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# Design of the Test Rig for Experimental Study on Flow Dynamics of Air-Water Bubbly Flow in a Bundle Array

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## 1. Introduction

Understanding of the two-phase flow structure in a subchannel is extremely important in a view point of the safety analysis in nuclear power plants. The basic characteristic of bubble behavior in a two-phase flow is clarified by two parameters such as void fraction and interfacial area concentration. The other important parameter of liquid behavior is a velocity profile. Up to now, extensive analytical and experimental studies have been performed on basic flow channels such as round tube and annulus. But studies on subchannels were very limited because of the geometrical complexity. Recently, experimental studies on a rod bundle have been published. Yun et. al.[1] have been presented the interfacial flow structure of subcooled water boiling flow in a subchannel of a 3x3 rod bundle. Paranjape et. al.[2] have been obtained a flow regime maps for an adiabatic air-water two-phase flow through a flow channel with 8x8 rod bundle. It is insufficient to understand the detailed flow structure in bundle geometry because of the coarse data. One effort has been performed to provide the full profile of the bubble distribution in a subchannel by using a two-sensor optical probe.[3] Various bubble distributions have been disclosed in a subchannel as changing the bubble diameters and the void fraction. For the development of the useful model of source terms in the interfacial area transport equations in such bundle geometry, additional data would be required in different positions along the axial flow direction.

This paper suggests an experimental study of the simultaneous measurement method of void fractions in a subchannel at multi-positions along the axial direction of the bundle.

## 2. Design of the Experimental Facility

### 2.1 Test Facility

The experimental loop (MATiS-V) consists of a water storage tank (0.9 $m^3$) with a heater and a cooler, a circulation pump (2 $m^3$/min max.) and a test rig which includes a 1.427 m long 4x4 rod bundle. This facility has been designed to perform various internal flow experiments in atmospheric conditions. Fig. 1 shows a schematic of the test facility and the dimensions of a rod bundle cross section. A 3x3 nozzle-type air/water injection unit was installed at the inlet of the rod bundle.

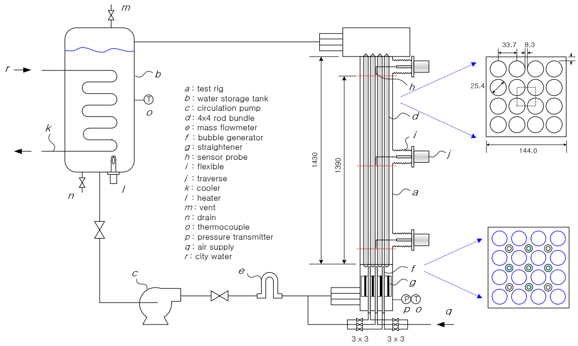
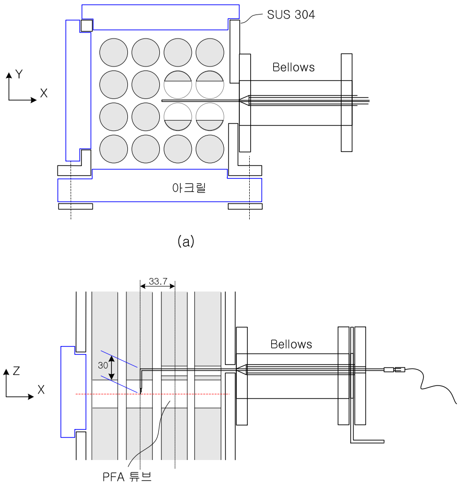


Fig. 1 Schematic of the test facility (MATiS-V)

### 2.2 Test Rig

The test rig consists of a 1.427 m long vertical flow channel with square cross section having sides of length 144 mm. It contains a 4x4 array of 16 stainless steel tubes each having a diameter of 25.4 mm arranged at a pitch distance of 33.7 mm. These dimensions are 2.6 times larger than the real PWR rod bundle size. Measurement resolutions are highly improved with this enlarged rod bundle. Three measurement locations were selected along the main flow direction in a test rig from the inlet of the bundle as shown in Fig. 1. The distances of each measurement section are 158, 726 and 1,377 mm from the inlet of the bundle, respectively.



