Introduction of the ATLAS Test Facility Upgrade

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1. Introduction

The ATLAS(Advanced Thermal-hydraulic Test Loop for Accident Simulation) is one of the three largest integral effect test facilities in the world. The reference plant of the ATLAS is the APR1400 (Advanced Power Reactor 1400 MWe), which has a rated thermal power of 4000 MW and a loop arrangement of 2 hot legs and 4 cold legs for the reactor coolant system.

The ATLAS is a half-height and 1/288-volume scaled test facility with respect to the APR1400 and it is scaled for full pressure and temperature conditions. The ATLAS was designed to investigate major design basis accidents and operational transients that may occur in a reactor coolant system.

Since the first operation of the ATLAS in 2007, the operational technique and managing system of the ATLAS facility have been satisfactorily established. During previous operating experiences. During last 10 years, the instrumentation and measurement techniques were developed significantly. Thus, the ATLAS have continually updated to keep pace with ever-changing technology to investigate the multi-dimensional behavior of two phase flow and appropriately simulate the actual phenomena in the prototype in detail.

In this paper, the upgrade points of the ATLAS test facility will be introduced with expected effects briefly.

2. Upgrade of the ATLAS Test Facility

2.1 Core Heater and Reactor Pressure Vessel

The ATLAS core heater is consists of electrical heating rods which have no risk of radioactive material release. The design temperature of the core heater is 800^{o}C and the detailed design of the core heater and the reactor pressure vessel can be found in the literature [1]. During last 10 years of operation, the core heater was exposed to the high temperature condition near the design temperature several times and it is time to examine its integrity. Thus, new core heater which has the same composition and same output power, was made.

To replace the core heater, all the instrumentations that are connected on the reactor pressure vessel such as thermocouples and pressure transmitters should be disjointed including the reactor pressure vessel itself. In addition to that, the lower part design of the reactor pressure vessel need to be changed to install the partial blockage of the flow skirt that will be explained in the section 2.3.

Thus a new electrical core heater and the reactor pressure vessel are recently installed in the ATLAS test facility. With the new core heater, instrumentation system of the reactor core was supplemented so measurement of the core exit temperature was upgraded. And the multi-dimensional phenomena which can be occurred in the downcomer of the reactor pressure vessel is became more practicable based on these enhancement.

Fig. 1. New core heater of the ATLAS

2.2 Containment Simulation System

There are several test facilities to simulate a containment system in the world. However, there is no containment simulation system which is connected with the reactor cooling system of the integral effect test facility. In the ATLAS, a containment simulation system was designed and constructed connecting with RCS of the ATLAS. Figure 2 shows it's schematic diagram.

In the consideration of the ATLAS scaling ratio to the power plant [2], containment simulation system was also scaled mainly based on the linear scaling method. It was focused to preserve the free volume of the containment and the IRWST volume. The estimated size of the containment simulation tank is 13.2 m of the height and 340 m^3 of the volume with 0.7 MPa design pressure. Compartment, heat sink and engineering safety features such as spray system will be added in the containment simulation tank, later.

This containment system will be contribute on the development of the containment M/E and P/T analysis method. And the experimental data base can be utilized for the code development and validation such as CAP and CUPID.

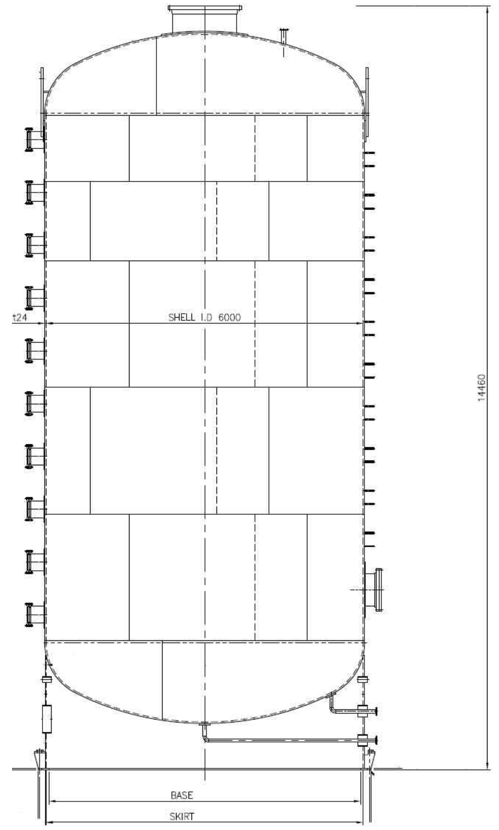

Fig. 2. Schematic Diagram of Containment Simulation Tank

2.3 Partial Blockage of the Flow Skirt

In the case of a LOCA condition, the debris may be produced and flowed in different paths inside the containment. The sump screens are installed in the in-containment refueling water storage tank (IRWST) to filter the amount of debris that could be flowed into the primary system and to minimize the impact of debris on the core cooling. Some fine debris, however, may pass thought the sump screen. The passed debirs can be flowed into the core and may be deposited on the inlet of core assembly. The coolant flow may be blocked by the debris deposition and accumulated in the fuel assemblies. Due to the partial blockage of core, the degradation of core cooling may lead to core damage.

