# Measurement of Void Fraction in the Horizontal Jet Pool Scrubbing Regime by Using Optical Fiber Probe

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## 1. Introduction

- **In case of SGTR accident**
  Coolant water might be injected in the secondary side of a steam generator to prevent fission products release into environment, usually aerosol type fission products. The aerosol concentration before and after passing the pool has been estimated in case of a submerged jet pool scrubbing.
- **Study Topic :** Void fraction in the horizontal jet pool scrubbing regime
- **Purpose :** To Introduce the method of measuring void fraction in the regime by using optical fiber probe (OFP) and discuss the experimental results.

## 2. Method

### 2.1 Experimental Setup

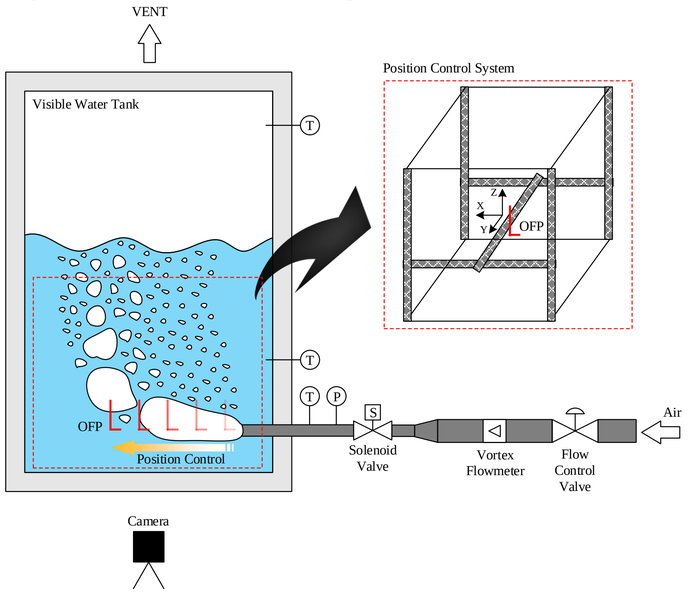


**Fig. 1. Schematic diagram of the jet pool scrubbing experiment facility**

- ✓ It consists of visible water tank, visualization system, air injection system, position control system, OFP, and data acquisition system.
- ✓ The cuboid water tank(1 m×1 m×2 m) has three sides of polycarbonate windows to visualize the jet pool scrubbing by using cameras and LED lamps.
- ✓ Air is injected through submerged horizontal nozzle. By using a vortex flow meter and a control valve, it is possible to control the flow rate of air.
- ✓ The position control system is constructed to shift point measuring equipment accurately without water drainage. The system has three hand wheels and three position indicators outside of water tank. These wheels and indicators take charge of X-direction, Y-direction, and Z-direction, respectively.
- ✓ OFP is based on measuring the light reflection from a tip of an optical fiber. Because of the difference in refractive indexes between gas and liquid, the amount of reflected light is either large or small depending on which phase surrounds the tip. This optical signal is converted into analog voltage output signal by a photodetector.
- ✓ To withstand the air jet flow, OFP is inserted into 1/8” sus tube except the tip and bonded by epoxy.

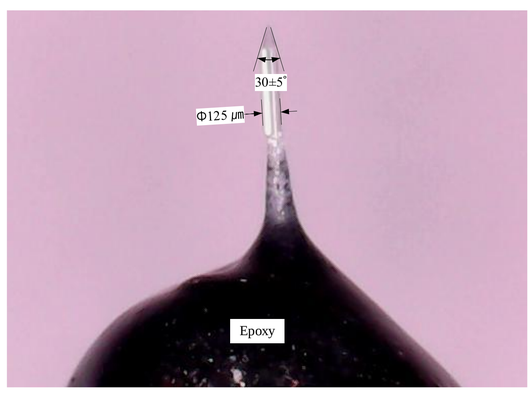


**Fig. 2. The tip of OFP used for present experiment**

### 2.2 Experiment Conditions & Methods

**Table 1: Experiment Thermal hydraulic Conditions**

| Water level $(m)$ | Water temp. (℃) | Nozzle i.d. $(mm)$ | Air mass flow $(kg/s)$ | Air Inlet Press. $(bar\ a)$ | Air temp. (℃) |
|---|---|---|---|---|---|
| 1 | 24 | 16.56 | 0.089 | 2.4 | 34 |

- ✓ Starting at 9 mm in the X-direction from the center of the nozzle tip, OFP is located every 20 mm intervals in the X-direction.
- ✓ The OFP signal is saved at 5 kHz sampling rate for 10 seconds in every case.

