

Preliminary Experimental Study on the Elemental Iodine Removal Performance of Adsorbent for Filtration System

Jaehoon Jung ^{a*}, Seokgyu Jeong ^a, and Chang Wan Kang ^a

^aIntelligent Accident Mitigation Research Division, KAERI, Daeduk-daero 989-111, Daejeon, Korea

*Corresponding author: jhjung@kaeri.re.kr

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. This paper introduces the elemental iodine test set up for obtaining the elemental iodine removal efficiency and characteristics of adsorbents.

2. Experiment for Iodine Test

2.1 Experimental setup

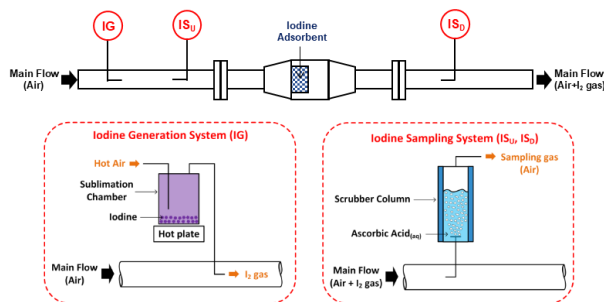


Figure 1. Schematic diagram of elemental iodine test set up

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. The main flow is through a 2-inch pipe, and 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 indicated in Table 1. The main flow system is connected to ARIEL system[2], 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 aerosol/iodine losses at cold walls.

Table 1. Test condition

| Parameter | Unit | Value | Comment |
|------------|------|----------|------------------------|
| Air vol% | - | 0-100 | |
| Steam vol% | - | 0-100 | 0% means dry condition |
| Velocity | m/s | 0.2~1 | |
| Temp | K | Sat temp | |

2.2 Elemental iodine generation and sampling system

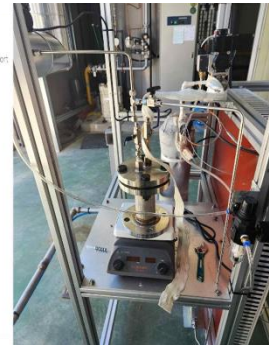
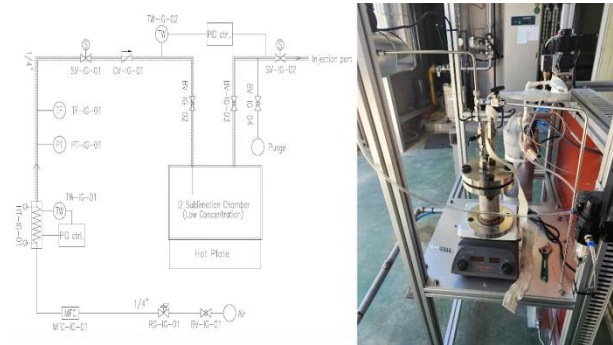


Figure 2. Elemental iodine generation system

Gaseous elemental iodine is easily generated by heating solid iodine crystal, because the solid iodine is easily vaporized under 110°C[3]. Figure 2 shows the iodine generation system. The chamber which has the solid iodine crystal up to 50 g is heated by the hot plate. The gaseous elemental iodine is fed by the nitrogen or air to the main test system.

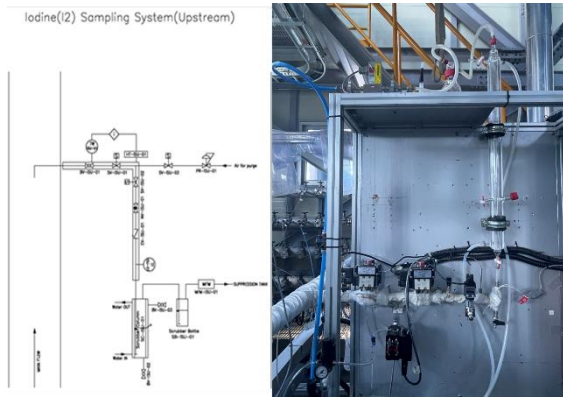


Figure 3. Elemental iodine sampling system

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 aerosol/iodine losses at cold walls.

Elemental iodine was sampled to liquid gas scrubber columns with a coolant jacket as shown in Fig. 3. The temperature of the operation gas can reach to near the saturation temperature, the coolant jacket is need to prevent the evaporation of the scrubber solution.

The samples were analyzed by iodide ion selective electrodes (ISE). 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.

After the scrubber, there is another scrubber which is to confirm that all the iodine are collected in the scrubber system.

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 1.5 and 5 bars(g), and the gas velocity were between 0.2 ~ 1 m/s

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

In the preliminary tests, we confirm that the pressure (Fig.3), the temperature (Fig.4) and the velocity were well controlled. Also, the generation (Fig.5) and

sampling system (Fig.6) 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.