To simulate such phenomena, a blockage simulation system, which can control the blockage ratio during a test, is installed at the flow skirt of the ATLAS reactor pressure vessel [3].

A 3-D diagram of the partial blockage simulation system is shown in Fig. 3. 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.

With this blockage simulation system, it is possible to investigate the effect of core inlet blockage (especially, time dependent blockage ratio)on the core cooling behavior for cooling phase of LOCA.

The pre-characteristic test for the partial blockage system is now performing and, prior to the main test, so that relation table between the blockage ratio and pressure drop will be quantified.

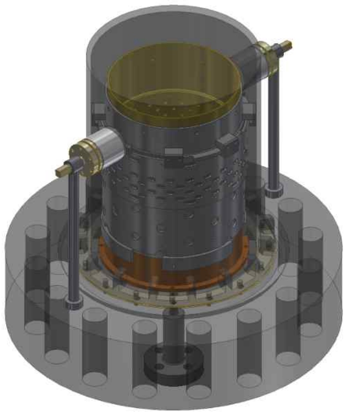

Fig. 3. Core Partial Blockage Simulation system

2.4 Hybrid-SIT System

The concept of Hybrid safety injection tank(Hybrid SIT), proposed by KAERI, is a passive safety injection system that allows high-pressure core makeup over the operating pressures of light water reactor (LWR). The conceptual design diagram is shown in Fig. 4.

The current SITs are pressurized with nitrogen gas to an intermediate pressure (generally about 4MPa), and thus the emergency core cooling water from SIT can be supplied into the RCS when the RCS pressure drops below the SIT set-point pressure. On the other hand the Hybrid-SIT can be pressurized equally to the RCS pressure through a pipe connection between the SIT and the pressurizer, along with nitrogen charging, in which case the coolant can be injected by gravitational head between the RCS and the SIT.

For this Hybrid-SIT concept simulation, new SITs were installed with newly added instrumentations in the SIT. In the Hybrid-SIT system, the coolant will be injected to direct vessel injection (DVI) nozzle. The relevant thermal-hydraulic phenomena anticipated in the Hybrid SIT and the effects of system variables affecting the pressure balancing of the Hybrid-SIT and the pressurizer, such as a steam flow rate on each pressure balance line, thermal mixing behavior inside the Hybrid SIT, core makeup flow rate, and core coolability by passive core makeup will be intensively examined.

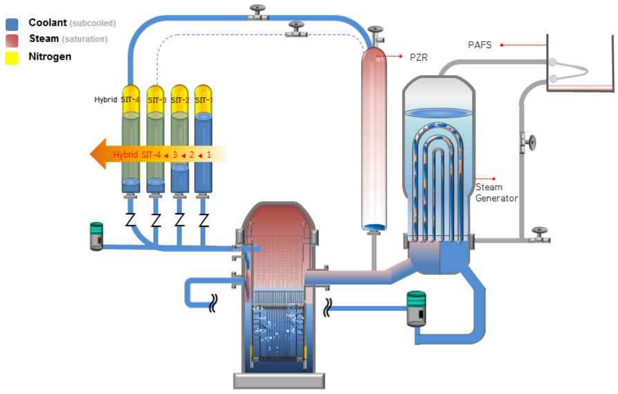

Fig. 4. Passive Core Make-up Concept by Hybrid SIT

2.5 Video Probe Instrumentation

In the ATLAS test, complex flow characteristics can be occurred during the transient. Even though there is much instrumentation in the ATLAS, it is still hard to investigate certain phenomena such as counter current flow or various two-phase flow conditions.

To investigate these complex flow characteristics clearly, the video probe, which is shown in Fig. 5, is now installed on the hot-leg of the ATLAS and it can be installed any other part of the ATLAS as necessary.

This video probe has a small camera at the tip with 1.5 mm diameter and it can be operated at the high temperature ns pressure condition up to 350^{o}C and 180bar. The complex two-phase flow phenomena can be visualized and recorded using this video probe during the ATALS test simulation transient.

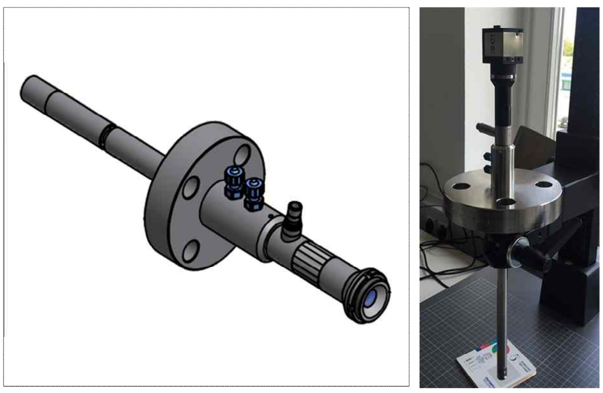

Fig. 5. Video Probe

3. Conclusions

Through these changes of the ATLAS, it is possible to produce more accurate and delicate experimental results and the result analysis can be more confident. Making the best use of new ATLAS, scope of the code validation will be enhanced with the contribution of the safety improvement of the accident management procedure of the nuclear power plant.

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