Preliminary SBO results from SMART-ppe with the Change of ADS discharge location and the Venting loop from SIT building to IRWST-2 using MELCOR1.8.6

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1. Introduction

This paper shows the preliminary analysis results for the effect of the discharge location of ADS and the venting loop from SIT building to the second IRWST (IRWST-2) through ECT-HX (heat exchanger) on the containment pressure and the distribution of H_2 in SMART-ppe (365 Mwt). The simulation on SBO has performed with MELCOR version 1.8.6 YT. The analysis on the source term was not performed.

This calculation shows that the change of ADS discharge location from IRWST-1 to CPRSS and the installation of the venting loop made the possibility of H_2 burning in CPRSS and IRWST-1 remain at very low. Although the H_2 burning was turned off, the inclusion of IRWST-2 will make the maximum containment pressure remain at low level of 1.3 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 fail was predicted so high (> 1500 K) that the boundary of CPRSS or the venting loop may fail.

2. Methods and Results

2.1 Backgrounds

In this study, three modifications are proposed to enhance the level of safety on SMART-ppe. The first one is the inclusion of IRWST-2 and the change of ADS discharge location from IRWST-1 to CPRSS space. The third one is the inclusion of the venting loop from the SIT building to the IRWST-2 through the ECT-HX. It assumed that the ADS and the venting loop between ECT-HX and IRWST-2 start to open at the SAMG entry condition, which means the core exit gas temperature of 923.15 K [1].

The IRWST-1 has a large pool of 3800 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 pass into the IRWST-1 through the 'pressure discharge line'.

The most of the steam passing through 'pressure discharge line' will be condensed in the pool of IRWST-1. The additional surviving steam will be removed from the IRWST-2 finally. The volume of IRWST-2 is only 150 m^3. The surface of pool in IRWST-2 was fully opened to the upper containment area. Figure 2.1 shows the conceptual view of the proposed modified PCCS system.

The modeling of the top structure (Lid) in CPRSS is to calculate heat convection with the upper containment space. The SIT and CMT spaces are considered as separate volume. 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.

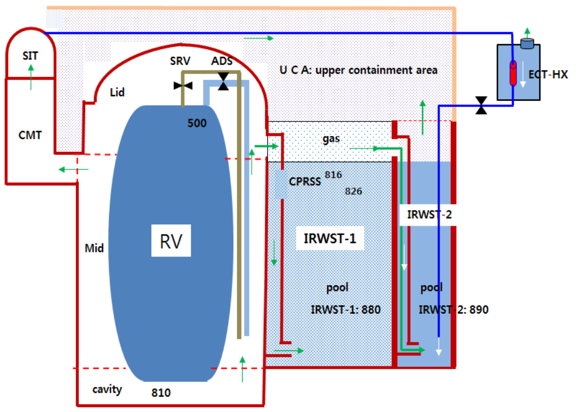

Figure 2.1 Conceptual view of PCCS system

The calculation was completed up to 200,000.0 seconds (more than 2.3 days). The important issues in this study are the possibility of H_2 burn in the SMART system, especially within the CPRSS or IRWST-1 and the level of possible 'maximum containment pressure'.

2.2 Distribution of gas material in CPRSS

There was a concern about the possibility of H_2 burn in the CPRSS. Before the opening of the ADS, the mole fraction of air was decreased and the mole fraction of steam was increased slowly. However, just after the opening of the ADS, most of the air was expelled to the IRWST-2 and all the steam was rush into the SIT building due to the installation of the loop path to the IRWST-2. Therefore, it may expect that the possibility of H_2 burn in the CPRSS will be very low.

But the ingression of high temperature of gas from CPRSS may cause a failure on the pipe lie between the SIT building and the ECT-HX. Figure 2.2 showed the mole fractions for the gases such as air, H_2 and the steam in SIT building.

