A Two-Dimensional Void Profile Measurement in DYNAS having a 2D Slab Test Section

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1. Introduction

Multi-dimensional two-phase phenomena occur in many industrial applications, especially in nuclear reactors during steady operations or postulated transient conditions which are sometimes considered to significantly affect reactor safety. In order to validate a newly developed computational safety analysis code, SPACE, a two-dimensional two-phase flow test was performed with a test section having slab geometry with a dimension of 1.43m X 1.43m X 0.11m which is named "DYNAS". Various kinds of two-dimensional flows are simulated with a selection of inlet and outlet nozzles. The major measured parameters are the two-dimensional void fraction profile in the slab type test section as well as thermal hydraulic boundary conditions. The void fraction was converted from the impedance measured between two electrodes on the inner surfaces of slab acryl plates. Experiments were performed at 130kPa of pressure and 35oC of temperature based on the flow outlet conditions. Various flow rates of water and air were set in order to take data representing the dynamic multi-dimensional two-phase movement. For each selected inlet and outlet nozzle combination, the water flow had from 2 to 20 kg/s and the air flowrate was from 2.0 to 20 g/s.

2. Experiments

2.1 Test Facilities

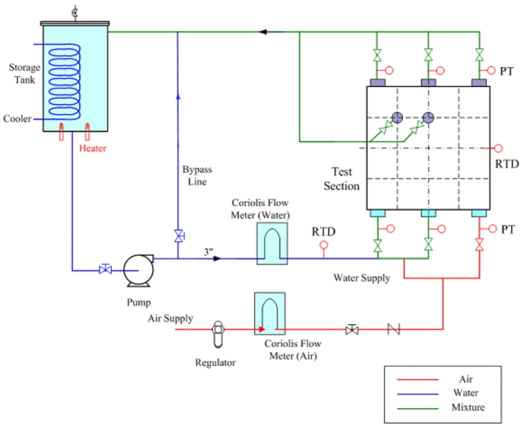


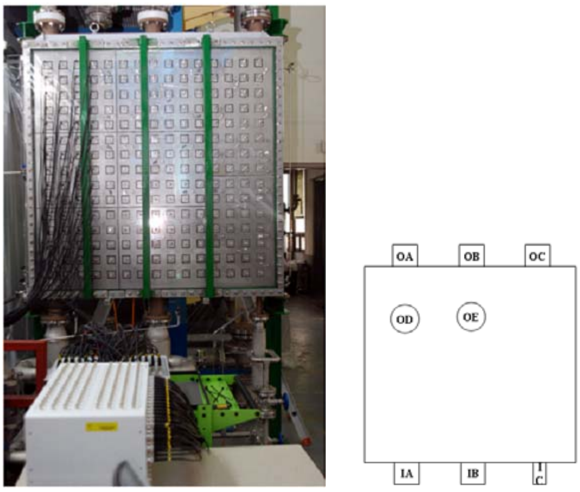
Fig. 1. Schamatics of Test Facilities

Figure 1 shows a schematic of the test facility. The test facility consists of a test section, water and air supply systems, a pump and a storage tank including temperature control devices. Air is supplied from the compressor which is maintained at 6 gage bars. The system water temperature is controlled by a cooler and heater imbedded in the storage tank which is installed at the top elevation of the facility. The test section has a dimension of 1.43m X 1.43m X 0.11m based on the internal fluid volume. In order to reduce the wall shear effect induced by a large slug, two transparent acrylic plates were installed with a gap dimension of 0.11 m which corresponds to the maximum stable bubble size at the atmospheric pressure condition. Each acrylic plate has a 60mm thickness. Support bars were installed on both faces of the acrylic plates to prevent inflation induced by the hydrostatic head of water. A steel frame was designed to support the weight of the fluid and acrylic structure. The test section has three inlet nozzles and five outlet nozzles. All the nozzles have a size of 3" except for the air inlet nozzle which is connected only to the air supply line. Through the other two inlet nozzles, single-phase water or s two-phase mixture flow can be supplied. Three out nozzles were installed on the top face of the steel structure while two outlet nozzles were installed on the face of an acrylic plate. The nozzle corresponds to the broken cold leg. By selecting a combination of inlet and outlet nozzles, various kinds of multi-dimensional flow behavior can be simulated. Figure 2 shows a photograph of the test section and components at the inlet and outlet of it including the instrumentation.

