CHAPTER 4

EXPERIMENTS

4.1 Experiment for Prediction of Hydrochloric Acid Vaporization Rate.

Experiments for predict vaporization rate of hydrochloric acid are conducted to verify accuracy of assumption in mathematical model for predict vaporization rate from hydrochloric acid in hydrochloric acid storage tank of normal chemical plant, the storage tank is installed both at indoor and outdoor conditions depending on tank size and plant operation

4.1.1 Experimental Method

The experiment used hydrochloric acid product at concentration of 35% by weight which was normal product in industry. The experiment was separated into two cases; the experiment for outdoor vaporization and the experiment for indoor vaporization. The experiment was set using ten plastic bottles of hydrochloric acid which weight, concentration, temperature and surrounding temperature were measured before they were exposed to atmosphere.

Five bottles were exposed to the air at outdoor condition and others five bottles were exposed to the air at indoor condition. One bottle from outdoor condition exposure and one bottle from indoor condition exposure were taken at the end of the hour to measure their weight, concentration and temperature. The surrounding temperature was also measured for both outdoor and indoor.

4.1.2 Experimental Results

Experimental results are summarized in Table 4.1 for outdoor exposure and Table 4.2 for indoor exposure.

Table 4.1 Results of experiment to estimate vaporization rate from hydrochloric acid at outdoor condition.

Experiment to estimate vaporization rate from hydrochloric acid at outdoor condition.											
		Hydrochloric acid in sampling bottles									
		before exposure				after exposure				vaporization	
sample no.	exposure time (hour)	concentration (% by wt)	temperature (C)	weight (g)	surrounding temperature (C)	concentration (% by wt)	temperature (C)	weight (g)	surrounding temperature (C)	total vaporized (g)	vaporized rate (g/hour)
1	1	35	30	382.26	24	34.97	38	379.01	30	3.25	3.25
2	2	35.52	31	410.09	24	34.6	40	404.9	31	5.19	2.60
3	3	35.32	31	402.31	24	34.33	41	395.29	33	7.02	2.34
4	4	35.32	31	390.42	24	34.48	40	383.25	35	7.17	1.79
5	5	35	30	374.6	24	34.68	42	355.12	35	19.48	3.90
										average	2.77

Table 4.2 Results of experiment to estimate vaporization rate from hydrochloric acid at indoor condition.

Experiment to estimate vaporization rate from hydrochloric acid at indoor condition.											
sample no.	exposure time (hour)	Hydrochloric acid in sampling bottles									
		before exposure				after exposure				vaporization	
		concentration (% by wt)	temperature (C)	weight (g)	surrounding temperature (C)	concentration (% by wt)	temperature (C)	weight (g)	surrounding temperature (C)	total vaporized (g)	vaporized rate (g/hour)
1	1	35	30	399.68	24	34.8	30	396.82	30	2.86	2.86
2	2	35	30	364.32	24	34.92	31	361.71	31	2.61	1.31
3	3	35.2	30	390.85	24	34.56	33	387.08	33	3.77	1.26
4	4	35.4	30	399.99	24	34.45	34	396.08	35	3.91	0.98
5	5	35.4	30	368.77	24	34.43	34	363.65	35	5.12	1.02
										average	1.48

4.2 Experiment for Prediction of Composition in Vaporized Gas from Hydrochloric Acid.

Experiments for prediction of composition in vaporized gas from hydrochloric acid are conducted to verify accuracy of assumption in calculation for composition in vaporized gas from hydrochloric acid in hydrochloric acid storage tank.

4.2.1 Experimental Method

The experiment used hydrochloric acid product at concentration of 35% by weight which was normal product in industry. The experiment was separated into two cases; the experiment for outdoor vaporization and the experiment for indoor vaporization. The experiment was set using four plastic bottles of hydrochloric acid which weight, concentration, temperature and surrounding temperature were measured before they were exposed to atmosphere.

Two bottles were exposed to the air at outdoor condition and others two bottles were exposed to the air at indoor condition. One bottle from outdoor condition exposure and one bottle from indoor condition exposure were taken at the end of the hour to measure their weight and concentration.

4.2.2 Experimental Results

Experimental results are summarized in Table 4.3 for both outdoor exposure and indoor exposure.

