CHAPTER 3
MATERIALS AND METHODS

3.1 Experimental setup

The diagram of the experimental setup is shown in Fig. 3.1. This contactor consists of a cylindrical vessel, 14.4 cm inside diameter and 150 cm in height, and a 100 cm high concentric draft tube. There are 4 available sizes of draft tube diameters: 3.4, 7.4, 8.4, 9.4 cm. The draft tube is located 10 cm above the base of the contactor. The gas is dispersed by a porous sparger installed in the middle of the cylindrical vessel. The gas flow rate is regulated in the range from 0 to 20 cm/s by a calibrated rotameter. The experiment is gas-liquid system which water and sea water are used as the liquid phase and air as the gas phase. During the experiment, water or sea water is pumped into the column until the liquid level is 3 cm above the draft tube, Air is then supplied into the system and the system is left running for a certain period of time to ensure a steady state operation.

3.2 Experiment

3.2.1 Experimental Methods

The determinations of overall volumetric mass transfer coefficient and hydrodynamic parameters can be achieved via experiments as detailed below:

(a) <u>The measurement of an overall volumetric oxygen transfer coefficient</u>

1. Set equipment as Fig. 3.1 and use DO meter (Jenway, model: 9300) to monitor a time profile of DO concentration.
2. Fill liquid at defined level over draft tube
3. Remove dissolved oxygen by purging nitrogen into column
4. Read dissolved oxygen in liquid phase
5. When DO reaches zero, turn off nitrogen valve and turn on air at pre-defined flow rate
6. Monitor %DO until it reaches 100%
7. Collect data and calculate k_la *(See Eq. (3.1) in Sect. 3.2.2)*

8. Repeat Steps 3 to 7 by varying air flow rate from 0 to 20 cm/s
9. Repeat Steps 3 to 8 by changing liquid phase from water to sea water (15, 30, 45 ppt)
10. Repeat Steps 3 to 9, vary A_d/A_r from 1.2 to 1.79 , 2.61 and 16.5

(b) The measurement of liquid velocity

1. Set equipment as Figure 3.1, use injection tracer
2. Define the distance for the tracer in draft tube and in the annulus
3. Turn on air valve at a definite flow rate
4. Measure the time required for the color to travel between the two defined distances
5. Collect data and calculate liquid velocity *(See Eqs. (3.2) and (3.3) in Sect. 3.2.2)*
6. Repeat Steps 2 to 5 by varying gas flow rate from 0 to 20 cm/s
7. Repeat Steps 2 to 6 by changing liquid phase from water to sea water (15, 30, 45 ppt)
8. Repeat Steps 2 to 7 by varying A_d/A_r from 1.2 to 1.79 , 2.61 and 16.5

(c) The measurement of gas holdup

1. Set equipment as Figure 3.1, use manometer
2. Monitor the liquid phase level before and after the aeration in the outer column to calculate overall gas holdup *(See Eq. (3.7) in Sect. 3.2.2)*
3. Use manometer to measure pressure difference in downcomer
4. Calculate gas holdup in downcomer *(See Eq. (3.12) in Sect. 3.2.2)*
5. Calculate gas holdup in riser *(See Eq. (3.18) in Sect. 3.2.2)*
6. Repeat Steps 2 to 4 by varying air flow rate from 0 to 20 cm/s
7. Repeat Steps 2 to 5 by changing liquid phase from water to sea water (15, 30, 45 ppt)
8. Repeat step 2 to 6 by varying A_d/A_r from 1.2 to 1.79 , 2.61 and 16.5

The gas holdup is a volumetric gas fraction in each section. The overall gas holdup is determined by using a volume expansion technique, and is measured from the difference between the ungassed and gassed liquid level.

Firstly,
$$\varepsilon_o = \frac{V_{gT}}{V_{gT} + V_{lT}} \tag{3.4}$$

$$\varepsilon_o = \frac{\varepsilon_o (A_d + A_r) H_D}{\varepsilon_o (A_d + A_r) H_D + (A_d + A_r) H_L} \tag{3.5}$$

$$\varepsilon_o (\varepsilon_o H_D + H_L) = \varepsilon_o H_D \tag{3.6}$$

Finally,
$$\varepsilon_o = \frac{H_D - H_L}{H_D} \tag{3.7}$$

where ε_o : overall gas holdup

H_D : dispersed liquid height (cm)

H_L : liquid height (cm)

The downcomer gas holdup is estimated by measuring the pressure difference between two measuring ports of the column. Neglecting the wall friction loss and $\rho_L >> \rho_G$, the gas holdup can be deduced from :

Firstly,
$$\Delta P = \Delta Z_{\text{monometer}} \tag{3.8}$$

$$(\rho_L \varepsilon_L + \rho_G \varepsilon_G) g \Delta H = \rho_L g \Delta Z \tag{3.9}$$

$$\varepsilon_L = \frac{\rho_L g \Delta Z}{\rho_L g \Delta H} \tag{3.10}$$

$$1 - \varepsilon_G = \frac{\rho_L g \Delta Z}{\rho_L g \Delta H} \tag{3.11}$$

Finally, $$\varepsilon_d = 1 - \frac{\Delta P}{\rho_L g \Delta H} \tag{3.12}$$

where ρ_G : density of gas

ρ_L : density of liquid

ΔP : pressure difference of defined liquid level

ΔZ : distance of liquid level in manometer

ΔH : distance of liquid level

The riser gas holdup is calculated from following equation:

