The study on the SCC behaviors of type 304 stainless steel piping in the presence of Na_2S

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1. Introduction

Type 304 austenitic stainless steel has been used as structural material in various industries such as nuclear power, electric power, and petrochemistry because of having superior mechanical property. Type 304 austenitic stainless steel which has a superior property of corrosion resistance and mechanical strength has been used in Pressurized Water Reactor (PWR) in nuclear industry. However, type 304 stainless steel is susceptible to generate the SCC under corrosive environment such as high temperature and pressure. So, it is the most important to figure out the behavior of cracking including SCC (stress corrosion cracking) for stability evaluation in nuclear industry. This study was conducted to understand the influence Na_2S hydrates on corrosion of stainless steel through measurement the corrosion potential and corrosion current, and the SCC of stainless steel was ingenerated in each Na_2S solution as accelerated corrosion atmosphere using piping system. And then, the SCC behavior of pipe type stainless steel 304 was investigated which was applied to piping system in Na_2S solution. Na_2S as corrosive agent was used in forms of several hydrates, for example, $Na_2S{\cdot}xH_2O$ (-anhydrate), $Na_2S{\cdot}5H_2O$ (-pentahydrate), and $Na_2S{\cdot}9H_2O$ (-nonahydrate).

2. Experimental procedures

2.1 Materials

In this study, austenitic stainless steel 304 which is widely used in pipelines of the nuclear power plant’s reactor coolant system was used to examine the SCC behavior and corrosive property depending on the influence of Na_2S hydrates. Table I shows the chemical compositions of the tested stainless steel 304.

Table I: Chemical compositions of tested STS 304

Material	Chemical composition (wt %)
Fe	Bal.
Cr	18.3
Ni	8.25
Mn	1.1
Si	0.55
C	0.055
P	0.025
S	0.005

Also, Na_2S as corrosive agent was used by the 3 types Na_2S solution of $Na_2S{\cdot}xH_2O$ (ACROS Organics, Belgium), $Na_2S{\cdot}5H_2O$ (Daejung chemical, Korea), and $Na_2S{\cdot}9H_2O$ (Junsei chemical, Japan), respectively. As shown in Fig.1 (a), the specimen was prepared with the plate type stainless steel 304 (10 mm X 10 mm X 1 mm) for corrosion potential test. Pipe type stainless steel 304 (150 mm X 89.1 mm X 7.6 mm) was used to investigate the SCC behavior in piping system as Fig.1 (b).

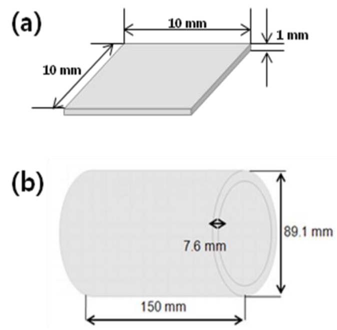

Fig. 1. Schematic of specimens for corrosion potential test (a) and SCC behavior test in piping system (b).

2.2 Corrosion Potential Test (Tafel method)

The experiments were performed with type 304 stainless steel (type 304 stainless steel 10 mm x 10 mm x 1 mm) to measure the corrosion behavior of it using a Potentiostat/Galvanostat (EG&G 263A, PAR) as shown in Fig. 2.

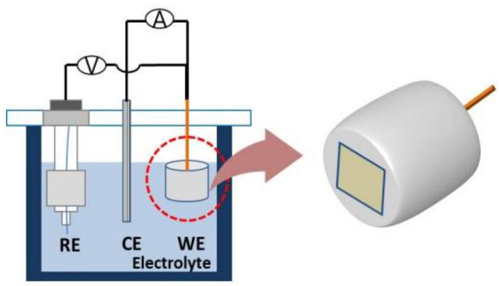

Fig. 2. Schematic of corrosion potential test; RE (Reference Electrode), CE (Counter Electrode), WE (Working Electrode).

All the experiments were performed in three aqueous solution of $Na_2S{\cdot}xH_2O$ (1 M), $Na_2S{\cdot}5H_2O$ (1 M), and $Na_2S{\cdot}9H_2O$ (1 M), respectively. The counter electrode was a Pt wire and the reference electrode a saturated calomel electrode (SCE). All the potentials are referred to SCE. The potential scan rate of the working electrode was 1 mV/s, which appeared to be sufficiently slow to consider the polarization curves to have been obtained under a quasi-steady state condition [1].

2.3 SCC behavior test in piping system

In this test, the dimensions of specimen were 89.1mm in diameter, 7.6mm in thickness and 150 mm in length. As shown in Fig. 3, SCC manufacturing equipment was composed to generate SCC in pipe type specimen under simulated PWR condition. The specimen was heated using a ceramic heating coil. The experimental system was controlled by vapor temperature. Also, the residual stress in inner surface of specimen was given by Tungsten Inert Gas (TIG) welding.

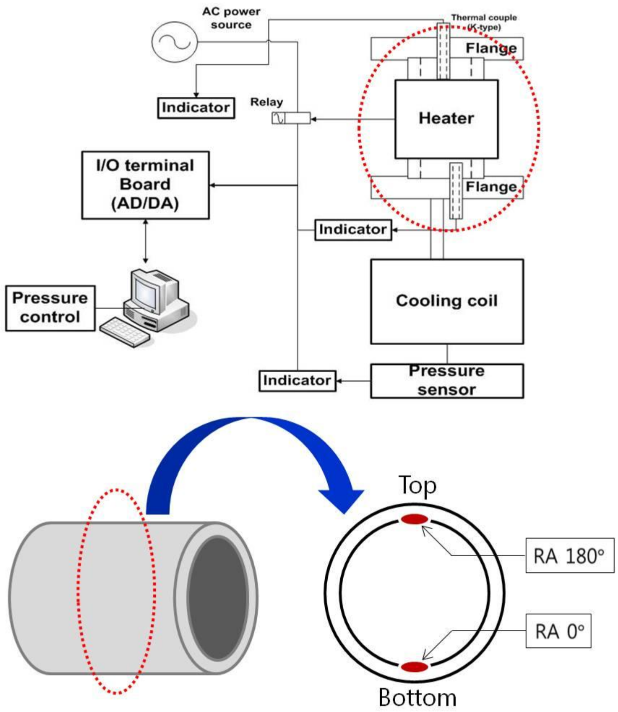

Fig. 3. Diagram of SCC manufacturing equipment and the location of weld bead.

The presence of Na_2S in concentrated corrosive environments enhances the corrosion sensitivity of type 304 stainless steel [2]. In this study, behavior of sulfur which generates SCC will be confirmed as the 3 types of Na_2S hydrates because sulfur existing at Na_2S has a decisive influence in corrosion [3].

3. Summary

The corrosion potential test and SCC behavior test in piping system were accomplished for stainless steel 304 specimens under the corrosive atmosphere in presence of Na_2S hydrates. By the results of these tests, effect of hydrates solution on SCC of stainless steel will be confirmed. Also, behavior and shape of SCC formed after the pipe test will be investigated through the analysis of EDS, XPS, SEM and NDT (Non Destructive Test; Liquid penetrant inspection).

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