Hydrogen analysis using MELCOR at CANDU plant

Sungchu Song, Jaehong Park, Hanchul Kim
Korea Institute of Nuclear safety, 34 Gwahak-ro, Yuseong-gu, Daejeon, Republic of Korea,305-338
**Corresponding author:scsong@kins.re.kr*

1. Introduction

As a part of a submitted Wolsong Severe Accident Management Plan(SAMP) at the end of 2009, KINS needs to the review of it.[1,2,3] In this the focus is on the hydrogen behavior during the station blackout(SBO) because the hydrogen explosion during severe accident in CANDU plants such as Wolsong units has been safety issue. A SBO occurs with failure of the emergency power system when loss of class IV electric power happens because the loss of class IV power is the most dominant internal event causing core damage for Wolsong units[4]. And following a SBO event, most of the engineered safety features(ESFs), including hydrogen igniters, are inoperable except the passive systems such as Dousing systems. Hydrogen is generated due to Zr-steam reaction in fuel channels and core debris oxidation in the suspended debris beds, jet breakup of molten debris in the water pool of the reactor vault and molten core-concrete interaction (MCCI). A combustible gas control system consisting of Passive Autocatalytic Recombiner(PAR) is currently installed at Wolsong unit 1. The results of MELCOR analysis are presented.

2. Methods and Results

In this section some of the assumption, condition and input description for MELCOR code calculation are described[5]. The MELCOR analysis developed and optimized the containment model for Wolsong Unit 1.

2.1 Input Description

This analysis used the MELCOR 1.86YV3084 version. The MELCOR code is used to analyze containment behavior following the released rates of steam, water and hydrogen at SBO condition. A detailed nodalization of 51 control volumes, 102 flow paths and 254 heat structures is constructed as shown in figure 1. This nodalization is appropriate for thermo-hydraulic variables predicted for each distinct containment room.

The input data files described in this paper provided simplified representations of the geometric layout of the reactor building (volumes, dimensions, flow paths, doors, panels, etc) and performance characteristics of the various containment subsystems.[3,4,6] The analysis values are determined by conservatism depending on the analysis objective and may be different for various analysis objectives. That is, a conservative assumption for one objective may not necessarily be conservative for the other objectives.[6]

The input that developed and optimized of the containment model for MELCOR analysis is used. The PAR model is included that is 6 EA for DBA and 21 EA for severe accident[1]. In addition, large control volumes are divided and dead-end compartments is merged. The heat structure was added and modified specifically. Similar results analyzed by ISSAC code have been obtained by the MELCOR analysis of the containment[7]. It is applicable to analyze hydrogen behavior of CANDU plant.

Because Calandria can be simulated in this code, the discharge rate of heavy water, steam and hydrogen are used as input of MELCOR. From these the movement, distribution and combustion states of combustible gas, hydrogen, are analyzed.

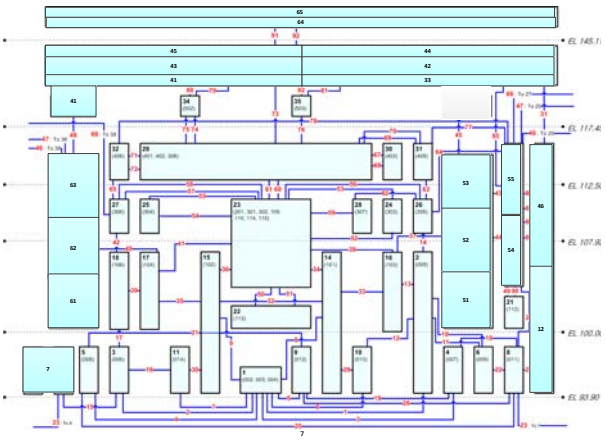

Fig. 1. Node configuration of Wolsong units containment

2.2 PAR Model

As the input description 2.1, PAR model is installed in this analysis. The hydrogen removal rate of PAR is different by suppliers. In this PAR model the NUKEM's PAR model that is most conservative large PAR model is used.

2.3 Analysis Results

For this analysis, the hydrogen concentration and the removal amount of steam generate room with and without PAR are shown in figure 2 and figure 3.

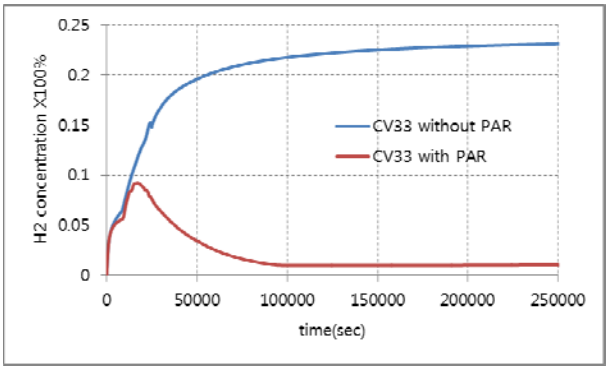

Fig. 2. The Hydrogen concentration at the steam generator room with and without PAR

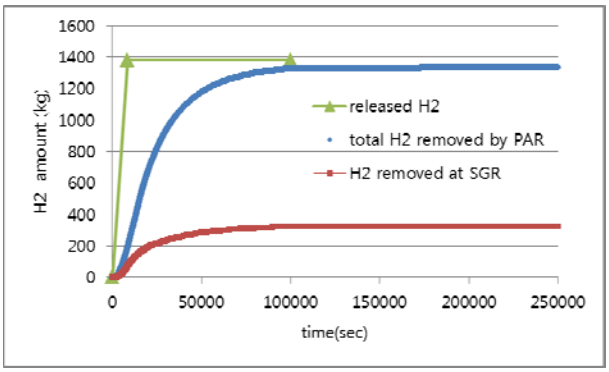

Fig. 3. The trend of hydrogen removal amount in containment

The Hydrogen concentration with PAR installed is maintained below 10% as shown in figure2. The hydrogen discharged into the boiler room has been almost removed in the long-term and the removed hydrogen at the boiler room is also presented in the figure 3.

3. Conclusions

Hydrogen behavior with PAR and without PAR during a station blackout at Wolsong unit1 was simply analyzed using MELCOR code. Hydrogen concentration in the containment could be controlled by passive systems. After this study the flame acceleration and deflagration-to-detonation transition analysis would be performed. These analyses give us insights on the need of measures to control hydrogen concentration following a severe accident.

REFERENCES

[1] 월성 1 호기 최종안전성분석보고서, 6.2.5 절, "격납건물내 가연성기체제어," 한국수력원자력주식회사.
[2] 가압중수형 원전 계속운전 심사지침서(Review Guidelines for Continued Operation of PHWR Plants), 한국원자력안전기술원, 2007, 12.
[3] 월성 1 호기 가연성기체 제어설비 설계 및 연소안전성 평가, 한국수력원자력주식회사, 2010.6.
[4] 월성 1 호기 확률론적안전성평가(PSA) 보고서, 한국수력원자력주식회사, 2007.
[5] R.O. Gauntt, et al., "MELCOR Computer Code Manuals," NUREG/CR-6119, SAND 2000-2417/1, vol. 1, Rev. 2, May, 2000.
[6] Analysis Report "Containment Models Wolsong NPP 2,3,4," 86-03500-AR-006, Rev. 2, 1997, May.
[7] ICAPP'10, "Hydrogen behavior following a station blackout at Wolsong units 1~4," 2010, June.