Study on phase volume fraction of gas-liquid two-phase flow detection technology based on four groups of near-infrared detection device

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Abstract. In this paper, a measurement system with the near infrared spectrum technique is introduced. The experimental pipeline is designed for the stainless steel pipe which can reduce the interference of external light and have the four groups of measuring device. While the data are collected by high frequency data acquisition card to achieve the purpose of simultaneous measurement of four sets of probes with different flow patterns and different positions.

Introduction

The two phase flow exists widely in the fields of oil industry, petrochemical industry , pipeline transport and so on, so the study on the two phase flow is of far-reaching significance[1], many scholars pay attention on it and provide many methods about it[2,4]. In the gas-liquid two phase flow, gas and water have their own characteristic absorption peak. Under the specific wavelength, the gas-liquid two phase flow patterns can be distinguished well.

The dynamics experiments of bubbly flow, stratified flow and annular flow were made on the horizontal pipe. Compare the voltage value and the initial value of the steady state to get the ratio. The flow pattern can be distinguished by the characteristics of the different ratio.

Experiment principle

Near infrared light is a kind of between the visible(VIS) and infrared(IR) between the electromagnetic wave and the wavelength range from 780nm to 2526nm. The principle of near infrared can be used to measure the flow phase holdup is according to the absorption laws of the Lambert-Beer. Because of the difference between the absorption coefficient of the glass and water in the near infrared light, it can be very good to distinguish the gas-liquid two phase at a specific wavelength.

In order to determine the absorption of organic glass, water and air in the near infrared band, based on the experiment that Qinghua Lu[5] has carried on to the liquid water and the organic glass in the near infrared spectrometer the paper used the laser diode of 980nm to detect the flow status.

Measurement set-up

The design of experimental device for stainless steel tube section to replace the glass pipe section on the basis of the existing equipment in the laboratory, which can effectively overcome the interference of the external light, weaken the light irradiation intensity, thus ensuring the tightness of measurement. Meanwhile, the four sets of detecting devices are installed on the stainless steel pipe to ensure the coaxial. The system diagram of the detecting device is shown in Fig.1. The experimental installation diagram in horizontal direction shown in Fig.2.

