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Appendix A

CALIBRATION DATA

Calibration of Rotameter for Ammonia

A rotameter of "Brooks" No.7 was calibrated. Triplicated data of air were obtained and the average values were reported. Volumetric flow rate of ammonia were calculated and also reported here.

Table A-1

T = 301° K

Rotameter reading	Volumetric flow rate of air (cm^3/sec)	Volumetric flow rate of NH_3 (cm^3/sec)
10	115	149
20	241	312
30	327	424
40	414	536
50	491	636
60	555	719
70	588	762

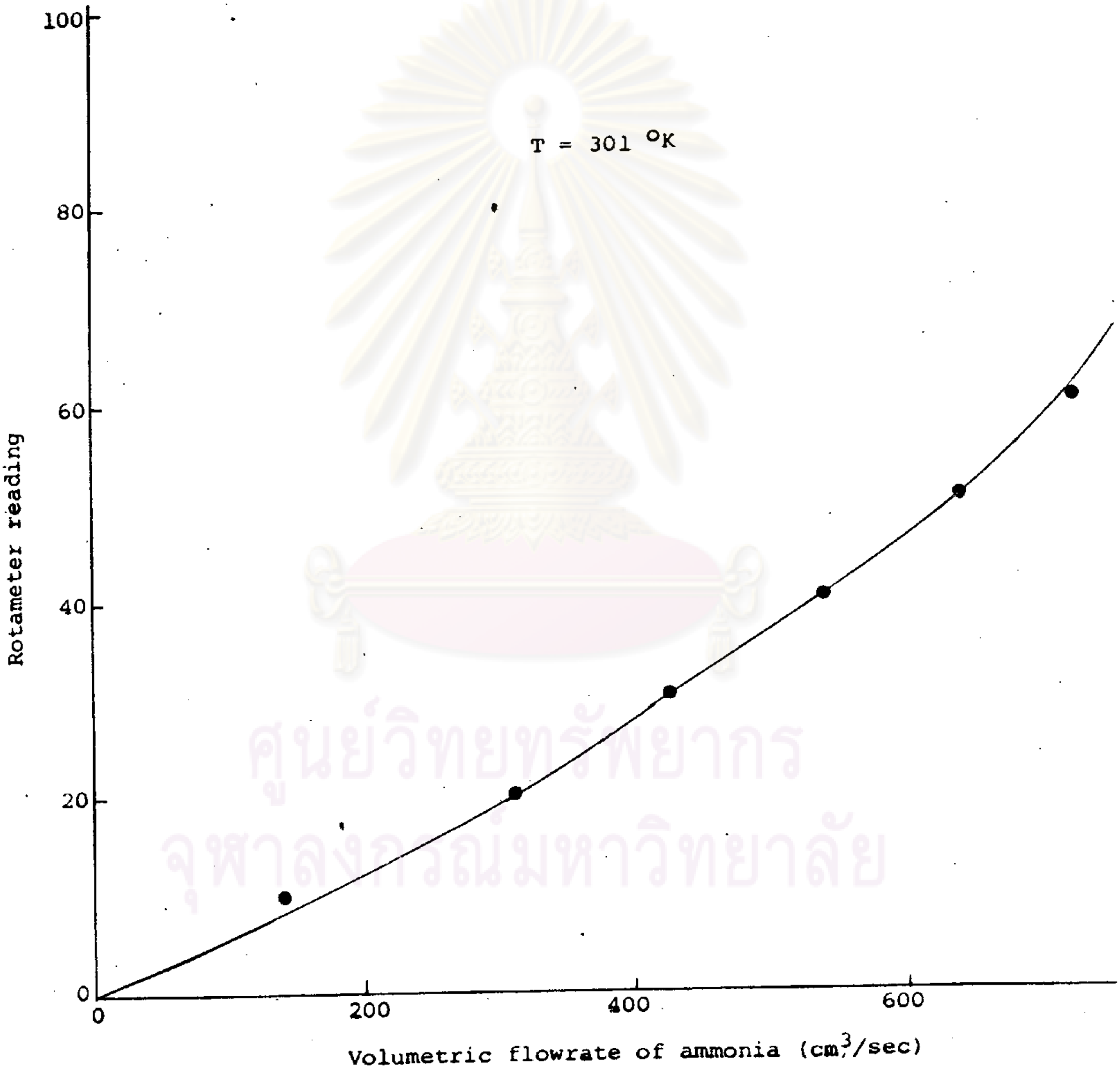

Fig.A.1 Calibration curve of ammonia rotameter

Calibration of Rotameter for Water

Table A-2

Rotameter reading	18	25	38	50	63	75	87	100
Volumetric flow rate of water (cm^3/sec)	11.0	15.4	23.2	30.9	39.4	47.6	54.2	63.3

