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Preliminary SBO results from SMART-ppe with the ADS Venting to IRWST through ECT system and RRT using MELCOR1.8.6

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1. Introduction

This paper shows the preliminary analysis results for the effect of the new ADS venting path from SIT building to the IRWST through ECT-HX (heat exchanger) on the containment pressure and the distribution of H_2 in SMART-ppe (365 Mwt) system. The simulation on SBO (station black out) has performed with MELCOR version 1.8.6 YT. It was assumed that SBO occurred at 0 second. Therefore the reactor, RCP and MFW trips were occured at 0 second. The analysis on the source term was not performed. The ERVC was not performed.

This calculation shows that the ADS discharge location from CPRSS to SIT and the installation of the venting loop to IRWST through ECT-HX made the possibility of H_2 burning in CPRSS and IRWST-1 remain at very low. This new venting loop made the maximum containment pressure remain at low level of 1.43 bar. But the possible hydrogen burn in upper containment area should be estimated more. The gas temperature in the SIT building after the lower vessel head failure was predicted so high (> 1600 K) that the boundary of CPRSS or the venting loop may fail.

2. Methods and Results

2.1 Backgrounds

In this study, the following modifications are proposed to enhance the level of safety on SMART-ppe [1]. The first one is the change of ADS venting loop from CPRSS to SIT space. The second one is the actuation signal of the ADS venting. The condition for the actuation signal was changed from the SAMG condition to the 30 minutes after SAMG condition.

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

But after the actuation condition reaches, the venting loop of ADS from the SIT building to the IRWST through the ECT-HX will change into other path. In this new other vent path, the vent to the RRT will be done. It assumed that the SAMG condition, means the core exit gas temperature of 923.15 K.

There are two IRWST and RRT. One is more lager than the other. The IRWST-1 has a large pool of 3677 m^3, The IRWST-2 has a small pool of 1843 m^3. The initial pool temperature was at 323 K. The 'pressure discharge line' is submerged to the pool from the top level of CPRSS (Lid). The hot steam and H_2 in the CPRSS design to discharge into the IRWST-1&2 through the 'pressure discharge line'.

The most of the steam passing through 'pressure discharge line' will be condensed in the pool of IRWST. The additional surviving steam will be removed from the RRT finally. The volume of RRT-1 is only 323 m^3. The small one is 181 m^3. The surface of pool in RRT were fully opened to the upper containment area. Figure 2.1 shows the conceptual view of the component volumes and the flow paths in SMART-ppe plant.

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The top of SIT building 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.

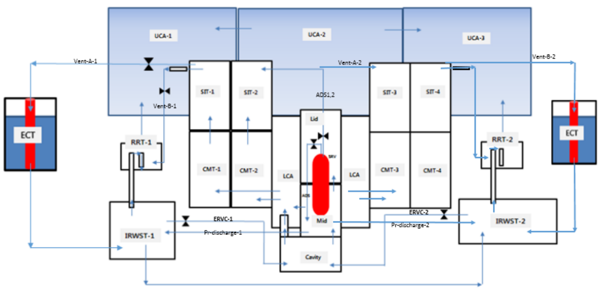

Figure 2.1 Conceptual view of the volumes and flow paths in SMART-ppe

The calculation was completed up to 300,000 seconds (about 3.47 days). The important issues in this study are the estimation of the distribution of H_2 over the SMART system, especially within the CPRSS or IRWST and the level of possible 'maximum containment pressure'[1].

2.2 Distributions of gas material in SIT building

There was a concern about the possibility of H_2 burn in the CPRSS. Before the opening of the ADS (~45,847 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 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.

But the ingression of high temperature of gas from CPRSS may cause a failure on the structures in the SIT building and the ECT-HX. Figure 2.2 showed the mole fractions of the gases such in SIT building.

