Analysis of the containment cooling using the SPACE code

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1. Introduction

The Fukushima accident was an opportunity to re-check the nuclear facilities of each country and reestablish the response system. The United States has developed a strategy to prepare for extreme disaster accidents beyond design extension conditions such as Fukushima accident, and developed a FSG(FLEX Support Guidelines) that reinforces portable facilities. The FSG-12[1] has a procedure to cool the containment building using a portable spray. The purpose of this study is to investigate the effect of the cooling method of containment building using portable spray on domestic power plant.

2. Methods and Results

For analysis of containment cooling, SPACE code(version 3.2), which is a comprehensive thermal hydraulic performance analysis code developed by KHNP, was used. And, the target nuclear power plant was Hanul units 3&4.

2.1 Analysis Conditions

The main design parameters of the containment building were referenced to FSAR(Final Safety Analysis Report)[2] of Hanul units 3&4, and their values are shown in Table I.

The flow rate of the portable spray was assumed to be 500gpm[3].

The containment cooling was analyzed for two conditions. The first assumes that the containment is filled with air at the design temperature and pressure, and the second analysis assumes that the decay heat is generated in the containment and the initial temperature is 283.15K. The decay heat is assumed as shown in Table II[4].

Table I: Main Design Parameters of the Containment

Parameters	Design value
Internal Design Pressure	57.0 psig (4.0 ㎏/㎠)
Design Temperature	285˚F (140.6℃)
Containment Free Volume	2.727×10^6 ft^3 (77220.0 ㎥)
Diameter	144ft (43.9m)
Height	216ft (65.84m)

Table II: Decay heat after reactor shutdown

Elapsed time after reactor shutdown	Reactor Power (%)
1 second	6.0
1 minute	4.5
30 minutes	2.0
1 hour	1.6
8 hours	1.0
24 hours	0.7
48 hours	0.6

2.2 SPACE Modeling

The SPACE code nodalization for the containment cooling analysis is shown in Fig. 1. A thermal structure to simulate concrete was attached to the side of the containment(cell-001). And a thin cell(cell-002) was attached to allow to flow the water from the portable spray, and the TFBCs were connected to top and bottom. The portable spray was assumed to droplet. In addition, the cell-100 was attached to simulate the natural circulation flow of the atmosphere. The thickness of the concrete is assumed to be 1m. The thermal conductivity and the volumetric heat capacity of concrete are 2.6W/m·K and 2016kJ/㎥·K at 24℃[5].

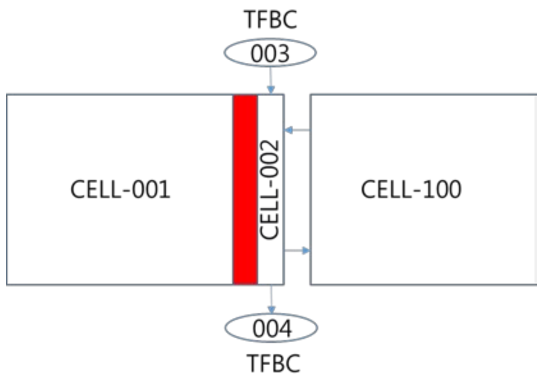

Fig. 1. Containment cooling analysis nodalization.

2.3 Analysis Results

The temperature changes in the case of decay heat in the containment and in the case of no decay heat are shown in Fig. 2. In the case of no decay heat, the containment inside temperature dropped by about 100K after 50 hours of cooling. However, in the case of decay heat, the containment inside temperature increased by about 350K after 50 hours of cooling. It is considered that there is no cooling effect, due to decay heat is generated in the containment.

In the case of decay heat in the containment inside, the case of natural cooling of the containment and the case of cooling by portable spray were also compared. The comparison results are shown in Fig. 3. As a result of analysis, there was almost no temperature difference according to two cooling methods after 25 hours of cooling. After 50 hours of cooling, the temperature difference is about 50K. As time passes, the temperature difference will be larger, but if decay heat is generated, it can be confirmed that there is no cooling effect by portable spray at the beginning of the event.

Finally, the temperature change of the containment outside surface was compared. The comparison results are shown in Fig. 4. As a results of the analysis, the surface of the containment is cooled well, unlike the inside of the containment. The surface of the containment that reaches the water sprayed from the portable spray is cooled, but it is considered that the cooling effect is not enough to the inside due to the thickness of the containment.

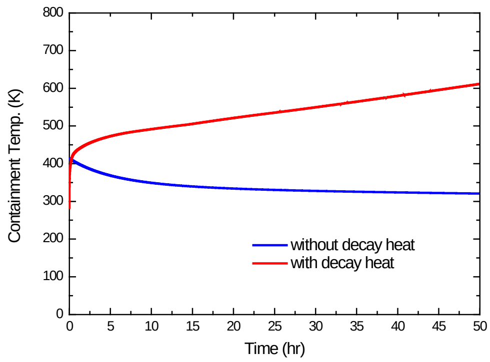

Fig. 2. Comparison for temperature change of containment inside with decay heat generation.

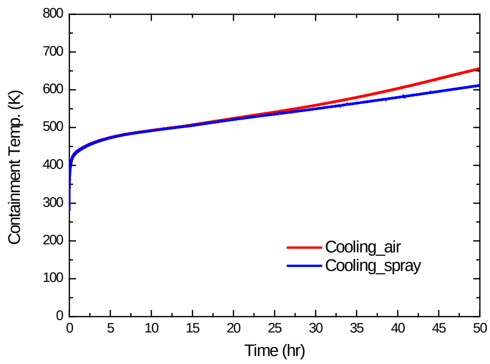

Fig. 3. Comparison for temperature change of containment inside according to cooling method during decay heat.

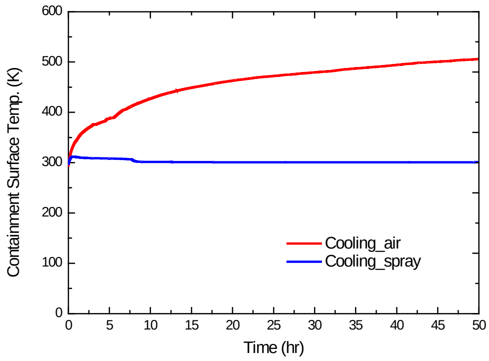

Fig. 4. Comparison for temperature change of containment surface according to cooling method during decay heat.

3. Conclusions

The effect of cooling method of containment building using the portable spray was analyzed by SPACE code. As a results of the analysis, there was almost no cooling effect when decay heat was generated inside the containment, but cooling effect when decay heat was not generated. Therefore, it is considered that the cooling of the containment by the portable spray shown in FSG-12 is effective only when cooling time is very long and decay heat is low.

REFERENCES

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