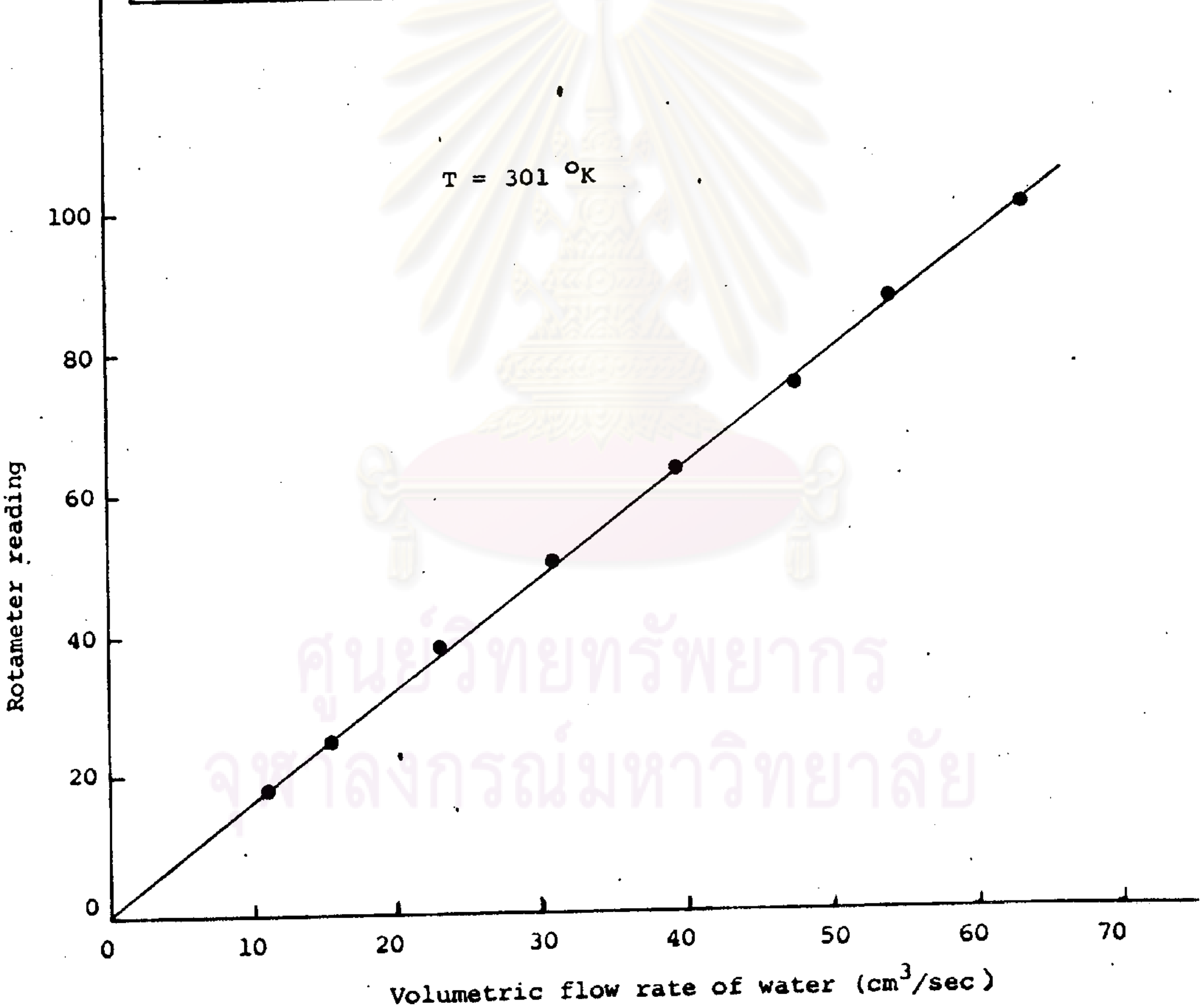

Fig.A.2 Calibration curve of water rotameter

Calibration of Orifice meter

Table A-3

T = 301 °K

Manometer reading (mm)	Superficial gas velocity (cm/sec)	Gas mass velocity (gm/sec cm^2)
3	50	0.05863
6	77	0.09029
10	108	0.12664
16	142	0.16650
20	157	0.18409
30	200	0.23451
40	232	0.27203
50	258	0.30252
60	283	0.33183
70	300	0.35176
80	322	0.37756
90	342	0.40101
110	372	0.43618
130	403	0.47253
150	443	0.51943
170	470	0.55109
190	507	0.59448
210	533	0.62496
230	570	0.66830
250	627	0.73518

