39.67	0.1660	0.0698	0.2358	0.2335	-0.97
127	3.8660	37.81	37.81	0.1735	0.0803	0.2538	0.2657	4.47
128	3.8660	35.32	35.32	0.1847	0.0980	0.2827	0.2301	-22.90
129	3.8660	33.13	33.13	0.1960	0.1182	0.3143	0.3054	-2.91
130	3.8660	32.08	32.08	0.2019	0.1298	0.3317	0.3561	6.85
131	3.8660	29.76	29.76	0.2164	0.1618	0.3781	0.3525	-7.29
132	3.8660	26.64	26.64	0.2397	0.2238	0.4635	0.4321	-7.25
133	2.8230	20.92	20.92	0.1584	0.1122	0.2705	0.2138	-26.55
134	2.8230	22.57	22.57	0.1477	0.0899	0.2375	0.1795	-32.34
135	2.8230	21.73	21.73	0.1529	0.1004	0.2533	0.1956	-29.49
136	2.8230	27.20	27.20	0.1243	0.0521	0.1764	0.1499	-17.65
137	2.8230	21.29	21.29	0.1558	0.1066	0.2625	0.2154	-21.83
138	2.8230	20.43	20.43	0.1618	0.1202	0.2820	0.2294	-22.91
139	2.8230	19.90	19.90	0.1658	0.1298	0.2956	0.2593	-14.03
140	2.8230	18.27	18.27	0.1795	0.1668	0.3463	0.2958	-17.09
141	2.0157	14.34	14.34	0.1149	0.0809	0.1958	0.1500	-30.50
142	2.0157	14.73	14.73	0.1121	0.0749	0.1870	0.1471	-27.11
143	2.0157	13.26	13.26	0.1235	0.1018	0.2253	0.1799	-25.20
144	2.0157	12.62	12.62	0.1292	0.1177	0.2469	0.1983	-24.55
145	1.4501	9.77	9.77	0.0858	0.0644	0.1502	0.1247	-20.38
146	1.4501	8.81	8.81	0.0943	0.0871	0.1814	0.1414	-28.31

Table - 8.4.2 (contd.)

No.	$\sqrt{D_L k_2 [B]}$ x 10^3	γ	β	$\sqrt{D_L k_2 [B]} . a_{st}$	$\beta . k_L a$	$k_L'a$ s^{-1} pred.	$k_L'a$ s^{-1} obs.	% err
147	9.6226	46.30	46.30	0.2616	0.6240	0.8856	0.8548	-3.60
148	7.0974	34.15	34.15	0.1930	0.4602	0.6532	0.6502	-0.46
149	8.4354	40.60	40.60	0.2296	0.5473	0.7770	0.7594	-2.32
150	6.2397	30.00	30.00	0.1702	0.4065	0.5767	0.5785	0.31
151	5.9277	28.50	28.50	0.1617	0.3862	0.5479	0.5447	-0.60
152	7.0290	33.80	33.80	0.1917	0.4580	0.6497	0.6357	-2.20
153	4.7013	22.60	22.60	0.1282	0.3063	0.4346	0.4373	0.63
154	5.2941	25.40	25.40	0.1447	0.3469	0.4916	0.4918	0.04
155	3.8136	18.30	18.30	0.1042	0.2499	0.3541	0.3599	1.60
156	4.9181	23.60	23.60	0.1344	0.3223	0.4567	0.4641	1.60
157	3.9081	18.75	18.75	0.1068	0.2561	0.3629	0.3614	-0.40
158	3.9462	18.90	18.90	0.1081	0.2601	0.3682	0.3774	2.44
159	3.7583	18.00	18.00	0.1029	0.2477	0.3507	0.3591	2.35
160	2.6310	12.61	12.61	0.0722	0.1736	0.2457	0.2547	3.52
161	3.2132	15.40	15.40	0.0882	0.2120	0.3001	0.3065	2.09
162	2.2235	10.65	10.65	0.0610	0.1469	0.2080	0.2169	4.09

Note :- Data points with * indicates that reaction follows third order kinetics hence the parameter in second column for these points is $\sqrt{D_L k_3 [B]^2}$.

transfer. Therefore, under these conditions instead of equation (6.30) one should use equation (6.31) for predicting the values of $k_L a$. However to test the validity of this statement, the values of $\sqrt{D_L k_2 [B]}$. a_{st} were also estimated for the case under consideration i.e. concentration of reactive species being very low.

