Introduction of High Speed Jet Pool Scrubbing Test Facilities

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1. Introduction

After Fukushima accident, countries around the world are tightening regulations to ensure the ability to coping with severe accidents not only for upgraded light-water reactors but also for nuclear power plants that are already in operation. In Korea, nuclear safety act on severe accident were enacted in June 2016 [1]. An accident management plan, including a severe accidents, was submitted for all operational nuclear power plants in Korea. If water is injected into the secondary side of the steam generator in an external water injection state, which is one of the accident management strategies, there is a possibility that pool scrubbing will occur at high speed in the event of a stream generator tube rupture. At this time, accurately evaluating the amount of fission products removed through high speed pool scrubbing is essential to establish the direction of future accident management strategies in the future. In the case of high speed jet pool scrubbing model, there has been less active research around the world [2]. Therefore, experimental facilities to develop a high speed jet pool scrubbing model was established in the study.

2. Experimental Facility

2.1 Visible Water Tank

Figure 1. visible water tank

Figure 1 shows the overall visible water tank. The visible water tank has the size of 1 m x 1 m x 2 m. In order to withstand hydraulic pressure and protect from corrosion, the frame is made with stainless-steel frame. It has three sides of polycarbonate windows to visualize the jet pool scrubbing by using cameras and led lamps. There are nine flanges on one side, which are used for installation of instruments such as pressure gauges, thermometers, and differential pressure gauges, and for installation of position control system and air supply piping. The tank has ports at the top and bottom for water supply and drainage.

2.2 Visualization System

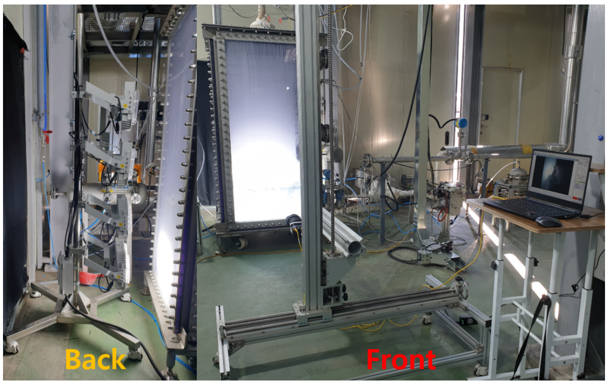

Figure 2. visualization system

Figure 2 shows the overall visualization system. We construct a visualization facility to observe the shape of the jet against velocity. The system consists of a high-speed camera, a light, a diffuser, a control laptop, and a transport device. The diffuser used polycarbonate material to create uniform lighting conditions.

2.3 Air Injection System

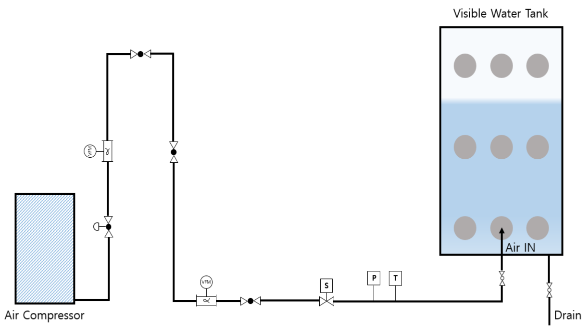

Figure 3. schematic diagram air injection system

Figure 3 shows a schematic diagram of the air injection system. Air is injected through submerged horizontal nozzle, which has outer diameter of 1/2 inch. By using a vortex flow meter and a control valve, it is possible to control the flow rate of air. Instruments are installed to measure air pressure and temperature in the pipes.

2.4 Position Control System

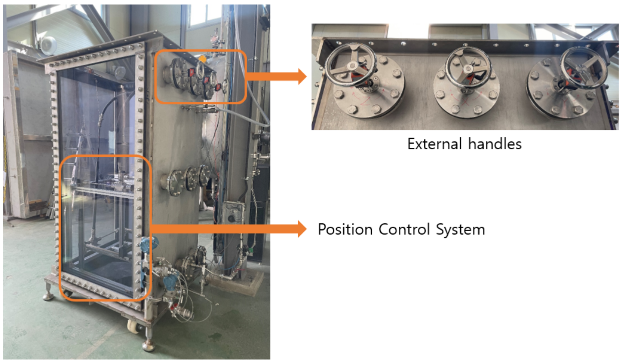

Figure 4. position control system

Figure 4 shows the overall position control system. It is possible to shift a point measuring equipment accurately using the system, such as optical fiber probe(OFP) or pitot tube, without water leakage. It is designed to allow movement to the X,Y, and Z axes through external handles. The indicators are also installed, so accurate movement is possible.