Appendix B

SOME PROPERTIES OF GAS AND LIQUID

Partial pressure of ammonia at the interface is the pressure of ammonia that is in equilibrium with ammonia solution. Partial pressure of ammonia that used in this experiment have been obtained from International Critical Tables (23) as shown in Figure B-1

Various physical data of water, gas ammonia and air that used in this experiment have been obtained from Perry (24)

Diffusivity of Ammonia in Water

The theory of diffusion in liquid is less well developed than for gases. There are few measurements of liquid diffusivities outside the temperature range 0° to 40°C. Wilke and Chang (25) had proposed the relation for estimation of diffusivities of non-electrolytes in liquids at low concentrations of the diffusing component as below:

$$\frac{D_L \mu}{T} = 74\times10^{-8}\frac{(XM)^{0.5}}{V_o^{0.6}}$$

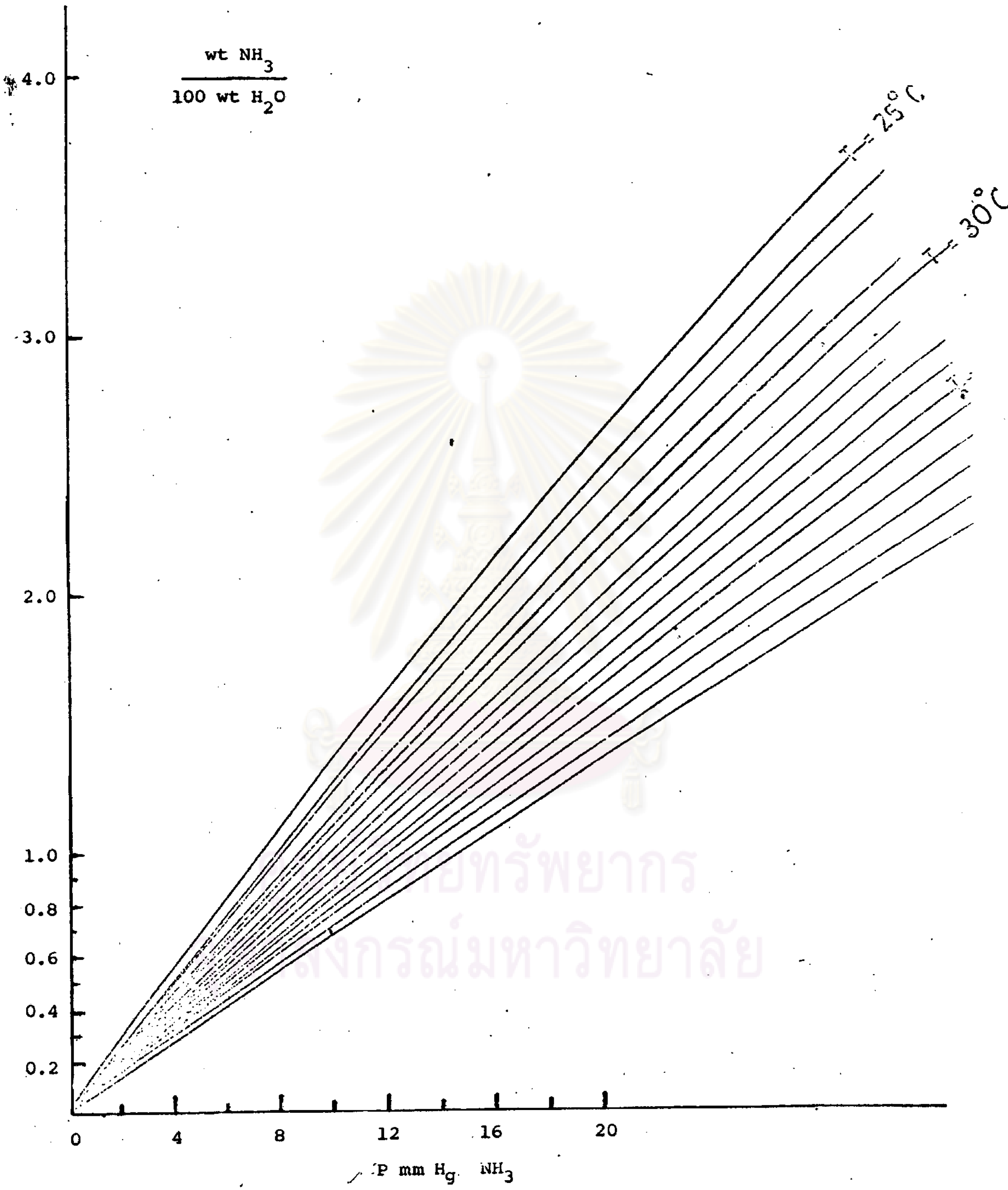

Fig.B.1 Partial pressure of ammonia at the interface in equilibrium with ammonia solution

