Performance Test of Micro Thermocouple for Water Leakage Detection System

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1. Introduction

A development of water leakage detection system has been performed at Korea Atomic Energy Research Institute. A requirement of this system is to detect a water leakage less than 0.5 gpm in real-time. This system includes a gas sampling system to analyze gas properties change when water is leaked at somewhere. A gas temperature is one of gas properties that have to be monitored in real-time. Temperature monitoring system is required fast time response. It is also required a permanence under a high gas flow condition and an irradiated condition. In this study, thermocouples that has micro scale junction were developed to satisfy required time response. And the permanence tests for developed thermocouples were performed under a high gas flow condition and an irradiated condition.

2. Micro Thermocouples

Developing leakage system requires thermo-couples with fast time response. For this requirement, micro thermo-couples those have small junction diameter less than 200 μm. The thermocouples may be exposed high flow condition and irradiation condition. Failure of thermocouples is possible under these severe conditions. To improve permanence of measurement with thermocouple, three thermocouples were installed and they were connected to one measuring channel with parallel connector. One of advantages of this connection is that the average temperature of three thermocouples is monitored when all thermocouples are available. Another advantage is that fluid temperature can be measured by remained thermocouple(s) even though one or two thermocouples are failed. Therefore, parallel installation of thermocouples is can be a solution for stable measurement under severe conditions.

3. Test Methods and Results

3.1 Flow Resistance Test

For permanence under high flow condition, the developed thermocouples were installed in gas flow loop. The flow loop had a gas flow meter and was connected to air compressor to make gas flow. The test was performed under ambient temperature condition and the range of flow speed was 13 ~ 42 m/s that is operating condition of leakage detection system test loop.

Three thermocouples were exposed a flow condition and temperatures were recorded for over 300 second. The test results are summarized on Table I and plotted on Fig 3. The thermocouples were available after flow resistance test and verified permanence under test conditions.

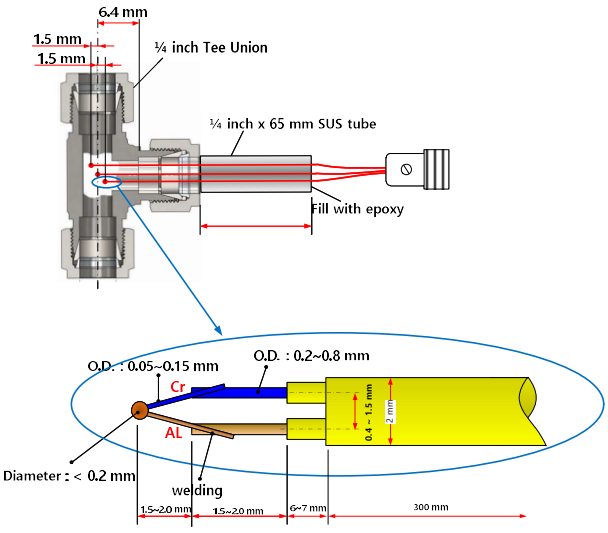

Fig. 1. Configuration of micro thermocouple

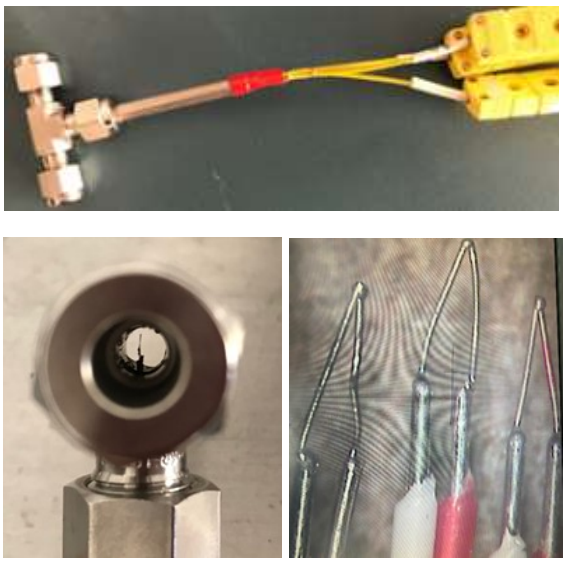

Fig. 2. Pictures of developed thermocouples

Table I: Flow resistance test result

Flow speed	Temperature / stdev for TC1	Temperature / stdev for TC2	Temperature / stdev for TC3
m/s	℃	℃	℃
13.33 / 0.01	25.4 / 0.34	25.1 / 0.24	25.6 / 0.25
26.04 / 0.02	24.7 / 0.05	24.6 / 0.03	25.1 / 0.04
41.98 / 0.03	24.7 / 0.07	24.7 / 0.07	25.0 / 0.04