(a)

(b)

Fig. 2 Conceptual design of the sensor probe installation in a rod bundle array

For the measurement of flow properties (void fraction, flow velocity) in a subchannel at the above distances from the bundle inlet, the sensor probes are inserted from the side wall of the square channel. Fig. 2

shows the conceptual design of the sensor probe installation at the measurement section in a rod bundle array. This approach solves the problem of the occurrence of dead zone at which the sensor probe can not reach because of the intervention of rod walls. Fig.2 (a) shows the top view of the sensor probe insertion in a rod bundle array. Four rods were partly cut for moving a sensor probe at both sides in a center subchannel. Fig. 2 (b) also presents the slit cut of the rods. The sensor probes are connected to the outside with the bellows which provides the flexibility. Thus, the full measurement in a subchannel is possible in this way. Another important thing is the alignment of the sensor probe. For monitoring the exact location of the sensor tip in a subchannel, special transparent material (PFA) which has almost same refraction index with water is adopted as sixteen rods in a short range at each measurement section. So, the sensor probes can be aligned visually through the transparent rods and the view windows at three sides of the square channel.

## 3. Measurements

Fig. 3 shows one example of the coordinates of measurement locations in a full subchannel.

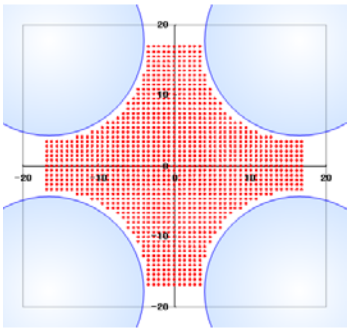


Fig. 3 Coordinate of the measurement locations

Two-sensor conductance probe is considered to measure the bubble properties such as void fraction and bubble velocity. The measurements of flow properties are conducted simultaneously at three sections in a rod bundle array. For this purpose, the unified automatic traversing system is designed and installed at the test rig as shown in Fig. 4. Fig. 5 shows the logic diagram of the flow measurement and the traverse control during the experiment.

## 4. Conclusions

Improved experimental method has been suggested in related to the study of two-phase flow in rod bundle geometry. It has a capability of full measurement in a subchannel with high resolution as the same with earlier study [3]. In addition, this method provides the measurement capability at arbitrary section of the rod bundle (three positions in this study). It is expected that the data set from this later experimental work would contribute to develop the model of source terms in the interfacial area transport equations.

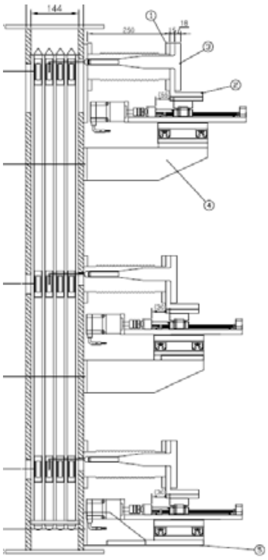


Fig. 4 Unified traversing system installed at the test rig

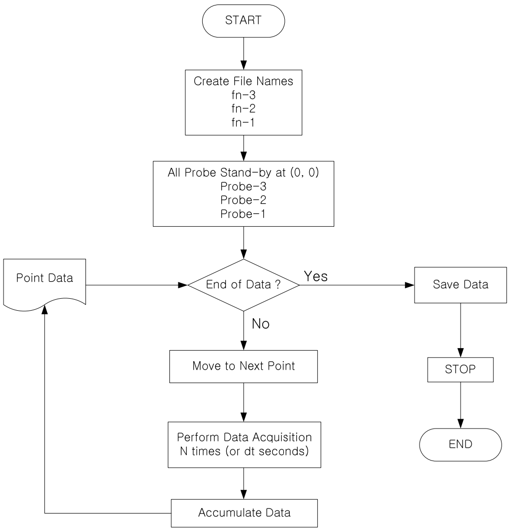


Fig. 5 Logic diagram of the measurement and the control

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