Appendix C

EXPERIMENTAL DATA AND NUMERICAL RESULTS

a. **Static packing height 5 cm** T = 301 ^oK

Table C-1

U_G (cm/sec) \ U_L (cm/sec)	Hydraulic resistance of bed (mm.H_2O)			
	0.0906	0.1820	0.2807	0.3728
50	2.0	2.0	3.5	3.5
77	5.5	6.0	8.5	10.0
102	-	-	-	-
108	11.0	11.0	14.0	17.0
109	-	-	15.0	-
111	12.5	13.0	15.0	17.0
114	13.5	-	-	-
142	13.5	14.0	16.0	18.0
157	13.5	14.0	16.0	18.0
200	13.5	15.0	16.0	18.0
232	13.5	15.0	16.0	18.0
283	13.5	15.0	16.0	18.0
322	13.5	15.0	16.0	18.0
360	14.0	16.0	17.0	18.0
390	14.0	16.0	17.0	18.5
420	14.0	16.0	17.0	19.0

b. Static packing height 20 cm $T = 301\ ^{o}K$

Table C-2

U_G (cm/sec) \ U_L (cm/sec)	Hydraulic resistance of bed(mm.H_2O)			
	0.0906	0.1820	0.2807	0.3728
50	2.0	2.0	3.5	3.5
77	5.5	6.0	8.5	10.0
102	-	-	-	-
108	11.0	11.0	14.0	17.0
109	-	-	15.0	-
111	12.5	13.0	15.0	17.0
114	13.5	-	-	-
142	13.5	14.0	16.0	18.0
157	13.5	14.0	16.0	18.0
200	13.5	15.0	16.0	18.0
232	13.5	15.0	16.0	18.0
283	13.5	15.0	16.0	18.0
322	13.5	15.0	16.0	18.0
360	14.0	16.0	17.0	18.0
390	14.0	16.0	17.0	18.5
420	14.0	16.0	17.0	19.0

Table C-3

Air velocity 283 cm/sec

U_L (cm/sec) \ H_s (cm)	Hydraulic resistance of bed(mm.H_2O)		
	10	15	20
0,0906	20	32	43
0.1820	22	35	46
0.2807	25	38	49
0.3728	29	40	52

Table C-4

Air velocity 283 cm/sec

H_s (cm) \ U_L (cm/sec)	Hydraulic resistance of bed(mm.H_2O)		
	0.0906	0.2807	0.3728
5	13.5	16	18
10	20.0	25	29
15	32.0	38	40
20	43.0	49	52

Table C-5

H_s (cm) / U_L (cm/sec) / G (gm/sec.cm²)	Height of fluidized bed (cm)															
	5				10				15				20			
	.0906	.1820	.2807	.3728	.0906	.1820	.2807	.3728	.0906	.1827	.2807	.3728	.0906	.1827	.2807	.3728
0.1665	7.0	7.5	8.0	8.5	12.5	13.0	13.5	15.0	19.0	20.0	20.5	21.0	25.5	26.5	27.5	28.0
0.1841	8.0	8.5	9.0	9.5	13.5	14.5	15.0	15.5	20.0	21.0	22.0	22.5	27.5	28.0	29.0	30.0
0.2345	9.5	10.0	10.5	11.0	16.5	17.0	17.5	18.0	24.0	25.0	25.0	26.0	31.5	33.0	33.0	34.0
0.2720	10.5	11.0	11.5	12.5	19.0	19.0	20.0	22.0	27.0	28.0	28.5	29.0	36.5	37.0	38.0	39.0
0.3318	12.5	13.5	13.5	14.5	22.0	23.0	23.0	23.5	31.0	31.5	32.0	33.0	42.0	43.0	44.0	45.0
0.3776	14.5	15.5	15.5	16.0	25.0	25.5	26.0	26.5	34.0	35.0	36.0	36.0	47.0	48.0	48.0	50.0
0.4221	16.0	17.0	17.5	18.0	27.5	29.0	28.0	28.5	37.0	39.0	39.5	40.0	50.0	50.0	51.0	53.0
0.4573	18.0	17.5	18.5	19.0	30.0	31.0	31.0	31.5	42.0	41.5	42.0	43.0	53.0	53.0	55.0	56.0
0.4950	19.0	19.0	20.0	20.5	32.0	32.5	34.0	34.0	45.0	45.0	45.0	46.0	-	-	-	-

