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Improved Measurement System and Design Characteristics of the ATLAS Facility

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1. Introduction

ATLAS facility is an integral test loop for simulation of thermal hydraulic phenomena during anticipated accidents in a nuclear power plant.[1] It has scaled down the APR1400 (Advanced Power Reactor 1400 MWe) with a scaling ratio of 1/2 in length and 1/144 in area according to the three-level scaling method.[2] As shown in Fig. 1, the facility has the same configuration of the primary and secondary systems compared to the APR1400.

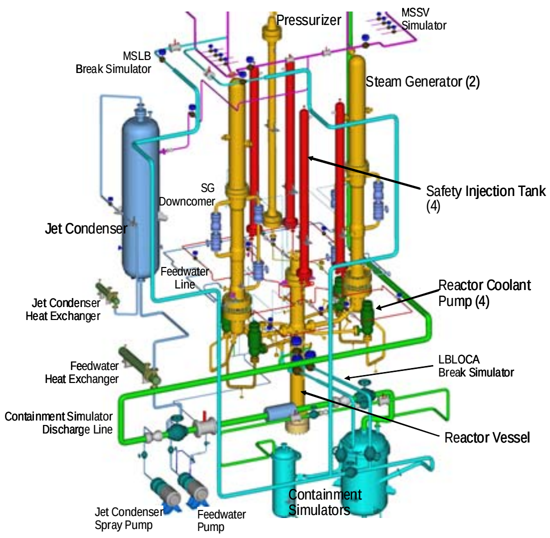

Fig. 1 Overview of the ATLAS facility [1]

In order to investigate complex behavior of the thermal hydraulic transient in the ATLAS facility, it is required to improve measurement system and design characteristics for major components of the facility. This paper introduces current work for the improvement of the facility, which includes a new design of the flow skirt and advanced temperature measurement in the core and the steam generator.

2. Design of Flow Skirt

A flow skirt in the reactor pressure vessel plays a role to mix the coolant in a lower plenum and make a uniform distribution of the flow field. The previous design of the flow skirt in the ATLAS facility was composed of six rectangular holes, which could not appropriately simulate the actual mixing behavior.

In the current design for a new flow skirt, structure of the holes was improved according to a porous design of the prototype flow skirt as shown in Fig. 2. Similarly to the APR1400 design, the holes in the ATLAS flow skirt were composed of three types and distribution of the holes in a lateral direction was determined considering a direction of the hot leg and cold leg nozzles. The design of the flow skirt in the facility should conserve a scale for the pressure drop, which is a half scale according to the scaling methodology. The number and size of the holes were determined from a series of iterative calculation with ANSYS CFX code. Fig. 3 shows the computational analysis model for the ATLAS flow skirt. According to the result, the new design of the flow skirt was proved to induce a half of the pressure drop in the prototype. Fig. 4 presents calculated result for the vertical velocity profile in the lower plenum of the ATLAS facility.