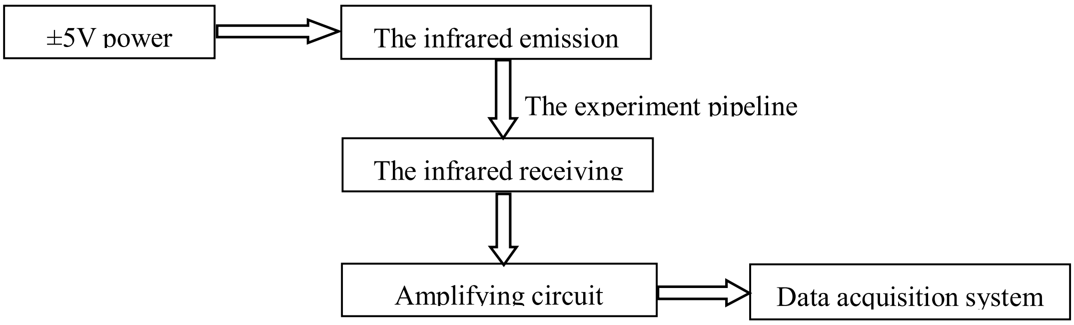


Fig.1. Block diagram of experimental system

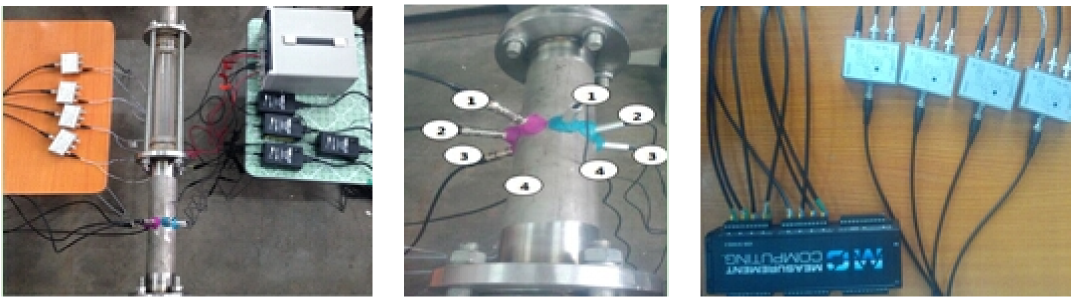
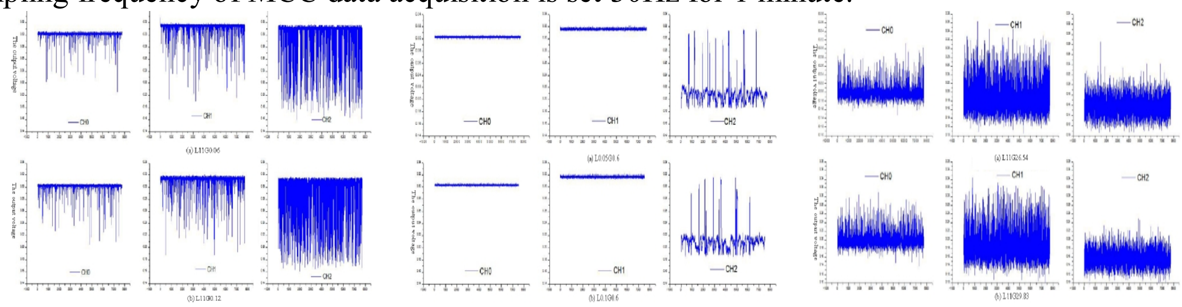


Fig.2. Experimental installation diagram

Measurement results

The experiment is carried out in the laboratory of multiphase flow in Hebei University and the sampling frequency of MCC data acquisition is set 30Hz for 1 minute.

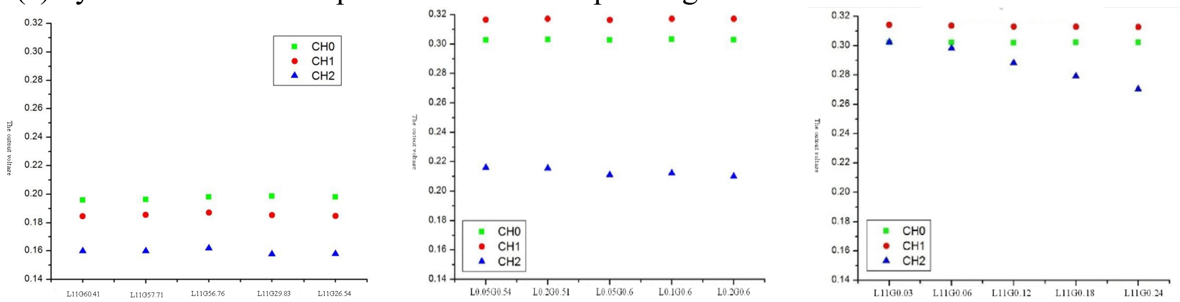


(a) the bubbly flow (b) the stratified flow (c) the annular flow

Fig.3. The time domain graph of the flow patterns

The data acquisition of the typical operating point under different flow patterns is acquired and the time domain graph of the flow patterns is shown in Fig.3.

The voltage value of CH0 and CH1 is relatively stable and the CH2 channel is most obvious that can be seen from the time domain graph of bubbly flow. With the increase of gas volume flow, the voltage fluctuations become increasingly intense. The mean value of the three channels voltage is analyzed as shown in Fig.4(a) by means of the flow pattern of the corresponding bubbly flow. While the voltage value of CH0 and CH1 is stable and the CH2 channel appear peak value occasionally. With the increase of the volume of the liquid, the fluctuation of the voltage is decreased. The mean value of the three channels voltage is analyzed as shown in Fig.4(b) by means of the flow pattern of the corresponding stratified flow. It can be concluded from the time domain of the annular flow that the voltage of the three channels is more obvious and the rate of the voltage value is increased fastest.The mean value of the three channels voltage is analyzed as shown in Fig.4(c) by means of the flow pattern of the corresponding annular flow.



