Distribution of H_2 in SMART-100 system for the SLOCA with the assumption of 100% oxidation of the core and the ERVC using MELCOR1.8.6

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1. Introduction

This paper shows the preliminary analysis results for the effect of 100% oxidation of the core and the ERVC on the containment pressure and the distribution of H_2 in SMART-100 (365 Mwt) system. The simulation on SLOCA (small break loss of coolant accident: 2 inch diameter) has performed with MELCOR version 1.8.6 YV.

To simulate the steam generation from the gap under the condition of ERVC, the steam was directly injected into the LCA (lower compartment area) region based on the results from SPACE code. It was assumed that SLOCA occurred at 0 second. Therefore the reactor and MFW trips were occurred at 0 second. The analysis on the source term was not performed.

This calculation shows that the consideration of gap boiling under the condition of ERVC was very effective to reduce the H_2 concentration in LCA region for the100% metal-water reaction.

2. Methods and Results

2.1 Backgrounds

In the previous SLOCA study that the core was oxidized up to 50%, H_2 mole concentrations in all the LCA region were predicted as they remain below 0.1 mole fraction. So the requirement for preventing the H_2 burn under the condition of severe accident was satisfied. In the SBO accident, there are no chance that the H_2 gas remain in the LCA region because the generated H_2 gas from the core discharge to the RRT directly without staying in the LCA region.

In this study, pre-calculation was performed to estimate the H_2 distribution in the LCA region under the 100% core oxidation condition [1]. The level of H_2 mole fraction was satisfied in all the LCA region except the SIT room. The level of H_2 mole fraction in the SIT room was predicted ~ 0.26 at the maximum.

The reason for this like high level of H_2 concentration in the SIT room was because there were insufficient steam in LCA region although the boiling of water within the gap is occurring under the ERVC.

Therefore, the steam generation from the gap between the hot lower vessel head and a water filled insulator are modeled to enhance the driving force to push out a mixture gas from the LCA region to RRT.

H_2 generation phenomena from the core under the 100% metal-steam reaction was simulated with injecting linearly the additional H_2 mass for the 100% core-oxidation into the core based on the normal oxidation transient (~50% oxidation) under the SLOCA accident. Figure 2.1 shows the time-history for the additional injection of H_2 into the core to simulate the 100% metal-water reaction.

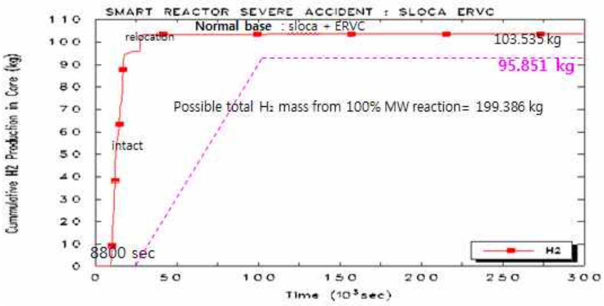

Fig. 2.1 Additional H_2 injection for the 100% metal-water reaction

Before reaching the 30 minutes after SAMG condition, the pressure level of LCA region was checked whether it is greater than 1.6 bar or not. If it reaches 1.6 bar, then venting loop from SIT room to IRWST through ECT-HX will be installed. But if not, then this loop will remain at the closed state.

The SIT room is connected to the ECT heat exchanger tubes. The ECT heat exchanger system includes the pool tank and the heat exchanger tubes (500) with axial length of 1.5 m. But after reaching the 30 minutes after SAMG condition, the venting loop from the SIT building to the IRWST through the ECT-HX will be closed. Then new vent pathes from SIT rooms to the RRTs will be installed. However, Apportion of the loops from the 4 SIT rooms was made.

One SIT room vents to the small RRT tank and the other three SIT rooms vent to the large RRT tank. It assumed that the SAMG condition, means the core exit gas temperature of 923.15 K. The calculation was completed up to 300,000.0 seconds (about 2.8 days). Figure2,2 shows the conceptual view of the SMAT-100.