Table 4.3 Results of experiment to estimate composition in vaporized gas from hydrochloric acid.

Experiment to estimate composition in vaporized gas from hydrochloric acid.											
		Hydrochloric acid in sampling bottles									
		before exposure		after exposure		gas vaporization rate				gas phase	
sample no.	exposure time (hour)	concentration (% by wt)	weight (g)	concentration (% by wt)	weight (g)	total vaporized (g)	vaporization rate (g/hour)	vaporization rate of HCl (g-mole/hr)	vaporization rate of H2O (g-mole/hr)	mole ratio of HCl	mole ratio of H2O
outdoor exposure											
1	1	35.52	307.98	35.41	306.31	1.67	1.67	0.03	0	1	0
2	2	35.66	349.52	35.51	345.64	3.88	1.94	0.05	0	1	0
indoor exposure						average	1.80	0.04	0	1	0
3	1	35.4	340.01	35.37	338.34	1.67	1.67	0.02	0	1	0
4	2	35.6	338.65	35.56	336.89	1.76	0.88	0.02	0	1	0
						average	1.28	0.02	0	1	0

4.3 Experiment on Existing Packed Absorber in Plant Site

4.3.1 Experimental method

The experiment are conducted on a plant site to verified program accuracy. The experimental results of existing packed absorber testing is used as program simulation input data. Hydrochloric acid storage tank is a surge tank which is use to store hydrochloric acid from production unit before it is transferred to product storage tank. The level of acid in the tank is controlled by automatic tank liquid level control to maintain liquid level in the tank at 60%. Hydrochloric vapor generated during store is vented through tank top nozzle to packed absorber. The absorber continuously operates and the absorbed water which flows through the column is discharged to sump. At normal operation, both hydrochloric acid concentration and temperature in the tank are almost constant, so that assumption that the amount of hydrochloric vaporized is constant and packed absorber is operated at steady-state on applied. Detail of packed absorber and storage tank are presented in Tables 4.4 and 4.5.

Table 4.4 Packed absorber in the experiment

Name	Packed absorber for a surge tank of hydrochloric synthesis unit		
Unit description Packed absorber to prevent hydrochloric vapor from hydrochloric acid product emitted to atmosphere, hydrochloric vapor is continuously absorbed by water.			
Equipment details			
	Packed column diameter=		0.204 m
	Packed column height	=	1.5 m
	Packing type	=	pall rings
	Packing size	=	5/8 inches
	Packing material	=	polypropylene

Table 4.5 Hydrochloric acid storage tank in the experiment.

Name	Hydrochloric acid surge tank for hydrochloric synthesis unit
Unit description	Hydrochloric acid surge tank used to store hydrochloric acid product from hydrochloric acid synthesis unit before transfer to product storage tank and internal process use.
Equipment details	Tank location : First floor of hydrochloric synthesis unit Tank material : Polyvinyl chloride reinforce with fiberglass Tank type : Horizontal cylinder tank Tank volume : 5 m^3 Estimated cross surface area of tank = 5 m^2 Estimated total surface area of tank = 16 m^2 Average hydrochloric acid temperature = 43.3 $^{\circ}C$ Average surrounding temperature = 32 $^{\circ}C$

The scheme of experiment is shown in Figure 4.1. The experiment was commenced by fixing flow rate of the absorbed water to the absorbed by beginning at 0.05 m^3/h (flow rate is indicated at water flow meter). The experiment was taken 10 minute to system stable after water flow rate is adjusted. Experimental results were measured hydrochloric acid concentration and temperature of hydrochloric acid in storage tank, hydrochloric vapor emitted to the atmosphere, vented vapor temperature, outlet water temperature, hydrochloric dissolved in outlet water, vented gas velocity and actual water flow rate.

Water flow rate is increased at about 0.05 to 0.1 m^3/h per experimental step and experimental results are measured as previously described in every experimental steps until flow rate was equal 0.5 m^3/h.