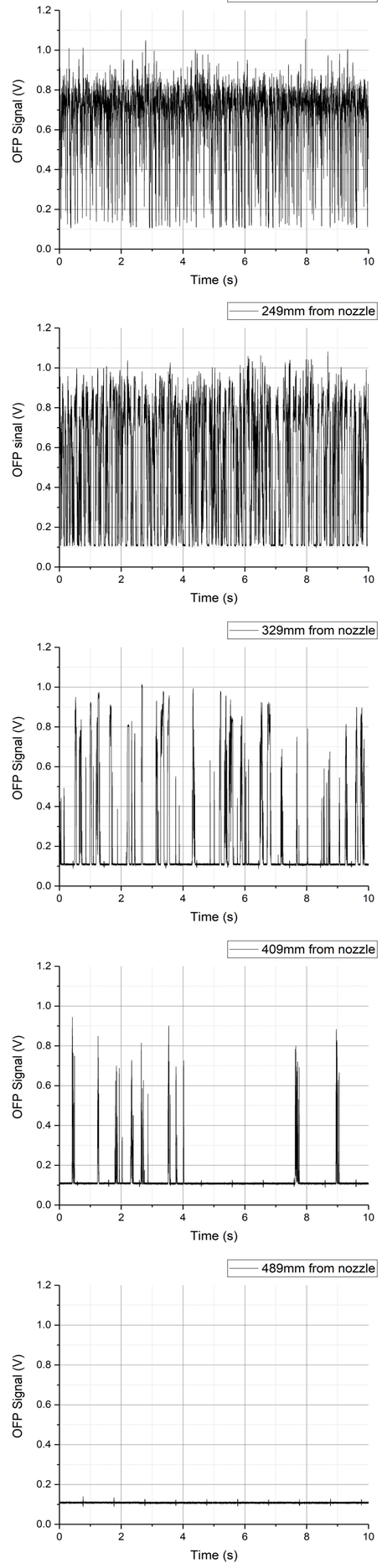


**Fig. 3. The OFP signal by position**

## 3. Results

- ✓ When the OFP is located at 9 mm from nozzle, the signal has average 0.6 V and relatively small amplitude. It means that the surroundings of the OFP is almost air.
- ✓ However, increasing the distance between nozzle and OFP, signal drops were found more frequently. It means that the fraction of water become bigger in the surroundings of OFP. Although the OFP is in the air jet bubble region as shown by Fig. 4, there would be very tiny water droplets.
- ✓ At 489 mm from nozzle, the signal became average 0.1 V and has small amplitude again. This is because the OFP is located totally out of the air jet’s reach.

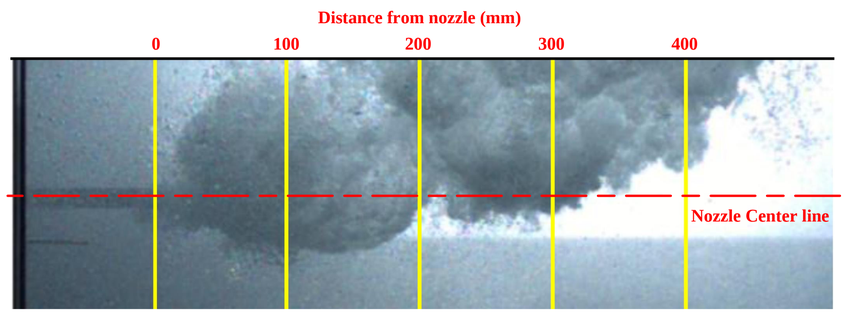


**Fig. 4. The camera images of jet pool scrubbing**

- ✓ Typically, local void fraction is calculated as the ratio of the cumulated bubble residence times on the probe tip over the total measurement time.
- ✓ However, it is hard to apply the method since local minimum points and local maximum points of the OFP signal are not a constant level. It seems because, in the jet pool scrubbing regime, there would be too tiny droplets and bubbles to measure those compared with the size of the probe tip.
- ✓ In this paper, standard deviation is used in order to find void fraction. If there is only one-phase, standard deviation would approach 0 V. On the contrary, as void fraction becomes closer to 50 %, it would have greater value.
- ✓ Therefore, on the left side of the maximum point, it could be thought that the fraction of air would be higher than that of water. On the right side, it would be the opposite.
- ✓ However, additional studies are needed to present quantitative calculation result of local void fraction and validation of this method.

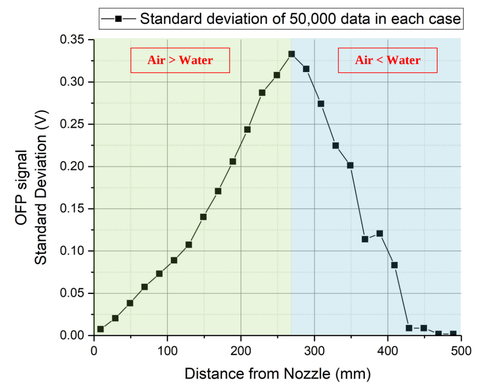


**Fig. 5. Standard deviation of OFP signal by position**

## 4. Conclusions

- ✓ KAERI has carried out various experiments to figure out the aerosol decontamination mechanism in the jet pool scrubbing regime.
- ✓ As part of the study, OFP is used to measure local void fraction. In the OFP signal processing, this paper introduces the new method using standard deviation since it is difficult to apply the previous method.
- ✓ If the new method is validated through additional studies, it is expected that the map of void fraction in the jet pool scrubbing regime would be obtained in three dimensions and it contributes to development and validation of the modeling about the regime.