Firstly, $$\varepsilon_r = \frac{V_{gr}}{V_{gr} + V_{lr}} \tag{3.13}$$

$$\varepsilon_r = \frac{V_{gT} - V_{gd}}{V_{gT} - V_{gd} + V_{lT} - V_{ld}} \tag{3.14}$$

$$\varepsilon_r = \frac{\varepsilon_o V_T - \varepsilon_d V_d}{V_T - V_d} \tag{3.15}$$

$$\varepsilon_r = \frac{\varepsilon_o - \varepsilon_d (V_d / V_T)}{1 - (V_d / V_T)} \tag{3.16}$$

$$\varepsilon_r = \frac{\varepsilon_o - \varepsilon_d [A_d h / (A_d + A_r) h]}{1 - [A_d h / (A_d + A_r) h]} \tag{3.17}$$

Finally, $$\varepsilon_r = \varepsilon_o + (A_d / A_r)(\varepsilon_o - \varepsilon_d) \tag{3.18}$$

Where ε_o : overall gas hold up

ε_r : gas holdup in riser

ε_o : gas holdup in downcomer

A_d / A_r : ratio between cross sectional area of downcomer to riser

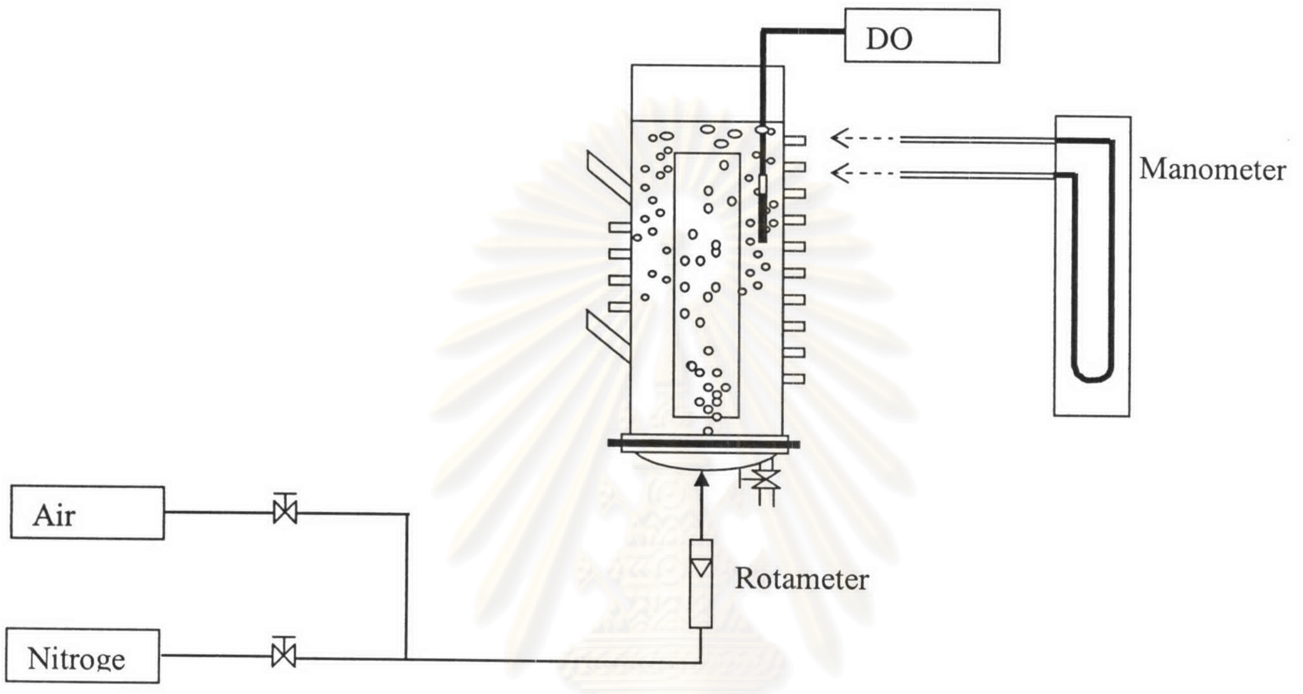

Figure 3.1 Experimental setup of the internal loop airlift contactor

Table 3.1 Dimension of draft tube employed in this work

No.	D_o (cm)	D_i (cm)	A_d/A_r*
Draft tube 1	4	3.4	16.55
Draft tube 2	8	7.4	2.61
Draft tube 3	9	8.4	1.79
Draft tube 4	10	9.4	1.21

D_o : Outer diameter of draft tube (cm), Di : Inner diameter of draft tube (cm), A_d/A_r : Ratio between cross sectional areas of downcomer to riser

* Outer diameter of the airlift column is 15 cm and inner diameter is 14.4 cm.