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Sensor for Hydrogen Concentration Monitoring in Cover Gas

Tae-Joon Kim*, Ji-Young Jeong, Jong-Man Kim, In-Koo Hwang, Jae-Hyuk Eoh, Yong-Bum Lee
Korea Atomic Energy Research Institute, 150 Dukjin-dong, Yuseong-gu Daejeon 305-353, Korea
**Corresponding author: tjkim@kaeri.re.kr*

1. Introduction

KAERI (Korea Atomic Energy Research Institute) will perform a test for a thermal hydraulic simulation with STELLA-1 for a Component Performance Test Sodium Loop in 2012, and subsequently will construct STELLA-2 for a Sodium Thermal-hydraulic Experimental Facility [1] in 2016. These facilities need to consist of a sensor for hydrogen concentration monitoring to control some of the impurities in a purification system in the future.

In this paper, the senor manufactured by a shop at KAERI was introduced and tested.

2. Experimental system

The sensor consists of a nickel membrane with a thickness of 0.2 mm and diameter of 10 mm. The membrane material is pure nickel, and the body sensor material is SUS304. The length of the tubular nickel membrane is 200 mm. During operation, the inside of the tubular nickel membrane will be a high vacuum, and outside of the tubular nickel membrane will flow gas such as cover gas with a traced hydrogen concentration of 0.3ppm in 99.9999% purified Argon gas. Fig. 1 shows a photograph of the external form of the hydrogen sensor.

Fig. 1. Hydrogen concentration monitoring sensor.

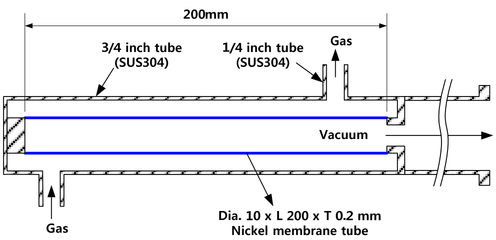

Fig. 2 Schematic drawing of hydrogen concentration monitoring sensor.

The extrusion of hydrogen gas through a nickel membrane is shown. The experiment performed using hydrogen concentration monitoring sensor is shown in Fig 1 and Fig. 2, and the vacuum system installed with measurement sensors is shown in Fig. 3 and Fig. 4.

Creating a high vacuum, a rotary vacuum pump was first operated, followed by a turbo-molecular vacuum pump. A triode ion pump was then operated. When the ion pump was operated, the rotary vacuum pump and turbo-molecular vacuum pump were stopped. To obtain a regular vacuum condition, a valve of the ion pump was slowly controlled at up to 2×10^{-7} mbar.

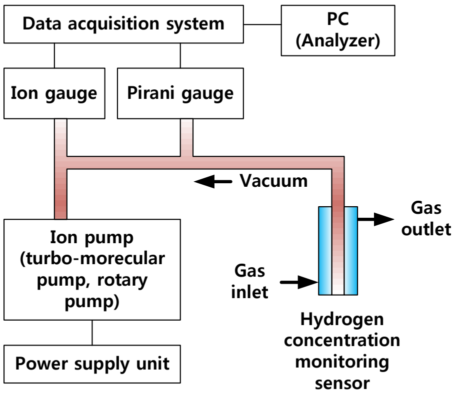

Fig. 3. Schematic drawing of a hydrogen concentration monitoring system.

Also, the experimental system for hydrogen concentration monitoring is as shown in Fig. 4. The experimental system consists of a dry vacuum pump, a turbo-molecular pump, an ion pump, a Pirani gauge, a current meter, and a power supply for the ion pump and hydrogen sensor.

A calibration followed since their output signal depends on both the temperature of the medium measured (cover gas) and the nickel membrane material. Because a precise measurement for hydrogen permeation in the area near the small-dimension membrane tube is needed, a calibration of the sensor is also required.

Fig. 4. Experimental system.

3. Results and Discussion

3.1 Conditions of weld part

After using the hydrogen concentration monitoring sensor manufactured at the KAERI shop several times, a crack was partly developed at the welded part between the SUS304 body and nickel membrane tube located inside the hydrogen concentration monitoring sensor shown in Fig. 5.

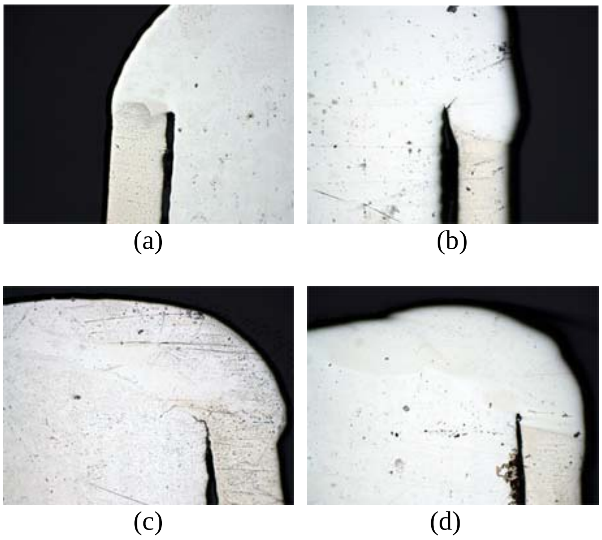

Fig. 5. A crack at the welded part between the material of the SUS304 body and nickel membrane.

3.2 Test results of the sensor

Fig. 6 shows the results when Argon gas with 0.3ppm hydrogen was injected with the flow rate of 5.7cc/sec into hydrogen concentration monitoring sensor. The measurement was the signal of the pressure value of the ion pump.

This was differentiated from the profile of the pressure measurement of the ion pump. After the injection of Argon gas with 0.3ppm-hydrogen, the response time was 38 sec.

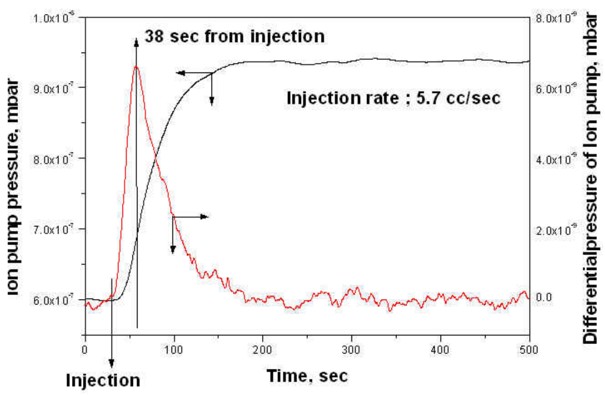

Fig. 6. Test results of the hydrogen concentration monitoring sensor.

3.3 Evaluation of response time

The response time of the hydrogen concentration monitoring sensor in this paper was 38sec at a concentration of 0.3ppm hydrogen in Argon gas. If it will be used for water steam during an sodium leak detection, it is possible to be used for leak detection of a steam generator under conditions within sodium hydrogen meter sensitivity improvement better than current conditions of 0.1 to 0.5ppm, and under a response time of sodium hydrogen monitoring sensor shortage less than 60sec [2]. Thus this sensor can also be used for this feasibility study.

4. Conclusion

We obtained a result in which Argon gas with 0.3ppm hydrogen was injected with a flow rate into the hydrogen concentration monitoring sensor. The developed sensor will be applied in STELLA-2 or a sodium loop to control the purification of sodium. This technology will be very applicable to any liquid metal processes in STELLA-2.

Also, if this sensor detects 0.3ppm-hydrogen within 60sec, it will be possible to use as a leak detector.

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