Estimation of different model parameters :-

The generalised correlations developed in this investigation for predicting the values of $(k_L a)_{phy}$, k_L and a_{st} [Equations (8.6), (8.18) and (7.16) respectively] were utilised. Based on the values of L, a_t, ρ_L, μ_L, σ , (σ / σ_c) and D_L reported in Tables (5.8) and (8.5.1 A), the values of $(k_L a)_{phy}$, k_L and a_{st} were calculated under otherwise identical conditions for all the 24 data points under consideration and are reported in Table (8.5.1 B).

From the values of [B] and k_2 reported in Table (5.8) and the values of D_L reported in Table (8.5.1 A), the values of $\sqrt{D_L k_2 (B)}$ were estimated. The values of γ and β were estimated using equations (6.28) and (6.27) respectively. All the relevant values of γ , β $\sqrt{D_L k_2 [B]}$ were thus calculated under otherwise identical conditions for all the 24 data points under consideration and are reported in Table (8.5.2). Finally, the relevant values of $[k_L a]_{phy}$ and $\sqrt{D_L k_2 [B]}$, a_{st} and $k_L' a$ predicted using equation (6.31) are also reported in Table (8.5.2).

Table - (8.5.2)

Results inclusive of processing parameters for k_L'a based on K_Ga data bank (II) for very low concentration of reactive species.

No.	$\sqrt{D_L k_2[B]}$ x 10^3	γ	β	$\sqrt{D_L k_2[B]}.a_{st}$	β.kLa	kL'a s^{-1} pred.	kL'a s^{-1} obs.	% err
1	1.3064	12.99	12.99	0.1233	0.0454	0.0454	0.0416	-9.23
2	0.8349	6.73	6.73	0.0929	0.0480	0.0480	0.0376	-27.45
3	0.8349	6.70	6.70	0.0933	0.0486	0.0486	0.0391	-24.23
4	0.7763	8.06	8.06	0.0694	0.0225	0.0225	0.0180	-25.24
5	1.4340	13.28	13.28	0.1445	0.0613	0.0613	0.0524	-16.95
6	1.5802	12.08	12.08	0.1900	0.1182	0.1182	0.1101	-7.34
7	0.9364	7.88	7.88	0.1001	0.0474	0.0474	0.0523	9.39
8	0.8588	6.22	6.22	0.0653	0.0500	0.0500	0.0568	11.92
9	0.8735	6.37	6.37	0.0659	0.0497	0.0497	0.0531	6.43
10	0.4473	3.57	3.58	0.0375	0.0407	0.0407	0.0425	4.33
11	0.4103	3.69	3.69	0.0309	0.0265	0.0265	0.0287	7.63
12	0.2442	2.43	2.47	0.0168	0.0119	0.0119	0.0162	26.78
13	0.1964	1.96	2.04	0.0135	0.0098	0.0098	0.0140	30.08
14	0.9915	6.80	6.80	0.0572	0.0402	0.0402	0.0557	27.88
15	0.9915	7.34	7.34	0.0533	0.0322	0.0322	0.0419	23.28
16	0.9915	7.06	7.06	0.0552	0.0360	0.0360	0.0480	25.17
17	0.9915	8.91	8.91	0.0446	0.0182	0.0182	0.0195	6.62
18	0.9915	8.89	8.89	0.0447	0.0183	0.0183	0.0183	0.00
19	0.9915	7.91	7.91	0.0497	0.0258	0.0258	0.0302	14.56
20	0.9915	6.50	6.50	0.0596	0.0459	0.0459	0.0662	30.68
21	0.9915	5.90	5.90	0.0652	0.0609	0.0609	0.0858	29.05
22	2.1721	11.80	11.80	0.2013	0.2252	0.2252	0.2858	21.21
23	1.8779	10.20	10.20	0.1740	0.1947	0.1947	0.2497	22.04
24	1.5532	8.44	8.44	0.1440	0.1610	0.1610	0.2068	22.12

8.4.3 Comparison between the observed values and predicted values of $k_L'a$:

$[k_L'a]_{obs.}$ versus $[k_L'a]_{pred.}$ for Data bank - (I) :

The observed values of $(k_L'a)$ obtained by using data bank - (I) of K_Ga (chemical absorption) and the predicted values of $k_L'a$ obtained by using the mass transfer coefficient model [Equation (6.30)] are tabulated in Table (8.4.2) and are plotted in Figure (8.4).

