Water Chemistry Control of a Fuel Test Loop

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1. Introduction

Fuel Test Loop (FTL) is a test facility which can conduct a fuel irradiation test at HANARO [1]. The FTL provides the test conditions of a high pressure and temperature similar to those of commercial PWR and CANDU reactors. The commissioning of the FTL is performing since April, 2007. The FTL will be used for the irradiation test of high burn-up PWR fuels after its commissioning is completed. In this paper, the water chemistry control of the FTL facility and the experimental results are introduced.

2. Fuel Test Loop

The FTL is composed of an OPS (Out Pile system) and an IPS (In-Pile test Section) [2][3]. The OPS is composed of a process system and I&C (Instrumentation and Control) system. The IPS is to be loaded into the IR-1 position in the HANARO core. Figure 1 shows a schematic diagram of the FTL.

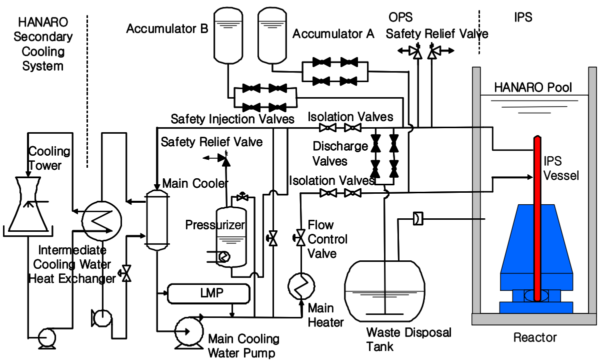

Fig. 1. Schematic diagram of the FTL.

The process system contains several equipments such as a pressurizer, a cooler, a heater, pumps, and a purification system which are necessary to maintain the proper fluid conditions. The process system includes the following systems [1];

- Main cooling water (MCW) system,
- Emergency cooling water system,
- Penetration cooling water system,
- Letdown, makeup, and purification system,
- Waste storage and transfer system,
- Intermediate cooling water system,
- Sampling system,
- IPS inter-space gas filling and monitoring system,
- Miscellaneous systems.

The FTL coolant is supplied to the IPS at the required temperature, pressure and flow conditions that are consistent with a test fuel. The nuclear heat generated within the IPS is removed by the main circulating water cooler. The main circulating pump provides the motive power to circulate the FTL coolant within the loop. After a pump discharge, an in-line heater provides the capability to increase the temperature for a start-up and for a positive temperature control. A pressurizer is provided to establish and maintain the coolant pressure for the test fuel type.

The I&C system is divided into a safety control system and a non-safety control system and has the following functions;

- Maintaining the irradiation test conditions by an automatic control,
- HANARO trip and a FTL safe shutdown during transient or accident conditions,
- Satisfaction of the safety design requirements such as a redundancy, independency and single-failure criterion,
- Simultaneous operation of the FTL with HANARO.

3. Water Chemistry Control and Results

The LMP (Let down, Make-up & Purification) system controls the volume, purification and chemical quality of the main cooling water. The LMP system is composed of a purification heat exchanger, filters, ion exchangers, a degasifier tank, a chemical addition tank, a purification return pump, etc. The LMP system extracts the cooling water from the MCW system and returns it to the MCW system using the purification return pump. The cooling water can be sampled and monitored periodically at the sampling system. Table 1 shows the limit criterion of the main cooling water chemistry at a steady state condition [4].

Fig. 2 shows the FTL operation trend in commissioning stage. FTL operation modes are divided into LSD (Loop Shutdown), CSB1 (Cold Standby 1), CSB2 (Cold Standby 2), HSB (Hot Standby) and HOP (Hot Operation). The N_2H_4 was added to remove the DO(Dissolved Oxygen) and the Li^7OH was added to increase the pH at CSB1(50℃). The temperature of the main cooling water was maintained at 86℃ until the DO concentration was reduced to under the limit criterion. Fig. 3-5 show the water chemistry analysis results for the main cooling water. It is concluded that the water chemistry is controlled within the limit criterion shown in Table 1.

