Chapter III

APPARATUS AND EXPERIMENTAL METHOD

3.1 Apparatus

The adsorption unit shown in Fig 3.1 consists of several units of equipment combined together. These units are; column, distributor chamber, screen, liquid collector, manometer, pump, storage tank and rotameter. The simplified flow diagram is shown in Fig 3.2. The assembly are to follow.

1. Column. The experimental up-flow column is made of transparent P.V.C. of 5.08 cm. in diameter and 43.5 cm in length.

2. Distributor chamber. The distributor chamber is filled with a large number of glass beads which serve to dissipate the velocity head at influent section.

3. Screen. A 250 mesh stainless steel screen is used to support activated carbon in the column and to cause a pressure drop between column and distribute sufficiently to permit a homogeneous fluidization.

4. Liquid collector. It is a cylindrical shape made of transparent P.V.C. of 15.3 cm in diameter and 15.3 cm in height covered at nearing the top of the column to permit continuous flow of the treated liquid.

5. Manometer. The manometer is used to measure pressure drop occured from flowing of fluid through column. Water was used as a medium.

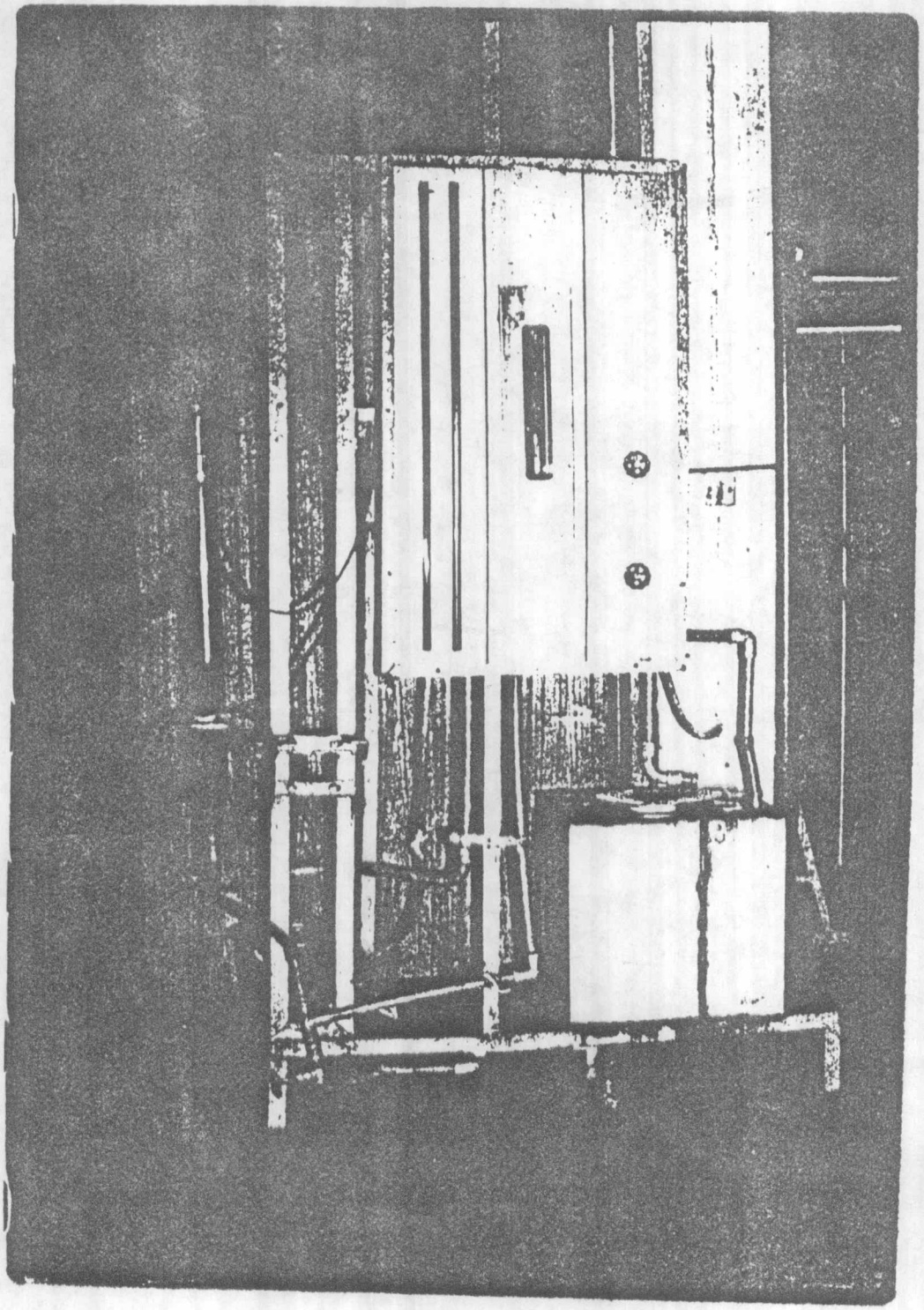

Fig. 3.1 Experimental Equipment.

1. Column
2. Distributor
3. Screen
4. Activated Carbon
5. Liquid Collector
6. Manometer
7. Feed Pump
8. Storage Tank
9. Rotameter
10. Drain Valve