For all the cases under consideration wherein the concentration of reactive species is not very low and the reaction essentially follows pseudo first order - fast/very fast reaction kinetics, also fast/very fast second order reaction kinetics, if one uses the model correlation [Equation (6.31)] instead of model correlation [Equation (6.30)] the predicted values of $k_L'a$ are expected to be 50 to 100 % less than the observed values of $k_L'a$.

Thus for example consider the following cases :

CASE I : System CO_2-NaOH.

For observation (1) wherein the concentration of reactive species [B] = 1.620 k mol/m^3, the observed value of $k_L'a$ (s^{-1}) is 1.0237. Under identical conditions the predicted values of $k_L'a$ (s^{-1}) by equations (6.30) and (6.31) are 1.1308 and 0.4188 respectively. The corresponding values of % error are -10.46 and 59 respectively.

For observation (53) wherein [B] = 0.825 k mol/m^3, the observed value of $k_L'a$ (s^{-1}) is 0.2004. Under identical conditions the predicted values of $k_L^{'}a$ (s^{-1}) by equations (6.30) and (6.31) are 0.1992 are 0.0798 respectively. The corresponding value of % error are 0.62 and 60.2 % respectively.

For observation (140) wherein [B] = 0.460 k mol/m^3, the observed values of $k_L^{'}a$ (s^{-1}) is 0.2958. Under identical conditions the predicted values of $k_L^{'}a$ (s^{-1}) by equations (6.30) and (6.31) are 0.3463 and 0.1668 respectively. The corresponding values of % error are -17.1 and 43.61 respectively.

CASE II : CO_2-Monoethanol amine system :-

For observation (66) wherein [B] = 1.573 k mol/m^3, the observed values of $k_L^{'}a$ (s^{-1}) is 0.5322. Under identical the conditions the predicted values of $k_L^{'}a$ (s^{-1}) by equations (6.30) and (6.31) are 0.5211 and 0.3166 respectively. The corresponding values of % error are 2.09 and 50.51 respectively.

CASE III : CO_2 - diethanolamine system :

For observation (113) wherein [B] = 0.619 k mol/m^3, the observed values of $k_L^{'}a$ (s^{-1}) is 0.0467. Under identical conditions the predicted values of $k_L^{'}a$ (s^{-1}) by equations (6.30) and (6.31) are 0.0460 and 0.0233 respectively. The corresponding values of % error are 1.45 and 100.5 respectively.

From these observations, it is crystal clear that the predicted values of $k_L^{'}a$ based on the model correlation [Equation (6.30)] compare very well with the observed values of $k_L^{'}a$. The predicted values of $k_L^{'}a$ based on the model correlation [Equation

(6.31)] do not compare at all with the observed values of $k_L^{'}a$. Therefore while predicting the values of $k_L^{'}a$, the contribution due to the semistagnant parts of the interface must be taken into account for all the cases under consideration mentioned in Data bank - (I).

Therefore for all the 162 data points [Data bank (I)] under consideration one should use model correlation [equation (6.30)] for predicting the values of $k_L^{'}a$.

The detailed statistical analysis of the model correlation [Equation (6.30)] can be described as follows :-

(i) The total number of data points used in correlation is 162 with 15 different systems/variations included.

(ii) The values of % E_{avg}, % E_{abs} and % S_{dev} were -4.2, 15.5 and 9.06 respectively.

(iii) From the 162 data points 80% of the predicted values of $k_L^{'}a$ were within ± 25 % of the observed values, 68 % were within ± 20 %, 60 % were within ± 15 % and 40 % were within ± 10 %.

(iv) Only 8 % of the predicted values of $k_L^{'}a$ showed deviations greater than ± 30 %, with the maximum deviation being 36.75 %.

Figure (8.4) shows a parity plot of $k_L^{'}a$, wherein the predicted values of $k_L^{'}a$ using equation (8.30) have been plotted versus observed values of $k_L^{'}a$. The satisfactory data fit in Figure (8.4) clearly reflects that the mass transfer coefficient model proposed in this investigation correlates satisfactorily all the data reported in data bank - (I) obtained from various sources.

