Preliminary Experiment on the Elemental Iodine Capture Filter Performance for Filtration System

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1. Introduction

After the Fukushima accident, lots of safety systems have been developed, and the safety of domestic nuclear power plants(NPPs) has also improved. To further improve the safety of NPPs, it is necessary to develop a radioactive material filtration system which operates in containment to minimize damage caused by release of radioactive material to the environment during the severe accident.

The goal of this project is the development of a passive radioactive material filtration system which can be applied the operating nuclear power plants[1]. It consists of two main components, the passive fluid induction system and a fission product filtration system. To evaluate the performance of the radioactive filtration system in the containment using the severe accident analysis code, it is necessary to develop the fission product removal efficiency model. Also, to optimize the system, we need to understand the characteristics of each component.

KAERI is preparing for the aerosol, elemental and organic iodine tests to understand the characteristics of each component. We developed the elemental iodine test set up for obtaining the elemental iodine removal efficiency and characteristics of adsorbents[2]. Based on the our preliminary experimental results [2], the design of the iodine capture filter was modified. The experiment facility was then modified to test the performance of the redesigned filter, and experiments were conducted accordingly.

2. Experiment for Iodine Test

2.1 Experimental setup

An experimental setup, as shown in Fig.1, has been constructed to assess factors such as pressure drop across the adsorbent and iodine removal efficiency. To eliminate the scaling effect, the test section was scaled up to actual size. The test section is the same as a real size with an area of 305 mm x 305 mm and heights of 1 inch as shown in Fig. 2. The measurements of pressure, temperature, and iodine concentration can be taken before and after the adsorbent. Also, the system pressure and the flow rate can be controlled by the inlet and outlet control valve.

The target experimental conditions are summarized in Table 1. The main flow system is connected to ARIEL system [3], allowing for implementation of the conditions specified in Table 1.

The fluid, gas and wall temperatures, the gauge and differential pressures along the test section and the flow rates at the inlet and outlet of the test section can be measured. The whole test section can be heated to compensate for heat losses, to prevent steam condensation and to reduce elemental iodine losses at cold walls.

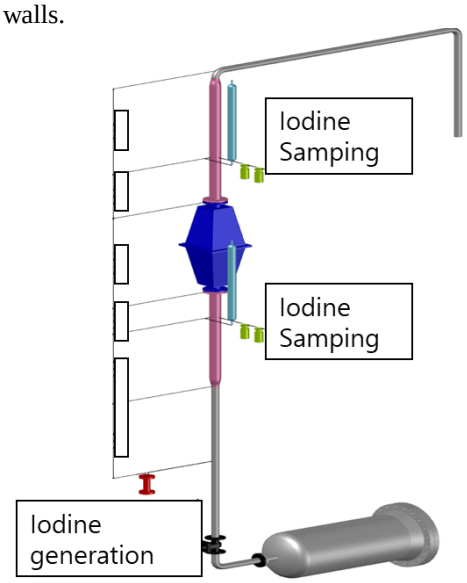


Figure 1. Elemental iodine test loop

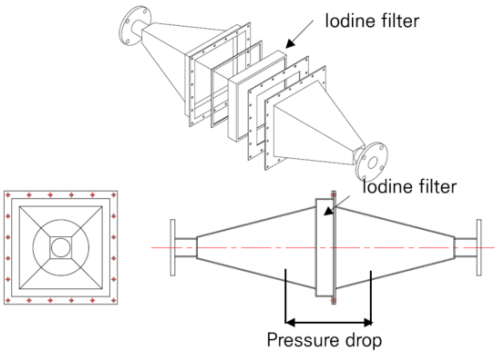


Figure 2. Iodine filter performance test component

Table 1. Test condition

Test No.	1	2	3	4	5	6
Pressure (bar)	3	3	3	2	5	3
Flowmeter (m/s)	0.8	0.8	1	0.8	0.8	Max velocity
Slpm	8998	8998	11247	6198	14350	
Temperature (°C)	133.5	133.5	133.5	120.41	151.8	133.5

2.2 Elemental iodine generation and sampling system

Gaseous elemental iodine is generated by heating solid iodine crystal, because the solid iodine is vaporized under 110°C [4]. So, the chamber which has the solid iodine crystal up to 10 g is heated by the hot plate. The gaseous elemental iodine is fed by the air to the main test system.

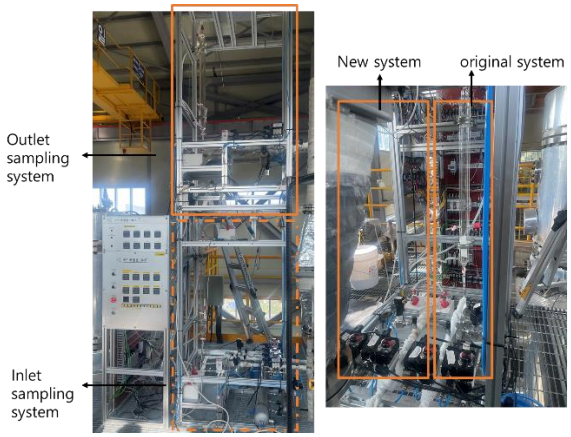
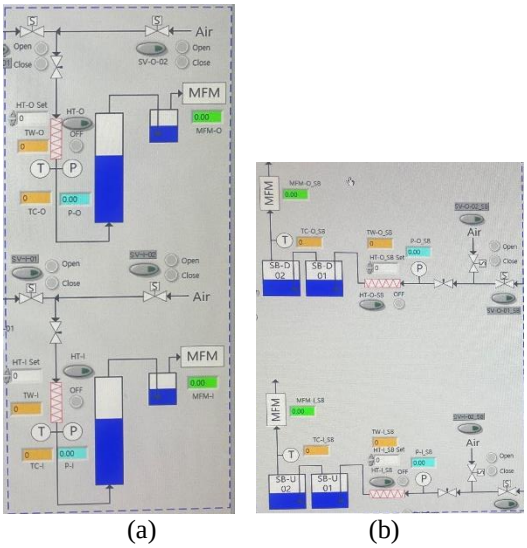