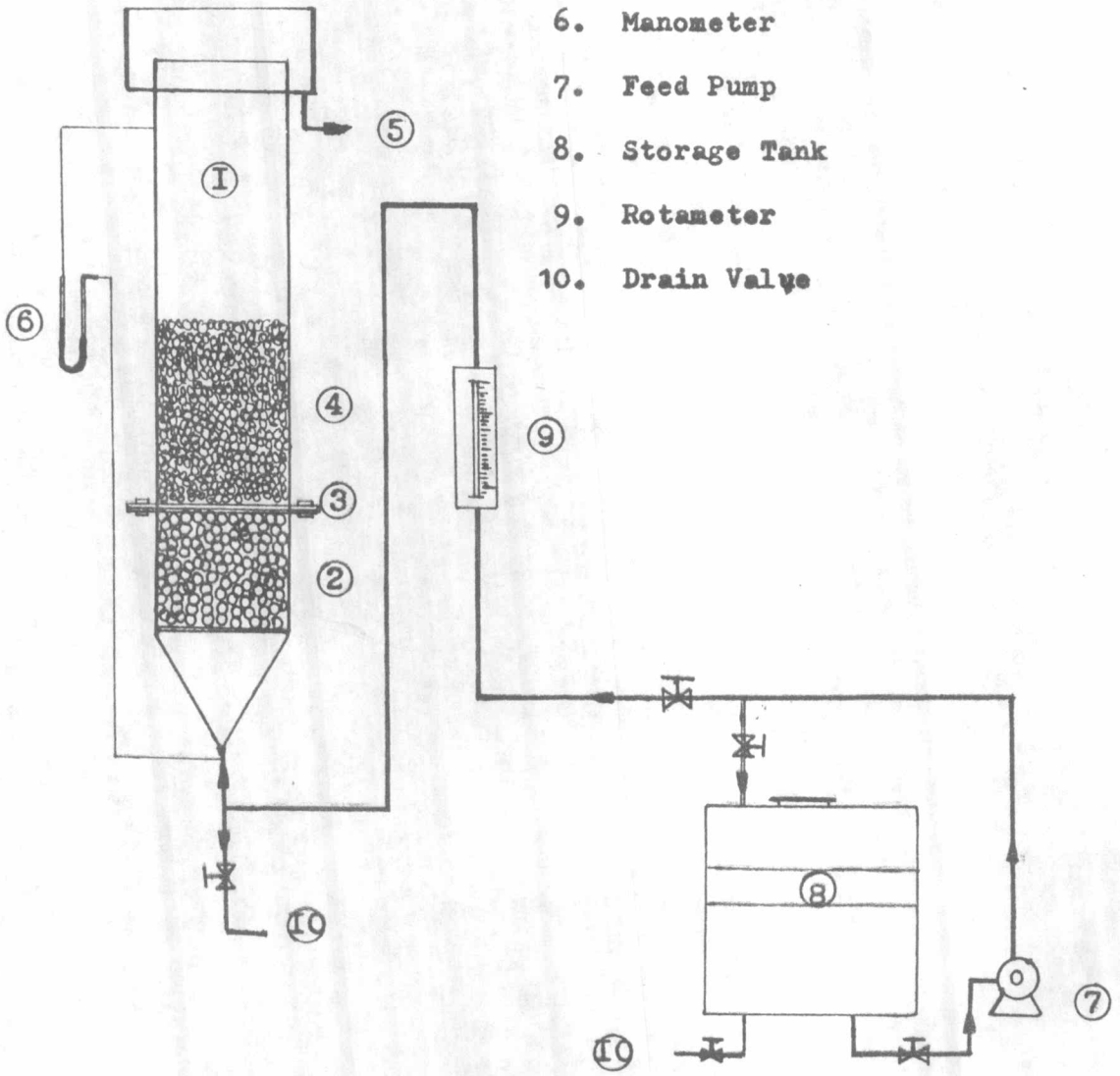

Fig. 3.2

Schematic Diagram of Adsorption Unit

6. Pump. It is used to transfer fluid from mixing tank to system. The ability for corrosive resistance to acid and base is required.

7. Storage tank. Storage tank is a stainless steel tank of 45.7 cm width by 45.7 cm depth and by 45.7 cm height. It is used to storage the fluid prepared for feeding to the system.

8. Rotameter. The rotameter is used to indicate fluid flow rate entering the adsorption unit. The meter has an attached scale of 10 divisions each divided into 10 subdivisions. The float is stainless steel.

3.2 Equilibrium Adsorption

The equilibrium adsorption was determined by using static method.

3.2.1 Equilibrium Adsorption of Formaldehyde

Each of 100 ml of formaldehyde with different concentration was prepared in 250 ml conical flask. About 2.0 gm of activated carbon was transfered into each flask then were shaken by shaking machine for 3 hours and left at 30°C for 24 and 48 hours. Formaldehyde remained in solution was determined by hydroxylamine hydrochloride method. The amount of formaldehyde adsorbed was calculated. The data and result were shown in Table A-1 and Fig A-1.

3.2.2 Equilibrium Adsorption of sodium Hydroxide

Each of 50 ml of sodium hydroxide with different concentra-

tion was prepared in 250 ml conical flask. About 20 gm of activated carbon was transfered into each flask and then were shaken by shaking machine for 3 hours and left at 30°C for 48 hours. The amount of NaOH remained in solution was determined by titrating with hydrochloric acid. The amount of NaOH adsorbed was evaluated. The data and result were illustrated in Table A-2 and Fig A-2.

3.2.3 Equilibrium Adsorption of Sodium Carbonate.

Each of 50 ml of sodium carbonate with different concentration was prepared in 250 ml conical flask. About 20 gm of activated carbon was transfered into each flask and then were shaken by shaking machine for 3 hours and left at 30°C for 48 hours. The amount of Na_2CO_3 remained in solution was determined by titrating the solution with hydrochloric acid. The amount of Na_2CO_3 adsorbed in each flask was determined. The data and result were illustrated in Table A-3 and Fig A-3.