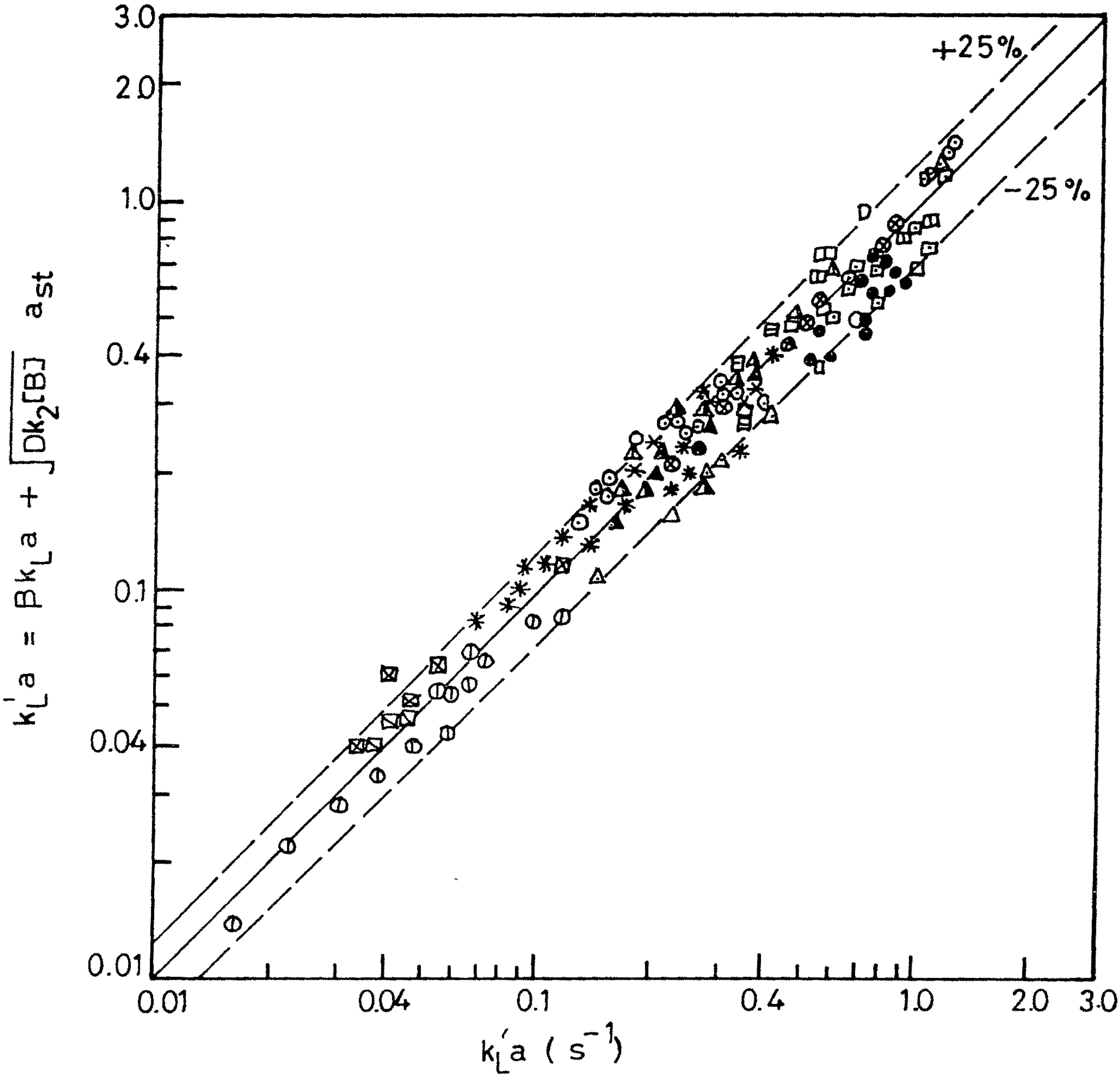

Fig. 8.4 VOLUMETRIC LIQUID SIDE MASS TRANSFER COEFFICIENTS DURING GAS ABSORPTION WITH CHEMICAL REACTION.
COMPARISON OF PREDICTED vs. EXPERIMENTAL (LIT.) DATA.

