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Preliminary experimental test for a micro crack detection technique using an ultra fine particle sensor

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1. Introduction

A detection technique for initial state of leakage in a high pressure and temperature system is very important to prevent serious accident which has large leakage. In nuclear power plant, there is a similar concept the leak-before-break (LBB).

There are several leakage detection techniques. For maintenance period, operator can apply the pressure drop test with pressurized liquid. Or the operator can inject detectable gas or liquid into the system to check the cracks in a system. For operating period, a detection technique using visualization of leaked fluid can be installed. Another method is detection of vibration or sound by leakage. The other one is gathering the leaked fluid at the bottom of system and measuring the amount of leaked fluid. Each technique has its own advantages and disadvantages. The best way to detect a leakage is a combination of these techniques.

There is a system was developed to detect the ultra fine particles (> 4 nm) [1]. For conventional system, working fluid is filtered using various cleaning system. Even though the working fluid was filtered, there are many ultra fine particles. If a fluid flows out from a crack, the particles, which are in the working fluid, also flow out and are spread into the air. Therefore, the crack can be detected by particle detection.

In present study, preliminary experiments were performed for a micro crack detection technique using an ultra fine particle sensor.

2. Methods and Results

2.1 Test facility

For this study, an experimental facility that includes a pressurized tank, fluid venting nozzles was developed. The design pressure was 1.0 MPa and experiments were performed for 0.6 ~ 0.7 MPa. A working fluid was tap water and deionized water. There was a heater to control the temperature and pressure of system. Several size cracks (hydraulic diameter 15 ~ 100 μm) were installed to simulate the micro cracks.

2.2 Test result

Micro crack detection technique using ultra fine particle detecting system was validated. The number of particle increased and oscillated at the near of crack, while the number was stable at the far from crack (Fig. 4).

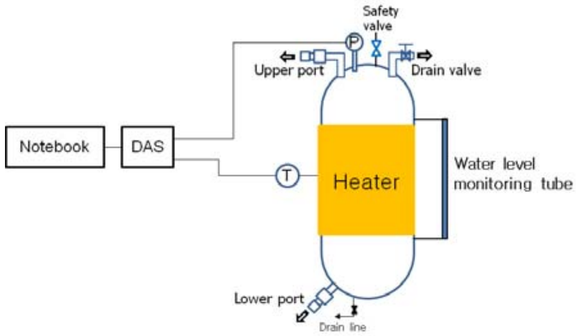

Fig. 1. Schematic of test facility

Fig. 2. Installed cracks

Fig. 3. Leaked steam through the crack

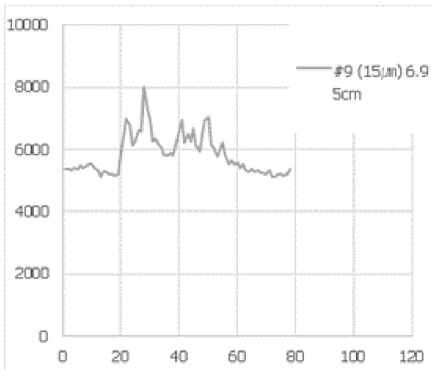

Fig. 4. Number of particle near of the crack (jet condition)

Present technique was also tested for the steam that flows up by buoyancy force and this technique was also valid for this condition (Fig. 5).

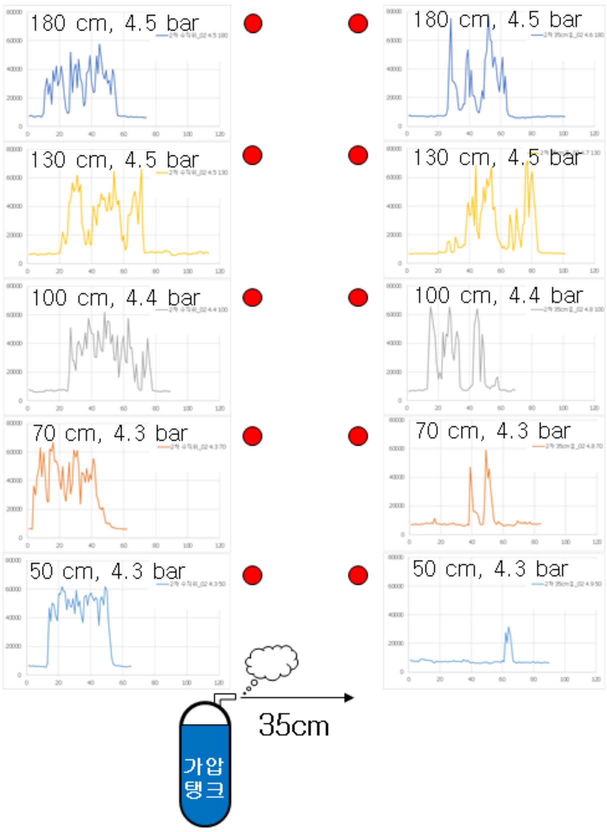

Fig. 5. Test results at various position for flow by buoyancy force

To compare the fluid condition, deionized water also used. In the case of the deionized water, the increasing rate was lower than tap water. However, the oscillation of number was also observed. Therefore, this technique using the oscillation is also available for the filtered fluid

3. Conclusions

Preliminary experimental test for a micro crack detection technique using an ultra fine particle sensor were performed. Micro crack detection technique using ultra fine particle detecting system was validated for 0.6 ~ 0.7 MPa with several size cracks (hydraulic diameter 15 ~ 100 μm). However, it is not lower pressure condition for nuclear power plant. Therefore, additional experiments for higher pressure condition is required to validation.

REFERENCES

[1] X. He, S.-Y. Son, K. James, M. Yermakov, T. Reponen, R. T. McKay, S. A. Grinshpun, Exploring a Novel Ultrafine Particle Counter for Utilization in Respiratory Protection Studies, Journal of Occupational and Environmental Hygiene, Vol 10, p.D52, 2013