2.5 Void Fraction & Jet Velocity Measurement system

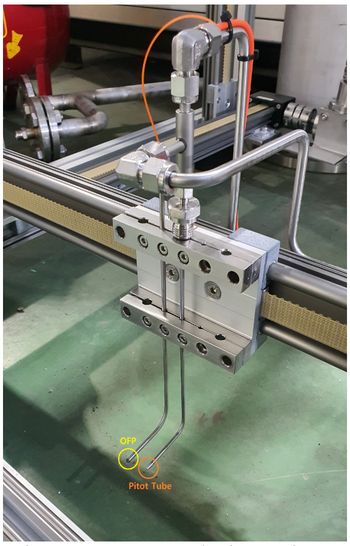

Figure 5. OFP and Pitot tube

Figure 5 shows OFP and pitot tube installed in the position control system. The void fraction is measured using OFP [3]. OFP is one of the most common tools for measuring void fraction in gas-liquid two-phase flow condition. Jet velocity is measured using pitot tube. The pitot tube was installed at the measurement point and the velocity was calculated by measuring the difference between total pressure and static pressure. In order to obtain the gas density at the measuring point, static pressure and temperature data were used.

2.6 Data Acquisition System (DAS)

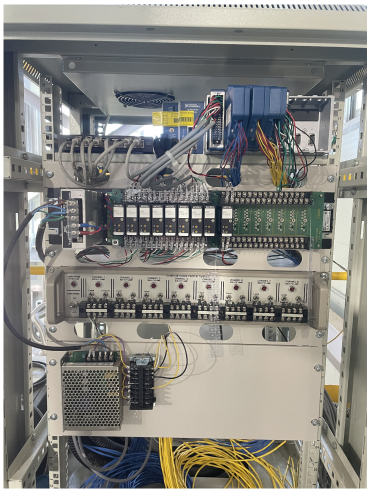

Figure 6. DAS

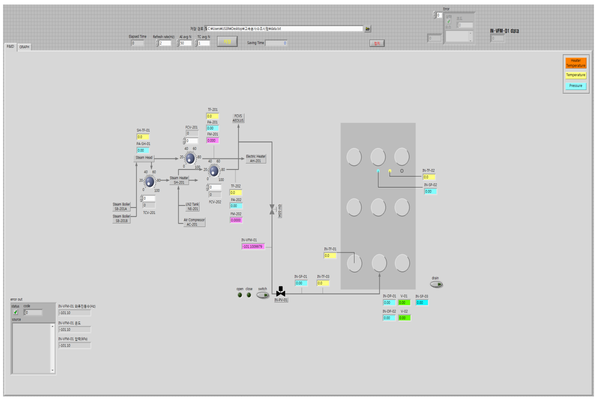

Figure 7. LabVIEW front panel

Figure 6, 7 shows DAS with modules and LabVIEW front panel. A data collection device was built to obtain instrument values. It consists of data acqusition modules (National Instruments). The modules receive output signals from instruments and transmits the electric signal to computer by ethernet-communication. The data was indicated in the monitor using LabVIEW program.

3. Conclusions

The Steam Generator Tube Rupture (SGTR) accident is one of the important accidents that must be considered to evaluate a reactor safety in operating plants. Because the fission product could be released directly to the atmosphere with bypassing the containment building even if the integrity of the containment is secured. The decontamination model of aerosols released at high speeds in the steam generator in the event of an SGTR accident is essential for accident risk assessment. It is expected that the built experimental facility will be utilized to measure the hydrothermal properties of high-speed jet pool scrubbing and present an aerosol decontamination model through future aerosol experiments in the future. Through the study, it is expected that it will be possible to evaluate accurate accident risks and contribute to improve the accident management strategies.

ACKNOWLEDGEMENT

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REFERENCES

[1] Nuclear Safety and Security Commission, 2016, Regulation on Specific Criteria for the Scope of Accident Management and Evaluation of the Accident Management Capability, Notice of the Nuclear Safety and Security Commission No. 2016-02.

[2] Luis E. Herranz, Virginia Peyres, Jesus Polo, Maria J. Escudero, Manuel M. Espigares and Jose Lopez-Jimenez, Experimental and Analytical Study on Pool Scrubbing Under JET Injection Regime, Nuclear Technology, Vol. 120, pp. 95-109, 1997.

[1] K. Park, S. Kim, C. Kang, “Measurement of Void Fraction in the Horizontal Jet Pool Scrubbing Regime by Using Optical Fiber Probe”, Transactions of the Korean Nuclear Society Virtual Autumn Meeting, December 17-18, 2020