Hot Operation of FTL for PWR Fuels Irradiation

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1. Introduction

Fuel Test Loop (FTL) in HANARO is the test facility which can conduct a fuel irradiation test with commercial NPPs' operating conditions such as their pressure, temperature, flow and water chemistry. The FTL is used for the irradiation test of PWR type or CNNDU type fuels. In this paper, the hot operation of FTL for irradiation test of PWR fuels is introduced. The experimental results show the excellence of operation performance.

2. Fuel Test Loop in HANARO

The FTL is composed of an OPS (Out Pile System) and an IPS (In-Pile test Section). Figure 1 shows a schematic diagram of FTL.

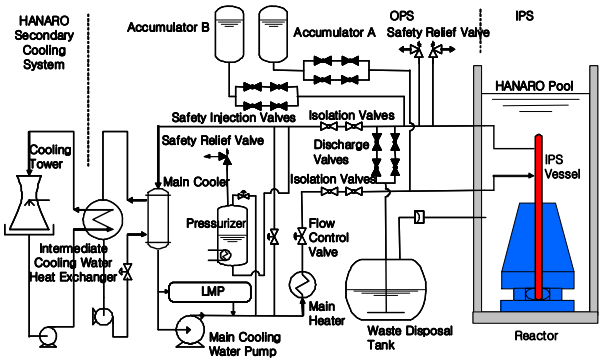

Fig. 1. Schematic diagram of FTL.

The OPS includes the following systems [1][2].
- Main cooling water (MCW) system
- Emergency cooling water (ECW) system
- Penetration cooling water (PCW) system
- Letdown, makeup, and purification (LMP) system
- Waste storage and transfer (WST) system
- Intermediate cooling water (ICW) system
- Sampling system
- IPS inter-space gas filling and monitoring system
- Instrumentation and control (I&C) system

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. 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 emergency cooling system is provided to maintain the experimental fuel cooling conditions in the event of an anticipated operational occurrence or the design basis accidents. The letdown, make-up & purification system controls the volume, purification and chemical quality of the main cooling water.

The I&C system for the FTL is composed of a safety control system and a non-safety control system [1]. The safety control system is used for controlling the safety related FTL process systems and a shutdown of the HANARO reactor from abnormal operating conditions [1][2]. The non-safety control system consists of a computer control system and a data acquisition system. The digitalized computer control system controls and monitors all the field signals. The data acquisition system collects and stores the signals from the in-pile instruments installed in the IPS.

The IPS including the test fuel assembly is to be loaded into the IR-1 position in the HANARO core [3]. Figure 2 shows the shape of IPS. The IPS includes 3 pins of PWR fuel. Three SPNDs are installed in the upper, middle and lower parts of the irradiated section. Three thermocouples are installed in the inlet, middle and outlet points of the test fuel assembly to measure the coolant temperature. A LVDT is installed to measure the fission product pressure, and thermocouples are installed to measure the centreline temperature of a test fuel.

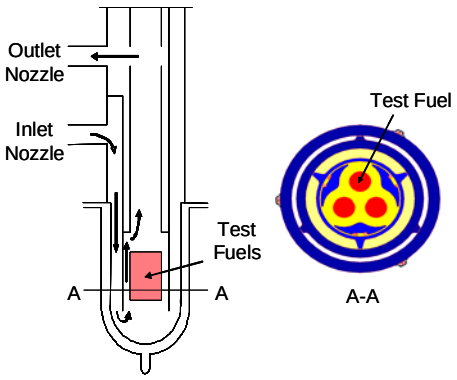

Fig. 2. Shape of IPS.

3. Operation

3.1 Operation Conditions

FTL operation modes are divided into LSD (Loop Shutdown), CSB1 (Cold Standby 1), CSB2 (Cold Standby 2), HSB (Hot Standby) and HOP (Hot Operation) as shown in Table I [4]. The operation conditions of FTL for irradiation test of PWR fuels are the normal operating conditions of commercial PWR

plant. The operation of FTL is started from LSD mode without reactor operation. The reactor operation is started after the FTL is arrived at HSB mode. Then, the FTL is arrived at HOP mode when the reactor power is reached to 30 MW.

Table I. FTL operation mode

Parameter	LSD	CSB1	CSB2	HSB	HOP
MCW Temp. (°C)	T<50	T<50	50≤T < 90	90≤T < 300	270≤ T
MCW pump	Off	On	On	On	On
Main heater	Off	Off	On	On	Auto
Pressurizer heater	Off	On	On	On	On
Reactor power (MW)	0	0	0	0	30

3.2 Experimental Results

Figure 3, 4, 5 show the experimental results for the FTL and reactor operation. Table II shows the experimental results of the FTL steady state operation for irradiation of PWR fuels at HOP mode. It is shown in Figure 3, 4, 5 and Table II that the temperature, pressure and flow are well controlled to the desired values for irradiation test of PWR fuels.

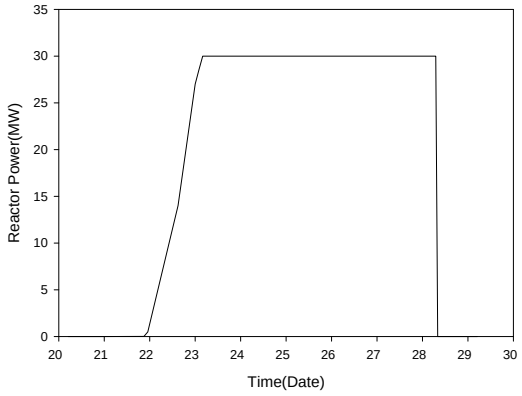

Fig. 3. Reactor operation.

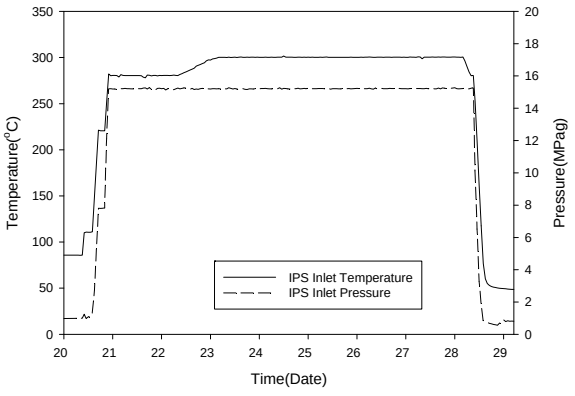

Fig. 4. Experimental results for temperature and pressure.

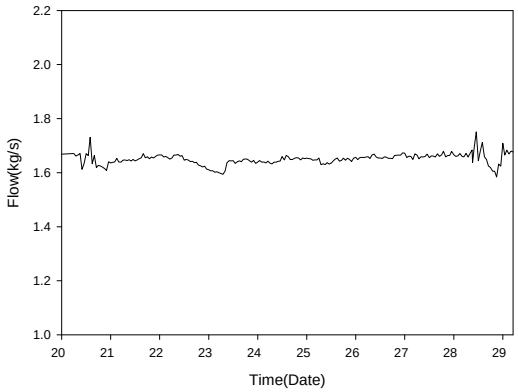

Fig. 5. Experimental result for flow.

Table II. FTL operation value at HOP mode

Items	Desired value	Measured value
IPS inlet temperature(℃)	300.3	300.3
IPS inlet pressure(MPag)	15.2	15.2
IPS inlet flow(kg/s)	1.65	1.65

4. Conclusions

In this paper, the hot operation of FTL for irradiation test of PWR fuels is introduced. The experimental results show that the operation values are well controlled to the desired values.

ACKNOWLEDGEMENTS

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