Development of Ion Exchange Resin Saturation Loop for IASCC Test Facility in Hot Cell

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1. Introduction

IASCC (Irradiation Assisted Stress Corrosion Cracking) test demonstration facility in mock-up hot cell was installed at the Materials Safety Technology Development Division of KAERI (Korea Atomic Energy Research Institute). To remove radioactive ionic species dissolved in the test solution, three ion exchangers are equipped in the test facility. The ion exchanger has a mixed resin of cations and anions with a 5 L capacity filled in the container. The container is a vertical cylinder covered with a lid and a screen is attached to the inlet and outlet passage to prevent the resin from escaping. The flow rate through the resin layer ranges from 25 to 200 L/h.

The ion exchange resin should be saturated with a proper cation or anion in a separate saturation loop prior to use to reduce the time and effort for test preparation. In addition, it is easy to control and maintain the water quality without interrupting the experiment using the test facility. The criterion for determining whether the ion exchange resin is saturated with desired ions is the value of the electric conductivity and pH of the test solution circulated in the saturation loop.

This paper is aimed to develop a separate saturation loop for ion exchange resin in order to control the conductivity and pH of the test solution in IASCC test facility in the mock-up hot cell.

2. Design of Ion Exchange Resin Saturation Loop

Fig. 1 shows the ion exchange resin saturation loop developed in this work. The saturation loop consists of ion exchangers, circulation pumps, solution tanks, and associated valves and piping. The flow rate of the saturation process loop is controlled at about 10 l/m by a P2 pump

The test solution is prepared by mixing boric acid and lithium hydroxide in deionized water of T1 tank with a capacity of 50 L. The test solution prepared in this tank is transferred to T2 tank with a capacity of 25 L of the IASCC test facility. The test solution in T2 tank is circulated through the ion exchanger by P2 pump, and the electrical conductivity is constantly monitored by the conductivity meter CE 1. When the electrical conductivity value of the test solution reaches the range that satisfies the criterion (20 to 30 $\mu S\cdot cm^{-1}$), the saturated ion exchanger is moved from the saturation loop to the IASCC test facility in the mock-up hot cell.

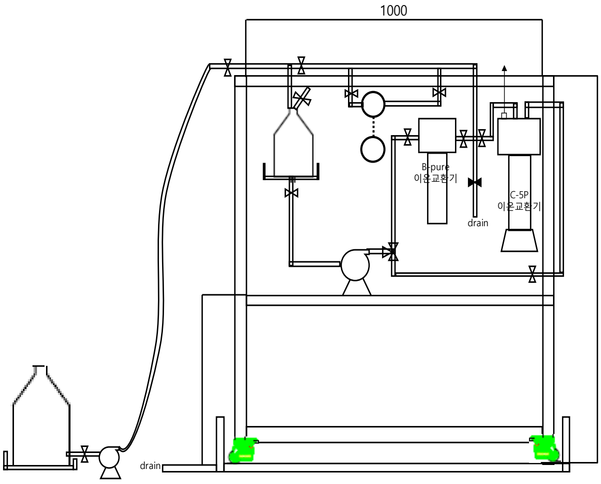

Fig. 1. Schematic diagram of ion exchange resin saturation loop developed in this work

Fig. 2 presents an assembly diagram of the C-5P type ion exchanger in detail in Fig. 1.
The ion exchange resin charged in the ion exchanger is a mixed resin of cation and anion. The physical and chemical properties of resins are shown in Table 1 [2].

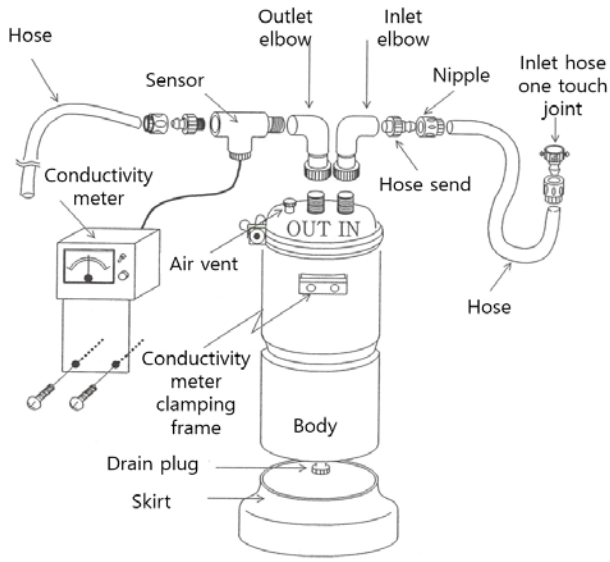

Fig. 2. An assembly diagram of the C-5P type ion exchanger

Table 1. Detailed properties of ion exchange resin

Properties		
Component	Mixed resin	
Ionic form	H^+ / OH^-	
Chemical equivalent ratio	1/1	
Shipping density (g/L)	710	
Maximum operating temp. (℃)	60	
Operating pH range	0 ~ 14	
Minimum bed depth (mm)	800	
Service speed (m/h)	10 ~ 60	
	Cation exchange resin	Anion exchange resin
Water content (%)	50 ~ 60	62 ~ 72
Mean particle size (μm)	700	720
Effective size (μm)	400 min.	400 min.
Ionic form conversion (H+) (eq %)	99 min.	-
Ionic form conversion (OH-) (eq %)	-	90 min.
Ionic form conversion (Cl-) (eq %)	-	1 max.
Particle density (g/mL)	1.20	1.08

The operation procedure of the ion exchange resin saturation process loop was summarized as follows,

1) The test solution is prepared by mixing 1200 ppm of boron (as H_3BO_3) and 2.2 ppm of lithium (as $LiOH.H_2O$) with deionized water in T1 tank with a capacity of 50 L.
2) Connect the T1 tank with the V01 valve to transfer the test solution to the saturation process loop.
3) Open V09 valve, drain the remaining test solution accumulated in the piping line, and close the V09 valve.
4) Open the V1, V2, and V11 valves. And then run P1 pump to transfer the test solution from T1 tank to T2 tank with a capacity of 25 L.
5) Close the V1, V2, V11 valves, and open the V3, V4 (3way valve), V5, V6, V10 valves. With the valves V7 and V8 closed, run P2 pump to circulate the test solution in T2 tank to the ion exchanger (C-5P). At this time, open the V09 valve and drain the test solution a little to remove the existing test solution in the ion exchanger. The V4 valve is a 3-way valve to form a flow path in the direction of the ion exchanger. Open the vent valve V11 of T2 tank after draining the test solution.
6) Repeat the procedure 1) ~ 5) with the additionally prepared solution to satisfy the water quality condition.
7) If the circulated solution satisfies the water quality conditions, move the saturated ion exchanger from the saturation loop to the IASCC test facility in the mock-up hot cell.

3. Conclusions

The ion exchange resin saturation loop was developed in this work to reduce the time and effort for controlling water quality of the test solution in the IASCC test facility in the hot cell. The criteria for determining whether the ion exchange resin is saturated with desired ions is the value of the electric conductivity (20 to 30 $\mu S{\cdot}cm^{-1}$) and pH (6.4 ~ 6.6) of the test solution circulated in the saturation loop.

REFERENCES

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