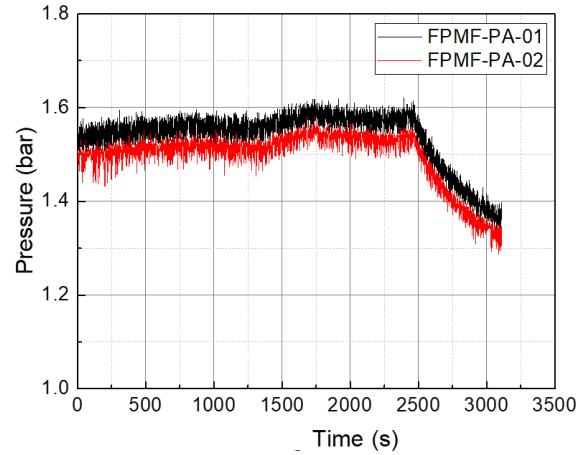


Figure 3. System pressure during the test

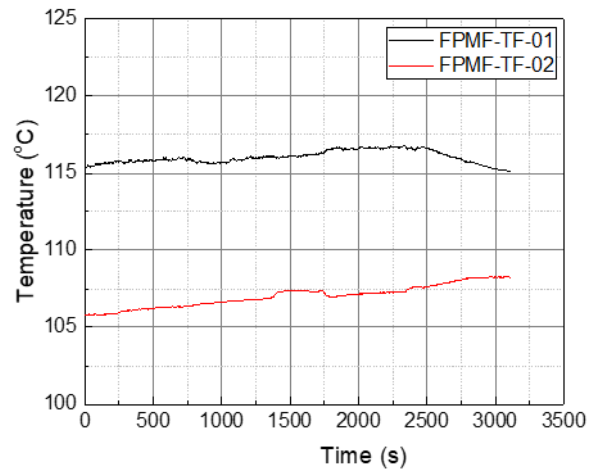


Figure 4. System temperature during the test

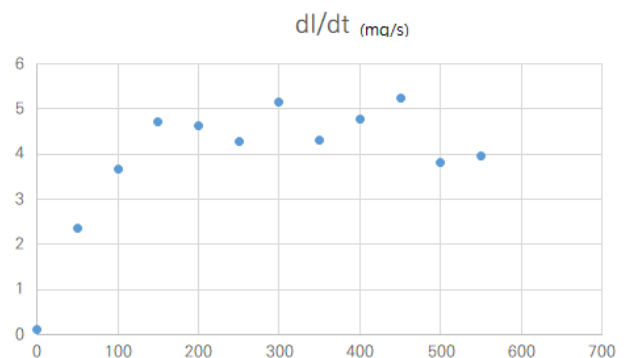


Figure 5. Elemental Iodine generation rate

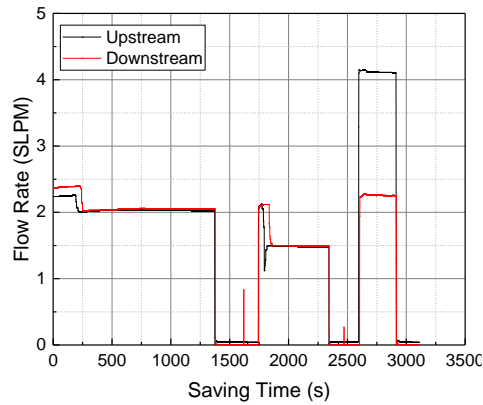


Figure 6. Sampling flow rate at inlet and outlet

3. Conclusions

The experimental setup to understand the characteristics of the adsorbent was constructed. 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

This research was supported by the National Research Foundation of Korea (NRF) funded by the Ministry of Science and ICT. (RS-202200144064)

REFERENCES

- [1] J. Jung, D.S. and S.H. Kim, Preliminary Evaluation on Radioactive Material Filtration System Effectiveness under Development, transactions of the Korean Nuclear Society Spring Meeting, Jeju, Korea, May 18-19, 2023.
- [2] J. Jung, K.S. Ha, S. Hong, S. I. Kim, and H. Y. Kim, INTRODUCTION OF ARIEL TEST FACILITY FOR VERIFYING THE PERFORMANCE OF FILTERED CONTAINMENT VENTING SYSTEM, The Tenth Korea-Japan Symposium on Nuclear Thermal Hydraulics and Safety, Kyoto, Japan, November 27-30, 2016
- [3] J. Jung, J. B. Lee, and H.Y. Kim, Experimental Investigation of Iodine Decontamination Performance of a Filtered Containment Venting System in ARIEL Facility, Proceedings of the International Conference Nuclear Energy for New Europe, Bled, Slovenia, Sep 11-14, 2017.