3.2.4 Equilibrium Adsorption of Mixture of Sodium Hydroxide and Sodium Carbonate.

Each 50 ml of mixture of sodium hydroxide and sodium carbonate with different concentration was prepared in 250 ml conical flask. About 20 gm of activated carbon was transfered into the mixture and then were shaken by shaking machine for 3 hours and left and 30°C for 48 hours. The amount of NaOH and Na_2CO_3 remained in solutions were determined by Warder Method. The data and result were shown in Table A-4 and Fig A-4.

3.3 Preparation of Adsorbent

3.3.1 Sieve Analysis

The activated carbon used in the experiment was separated into 4 ranges of sizes to study the effect of particle size. The sieve covering the expected range of particle size were selected and nested together in order of diminishing openings with the coarse sieve on the top and the pan on the bottom. The weighed amount of activated carbon was transfered to the top sieve of the stack. The stack was covered and placed in the mechanical sieve shaker. The sample was shaken for 15 minutes. After shaking the quantity of sample retained on each sieve was kept separately for the experiment. The 4 sizes of activated carbon separated are shown in Table 3.1.

Table 3.1

No.	Average diameter (mm)
1	1.19
2	1.00
3	0.76
4	0.59

3.3.2 Soaking of Activated Carbon

Before using, activated carbon was boiled with distilled water for 5 minutes to eliminate air clogging which will be effect during adsorption.

3.4 Determination of Calibration Curve of Rotameter

The calibration curve was determined by varying the rate of fluid flowing through the meter. The flow rate was evaluated by measuring the volume of fluid collected in one minute. The corresponding meter reading from the attached scale for each flow rate was also read and recorded. The result was shown in Table A-5 and Fig A-5.