Table 1. Limit criterion of main cooling water chemistry

Items	Limit criterion
F^-	≤ 0.15 ppm
Cl^-	≤ 0.15 ppm
SO_4^{-2}	≤ 0.15 ppm
DO (at coolant temp ≥ 121.5°C)	≤ 0.1 ppm
pH	5.5 ~ 8.0
Conductivity	≤ 50 μS/cm

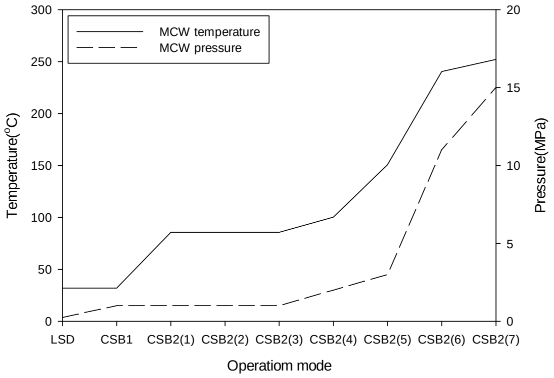

Fig. 2. FTL operation trend.

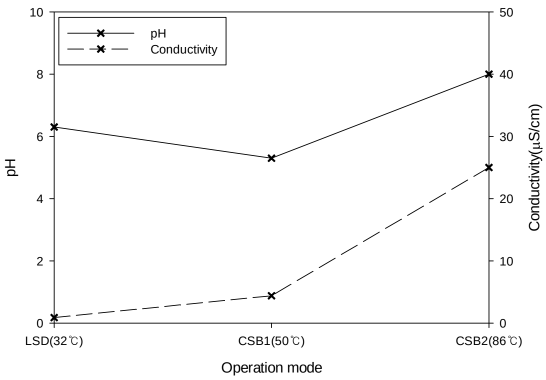

Fig. 3. pH and conductivity concentration.

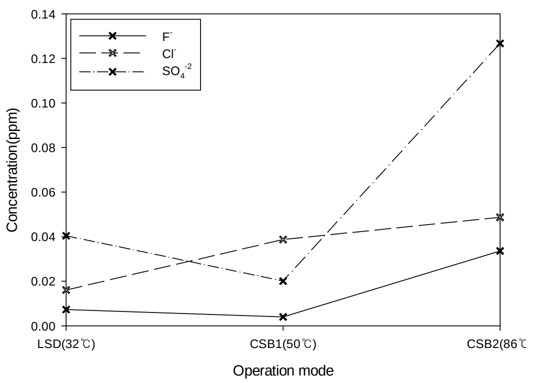

Fig. 4. F^-, Cl^-, SO_4^{-2} concentration.

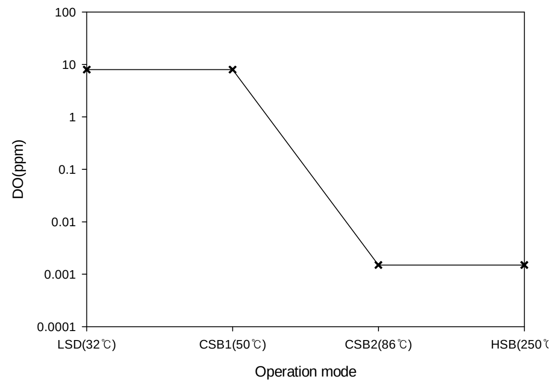

Fig. 5. DO concentration.

4. Conclusions

This paper introduced the experimental results for the water chemistry control of a fuel test loop at a commissioning stage. The experimental results showed that the water chemistry of the FTL is controlled to within the limit criterion. This water chemistry control scheme will be applied to a fuel irradiation test using a fuel test loop facility after its commissioning is completed.

ACKNOWLEDGEMENTS

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