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Preliminary Test of the Sodium Treatment Process

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1. Introduction

The use of sodium as a coolant necessitates the development of special post-operation procedures for the treatment of waste sodium, sodium contaminated equipment, or other purposes [1,2]. Only a few power and research reactors with sodium coolant have been constructed and operated worldwide. They are close to the end of their design lifetime and, in some cases, the decommissioning is in progress [3].

Conducted by countries that have operational experience with sodium cooled fast reactor, R&D programs are intended to provide a solid basis for design and operation of sodium waste processing facilities as well as for decommissioning planning.

Sodium waste, which has been generated from the test facilities related to the sodium since the beginning of the 1990s, requires now the safe sodium treatment in Korea [4].

Each work activity with sodium should be properly planned and managed to avoid potential chemical reactions or explosions with a high risk of consequent environmental contamination [5]. Special procedures should be implemented for removing and processing bulk quantities of sodium and sodium residuals in internal spaces and on internal surfaces of equipment.

The objective of this study is to design, construct, and test a technological facility for sodium waste treatment.

2. Waste sodium treatment test facility

2.1 Description of the test facility

As a treatment method of the waste sodium which was produced from a sodium facility, an investigation for a reaction procedure of the waste sodium with the sodium hydroxide has been developed.

The principle of this test facility consists in small quantities of the waste sodium to react after injection into a strong current of water confined inside cylindrical reactor with temperature controllers. The sodium was injected into a reaction vessel filed with a caustic soda through an atomizing nozzle to maintain the reaction uniformly. The reaction being highly exothermic, the reactor is continuously cooled and temperature of the sodium hydroxide solution is maintained between 35 and 45 ℃.

The sodium-water reaction evolves sodium hydroxide and hydrogen. The sodium is rapidly distributed in the water with no explosive reaction and the aqueous sodium hydroxide content is continuously adjusted to constant concentration.

Fig. 1 shows the P & I drawing of the waste sodium treatment test facility.

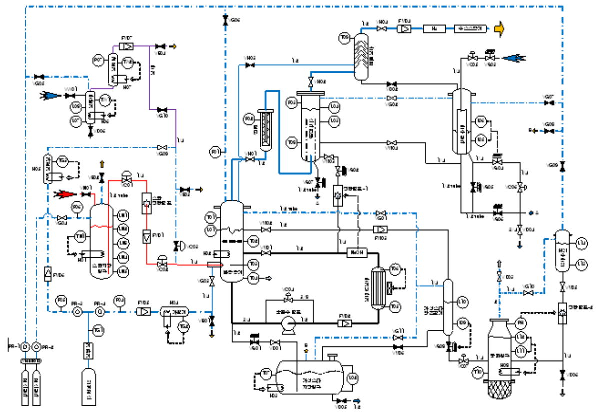

Fig. 1. P&ID drawing of the waste sodium treatment test facility.

And the waste sodium treatment test facility consists of a steam supply system, a nitrogen gas supply system, a reactor (cold trap), a gas release system, and a data acquisition system as shown in Fig.2.

Fig. 2. Photograph of the waste sodium treatment test facility.

2.2 Treatment procedure

Nitrogen gas was injected into the sodium hydroxide as atomizing gas in order to protect the sodium injection nozzle and also to mix sodium. Then the gas flow rate was also varied to see the desired effects. Injected sodium temperature and mass flow rate were 200 ℃and <1g/s, respectively. The atomizing gas flow rate, the temperature and concentration of the sodium hydroxide were varied in rages of 1.0 Nl/s, 60 ℃, and 50~60 wt%, respectively as shown in Table I. The influences of these parameters on the sodium conversion reaction were evaluated.

Table I: Experimental condition.

Experimental condition	range
Reaction temperature (℃)	60
Sodium injection pressure (MPa))	0.97
Water in reactor tank (ℓ)	111
Temperature of sodium storage tank (℃)	300
Injection rate of waste sodium (g/s)	< 1.0
Injection temperature of nitrogen(℃)	350
Injection rate of nitrogen (Nℓ/s)	1.0
Temperature of NaOH (℃)	60
Concentration of NaOH (wt %)	50~60

3. Results

The influences of these parameters on the sodium treatment reaction were evaluated. The experiments showed that increase of the atomizing gas resulted in stable injection of the sodium and also larger reaction area. Fig. 3 shows the temperature histories with time in reactor. The temperature of sodium hydroxide solution in reactor reached a maximum of 65 ℃.

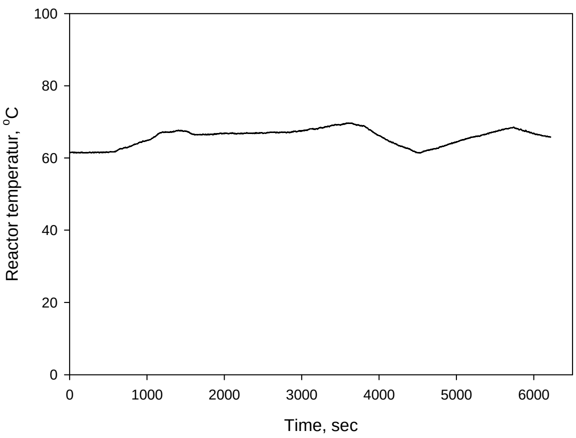

Fig. 3. Change of reactor temperature to time.

Fig. 4 shows hydrogen and NaOH concentration histories with time in reactor. As shown in Fig. 4, the hydrogen concentration remained constant at about 40%.

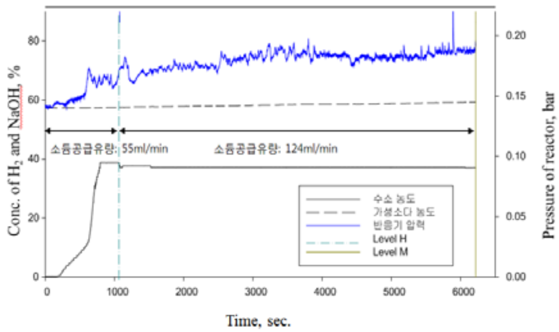

Fig. 4. Change of hydrogen and NaOH concentration in reactor.

4. Conclusions

We had first step toward the sodium treatment technology. A sodium removal by waste sodium test facility was conducted safely. No explosions were observed during the test. Based on the experimental results, the model for reaction is planning to be developed.

This medium scale experiment for removing the waste sodium enabled KAERI to acquire valuable experience. The experience acquired from this study will be applied to the project to clean contaminated components.

ACNOWLEDGEMENT

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