Ultrasonic Measurement of Water Layer Thickness by Flow Pattern Profile in a Horizontal Air Water Loop

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1. Introduction

Ultrasonic methods have the advantage, compared to other water layer thickness measurement techniques, of applicability to large volume objects, since most radiation techniques are limited by the thickness of the pipe & plate walls [1-4]. The ultrasonic experiment was performed to do an analysis for cooling performance in a complete test channel by the investigation of the two-phase flow that develops in an inclined gap with heating from the top [5]. This ultrasonic technique for measuring water layer thickness measurement employ the higher relative acoustic impedance of air with respect to that of liquids. By this method it is possible to determine both liquid water distance, void fraction in a gas-liquid two-phase flow. Instantaneous measurement of the water layer thickness is useful in understanding heat and mass transfer characteristics in a two-phase separated flow. An ultrasonic measurement technique for determining water layer thickness in the wavy and slug flow regime of horizontal tube flow has been produced.

2 Experiment

2.1 Ultrasonic Measurement System

Figure 1 shows a schematic of the present ultrasonic measurement system. The main components are an ultrasonic transducer, pulser-receiver, digitizer, application software, and a function generator. The ultrasonic transducer is pulsed, sending out an ultrasonic wave.

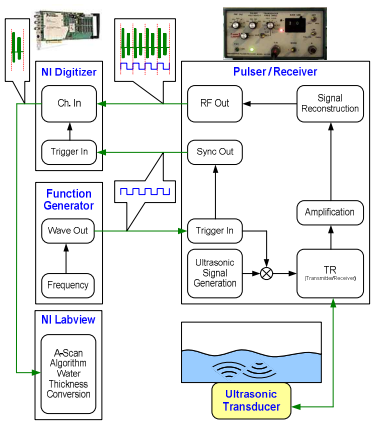

Fig. 1. Ultrasonic measurement system

2.2 Methods of Water Layer Thickness Calculation

The water layer is sounded by a pulse-periodic signal. During the intervals between the sounding pulses, the ultrasonic converter automatically switched to the echo signal receiving mode. Figure 2 shows an example of echo signals observed on the monitor in the course of the test.

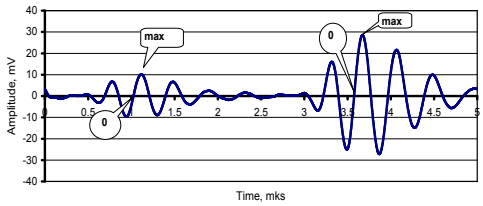

Fig. 2. Echo signals observed in the test

For calculation of the water layer thickness, peak detection and computation of the thickness based on water properties were used. In the A-scan (data from the digitizer), the first echo is from the front (or bottom) surface of the water layer, and the second echo is from the rear (or top) surface of the water layer. Using this information, the water layer thickness can be simply calculated by multiplying the speed of sound through the water layer with the time of flight.

2.3 Experimental Facility

The HAWL (Horizontal Air-Water Loop) facility is located at the KAERI (Korea Atomic Energy Research Institute), Korea. The HAWL is a test facility to investigate the horizontal air-water flow characteristics. A schematic diagram of HAWL is prepared to test. It consists of two circular channels whose inner diameters are 80 and 130 mm. The length-to-diameter ratios of the 80 and 130mm channels are 184 and 99, respectively. The test channels are made of 10 mm thickness transparent acryl pipes. Air and water injected into the test section through an inlet reservoir and the air and water injection velocity were measured by a vortex flow meter.

3. Test parameters and test results and Horizontal flow pattern profile

3.1 Influence of Ultrasonic Transducer Frequency

To investigate the influence of ultrasonic transducer frequency, water layer thickness was measured using three different ultrasonic transducers with frequencies of 5, 10 and 20 MHz. The data acquisition frequency of the 5, 10 and 20 MHz transducer was 10, 20 and 50 MHz, respectively. Figure 3~5 shows the A-scan graph obtained from the three different ultrasonic transducers directly coupled to a water layer. In the A-scan graph, the first echo is from the bottom surface of the water layer, and the second echo is from the top surface of the water layer. The water layer thickness can be calculated by distance between first and second echo. As shown in Figure 3~5, higher the ultrasonic transducer frequency results in a lower measurable water layer thickness.

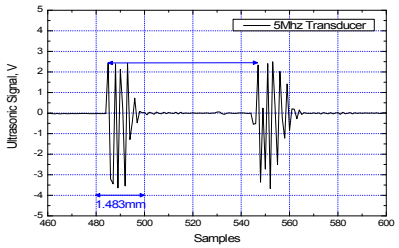

Fig. 3. A-Scan Graph using a 5 MHz Ultrasonic Transducer

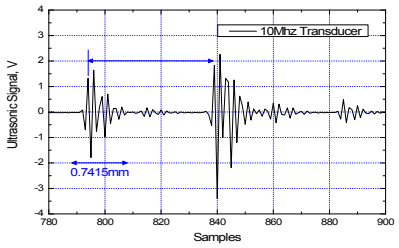

Fig. 4. A-Scan Graph using a 10 MHz Ultrasonic Transducer

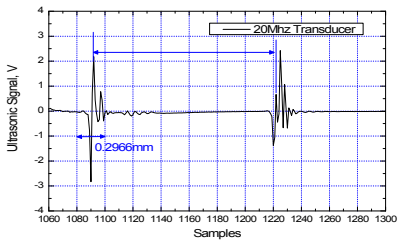

Fig. 5. A-Scan Graph using a 20 MHz Ultrasonic Transducer

3.2 Measurement of Water Layer Thickness

The water layer thickness of horizontal flow was measured using 0.5 inch round type ultrasonic transducer with frequency of 5 Mhz. The pulse repetition frequency (PRF) of the pulser-receiver was 80 Hz and data acquisition frequency of the digitizer was 10 MHz. The ultrasonic transducer was mounted at the outer bottom surface of the pipe. The water layer thickness was measured at 11000 mm down stream from the water inlet. All experiments were done at atmospheric pressure and at 10±1℃. The experimental variables were air injection velocity and water injection velocity. The experiments were conducted at 0.2 degree to the horizontal with 80 mm diameter pipe.

4. Conclusion

The ultrasonic measurement system was established for the measurement of water layer thickness in a KAERI Horizontal Air Water Loop. To investigate the influence of ultrasonic transducer frequency, the water layer thickness was measured using three different ultrasonic transducers. These results show that a higher ultrasonic transducer frequency results in a less measureable water layer thickness. By using ultrasonic measurement system water layer thickness of horizontal flow was measured. The ultrasonic measurement technique successfully measured the water layer thickness of horizontal wavy and slug flow.

ACKNOWLEDGMENTS

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