LEGENDS FOR FIG. 8.4

Data No.	Relevant Information	Symbol
1-9	Vidwans (53), CO_2-NaOH, C.R.R., 9.5mm, 25mm.	◖ ◗
10-26	Tepe (57), CO_2-NaOH, Carbon R.R., 13mm.	●
27-32	Blum (58,59), CO_2-NaOH, C.R.R., 9.5mm, 25mm.	◫ ⊟
33-52	Leva (60-61), CO_2-NaOH, C.R.R., 13mm, 19mm, 25mm.	◬ ▲ △
53-58	Leva (60-61), CO_2-NaOH, Steel R.R., 25mm.	▲
59-72	Teller (62), CO_2-MEA, Steel R.R., 25mm.	□
73-98	Vassilatos (63), CO_2- aq. Ammonia, C.R.R., 13mm.	✳
99-111	Yoshida (64), CO_2-NaOH, C.R.R., 25mm.	⦶
112-120	Cryder (65), CO_2-DEA, C.R.R., 19mm.	⊠
121-146	Onda (66), CO_2-NaOH, C.R.R., 15mm.	○
147-162	Yoshida (67), CO_2-KOH, C.R.R., 25mm.	⊗

$(k_L'a)_{obs.}$ versus $(k_L'a)_{pred.}$ for Data Bank (II) :-

For observed values of $k_L'a$ obtained by using data bank (II) of K_Ga (chemical absorption) and the predicted values of $k_L'a$ obtained by using the mass transfer coefficient model [Equation (6.31)] are tabulated in Table (8.5.2) and are plotted in Figure (8.5).

For the present case under consideration wherein the concentration of reactive species in the absorption media is very low, if one uses model correlation : Equation (6.30) instead of model correlation : Equation (6.31) for predicting the values of $k_L'a$, the predicted values of $k_L'a$ are expected to be 200 % to 300 % more than the observed values of $k_L'a$.

For example for observation (1) when the observed value of $k_L'a$ (s^{-1}) is 0.0416, the predicted values of $k_L'a$ (s^{-1}) by equations (6.31) and (6.30) are 0.0454 and 0.1688 respectively. The corresponding values of % error are -9.23 and 305.8 respectively.

Also for observation (17) when the observed value of $k_L'a$ (s^{-1}) is 0.0195, the predicted values of $k_L'a$ (s^{-1}) by equations (6.31) and (6.30) are 0.0182 and 0.0628 respectively. The corresponding values of % error are 6.62 and -222.05 respectively. Similar observations can be made for all the other 22 predicted values of $k_L'a$. Therefore in the region of very low concentration of reactive species, one must use model correlation - equation (6.31) and not model correlation - equation (6.30) for predicting the values of $k_L'a$.

The detailed statistical analysis of the model correlation [equation (6.31)] can be described as follows :-

(i) The total number of data points used in this correlation is 24 wherein the concentration of reactive species is in the range of 0.017 to 0.13 k mol/m^3.

(ii) The values of % E_{avg}, % E_{abs} and % S_{dev} were 8.66, 17.87 and 1.932.

(iii) From the 24 data points, 66 % of the predicted values of $k_L'a$ were within ± 25 % of the observed values of $k_L'a$ and 46 % were within ± 15 %.

Figure (8.5) shows a parity plot for $k_L'a$ wherein the predicted values of $k_L'a$ using model correlation [Equation (6.31)] have been plotted versus the observed value of $k_L'a$ obtained for data bank - (II). The satisfactory data fit in Figure (8.5) clearly reflects that "the mass transfer coefficient model" proposed in this investigation correlates satisfactorily all the data reported in data bank - (II).

8.4.4 Results for volumetric liquid side mass transfer coefficients (k_La) for two cases :-

CASE I : Regime of very low concentration of reactive species.

CASE II : Regime of instantaneous reaction.

The observed values of $k_L'a$ obtained for Case (I) with the help of data bank - (II) could be used conveniently to calculate the