Table C-6

H_s (cm) / L (gm/sec $\cdot$ cm^2)	Minimum fluidization velocity (gm/sec cm^2)				
	5	10	15	20	Cal. from Chen and Dauglas's correlation $G_{mf} = 0.0604 D_p^{1.15} \; 10^{-0.3812L}$
0.0907	0.112	0.115	0.108	0.106	0.106
0.1813	0.100	0.100	0.097	0.097	0.098
0.2795	0.092	0.093	0.090	0.088	0.090
0.3713	0.080	0.083	0.082	0.082	0.083

Table C-7

H_s (cm)	U_G (cm sec) / U_L (cm/sec)	Height of clear liquid (cm)			
		157	232	283	390
5	0.1820	1.2	1.3	1.3	1.2
	0.2807	1.9	1.9	1.9	1.8
	0.3728	2.1	2.0	2.0	2.1
10	0.1820	1.8	1.8	1.8	1.7
	0.2807	2.7	2.6	2.7	2.7
	0.3728	2.8	2.8	2.9	2.9
20	0.1820	2.5	2.6	2.6	2.6
	0.2807	3.5	3.6	3.5	3.5
	0.3728	4.2	4.1	4.1	4.1

Table C-8

H_s (cm)	U_L (cm) \ U_G (cm)	Gas hold-up from experiment ($\frac{H_G}{H}$)			
		157	232	283	390
5	0.1820	0.541	0.636	0.703	0.777
	0.2807	0.489	0.600	0.659	0.757
	0.3728	0.495	0.624	0.676	0.747
10	0.1820	0.504	0.620	0.690	0.770
	0.2807	0.460	0.600	0.650	0.740
	0.3728	0.470	0.630	0.650	0.740
20	0.1820	0.530	0.640	0.690	0.750
	0.2807	0.510	0.640	0.680	0.740
	0.3728	0.500	0.620	0.670	0.730
Gas hold-up calculated from Kito, et al.'s correlation (2.28)		0.51	0.61	0.67	0.77

Table C-9

H_s (cm)	U_L (cm/sec) \ U_G (cm/sec)	Liquid hold-up from experiment ($\frac{H_L}{H}$)			
		157	232	283	390
5	0.1820	0.141	0.118	0.096	0.069
	0.2807	0.211	0.165	0.141	0.097
	0.3728	0.22	0.160	0.138	0.111
10	0.1820	0.124	0.095	0.078	0.055
	0.2807	0.180	0.130	0.117	0.087
	0.3728	0.181	0.127	0.123	0.092
20	0.1820	0.089	0.070	0.060	0.049
	0.2807	0.121	0.095	0.080	0.064
	0.3728	0.140	0.105	0.091	0.073

Table C-10

H_s (cm)	U_L cm/sec \ U_G (cm/sec)	Liquid hold-up base on static bed height (ϵ_{SL}) from experiment: 157	232	283	390	ϵ_{SL} Calculated from Kito,et al.'s correlation (2.31)
5	0.1820	0.240	0.260	0.260	2.240	0.250
	0.2807	0.380	0.380	0.380	0.360	0.340
	0.3728	0.420	0.400	0.400	0.420	0.400
10	0.1820	0.180	0.180	0.180	0.170	0.190
	0.2807	0.270	0.260	0.270	0.270	0.250
	0.3728	0.280	0.280	0.290	0.290	0.300
20	0.1820	0.125	0.130	0.130	0.130	0.150
	0.2807	0.175	0.180	0.180	0.175	0.190
	0.3728	0.210	0.205	0.205	0.205	0.230

Table C-11

H_s (cm)	U_G (cm/sec) / U_L (cm/sec)	Liquid hold-up calculated from equation (2.34)			
		157	232	283	390
5	0.1820	0.157	0.125	0.106	0.074
	0.2807	0.191	0.152	0.129	0.090
	0.3728	0.210	0.168	0.142	0.099
10	0.1820	0.129	0.103	0.087	0.061
	0.2807	0.157	0.125	0.106	0.074
	0.3728	0.177	0.140	0.119	0.083
20	0.1820	0.108	0.086	0.073	0.051
	0.2807	0.129	0.103	0.087	0.061
	0.3728	0.148	0.118	0.100	0.070

Table C-12

Height of static packing 8.9 cm.