2.2 Instrumentation

Several kinds of commercially available instruments were installed in order to measure the boundary conditions. A mass flow rate of injected water is measured by a 3" Micromotion mass flow meter that is installed at the water supply line. The estimated uncertainty for a measured mass flow is 0.1% of its read value. A 1" Micromotion mass flow meter is used to measure air flow at the air supply line of which the accuracy is 0.5%. The system pressure is measured at the top and bottom of the test section by two SMART-type PTs (pressure transmitter). The estimated uncertainty of each PT reading is 0.065% of full scale. To measure the temperature of the fluid, two RTDs are installed at the water supply line and at the side of the test section, respectively. A Watrow class A 3-wire standard plug type of 0.25" RTD was used. The uncertainty of the RTD was expected to be 0.2 ^{o}C at 35 ^{o}C of the operation condition.

The local void fractions in the test section were obtained by measuring the impedance between two electrodes installed at each inside surface facing each other. The current test section has 15X15 electrode pairs each of which has a 4cm X 4 cm dimension. Each measured impedance value was normalized based on the impedance of water at the same water flow and temperature. A calibration of the void fraction with the measured impedance was performed at a separated test loop. The signal conditioner has 64 channels and a performance of 100 Hz sampling speed per channel. In order to apply the signal conditioner for 225 electrodes of the test section, a switching block was developed. The 225 channels were divided into 4 groups and 100 seconds data were taken for each group of channels.



(a) (b)

Fig. 2. Photograph of Test Facilities including instrumentation and definition of inlet and outlet nozzles

3. Results

Figure 2(b) shows a definition of the inlet and outlet nozzles. Figure 4 and Figure 5 show the measurement results of void fractions for BB01-I and AC04-I cases, the boundary conditions of which were summarized in Table I.

Table I: Boundary conditions

Case	Value	M_f (kg/s)	M_g (g/s)	TF (°C)	P_{out} (kPa)
BB01-I	Average	4.00	1.97	35.1	125.5
	STD	0.1	0.09	0.09	0.8
AC04-I	Average	20.0	20.6	34.9	128.7
	STD	0.06	0.22	0.02	0.05

3. Conclusions

. To identify and generate experimental data for the two-dimensional two-phase flow, an experiment was performed with a large scale of slab geometry. With a varied selection of combinations of inlet and outlet nozzles of the test section, various multi-dimensional two-phase flows were measured by using an impedance measurement system which was specially developed in KAERI. The test results were very plausible with a consideration of a visualization test. The experimental data will be utilized to validate and develop many thermal hydraulic models related to the momentum equation.

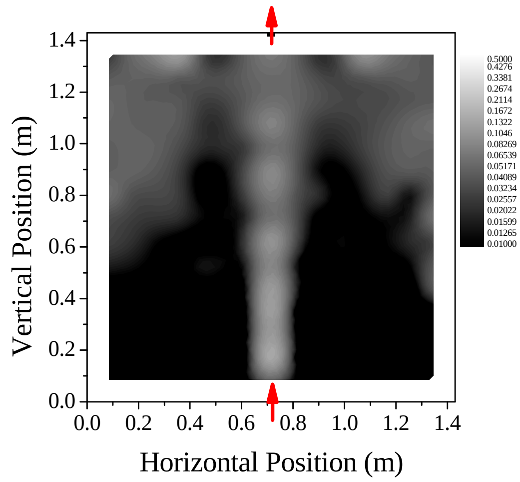


Fig. 3. Void Profile for BB01-I

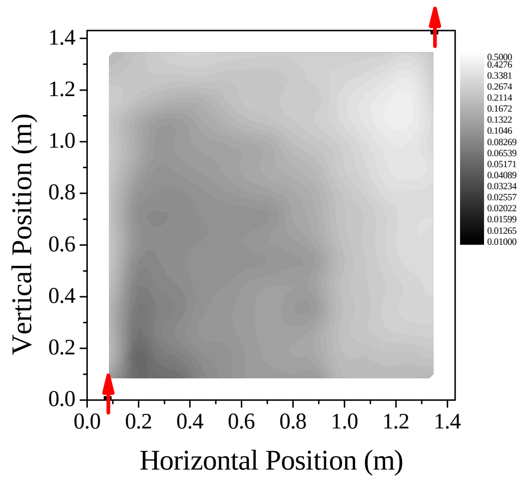


Fig. 4. Void Profile for AC04-I

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