# Water Mock-up for the Sodium Waste Treatment Process

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## 1. Introduction

It is important to safely treat the waste sodium which was produced from the sodium cooled fast reactors and the sodium facilities. About 1.3 tons of sodium waste has accumulated at KAERI from the sodium experiments which have been carried out since 1990. Also, large scaled sodium experiments are scheduled to verify the design of the sodium cooled fast reactor.

As a treatment method for the waste sodium produced at the sodium facility, an investigation of the reaction procedure of the waste sodium with the sodium hydroxide aqueous has been developed [1].

The NOAH process was developed in France for the treatment of waste sodium produced from sodium facilities and reactors [2]. In the NOAH process, a small amount of sodium waste is continuously injected into the upper space which is formed on the free surface of the aqueous and slowly reacted with sodium hydroxide aqueous. Since the density of the sodium is lower than that of the aqueous, the injected sodium waste sometimes accumulates above the free surface of the sodium hydroxide aqueous, and its reaction rate becomes slow or suddenly increases.

In the improved process, the sodium was injected into a reaction vessel filled with a sodium hydroxide aqueous through an atomizing nozzle installed on a lower level than that of the aqueous to maintain the reaction uniformly. Fig.1 shows the sodium waste process which was proposed in KAERI. The aqueous is composed of 60% sodium hydroxide, and its temperature is about 60℃.

The process is an exothermic reaction. The hydrogen gas is generated, and the concentration of the sodium hydroxide increases in this process. It needs several systems for the process, i.e. a waste sodium injection, a cooling of the aqueous, hydrogen ventilation, and neutralization with nitric acid. The atomizing nozzle was designed to inject the sodium with the nitrogen gas which supplies a heat to the sodium to prevent its solidification and to uniformly mix the sodium with the aqueous.

There are complex reacting phenomena in the system to observe with the naked eye. Therefore, a water mock-up was carried out for the practical use of the data in the waste sodium treatment test.

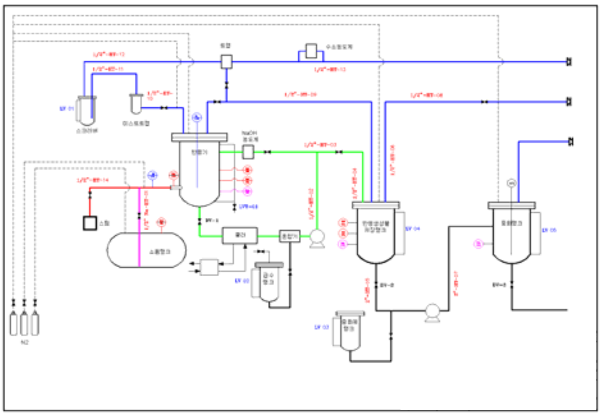

Fig. 1 Sodium waste process

## 2. Water Mock-up

The major experimental parameters were the flow rate of water through the atomizing nozzle and the recirculation rate. In addition, the positions and flow directions of the nozzles, the level of water, and the position and shape of a screen are also important parameters.

The test rig is shown in Fig.2, and the atomizing nozzle is shown in Fig. 3. In the practical operation, the atomizing nozzle is heated by the 3 electrical heaters. The waste sodium is simulated with a red coloring, and the water is used as a coolant instead of the sodium hydroxide aqueous in the experiment. The photo of the test rig is shown in Fig. 4.

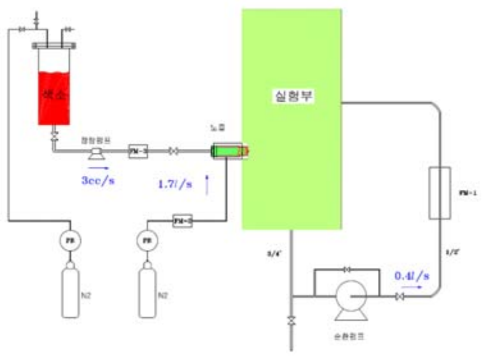


Fig. 2 Test Rig

Fig. 3 Atomizing nozzle

The inner diameter of the reaction vessel is 384mm, the height is 1200mm. From this experiment, 300 sets of data were obtained by analyses of the phenomena of the photographic records, and the optimum conditions were determined [3].

Fig. 4 Photo of the test rig

## 3. Result and Discussion

Several experiments have been carried out and the results were compared with each other according to the 9 kinds of test parameters. The optimum flowing conditions were obtained as shown in Table 1, and the mixing phenomenon in the optimum flowing conditions was shown in Fig. 5.

When the sodium flow rate increases, the sodium separated from the nitrogen jet increases. When there is a circulating flow or a screen, the position of the injecting nozzle should be lower because there is no direct suction of the sodium into the suction nozzle of circulating water.

As the angle of the atomizing nozzle becomes small, the tendency of the sodium and the nitrogen gas to mix increases. If a nitrogen flow rate is low, the nitrogen bubble reaches a free surface with a large diameter. When the nitrogen flow rate increases, the probability of the bubble with a large diameter decreases.

When the injection angle of the circulation water is greater than 45 degree based on the center line, mixing conditions are good. The circulation rate is optimized in 350cc/sec without a screen, but it is optimized in 550cc/sec with a screen. When the diameter of a screen hole is small, the nitrogen bubble is separated in a small size, and is accumulated below the screen.

Table 1 Optimum conditions

| Test parameters | Unit | Values |
|---|---|---|
| Nitrogen injection rate | cc/s | > 550 |
| Water(color) injection rate | cc/s | 1.0 |
| Water circulation rate | ℓ /s | 0.55 |
| Position of sodium injection nozzle | mm | 200 |
| Angle of sodium injection nozzle | degree | < 15 |
| Position of type circulation nozzle | mm | 400 |
| Angle of type circulation nozzle | degree | 60 |
| Water level | mm | 800 |
| Position of screen | mm | 600 |
| Dimension of screen (5t) | mm | Ø5 x P10 |

Fig. 5 Mixing phenomenon in optimum flowing condition

## 4. Conclusion

A conceptual design of the treatment of sodium waste was proposed, in which the sodium is injected into a reaction vessel filled with sodium hydroxide aqueous through an atomizing nozzle in order for it to be a uniform reaction. An experimental study has been carried out to optimize the flowing conditions for the sodium waste process using water as the fluid flow. Nine kinds of flowing conditions were tested and analyzed. Optimum conditions were obtained.

## Acknowledgement

This study has been supported by the Nuclear Research and Development Program of the Ministry of Education, Science and Technology, Republic of Korea.

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