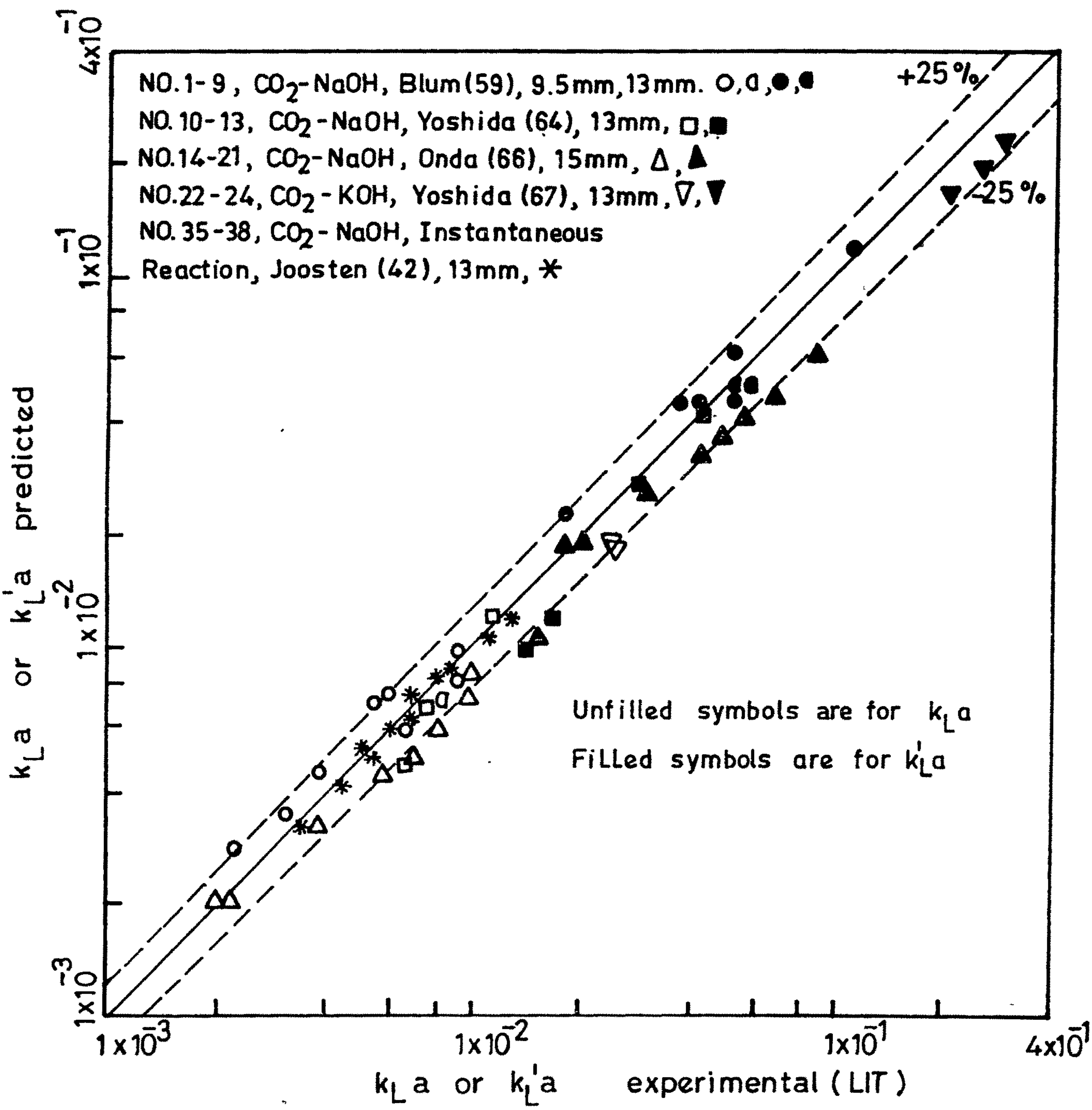

FIG.8.5. COMPARISON BETWEEN THE PREDICTED AND EXPERIMENTAL VALUES OF '$k_L a$' OR $k_L'a$ FOR THE CASE OF VERY LOW CONCENTRATION OF REACTING SPECIES.

values of k_La. The observed values of $k_L'a$ can be divided by β and one thus gets the observed values of $(k_La)_{phy.}$ The values of $(k_La)_{phy.}$ can also be predicted under otherwise identical conditions using the generalised correlation for k_La [Equation (8.6)] developed in this investigation. The observed values of k_La and the corresponding predicted values of k_La are reported in Table (8.6).

Table (8.6) also reports the experimental values of k_La obtained by chemical technique carrying out gas absorption with chemical reaction in the instantaneous reaction regime (42). These experimental values of k_La along with the predicted values of k_La under otherwise identical conditions obtained by using generalised correlation for k_La [Equation (8.6)] are also reported in Table (8.6) : observation numbers (25) to (38).

8.4.5 Comparison between the observed values/experimental values of k_La and predicted values of k_La :-

The observed/experimental values of k_La and the predicted values of k_La obtained by using the generalised correlation [Equation (8.6)] which have been tabulated in Table (8.6) are also plotted in Figure (8.5).