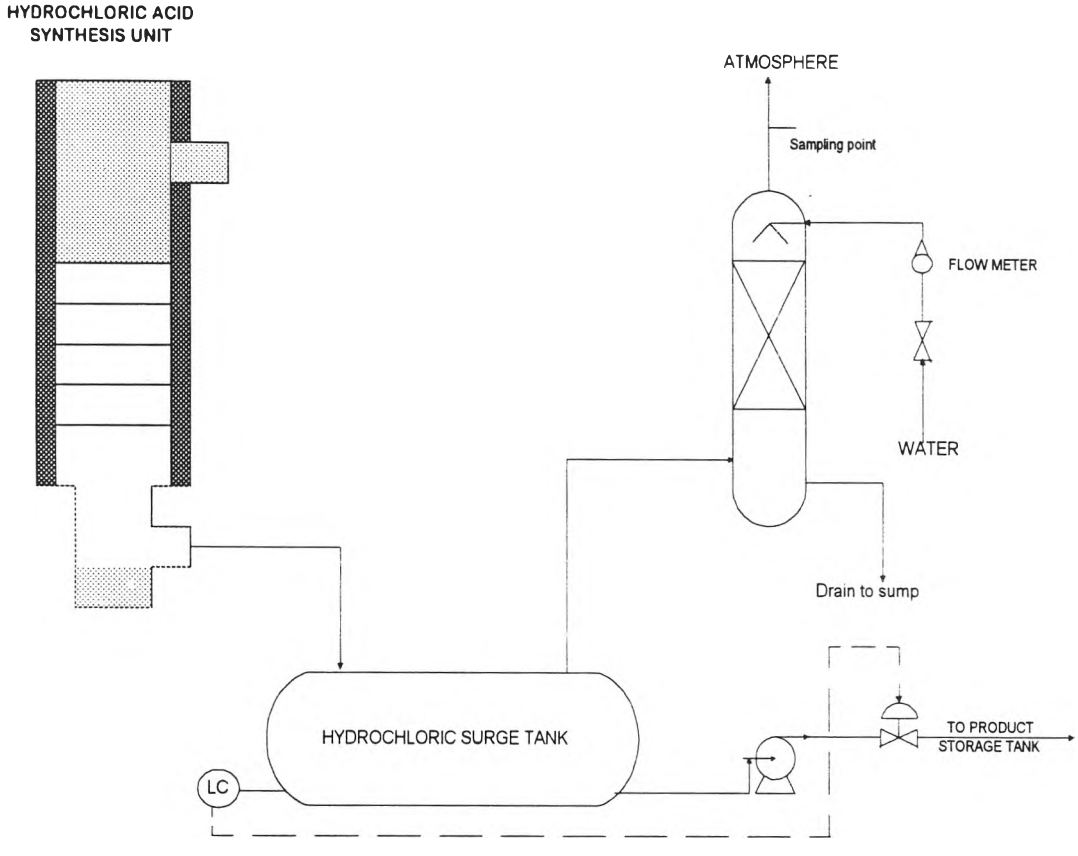

Figure 4.1 Scheme of the experiment on the existing packed absorber in plant site

4.3.2 Experimental Results

Experimental results are presented in Table 4.6.

Table 4.6 Experimental results on existing packed absorber

For hydrochloric solution storage tank packed absorber

Packed column height 1.5m, diameter .204m, packing type 5/8 inches polypropylene pall rings.

Experiment data 18 march 1998, 1.30-4.00 p.m. Ambient temperature = 32-33 C

hydrochloric solution		**Absorbed water**						**vent gas**		
Solution in tank		flow	inlet	outlet	inlet	outlet	hydrochloric in	Temperature	hydro-chloric	Velocity
temperature (C)	concen-tration (%wt)	rate (m^3/h)	temperature (C)	temperature (C)	pH	pH	outlet water (%wt)	(C)	compo-sition (mg/m^3)	(m/s)
34.5	35	0.035	35	40.5	7.6	0.7	1.75	32	0	<0.01
34	35.3	0.07	35	39	7.4	1	0.87	31	0	<0.01
33	35.2	0.089	35	40	7.3	1.9	0.96	29.5	0	<0.01
34	35.2	0.125	35	39	7.6	1.6	0.22	30.5	0	<0.01
34	35.4	0.143	35	39	7.5	0.9	0.85	32	0	<0.01
34	35.2	0.218	35	35.5	6.8	1.3	0.41	30.5	0	<0.01
34	35.4	0.324	35	36	7.2	1.7	0.14	28	0	<0.01
33.5	35.3	0.502	35.5	36	7	1.7	0.16	30.5	0	<0.01