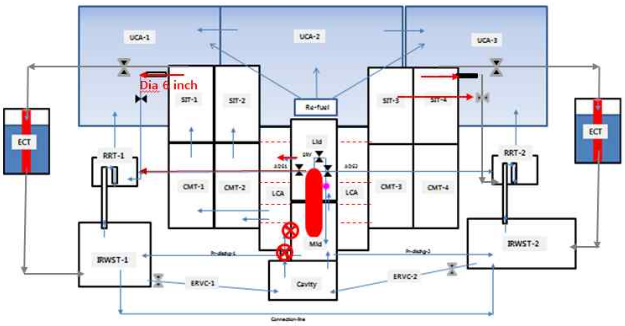

Figure 2.2 Conceptual view of the volumes and flow paths in SMART-100

2.2 Distribution of gas material in SIT building

There was a concern about the possibility of H_2 burn in the LCA region. Before the opening of the ADS (~10,196 s), the mole fraction of air was decreased and the mole fraction of steam was increased rapidly. Just after the opening of the ADS, most of the air was expelled from the SIT building and all the steam was rush into the SIT building due to the installation of the loop path to the IRWST through ECT-HX. Therefore, it may expect that the possibility of H_2 burn in the SIT building will be very low. Figure 2.3 showed the mole fraction changes of the H_2 gas in SIT room.

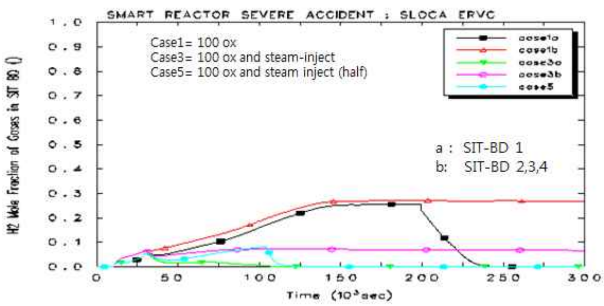

Fig. 2.3 Mole fraction of gas in SIT room

2.3 System Pressures

After SBLOCA occurs at 0.0 sec, the LCA pressure remains constant near 2.3 bar with the venting loop from SIT building to IRWST through ECT-HX. The actuation of the venting to RRT after 30 minutes after SAMG condition was effective to decrease the LCA pressure to the 1.7 bar. Thereafter, due to the ERVC, LCA pressure continues to decrease slowly. But finally the removed heat from external vessel head can heat up the coolant in the bottom of LCA region. It made the LCA pressure re-increase. The containment pressure did not show much change because ECT loop & IRWST and RRT were very effective to reduce the steam in the LCA region. Figure 2.4 showed the pressure change for the containment, IRWST, RRT and LCA, respectively.

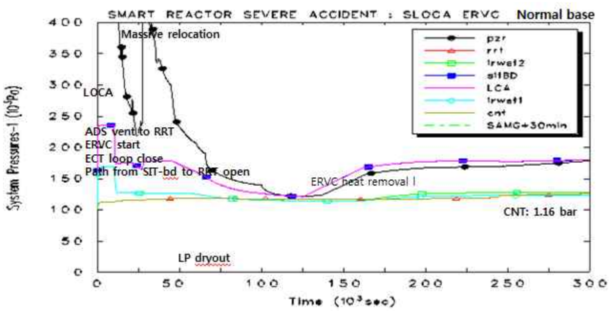

Fig. 2.4 Containment pressure change for LOCA

2.5 Summary of the LOCA accident progression

Table 2.1 is the summary table of LOCA accident events in SMART-100 .

Table 2.1 Summary table of SLOCA accident events

Events	SLOCA ERVC, 100% oxidation [sec]
LOCA by a break	0.0
R-X trip & MFW stop	0.0
If P_{LCA} >1.6 bar, SIT-BD vent to ECT	43.09
RCP trip	389.8
Start of core uncover	413.7
core dry-out	6769.1
Oxidation start	8800.0
SAMG Entry (Tcore-exit > 923.15 K)	**8396.6**
SAMG + 30minutes **ADS vent to RRT direct** **ECT loop close & CFS starts**	(8396.6+1800.0) = **10196.6**
Candling start	10196.9
Massive relocation of corium to Lower head	~25000/ ~100000
Reactor Vessel Failure by creep rupture	Not occur
MCCI start	NA
LP dry-out	62282.4

SAMG : core exit gas temperature: 923.15 K

3. Conclusions

It showed that the consideration of gap boiling under the condition of ERVC was very effective to reduce the H_2 concentration in LCA region for the 100% metal water reaction. All the H_2 mole fractions in LCA region are under 0.10. The strategy of external vessel cooling is essential to prevent the lower vessel head from failing.

REFERENCES

[1] Jong-Hwa Park, Sang-Ho Kim etc."Preliminary LOCA results from SMART-ppe with the ADS venting to IRWST through ECT system and RRT using MELCOR 1.8.6", Oct 2018, KNS autumn MT, Yeosu, Korea.