CHAPTER 4

EXPERIMENTAL SETUP AND PROCEDURE

Chapter 4

Experimental Setup and Procedure

This chapter deals with the apparatus used and experimental technique, it includes also the materials, the variables studied and the range within which these variables are investigated.

In this work the experiments are divided into two categories: studying the gas hold-up in air-water-sand slurry bubble column and studying the liquid phase, axial mixing characteristics for the same column.

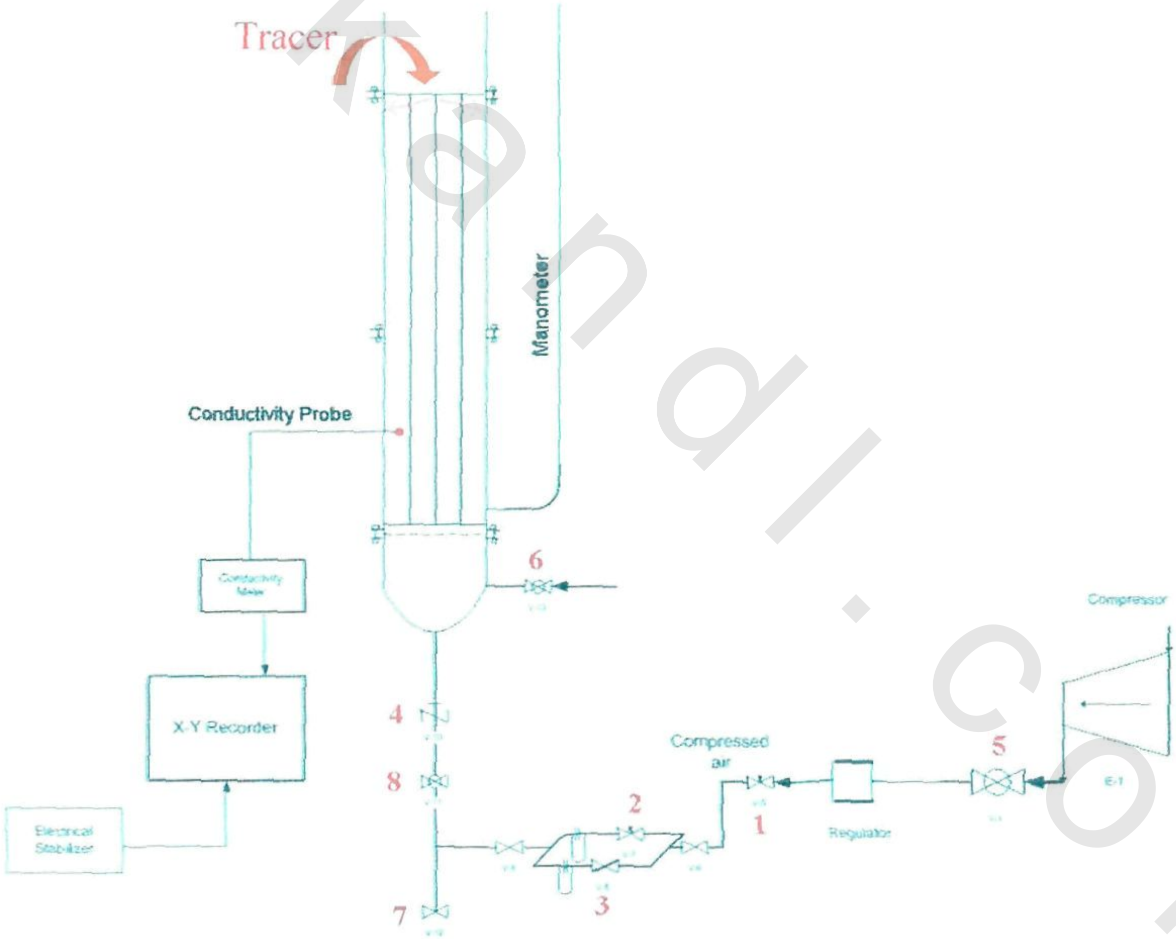
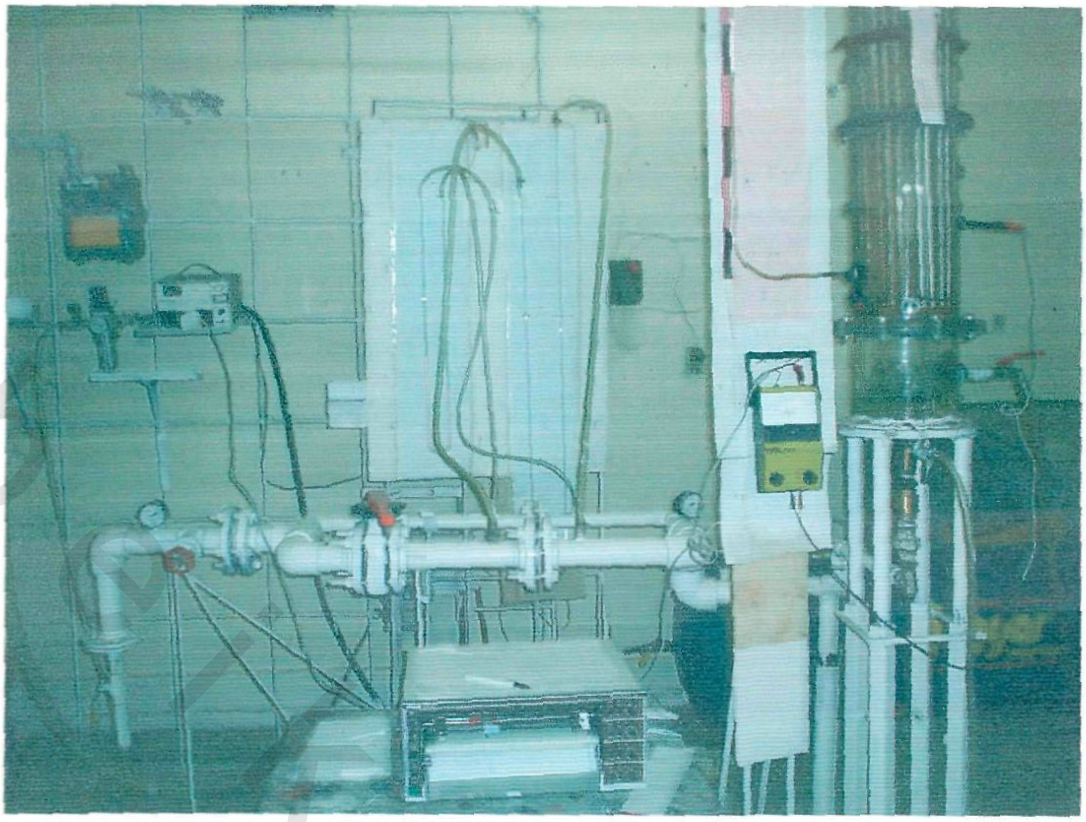