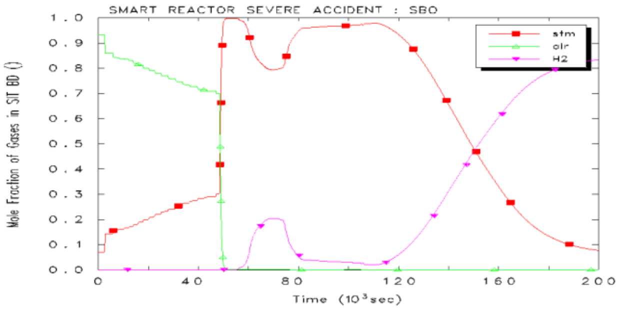

Fig. 2.2 Mole fraction of gas in CPRSS, SIT building

2.3 Containment Pressure

After the reactor lower vessel head fail at 104949 sec, the containment pressure has reached 1.3 bar at 2.3 days. Consequently, the inclusion of IRWST-2 and the loop from SIT building to IRWST-2 was very effective to reduce the steam content and pressure in the containment. Figure 2.3 showed the pressure change for the containment, IRWST-1,2 and CPRSS, respectively.

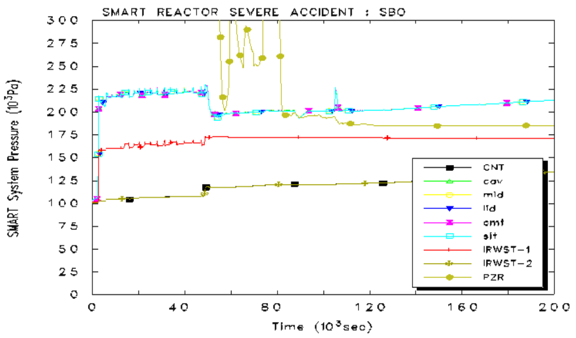

Fig. 2.3 Containment pressure change for SBO

2.4 Distribution of gas materials in IRWST-1

There was a concern about the possibility of H_2 burn in the IRWST-1. However, the installation of flow path from CPRSS to IRWST-2 just after the opening of the ADS prevented H_2 gas from flowing into the IRWST-1.

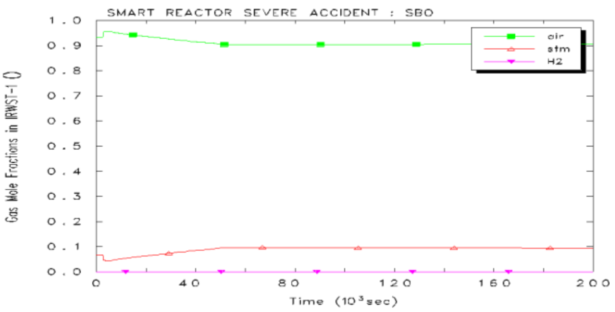

Fig. 2.4. Mole fraction of gas in IRWST-1

Therefore, concern about H_2 burn in IRWST-1 was cleared by changing the discharge location of ADS from IRWST-1 to CPRSS. Figure 2.4 showed the mole fractions for the gases such as air, H_2 and the steam in IRWST-1.

2.5 Summary of the SBO accident progression

Table 2.5 is the summary table of SBO accident events in SMART without considering the hydrogen burn in the containment.

Table 2.5 Summary table of SBO accident events

Events	Time [seconds]
SBO	0.0
R-X & RCP trip	0.0
MFW trip	0.0
SRV start to open	2482.5
Start of core uncover	2812.2
core dry-out	40022.8
ADS & ECT-HX Open at SAMG*	48495.8
Oxidation start	49900.0
Candling start	57293.2
LP dry-out	81336.3
Reactor Vessel Failure by creep rupture	104949.0
MCCI start	104949.0

* : core exit gas temperature: 923.15 K

3. Conclusions

The inclusion of IRWST-2 was very effective to reduce the steam content and the pressure in the containment.

The change of the discharge location of ADS from IRWST-1 to CPRSS and the venting loop from CPRSS to IRWST-2 through ECT-HX showed the complete depletion of air content from CPRSS. Also, it showed that the venting loop made the deprivation of the chance for entering the H_2 gas into IRWST-1. But the accumulated H_2 in the upper containment area can be burned at any times..

Although the heat losses from the CAP structure was considered in this study, the high gas temperature (>1500 K) in the CAP after reactor vessel lower head fails may damage the boundary structure of CPRSS and the venting loop..

REFERENCES

[1] Jong-Hwa Park, Sang-Ho Kim etc."Sensitivity Analysis of SBO in SMART-365 Mwt with CPRSS using MELCOR1.8.6", 2017 AMUG, Dae-jeon, Korea.