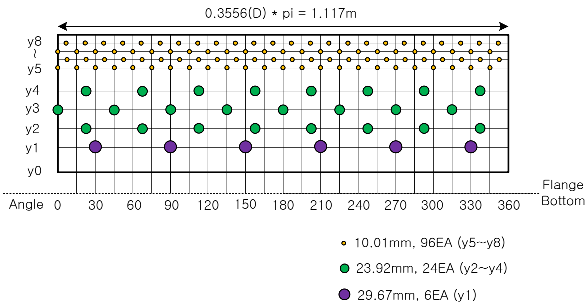

Fig. 2 Design of the new flow skirt in the ATLAS

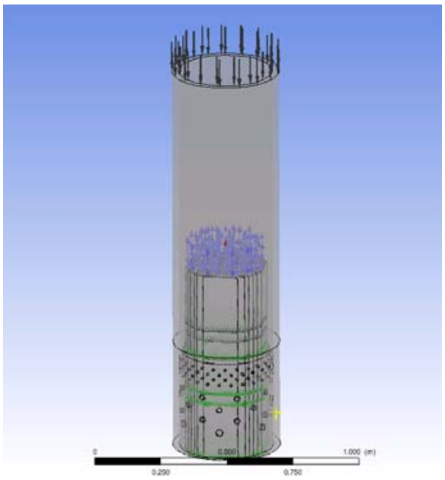

Fig. 3 Calculation model for ATLAS flow skirt

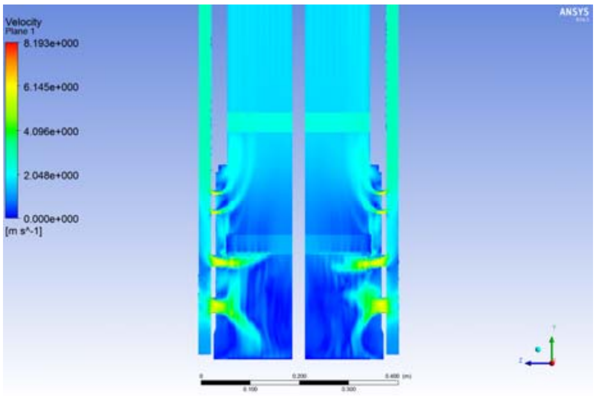

Fig. 4 Velocity distribution in the reactor pressure vessel of the ATLAs facility

3. Design of Temperature Measurement System

3.1. Reactor core

To acquire detailed information of the wall temperature at the reactor core heaters in the ATLAS facility, more thermocouples were installed on the heater surface. That will contribute to measure the exact PCT (Peak Cladding Temperature) and position during an accident simulation. Also, the temperature measurement for CET (Core Exit Temperature) was considered with installing thermocouples on the top region of the heated section in the core.

3.2. Hot leg and cold leg

A horizontally stratified flow regime or a thermal stratification can be observed in a hot leg or a cold leg during two-phase flow natural circulation in the ATLAS facility. To measure a profile of the fluid temperature inside the pipe, five thermocouples were installed in a vertical direction as shown in Fig. 5. The set of profile thermocouples were located at three positions per a hot leg and five positions per a cold leg. This improvement for the temperature measurement can provide the phase distribution inside the RCS pipes.

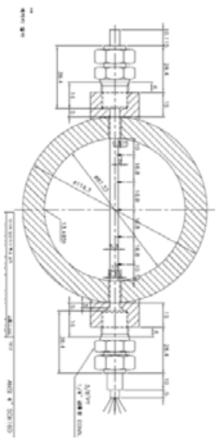

Fig. 5 Profile thermocouples in the hot leg and cold leg

3.3. Steam generator

A flow reversal phenomenon in the steam generator U-tube is of importance with respect to the two phase flow natural circulation in the primary system. From the improvement of the measurement system, 110 thermocouples per a steam generator were additionally installed at the inner and outer plenum in the primary side as shown in Fig. 6. They are located at the inlet and the outlet of the U-tube, so that it can give information for mixing behavior of the coolant in the steam generator and distinguish the temperature difference among U-tubes in the steam generator.

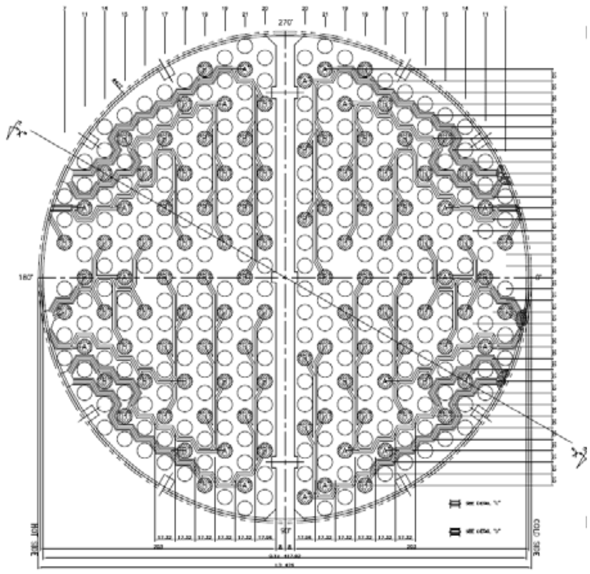

Fig. 6 Temperature measurement in the steam generator

4. Conclusion

The measurement system and the major component design in the ATLAS facility were improved to investigate the multi-dimensional behavior of two-phase flow and appropriately simulate the actual phenomena in the prototype. The flow skirt in the reactor pressure vessel was designed to have equivalent hole structure and make a half of the pressure drop in the prototype. The thermocouples has additionally installed at the reactor core, hot legs, cold legs, and steam generator to get a more detailed temperature distribution. This improvement for the facility is expected to enhance a capability of the facility for understanding complex two-phase flow phenomena during a transient simulation.

REFERENCES

[1] Kang, K. H. et al., Detailed Description Report of ATLAS Facility and Instrumentation, KAERI/TR-4316/2011, 2011.
[2] Choi, K. Y. et al., Scaling Analysis Report of the ATLAS Facility, KAERI/TR-5465/2014, 2014.