Set-up of the Facility for a Sodium Waste Treatment Process

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1. Introduction

It is important to safely treat the waste sodium which is produced from sodium cooled fast reactors and sodium facilities. About 1.3 tons of sodium waste has accumulated at KAERI from experiments which have been carried out since 1990. Furthermore , 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 by France for the treatment of waste produced from sodium facilities and reactors [2]. Through the NOAH process, a small amount of sodium waste is continuously injected into the upper area which is formed on a free surface of the aqueous and slowly reacts 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 slower or suddenly increases.

An improvement process was proposed by KAERI. The final product of the process is salt through a neutralization of the sodium hydroxide with the nitric acid. In the improved process, the sodium was injected into a reaction vessel filled with a sodium hydroxide aqueous through an atomizing nozzle installed on the lower level than that of the aqueous. The nitrogen gas was injected simultaneously into the reaction vessel through the annular channel of the atomizing nozzle to maintain a consistent reaction.

There are complex reacting phenomena in the system to observe with the naked eye. A water mock-up has been carried out already for the practical use of the data in the waste sodium treatment test [3]. Based on the data, an experimental facility was designed and installed for the sodium waste process to find out the effect of the sodium injection rate. But the neutralization process which is not an important parameter in the experiment was eliminated to simplify the process in the experimental facility.

2. Installation of the Facility

Fig.1 shows the experimental facility for the sodium waste process which was proposed by KAERI. 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 the nitrogen gas injection system. Also there are several auxiliary systems, i.e. a feed water, a cover gas supply, a sodium hydroxide storage tank, and a steam system for cleaning of the atomizing nozzle when backed up with solid sodium.

The atomizing nozzle was designed to inject the sodium with nitrogen gas which supplies heat to the sodium in order to prevent solidification and to uniformly mix the sodium with the aqueous. The aqueous is composed of 50% sodium hydroxide, and the temperature is about 60℃. The operating conditions are shown in Table 1 when the injection rate of sodium is 1g/sec.

The experimental parameter is the injection rate of sodium through the atomizing nozzle. The range of the injection rate is from 0.1 g/sec to 1.0 g/sec in the experiment. The major measuring parameters are the hydrogen generation rate, the concentration of the sodium hydroxide, the feed water rate, and the temperatures in the reaction vessel.

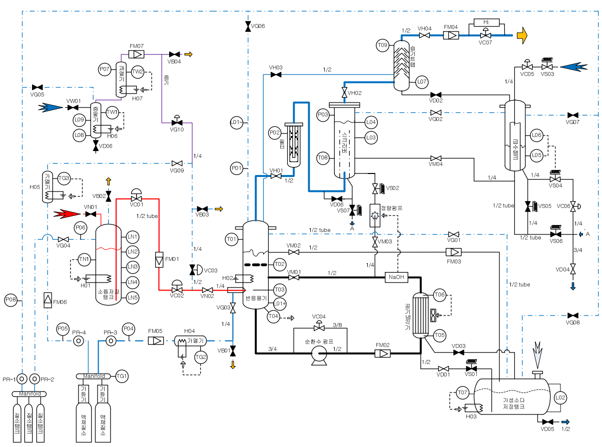

Fig. 1 Flow diagram for sodium waste experiment

Table 1 Operating conditions

Test parameters	Unit	Operation
Sodium injection rate	g/s	1
Temperature of sodium in storage tank	℃	200
Nitrogen injection rate	Nℓ/s	1
Temperature of nitrogen gas	℃	350
Hydrogen generation rate	Nℓ/s	0.49
Concentration of sodium hydroxide	wt.%	50
Temperature of NaOH aqueous	℃	60
Aqueous circulation rate	ℓ/s	0.55
Inlet temperature of cooler	℃	60
Outlet temperature of cooler	℃	57.5
Heat removal rate of cooler	kW	6.77
Injection rate of feed water	g/s	2.53
Temperature of feed water	℃	30
Position of sodium injection nozzle	mm	200
Position of circulation nozzle	mm	400
Position of screen	mm	600
Water level	mm	800
Angle of circulation nozzle	degree	60
Angle of sodium injection nozzle	degree	0
Dimension of screen (5t)	mm	Ø5 x P10

The concentration of the sodium hydroxide aqueous is kept above 50% by the injection of feed water related to the signal of the sodium hydroxide meter. The level of the sodium hydroxide aqueous in the reaction vessel is controlled by overflow into the sodium hydroxide storage tank.

The concentration of hydrogen gas in the outlet is about 33% in volume when the sodium injection rate is 1g/sec. Therefore, the outlet gas is discharged at a considerable distance off-site from the laboratory due to the danger of– explosion. The system is automatically comes to a halt by pushing an emergency button when a leak occurs. During the automatic process, two valves are shut off to prevent the sodium injection, the sodium hydroxide is drained into the storage tank, and the feed water is drained outside of the laboratory.

The atomizing nozzle is shown in Fig. 2 and an experimental facility is now under construction as shown in Fig. 3. The atomizing nozzle is heated by the 3 electrical heaters to 200 Watt each and the temperature is measured by one thermocouple.

Fig. 2 Atomizing nozzle

Fig. 3 Photo of the facility

3. 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 to achieve a uniform reaction. The optimal geometry of the process and the operating conditions were studied. An experimental facility was designed and installed to verify the sodium waste process.

Acknowledgement

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REFERENCES

[1] B. Kim, J. Kim, T. Kim, H. Nam, J. Jeong, B. Choi, J. Choi, and Y. Lee, "Current Status on Development of Sodium Waste Treatment Process," KAERI/AR-856/2010.

[2] E. Magny, "Fast Reactor Bulk Sodium Coolant Disposal NOAH Process Application, IAEA Secial Mtg. on Sodium Removal and Disposal from LMFBRs in Normal Operation and in the Framework of Decontamination," Aix En Provance, France, 1997.

[3] H. Nam, J. Kim, B. Kim, and Y. Lee, "Water Mock-up for a Sodium Waste Treatment Process," KNS Spring Meeting, Taeback, Korea, May 26-27, 2011.