Design Modification of Sparger in the IRWST

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1. Introduction

IRWST installed in the Korean nuclear reactor adopted I-type sparger. A simulated experiment indicated that, although temperature distributions in a water tank were relatively even, a vertical thermal stratification was formed around 40cm from the bottom. As a result, it is estimated that an excessive hear stress will be exerted to the lining around the stratification.

Therefore, it is required to improve the design of the sparger to remedy the defect of the I-type sparger. In this study, the check valve type-sparger is adopted instead of the I-type sparger. The cap installed in the check valve-type sparger shuts the downward vent hole in the vent clearing phase to minimize the load to the structure. In the normal operation, the extended downward vent hole opens so that sufficient amount of steam should reach the floor, preventing thermal stratification and maximizing the efficiency of the coolant. The improved sparger design was verified through the experiments of verification.

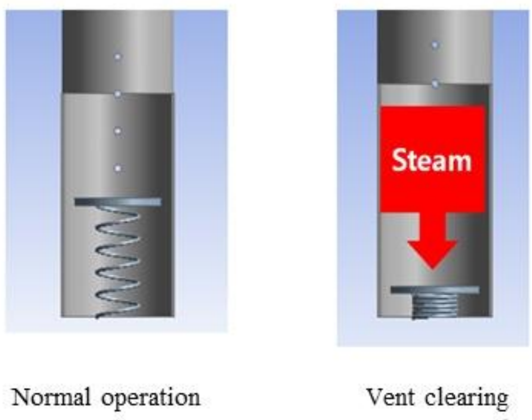

Fig. 1. Design of Check valve-type sparger

2. Experiment

2.1 The pool shape and water level

Sparger installed at a right angle inside a ring shape pool, but it is an experiment of performance of the sparger using air. Therefore, pool was designed to rectangular parallelepiped. Water level have not a decisive effect on the performance of sparger. Also to reduce the experimental time, the water level is determined 1.5m.

2.2 The sparger hole area

According to many studies, the maximum pressure of the steam flowing into the sparger 17bar. This test was to be performed at the maximum steam pressure of 8.5bar, and therefore, the size of the vertical holes was designed to be 1/2. In the actual power plant, the horizontal holes are 1cm in diameter, and are designed in 16 directions and 9 stages. Therefore, the total area of the horizontal holes is as following.

$$A_{h\_hole} = (0.5cm)^2\pi\times144 = 113.1cm^2 \qquad (1)$$

For this calculation, the sparger requires the total horizontal hole area of $57cm^2$, and therefore, 6 horizontal holes of 3.5cm in diagram were installed.

The downward vertical holes used in this experiment were 4cm in diameter, which is extended from that of the actual sparger, in order to improve the condensation capability at the IRWST floor and to reduce thermal stratification.

2.3 Design of spring inside the sparger

The cap must be spring-closed by the differential pressure at the vent clearing, and in normal operation, must open the vertical hole. Therefore, selection of the spring constant is critical. The spring constant was calculated as following, and as a result, the spring wire diameter of 3mm was selected.

$$k = \frac{Gd^4}{8{D_m}^3 n_e}\ [\text{N/mm}] \qquad (2)$$

where, G=modulus of rigidity, d=wire diameter, d_m=spring outer diameter, n_e=number of active windings

3. Result

3.1 Result of the I-type sparger

The test for the I-type sparger was performed for comparison with the Check valve-type. The test showed that the I-type sparger starts discharging air through the vertical holes in 0.7sec from opening of the air valve, and finishes discharging in 9.7sec. The penetration depth of the air was at least 60cm.

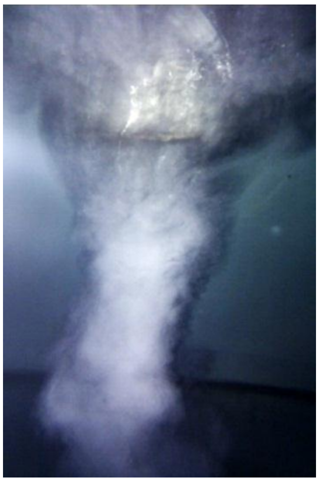

Fig. 2. Ventilation of air through I-type sparger

3.2 Result of Check valve-type sparger

The check valve-type sparger starts discharging air through the vertical holes in 1.8 sec from opening of the air valve, and finishes discharging in 4.2sec. The penetration depth of the air was approximately 41cm.

Fig. 3. Ventilation of air through Check valve-type sparger

4. Discussion and conclusion

In this study, a comparative test was performed between the I-type sparger and the improved Check valve-type sparger. As shown in the test result, the Check valve-type starts discharging air through the vertical holes in 1.8sec from opening of the valve, which was a delay of 1.1sec when compared with the I-type sparger. The test result shows that the Check valve-type sparger can provide the desired operation characteristics.

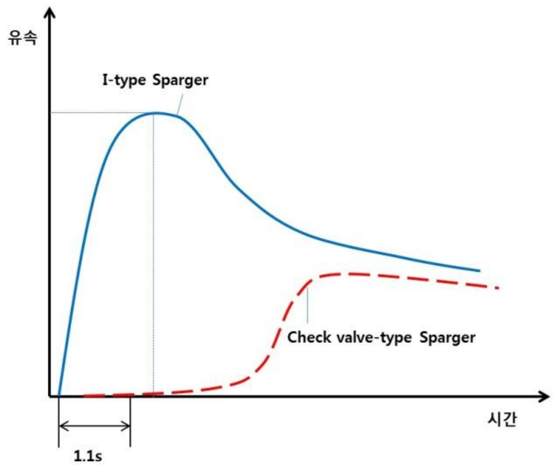

Fig. 4. Comparing with pressure inside the Sparger

The delay time can be adjusted with the strength of the internal spring. Adjusting delay time and the strength of the spring in consideration of the penetration depth requires a precise calculation.

An additional verification test is required for the effect of thermal stratification with steam and water.

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REFERENCES

[1]KOPEC, “IRWST T/H Load Analysis” KOPEC, Korea, 1996

[2]N.Kim, “An Experiment Study on the Temperature Distribution in IRWST”, KSME init. J., 2004