Figure (4-1): Experimental Setup



Photos of the Experimental System

4-1-Experimental Setup

The experimental setup is schematically shown in figure *(4-1)*.
All the experiments were performed at about atmospheric pressure. The experimental set up was designed for batch operation, i.e. there was no flow for the liquid phase. Air was used as the gas phase, water as the liquid phase, and sand particles of 0.5 mm diameter as the solid phase.

The set up mainly consists of a bubble column of 0.2 m diameter and 1.2m height made of Plexiglas. This column is divided into three parts connected to each other by flanges.

1) The entrance section: This is the bottom part of the column, in the center of which air is admitted through a stainless steel sparger. The bottom is fitted with a side connection to fill the column with water at the start of each experiment and drain it at the end.

Between the first and second part of the column, a fine stainless steel net (120 hole/cm^2) is placed between the flanges which achieves two goals, firstly it acts as a support for the sand particles bed, secondly it acts as a distributor to uniformly distribute the air flow to the column experimental section.

To prevent the falling of water from the column, a non return valve was fitted on the entrance of the bottom part.

2) The middle section: This is the main experimental section. Its length is 0.8 m, it has two side holes, one of them is located immediately above the bed support and is connected to a glass manometer for pressure drop measurements, the other is used for fitting the conductivity probe inside the column. This part contains a number of aluminum tubes of 1.1cm diameter vertically mounted using a supporting plate at the top, and extend downwards very close to the bed support.

A graduated millimeter marking tape glued to the outside walls of the column is used to measure the dispersion height.

3) The top section: This is where air bubbles disengage from the main bed. Also in this section the tracer is injected in the column center through a perforated distributor to ensure uniform distribution close to the expended bed top.

Gas was introduced at the bottom of the column. The experiments were carried out at various gas velocities, carefully regulated and controlled by using set of valves.