The detailed statistical analysis can be described as follows :-

(i) The total number of points are 38 with 24 points being of Case I : Regime of very low concentration of reactive species and 14 points of Case II : Regime of instantaneous reaction.

Table - (8.6)

Comparison between observed values based on data bank (II) and predicted values of k_La for two cases.

No.	T ^oC	a_t m^2/m^3	ρ_L kg/m^3	μ_L mNs/m^2	σ mN/m	D_L $\times 10^9$ m^2/s	L kg/m^2s	k_La $\times 10^3$ s^{-1} obs.	k_La $\times 10^3$ s^{-1} pred.	% err.
Case I : Very low concentration of reactive species :-										
1	23.3	470	1001.0	1.00	72.1	1.75	0.85	3.203	3.498	-9.23
2	26.6	470	1000.0	0.96	72.1	1.84	2.12	5.598	7.135	-27.45
3	26.6	470	1000.0	0.96	72.1	1.84	2.17	5.840	7.255	-24.23
4	25.0	470	1000.0	0.98	72.1	1.80	0.61	2.231	2.794	-25.24
5	23.8	470	1001.0	1.00	72.1	1.75	1.25	3.947	4.615	-16.95
6	23.9	470	1001.0	1.00	72.1	1.75	3.47	9.119	9.788	-7.34
7	26.7	470	1000.0	0.96	72.1	1.84	1.68	6.643	6.020	9.39
8	27.3	370	1000.0	0.96	72.1	1.85	2.93	9.126	8.038	11.92
9	27.8	370	1000.0	0.96	72.1	1.85	2.81	8.332	7.796	6.43
10	11.9	370	1003.0	1.27	74.0	1.33	7.18	11.900	11.386	4.33
11	10.7	370	1003.0	1.27	74.0	1.32	3.84	7.772	7.179	7.63
12	10.3	370	1001.0	1.27	74.0	1.32	2.22	6.554	4.799	26.78
13	10.0	370	1001.0	1.27	74.0	1.32	2.22	6.862	4.798	30.08
14	30.0	330	1001.0	0.81	71.3	2.17	1.67	8.191	5.907	27.88
15	30.0	330	1001.0	0.81	71.3	2.17	1.11	5.717	4.386	23.28
16	30.0	330	1001.0	0.81	71.3	2.17	1.36	6.802	5.090	25.17
17	30.0	330	1001.0	0.81	71.3	2.17	0.39	2.190	2.045	6.62
18	30.0	330	1001.0	0.81	71.3	2.17	0.40	2.060	2.062	-0.12
19	30.0	330	1001.0	0.81	71.3	2.17	0.74	3.818	3.262	14.56
20	30.0	330	1001.0	0.81	71.3	2.17	2.13	10.193	7.066	30.68
21	30.0	330	1001.0	0.81	71.3	2.17	3.57	14.547	10.322	29.05
22	30.0	370	998.2	0.86	71.0	2.08	8.08	24.217	19.081	21.21
23	30.1	370	998.2	0.86	71.0	2.08	8.08	24.480	19.085	22.04
24	29.9	370	997.2	0.86	71.0	2.08	8.08	24.500	19.080	22.12
Case II : Instantaneous reaction :-										
25	25.0	370	1156.5	1.40	75.6	1.48	1.86	4.360	4.237	2.83
26	25.0	370	1156.5	1.40	75.6	1.48	2.49	5.324	5.244	1.51
27	25.0	370	1156.5	1.40	75.6	1.48	2.93	6.222	5.912	4.98
28	25.0	370	1156.5	1.40	75.6	1.48	3.66	7.650	6.955	9.09
29	25.0	370	1156.5	1.40	75.6	1.48	4.59	8.166	8.202	-0.44
30	25.0	370	1156.5	1.40	75.6	1.48	5.71	9.861	9.621	2.43
31	25.0	370	1156.5	1.40	75.6	1.48	6.66	10.970	10.763	1.89
32	25.0	370	1156.5	1.40	75.6	1.48	7.52	12.480	11.753	5.83
33	25.0	370	1240.0	2.05	76.8	1.16	1.96	3.495	3.239	7.32
34	25.0	370	1240.0	2.05	76.8	1.16	2.67	4.205	4.063	3.38
35	25.0	370	1240.0	2.05	76.8	1.16	3.79	5.078	5.255	-3.49
36	25.0	370	1240.0	2.05	76.8	1.16	4.92	6.739	6.355	5.69
37	25.0	370	1240.0	2.05	76.8	1.16	6.08	6.862	7.417	-8.09
38	25.0	370	1240.0	2.05	76.8	1.16	7.46	8.749	8.611	1.57

(ii) The values of % E_{avg}, % E_{abs} and % S_{dev} were 6.40, 12.84 and 0.17 respectively.