3.5 Determination of Minimum Velocity of Fluidization

The experiment was taken step by step as follow.

3.5.1 The relationship between superficial velocity of fluid as flowing through empty column and pressure drop was recorded.

3.5.2 The relationship between velocity of fluid flowing through column packed with 100 gm of activated carbon and pressure drop occuring from flowing of fluid through activated carbon and column was determined.

From 3.5.1 and 3.5.2 the pressure drop occuring from flowing of fluid through bed or through activated carbon at various velocities

could be calculated by

$$\triangle P_{bed} = \triangle P_{(3.5.2)} - \triangle P_{(3.5.1)}$$

The result were illustrated in Table A-6, and Fig A-6

The average minimum fluidizing velocity is 0.34 cm/sec.

3.6 The Effect of Variables on Adsorption

Effect of concentration, flow rate and particle size of adsorbent were studied for CH_2O, NaOH, Na_2CO_3 and mixture of NaOH and Na_2CO_3 as shown in Table 3.2, 3.3, 3.4, 3.5 respectively.

Table 3.2

Experimental Schedule of Adsorption of Formaldehyde

Exp. No.	m_c (gm)	C_o gm/litre	d_p (cm)	q (cm^3/min)
1	100.00	9.85	0.100	1,260
2	100.00	5.30	0.100	1,260
3	100.00	3.40	0.100	1,260
4	100.00	6.60	0.076	1,600
5	100.00	5.85	0.076	1,600
6	100.00	6.60	0.076	1,780
7	100.00	6.45	0.076	1.780
8	100.00	6.70	0.076	1,440
9	100.00	6.60	0.076	1,440
10	100.00	6.60	0.076	1,260
11	100.00	6.50	0.076	1,260
12	100.00	6.60	0.100	1,600
13	100.00	6.60	0.119	1,600
14	100.00	6.60	0.059	1,600
15	100.00	9.90	0.076	1,600
16	100.00	3.40	0.076	1,600
17	100.00	8.00	0.100	1,260

Table 3.3

Experimental Schedule of Adsorption of Sodium Hydroxide

Exp. No.	m_c (gm)	C_o (Molar)	d_p (cm)	q (cm^3/min)
1	100.03	0.1800	0.119	1,600
2	100.07	0.1800	0.100	1,600
3	99.97	0.1800	0.076	1,600
4	100.16	0.1800	0.059	1,600
5	100.22	0.2322	0.100	1,600
6	99.86	0.1849	0.100	1,600
7	100.26	0.1706	0.100	1,600
8	99.40	0.1449	0.100	1,600
9	99.92	0.1914	0.100	1,260
10	99.99	0.1914	0.100	1,440
11	100.11	0.1914	0.100	1,600
12	100 11	0.1914	0.100	1,960

Table 3.4

Experimental Schedule of Adsorption of Sodium Carbonate

Exp. No.	m_c (cm)	C_o (Molar)	d_p (cm)	q (cm^3/min)
1	100.00	0.1761	0.119	1,600
2	100.04	0.1761	0.100	1,600
3	100.04	0.1761	0.076	1,600
4	99.88	0.1761	0.059	1,600
5	100.25	0.0631	0.119	1,600
6	99.83	0.0691	0.119	1,600
7	100.16	0.0741	0.119	1,600
8	100.60	0.0175	0.119	1,600
9	99.96	0.1898	0.100	1,600
10	100.12	0.1909	0.100	1,600
11	99.91	0.1901	0.100	1,600
12	100.00	0.0500	0.100	1,600
13	99.91	0.1898	0.100	1,260
14	100.04	0.1898	0.100	1,440
15	99.96	0.1898	0.100	1,600
16	100.01	0.1898	0.100	1,960

Table 3.5

Experimental Schedule of Adsorption of Mixture of Sodium Hydroxide and Sodium Carbonate

Exp. No.	m_c (gm)	C_o (Molar)	d_p (cm)	q (cm^3/min)
1	100.31	0.10725	0.119	1,600
2	100.54	0.09503	0.119	1,600
3	100.02	0.07213	0.119	1,600
4	100.72	0.09503	0.119	1,440
5	100.21	0.09503	0.119	1,780
6	100.31	0.09503	0.100	1,600
7	100.05	0.09503	0.076	1,600