U_L (cm/sec)	Fr \ $y \times 10^{-3}$	Over all mass transfer coefficient(gm-mole/sec cm^3atm)$\times 10^{-3}$			
		6.41	8.10	9.61	10.86
0.1820	1.307	0.80	0.90	0.83	0.82
	1.931	1.11	1.04	1.03	0.98
	2.344	1.21	1.21	1.15	1.17
	2.667	1.26	1.35	1.25	1.26
	2.982	1.39	1.36	1.33	1.41
0.2322	1.307	0.96	1.02	0.94	1.08
	1.931	1.12	1.20	1.13	1.20
	2.344	1.25	1.29	1.20	1.35
	2.667	1.30	1.44	1.35	1.43
	2.982	1.30	1.43	1.40	1.67
0.2807	1.307	1.14	1.10	1.08	1.13
	1.931	1.41	1.38	1.25	1.21
	2.344	1.47	1.48	1.41	1.43
	2.667	1.54	1.63	1.58	1.60
	2.982	1.69	1.61	1.57	1.81
0.3196	1.307	1.02	1.23	1.11	1.00
	1.931	1.46	1.33	1.28	1.30
	2.344	1.47	1.54	1.43	1.50
	2.667	1.58	1.68	1.47	1.61
	2.982	1.53	1.70	1.55	1.87

Table C-13

Height of Static Packing 15 cm.

U_L (cm/sec)	Fr \ $y \times 10^{-3}$	Over all mass transfer coefficient(gm-mol/sec cm^{3}atm)$\times 10^{-3}$			
		6.41	8.10	9.61	10.86
0.1820	1.307	0.72	0.74	0.73	0.74
	1.931	0.92	0.91	0.94	0.82
	2.344	0.89	1.08	0.96	0.99
	2.667	1.15	1.16	1.14	1.05
	2.982	1.09	1.14	1.20	1.25
0.2322	1.307	0.80	0.93	0.95	0.95
	1.931	0.94	1.05	1.03	1.12
	2.344	0.97	1.12	1.13	1.21
	2.667	1.19	1.18	1.24	1.26
	2.982	1.14	1.20	1.23	1.35
0.2807	1.307	0.74	0.86	0.90	0.91
	1.931	0.84	1.13	1.05	1.10
	2.344	1.03	1.15	1.17	1.15
	2.667	1.09	1.21	1.31	1.36
	2.982	1.20	1.25	1.34	1.38
0.3196	1.307	0.80	0.87	0.93	0.97
	1.931	0.90	1.06	1.06	1.06
	2.344	0.93	1.08	1.16	1.17
	2.667	1.07	1.18	1.27	1.23
	2.982	1.14	1.18	1.33	1.31

Table C-14

Height of static packing 8.9 cm.

U_G (cm/sec)	Re_L \ $y \times 10^{-3}$	Over all mass transfer coefficient (gm-mol/sec cm^3 atm)$\times 10^{-3}$			
		6.41	8.10	9.61	10.86
156.92	3.33	0.80	0.90	0.83	0.82
	4.24	0.96	1.02	0.94	1.08
	5.13	1.14	1.10	1.08	1.13
	5.85	1.02	1.23	1.11	1.00
	6.82	1.26	1.30	1.33	1.26
231.88	3.33	1.11	1.04	1.03	1.98
	4.24	1.12	1.20	1.13	1.20
	5.13	1.41	1.38	1.25	1.20
	5.85	1.46	1.33	1.28	1.30
	6.82	1.55	1.61	1.33	1.34
282.86	3.33	1.21	1.21	1.15	1.17
	4.24	1.25	1.29	1.20	1.35
	5.13	1.47	1.48	1.41	1.43
	5.85	1.47	1.54	1.43	1.50
	6.82	1.55	1.67	1.47	1.56
321.84	3.33	1.26	1.35	1.25	1.26
	4.24	1.30	1.44	1.35	1.43
	5.13	1.54	1.63	1.58	1.60
	5.85	1.58	1.68	1.47	1.61
	6.82	1.58	1.75	1.59	1.73

Table C-15

Superficial liquid velocity 0.2807 cm/sec

U_G (cm/sec)	$\frac{D_c}{H_s}$ \ $y \times 10^{-3}$	Over all mass transfer coefficient (gm-mol/sec cm^3 atm)$\times 10^{-3}$			
		6.41	8.10	9.61	10.86
156.92	1.652 0.980 0.735	1.14 0.74 0.63	1.10 0.86 0.64	1.08 0.99 0.68	1.13 0.91 0.76
282.86	1.652 0.980 0.735	1.47 1.03 0.84	1.48 1.15 0.89	1.41 1.17 0.88	1.43 1.15 0.90
321.84	1.652 0.980 0.735	1.54 1.09 0.81	1.63 1.21 0.92	1.58 1.31 0.93	1.60 1.36 0.99
359.82	1.652 0.980 0.735	1.69 1.20 0.92	1.61 1.25 1.02	1.57 1.34 1.00	1.81 1.38 1.05