(a) the bubbly flow (b) the stratified flow (c) the annular flow

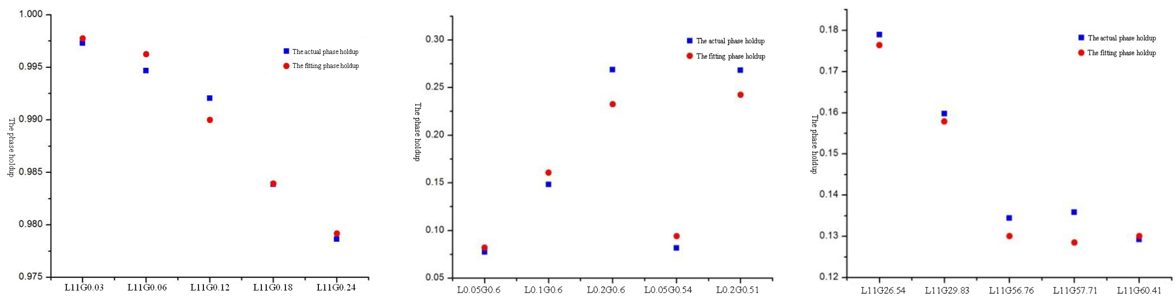
Fig.4. The mean graph of the flow patterns

The actual phase holdup of the three flow patterns in the horizontal direction can be calculated by the Eq.1. The fitting formula can be obtained which is used to calculate the fitting phase by fitting the three channels respectively. The relative error can be calculated with Eq.2 when compared the fitting value with the actual value calculated by the working conditions. The distribution maps of actual value and fitting value are shown in Fig.5.The relative error of the three flow patterns is shown in Fig.6.

$$b_l = \frac{Q_l}{Q_l + \frac{(101.3+P_g)\times Q_g \times (273.2+T_b)}{(273.2+T_l)\times(101.3+P_b)}} \times 100\% \quad (1)$$

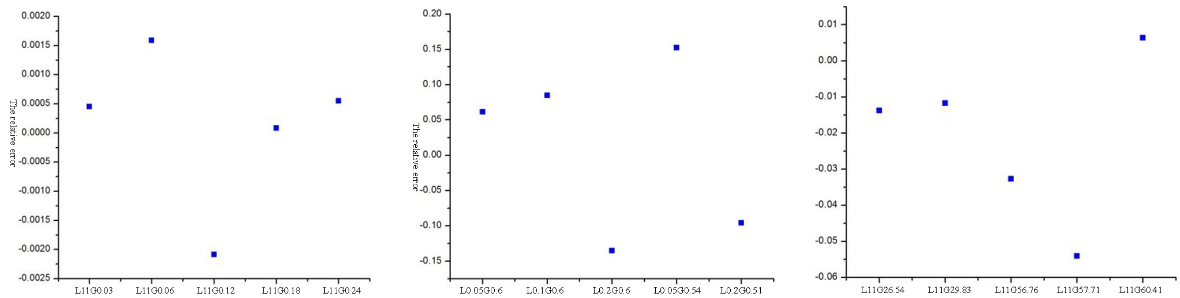
Where b_l is the liquid volume fraction, Q_l is the liquid volume flow, Q_g is the gas volume flow, T_b is the background temperature, T_l is liquid temperature, P_g is the gas pressure and P_b is the background temperature.

$$s_i = \frac{x_i - a}{a} \times 100\% \quad (2)$$



(a) the bubbly flow (b) the stratified flow (c) the annular flow

Fig.5. The distribution maps of actual value and fitting value



(a) the bubbly flow (b) the stratified flow (c) the annular flow

Fig.6. The relative error of the three flow patterns

Concluding remarks

The flow patterns can be distinguished by the radio of the output voltage values under the different conditions and positions and the value of the voltage when the pipe is full of gas. In the horizontal direction, the phase holdup of three flow patterns were fitted. The maximum error of the bubbly flow is ±0.25%, the stratified flow is ±18% and the annular flow is ±6%.

Acknowledgments

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