(iii) From 38 data points 80 % of the predicted values of k_La were within ± 25 % of the observed/experimental values, 63 % were within ± 15 % and 60 % were within ± 15 %.

Figure (8.5) shows a parity plot for k_La wherein the predicted values of k_La using generalised correlation [Equation (8.6)] are plotted versus experimental/observed values of k_La. The satisfactory data fit in Figure (8.5) clearly reflects that the mass transfer coefficient model proposed in this investigation correlates satisfactorily all the data for Case I and II obtained from various sources.

8.5.0 PREDICTION OF MASS TRANSFER COEFFICIENTS :-

By performing mathematical modelling of data on k_La, k_G and k_L, generalised correlations have been developed for predicting the values of k_La, k_G and k_L.

The following generalised correlation [Equation (8.6)] can be used satisfactorily to predict the values of volumetric liquid side mass transfer coefficient (k_La) :-

$$k_La = 0.0833\ [(Re)^{0.286}\ (We)^{0.22}\ (Fr)^{0.002}\ (\sigma / \sigma_c)^{-0442}]$$
$$\ldots.\ x\quad [(Sc)^{-0.5}\ (\rho_L / \mu_L g)^{-1/3}\ a_t].$$

The generalised correlation [Equation (8.11)] for predicting the values of true gas side mass transfer coefficient is as follows:-

$$k_G = 1.75\ (Re_G)^{0.7}\ (Sc_G)^{0.4125}\ (a_t d_p)^{-0.9}\ (RT/a_t D_G)^{-1}$$

The values of true liquid side mass transfer coefficient can be predicted satisfactorily by the following generalised correlation [Equation (8.18)] :-

$$k_L = 0.0999\ (Re)^{0.187}\ (Sc)^{-0.5}\ (\rho_L/\mu_L g)^{-1/3}$$

Based on the mass transfer coefficient model developed in this investigation, the volumetric liquid side mass transfer coefficient with chemical reaction can be splitted in two parts: $(k_L^{'}a)_{dy}$ and $(k_L^{'}a)_{st}$. Then,in combination with the static area model developed in this investigation, the values of $k_L^{'}a$ can be predicted satisfactorily by the following generalised correlation :-

$$k_L^{'}a = \beta\ k_L a + \sqrt{D_L k_2 [B]}\ \ a_{st} \qquad (8.19)$$

where $k_L a = 0.0833\ [(Re)^{0.286}\ (We)^{0.22}\ (Fr)^{0.002}\ (\sigma\ /\ \sigma_C)^{-0.442}]$
$\quad .... \times\ [(Sc)^{-0.5}\ (\rho_L/\mu_L g)^{-1/3}\ a_t]$.

$$a_{st}/a_t = 0.1605\ (Re)^{0.1726}\ (Fr/We)^{0.5}\ (\sigma\ /\ \sigma_C)^{-0.725}$$

It is interesting to observe that knowing mass transfer coefficient during physical absorption ($k_L a$) under otherwise identical conditions and the static area from the static area model also under otherwise identical conditions,the volumetric liquid side mass transfer coefficient with chemical reaction ($k_L^{'}a$) can be predicted.

Further, for the case of chemical absorption where the concentration of reactive species is very low or the reaction is an instantaneous reaction, the mass transfer coefficient model indicates that the following generalised correlation [Equation (6.31)] can be used for predicting the value of $k_L'a$:-

$$k_L'a = 0.0833\ (\beta)\ [(Re)^{0.286}\ (We)^{0.22}\ (Fr)^{0.002}\ (\sigma / \sigma_C)^{-0442}]$$
$$\ldots\ \times\ [(Sc)^{-0.5}\ (\rho_L / \mu_L g)^{-1/3}\ a_t]. \qquad \ldots(8.20)$$

Thus the mass transfer coefficient model developed in this investigation (189, 190) could be utilised conveniently for predicting the values of volumetric liquid side mass transfer coefficient during chemical absorption. The model correlations : Equations (8.19) and (8.20) proposed based on this model are not merely the empirical correlations but these correlations elucidate the mechanism of mass transfer during chemical absorption.