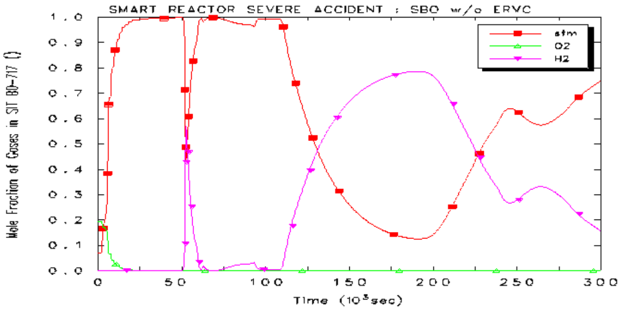

Fig. 2.2 Mole fraction of gas in CPRSS, SIT building

2.3 Containment (=UCA) Pressure

After the reactor lower vessel head fails, the containment pressure was continuously increased and it has reached near 1.43 bar at ~3.47 days. Consequently, the venting loop from SIT building to IRWST through ECT-HX and the RRT through SIT building were effective to reduce the steam content and pressure in the containment. Figure 2.3 showed the pressure change for the UCA, IRWST, RRT and LCA respectively.

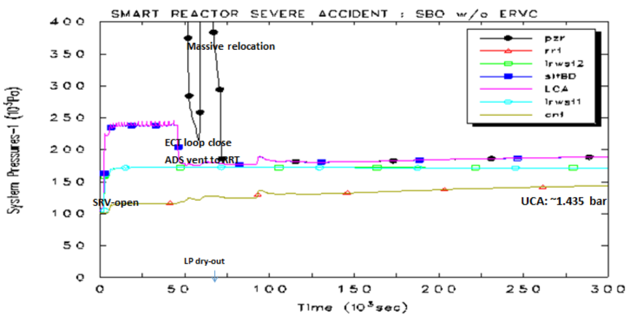

Fig. 2.3 Containment pressure change for SBO

2.4 Distribution of gas materials in IRWST & UCA

There was a concern about the possibility of H_2 burn in the IRWST. However, the installation of direct flow path from SIT building to RRT just after the opening of the ADS prevented H_2 gas from flowing into the IRWST.

Figure 2.4 showed the mole fractions for the gases such as air, H_2 and the steam in UCA.

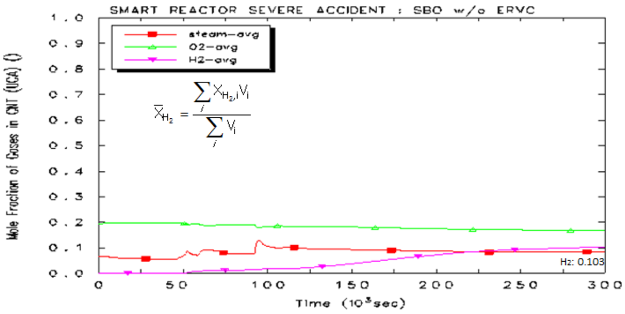

Fig. 2.4. Mole fraction of gas in UCA

2.5 Summary of the SBO accident progression

Table 2.5 is the summary table of SBO accident events in SMART-ppe.

Table 2.5 Summary table of SBO accident events

Events	Time [seconds]
SBO	0.0
Trip R-X & RCP & MFW	0.0
SRV start to open	2212.3
If P_{LCA} >1.6bar, SIT-BD vent to ECT loop	2369.0
Start of core uncover	32628.3
core dry-out	40665.9
* **Oxidation start**	44600.1
at SAMG + 30minutes, **ADS vent to RRT via SIT-BD close ECT loop & CFS starts**	(44098.6+1800.0) **= 45847.2**
Candling starts	51400.8
Massive corium relocation to Lower head	55000.0 ~ 60000.0
Lower Plenum dry-out	69277.9
Reactor Vessel Failure by creep rupture	92767.8
MCCI starts	92767.9

* : core exit gas temperature: 923.15 K

3. Conclusions

It showed that the venting loop of ADS before and after the 30 minutes from SAMG condition was effective to reduce the pressure level in CPRSS and containment. But the high gas temperature (>1000 K) in the CPRSS after the lower head creep failure may damage the boundary structure of CPRSS and the venting loop. The strategy of external vessel cooling is required to solve this issue.

ACKNOWLEDGEMENT

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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.