* stdev: standard deviation

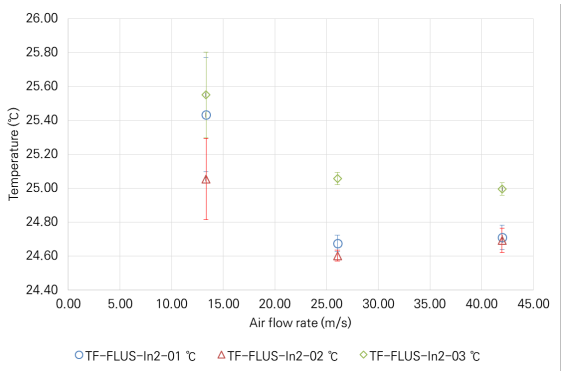

Fig. 3. Recorded loop temperature during flow resistance test

3.2 Irradiation Test

To validate the permanence under irradiation condition, three tests were performed using the developed two sets of thermocouples. First test was performed under room condition before irradiation test, second test was performed under irradiation condition, and third test was performed under room condition after irradiation test. During the first and third tests, two sets of thermocouples were placed at same position. However, one set of thermocouples was placed in front of radiation source and the other set of thermocouples was placed at radiation free zone to recognize the effect of irradiation during second test (Fig. 4).

The irradiated thermocouples were exposed about 3.5 kGy. This value is 6.7 times of exposure volume that a system can be exposed during 40 years in the annulus zone of containment. The exposed volume was calculated from measured result of alanine that was exposed at same place where the irradiated thermocouples was placed during the second test.

The temperature difference between two sets of thermocouples were lower than 1 ºC for all tests (Fig. 5 ~ Fig. 7). From these results, a result was concluded that the developed thermocouples have permanence under irradiation condition.

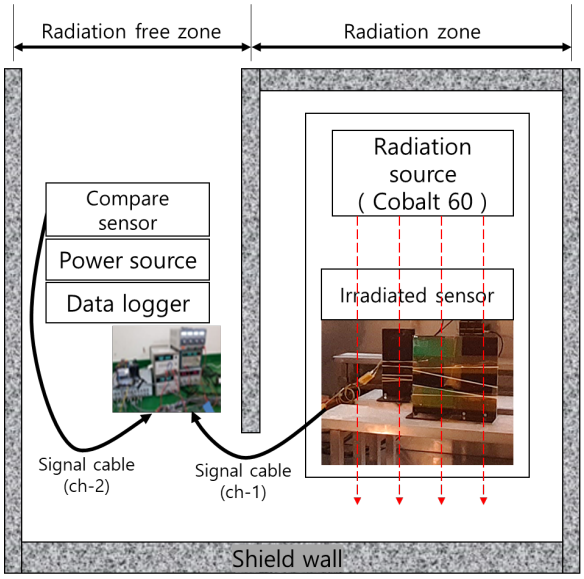

Fig. 4. Irradiation test configuration

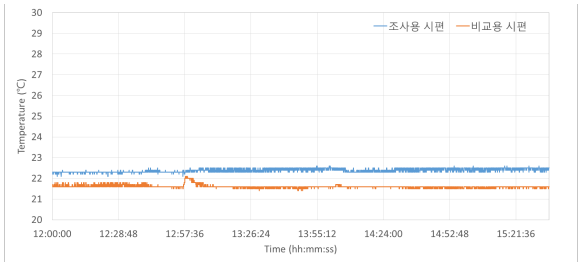

Fig. 5. Recorded room temperature before the irradiation test

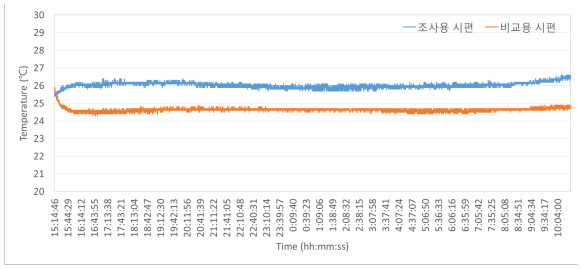

Fig. 6. Recorded room temperature during the irradiation test

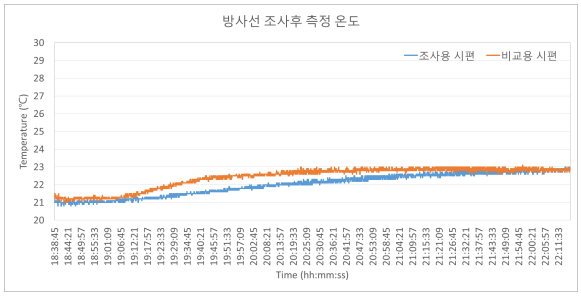

Fig. 7. Recorded room temperature after the irradiation test

3. Conclusions

A water leakage detection system has been developed for small leakage in a nuclear power plant. For this

system, a micro thermocouple system which has short response time was developed to measure a temperature of gas that is sampled from containment. To verify the permanence of developed thermocouple system, two tests were performed under a high gas flow condition and an irradiated condition. The developed thermocouple system showed good performance for permanence test.

Acknowledgement

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