Table C-16

Superficial liquid velocity 0.3196 cm/sec

U_G (cm/sec)	$\frac{D_c}{H_s}$ \ $y \times 10^{-3}$	Over all mass transfer coefficient (gm-mol/sec cm^3 atm)$\times 10^{-3}$			
		6.41	8.10	9.61	10.86
231.88	1.652	1.46	1.33	1.28	1.30
	0.980	0.90	1.06	1.06	1.06
	0.735	0.76	0.80	0.86	0.91
282.86	1.652	1.47	1.54	1.43	1.50
	0.980	0.93	1.08	1.16	1.17
	0.735	0.79	0.88	0.88	0.89
321.84	1.652	1.58	1.68	1.47	1.61
	0.980	1.07	1.18	1.27	1.23
	0.735	0.87	0.88	0.94	1.05
359.82	1.652	1.53	1.70	1.55	1.87
	0.980	1.14	1.18	1.33	1.31
	0.735	0.98	1.02	0.99	1.13

Table C-17

Superficial liquid velocity 0.3728 cm/sec

U_G (cm/sec)	$\frac{D_c}{H_s}$ \ $\gamma \times 10^{-3}$	Over all mass transfer coefficient (gm-mol/sec cm^3atm)$\times 10^{-3}$			
		6.41	8.10	9.61	10.86
282.86	1.652	1.55	1.67	1.47	1.57
	0.980	0.99	1.10	1.24	1.17
	0.735	0.86	0.86	0.93	0.94
321.84	1.652	1.58	1.75	1.59	1.73
	0.980	1.11	1.25	1.28	1.37
	0.735	0.97	1.03	0.98	0.98
359.82	1.652	1.58	1.74	1.66	1.89
	0.980	1.19	1.21	1.35	1.40
	0.785	1.02	1.11	1.05	1.14

Appendix D

SAMPLE OF CALCULATIONS

1. Calculation of G_{mf} from Douglas's correlation

For

$$H_s = 5 \quad cm$$

$$L = 0.0907 \quad gm/sec\ cm^2$$

$$G_{mf} = 0.0604\ (D_p)^{1.15} 10^{-0.3812L}$$

$$= 0.0604(1.75)^{1.15} 10^{-0.3812(0.0907)}$$

$$= 0.106 \quad gm/sec\ cm^2$$

2. Calculation of ϵ_G from experimental result

For

$$H_s = 5 \quad cm$$

Number of ball = 163

$$U_L = 0.1820 \quad cm/sec$$

$$U_G = 157 \quad cm/sec$$

$$H_L = 1.2 \quad cm$$

$$H = 8.5 \quad cm$$

$$\bar{H}_p = \frac{\frac{4}{3} \cdot \pi \frac{D_p^3}{8} \cdot 163}{A}$$

$$= \frac{\frac{4}{3} \cdot \pi \cdot \frac{1.75^3}{8} \cdot 163}{169.7}$$

$$= 2.7 \quad cm$$

$$\epsilon_G = \frac{H - H_p - H_L}{H}$$

$$= \frac{8.5 - 2.7 - 1.2}{8.5}$$

$$= 0.54$$

from Kito, et al's correlation

$$\epsilon_G = 0.19 \left(\frac{D_p U_G^{2} \rho_L}{\sigma} \right)^{0.11} \left(\frac{U_G}{(gD_p)^{0.5}} \right)^{0.22}$$

$$= 0.19 \left(\frac{1.75 \times 157^{2} \times .996}{72.8} \right)^{0.11} \left(\frac{157}{(981 \times 1.75)^{0.5}} \right)^{0.22}$$

$$= 0.51$$

3. Calculation of ϵ_L

from experimental result

For H_s = 5 cm

U_L = 0.1820 cm/sec

U_G = 157 cm/sec

$$\epsilon_L = \frac{H_L}{H}$$

$$= \frac{1.2}{8.5}$$

$$= 0.14$$

from Kito, et al's correlation

$$\epsilon_{SL} = 12.8 \left(f \frac{d}{D} \right)^{-0.58} \left(\frac{H_s}{D_p} \right)^{-0.4} \left(\frac{g D_p^{3} \rho_p^{2}}{\mu_L^{2}} \right)^{0.09}$$

$$\left(\frac{U_L^{2}}{g D_p} \right)^{0.83} \left(\frac{D_p U_L \rho_L}{\mu_L} \right)^{-0.34} \left(\frac{D_p U_L^{2} \rho_L}{\sigma} \right)^{-0.34}$$

f = free opening of supporting grid for mesh 6 = 0.684

d = equivalent diameter of slot = 0.395 cm

D = equivalent diameter of free sectional area = 12.15 cm

$$\epsilon_{SL} = 12.8\left(\frac{0.684\times0.395}{12.15}\right)^{-0.58}\left(\frac{5}{1.75}\right)^{-0.4}\left(\frac{981\times1.75^3\times0.238^2}{0.836^2}\right)^{0.09}\left(\frac{0.1820^2}{981\times1.75}\right)^{0.83}\left(\frac{1.75\times0.1820\times0.996}{0.836}\right)^{-0.34}\left(\frac{1.75\times0.1820^2\times0.996}{72.8}\right)^{-0.34}$$