Figure 3. Elemental iodine sampling system



(a) (b)

Figure 4. Schematic elemental iodine sampling systems (a) original sampling system, (b) new sampling system

To measure the elemental iodine concentration at the inlet and outlet, gas samples were taken simultaneously from the inlet and outlet piping of the test section during the test. The gas sample flow rates can be controlled by needle valve. The temperature of sampling system is controlled by the heating system to prevent steam condensation and to reduce iodine losses.

Elemental iodine was sampled to liquid gas scrubber columns with a coolant jacket as shown in Figs 3 and 4. Figure 3 shows the sampling system installed. Figure 4 (a) shows the sampling system used in Ref.2, Fig.4(b) shows the new sampling system that was improved for low-concentration iodine experiments. To enhance the reliability of the experimental results, sampling will be conducted using two different methods for comparison.

The samples were analyzed by iodide ion selective electrodes (ISE) as Ref. 2. To use ISE, the scrubber water is doped with ascorbic acid to reduce I_2 to I^- ions. Although this system can be used like on-line measurement with ISE, the data indicates the trend of the inlet and outlet concentration, it is not the precise result because ISE is very sensitive to temperature change. For the precise result, the calibration work should be performed for the ISEs after the test under well controlled conditions such as the temperature, and samples are analyzed under same conditions.

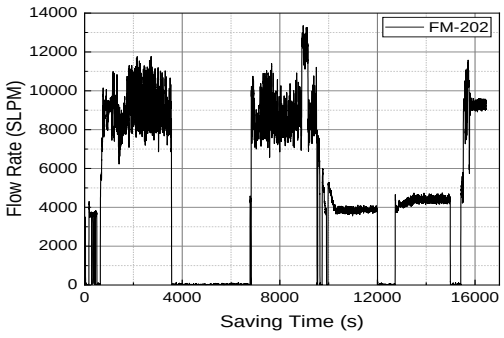
2.3 Preliminary test results & future works

Several experiments have been performed to characterize the pressure, the iodine generation and the sampling flow rate behavior and to use for detailed test planning. The test conditions were summarized in Table.1. The pressures in the inlet piping upstream of the injection nozzle were between 2 and 5 bars(g), and the gas velocity were between 0.8 ~ 1 m/s

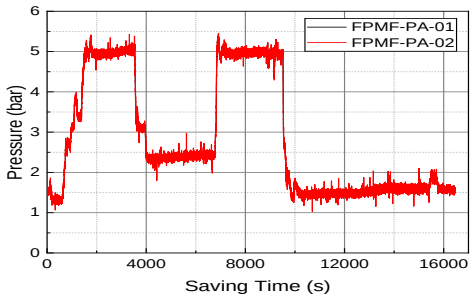
In this experiments, fluid, gas and wall temperatures, the absolute, gauge and differential pressures along the test section (Fig.5) and the flow rates at the inlet and outlet of the sampling test section were measured (Fig. 6).

In the preliminary tests, we confirm that the flow rate, the pressure, and the temperature well controlled. Also, the sampling system has been verified to operate reliably.

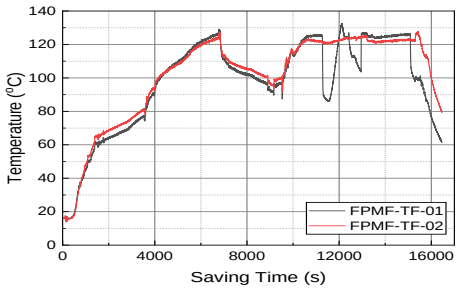
We plan to conduct adsorbent experiments at various concentration and conditions to develop a model for iodine removal performance.



(a) Flow rate



(b) Pressure



(c) Temperature

Figure 5. Thermal hydraulic data during the test

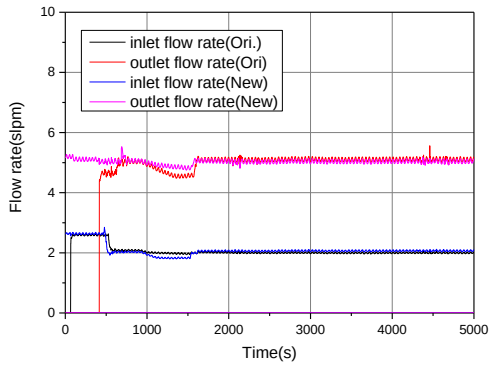


Figure 6. Sampling flow rate at inlet and outlet

3. Conclusions

The experimental setup to understand the characteristics of the adsorbent was modified. The thermal hydraulic tests under the targeted conditions have been conducted. Additionally, the elemental iodine generation and sampling system have been verified to operate stably. We plan to conduct experiments at various conditions to develop a model for iodine removal efficiency of the adsorbent.

ACKNOWLEDGMENTS

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