4-2-Auxiliary Equipments and Measuring Devices

❖Air Compressor

The used compressor is El- Haggar compressor, model HAF 500/680. Its head type N80, volume of the tank is 500 Liter, displacement 680 L/min, motor power is 7.5 cv/hp, maximum pressure is 10/12 bar, Rpm 1200, it has 2 cylinders and 2 stages, its weight is 200 kg, and its dimensions 196*60*116 (L*W*H).

❖Air Regulator

To adjust the pressure inside the tubes and to prevent any increase in the pressure and to filter out any condensed liquid to protect the system. The used regulator was (CAMOZZI).

❖Two Air Lines

1" and 2" diameter PVC pipe lines used to allow for small and high compressed air flow rates to be introduced to the column. Each line is fitted with a calibrated orifice and a manometer. The first orifice meter covers superficial velocity range of compressed air from 0cm/sec to 15cm/sec, and the second is calibrated to measure the superficial air velocity up to 30 cm/sec.

❖Valves

1) Needle valve connected to the air regulator.
2) Needle valve to adjust flow of air in the 1" diameter pipeline.
3) Butterfly valve to adjust flow of air in the 2" diameter pipeline.
4) Non return valve connected to the entrance tube at the bottom of the column to allow air to be introduced to the column and prevent reverse flow of water, air, or sand.
5) Non-return valve connected to the compressor.
6) Ball valve at the bottom of entrance section to introduce tap water and also to drain water off the column.
7) Ball valve on the air outlet.
8) Ball valve to introduce air to the column.

❖ Manometers (Water Manometers)

1) Manometer connected to 1" air line across the small orifice meter.
2) Manometer connected to 2" air line across the large orifice meter.
3) Manometer connected at the bed support to measure the pressure drop across the bed height.

❖Conductivity Cell and Meter

The used conductivity cell and meter are (Walden Precision Apparatus WPA). The cell (conductivity probe) was used to measure the tracer concentration at a fixed point inside the bed.

❖X-Y Recorder

The used recorder is (W+W electronic AG Basel). It was used to record the residence time distribution of a pulse tracer input as a function of time as measured by conductivity meter.

❖Stabilizer

The used stabilizer is (FRIEND). It was used to stabilize the voltage input to the x-y recorder because it was very sensitive to any voltage changes

4-3-Experimental Method

The main objective is to study the influence of particle concentration and the effect of internal cooling tubes on the hydrodynamics of Slurry bubble column reactors operating in homogeneous and heterogeneous flow regimes. Experiments were carried out in 20cm diameter and 120cm height column in presence of tubes fixed vertically, using tap water as the liquid phase , compressed air as the gas phase and sand particles (0.5 mm) as the solid phase.

Experiments were performed at:

a) Different superficial velocities 1,2,.....15 cm/sec.

b) Different solid concentration 0%, 1%, 2%, 3% and 4% by volume

c) Different number of cooling tubes 0, 13, 24, 35, 46 and 57

Table *(4-1)* illustrates the set of experiments performed.

The Procedure of Experiment

1. Fill the column with water to a certain height.
2. Weight the suitable amount of solid practical according to the suitable fraction 1% or 2% or 3% or 4%. Based on the volume of liquid inside the column.
3. Feed the column with the calculated amount of solid.
4. Adjust the height of water in column and the height of water in manometer connected to the column [H_B & H_m].
5. Open the outlet line of compressed air. Valve (7)
6. Open the valve (5) of compressed air slowly and carefully and notice the air regulator, until we reach to the suitable pressure.
7. Adjust the flow rate of air using needle valve (1) connected to the regulator and notice the height of water in the manometer connected to the air line.

8. Shut the valve (7) of outlet line of air to drive the compressed air toward the bottom of the column.
9. Adjust the required velocity of air using the needle valve (1).
10. Observe the change in height in the level of water in the manometer connected to the column and the expanded bed H_m & H_B, wait an ample time until reaching steady state, then, record H_m & H_B.
11. Gas holdup is calculated by using the simple static fluid mechanics as described in Chapter-3 (Theoretical Background).

Mixing experiments were started immediately after taking the necessary readings for the estimation of gas hold up. The conductivity meter was turned on as well as the x-y recorder. After ensuring steady state readings of the x-y recorder, a tracer pulse was introduced near the bed top layer. A mark on the x-y recorder chart was drawn indicating zero time.

The Tracer concentration measured by the conductivity cell and recorded by the x-y recorder was carefully observed. When the x-y recorder showed steady state again, this signifies the end of the experiment. The recorded data were analyzed for the calculation of the liquid phase axial mixing coefficient as described in Chapter-3 (Theoretical Background).