Chapter 2
Experimental

2.1 Apparatus and Set-ups

Figure 2.1 shows the experimental apparatus and set-up for gas–liquid bubbling system with single orifice [1–2].

The experiments were conducted in a Plexiglas column with an inner diameter of 0.07 m and a height of 1.55 m. Nitrogen was employed as the gas phase. Distilled water was used as the liquid phase and its temperature is typical about 302 K. The gas bubbles were injected consecutively into the bubble column with a static liquid height of 0.80 m through a horizontal orifice with a diameter of 1.2 mm, at the bottom and in the center of the column. The pressure signal near the orifice was measured relative to atmosphere with a high accuracy pressure transducer (IC-Sensor, 1220-2psid). The response time of this pressure transducer was about 10^{-5} s. The transducer probe was placed typically about 0.01 m above the orifice and 0.01 m away from the axis of symmetry of the bubble column. The bubbling process was the type of constant flow rate. The gas flow rate was set by a mass flow controller.

The experimental equipment and setup for the gas–liquid multi-orifice bubbling system is similar to that of the single orifice [1, 3]. Tap water and air were used as the liquid and gas phases, respectively. The superficial gas velocity was varied over the range of 0.177–9.929 cm/s. The superficial liquid velocity was zero, and the static liquid height was 0.88 m. The time series of pressure fluctuations were measured relative to atmosphere. The sensor probe was placed in the axial center of the column at an axial position of 0.49 m from the distributor of the bubble columns.

2.2 Data Acquisition

For the system of single-orifice gas–liquid bubbling, digitized time series of pressure fluctuations of more than 10 s were recorded with a sample frequency of 3,000 Hz when the operation of the bubble column was in a steady state. A typical

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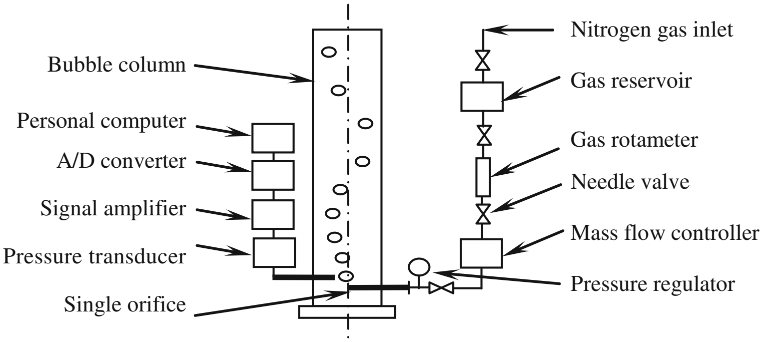

Fig. 2.1 Experimental apparatus and set-up of single-orifice bubbling system

sample size was 32,768 points. The data were logged into a personal computer via a signal amplifier and an A/D converter with 12-bit resolution and accuracy better than 99.97 % [1].

The pressure signals measured from the multiphase systems are subject to noise, especially for the gas–liquid bubble columns. The non-linear analysis is very sensitive to the noise of the signals. In gas–solid fluidized beds, the signals are transmitted to the probes by the suspension of particles in gas phase, and can be dampened considerably. However, in gas–liquid bubble columns, near all the pressure fluctuations can be transmitted very well to the pressure probes by the liquid phase. The noise can significantly increase the correlation dimension. Hence, some measures must be taken to reduce the noise even though the issue of noise reduction is still a worldwide challenge. In this work, the signals were filtered off-line with a frequency of 60 Hz by using a low-pass algorithm to reduce low amplitude, high frequency noise, and at the same time to ensure that the spectra of interest of the hydrodynamic signal were still captured. This treatment of noise reduction is similar to that of most studies on the chaos analysis of signals in a gas–liquid bubble column [4].

For the system of multi-orifice gas–liquid bubbling, a total of 32,768 data points were acquired for each pressure signal at a sample frequency of 300 Hz. Other data treatments are the same as those of the system of single-orifice gas–liquid bubbling.

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