$$= 0.254$$

$$\epsilon_{SP} = \frac{\text{volume of bed-volume of particle}}{\text{volume of bed}}$$

$$= \frac{169.7\times5 - 163\times\frac{4}{3}\times\pi\times\frac{1.75^3}{8}}{169.7\times5}$$

$$= \frac{848.5 - 457.6}{848.5}$$

$$= 0.46$$

$$\epsilon_L \doteq \frac{SL\,(1-\epsilon_G)}{1+\epsilon_{SL}-\epsilon_{SP}}$$

$$= \frac{0.254(1-0.51)}{1+0.25-0.460}$$

$$= 0.157$$

4. Calculation of over all mass transfer coefficient (K_Ga)

For H_S = 8.9 cm

U_L = 0.1820 cm/sec (Q_L = 30.89 cm^3/sec)

U_G = 159 cm/sec

y_1 = 6.41×10^{-3}

$$K_Ga = \frac{G_M\,(y_1 - y_2)}{H\,P\,\Delta y_{LM}}$$

$$\text{or}\quad K_Ga = \frac{Q_L\,(C_2 - C_1)}{H_S\,A\,P\Delta\,y_{LM}}$$

$$C_2 = \frac{N_1V_1}{25\times1000}$$

$$= \frac{0.1002 \times 32.37}{25 \times 1000}$$

$$= 0.0001297 = 1.30\times10^{-4} \quad \text{gm-mol/cm}^3$$

Mass flow rate of ammonia in water outlet = $17\times30.89\times1.30\times10^{-4}$ gm/sec

= 0.06811 "

Volumetric flow rate of ammonia in gas inlet = 171 cm^3/sec

Mass flow rate of ammonia in gas inlet = $171\times7.04\times10^{-3}$ gm/sec

= 0.12035 gm/sec

Ammonia in air outlet = 0.12035-0.06811 gm/sec

= 0.05224 "

= 74.70 cm^3/sec

Mole fraction of ammonia outlet (y_2) = $\frac{74.70}{26643}$

= 2.81×10^{-3}

Mole fraction of ammonia inlet y_1 = 6.41×10^{-3}

p_1^* determine from Figure B-1 = 1.915 mm H_g

y_1^* = 2.52×10^{-3}

$$\Delta y_{LM} = \frac{\Delta y_1 - \Delta y_2}{\ln \Delta y_1 / \Delta y_2}$$

$$= \frac{(6.41\times10^{-3} - 2.52\times10^{-3}) - (2.81\times10^{-3} - 0)}{\ln \dfrac{6.41\times10^{-3} - 2.52\times10^{-3}}{2.81\times10^{-3}}}$$

$$= 1.07\times10^{-3}$$

Hence $K_G a = \dfrac{30.89 \times 1.30\times10^{-3}}{8.9\times169.7\times1.07\times10^{-3}}$

$= 0.80\times10^{-3}$ gm-mol/sec cm^3 atm

5. Calculation of Sh, Re_L, Fr and H_{og}

from Table C-12 at U_L = 0.1820 cm/sec

U_G = 157 "

y = 6.41×10^{-3}

T = 301^oK

$$Sh = K_G a \frac{D_c^2}{D_f} RT$$

$$R = 82.06 \frac{\text{atm cm}^3}{\text{gm-mol }^oK}$$

$$D_f = 7.4\times10^{-8} \frac{(XM)^{0.5}}{V_o^{0.6}} \frac{T}{\mu_L}$$

$$= 7.4\times10^{-8}\frac{(2.6\times18)^{0.5}}{25.8^{0.6}} \times \frac{301}{0.836\times100}$$

$$= 2.59\times10^{-7}$$

So $Sh = 0.80\times10^{-3} \times \frac{14.7^2}{2.59\times10^{-7}} \times 82.06 \times 301$

$$= 1.65\times10^{10}$$

$$Re_L = \frac{D_c U_L \rho_L}{\mu_L}$$

$$= \frac{14.7\times0.1820\times0.996}{0.836}$$

$$= 3.3$$

$$Fr = \frac{U_G}{(g\ D_c)^{0.5}}$$

$$= \frac{157}{(981\times14.7)^{0.5}}$$

$$= 1.3$$

$$H_{og} = \frac{G_M}{K_G a \cdot P}$$

$$= \frac{0.1841/28.8}{0.80\times10^{-3}\times 1}$$

$$= 8.00 \text{ cm}$$

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