Transaction of the Korean Nuclear Society Autumn Meeting
PyeongChang, Korea, October 30-31, 2008

Characteristics of an ECC Injection Type

Tae-Soon Kwon, Chul-Hwa Song
KAERI, 150 Duckjin-Dong, Yuseong-Ku, Daejeon, tskwon@kaeri.re.kr

1. Introduction

APR1400 is equipped with a direct vessel injection system as an emergency core cooling system, however, some performance improvement is required such as direct ECC bypass, etc. The objective of the present research is to evaluate the performance difference due to an ECC injection type when compared to the CLI system or DVI system. The combined ECC injection of CLI with DVI is also compared the performances with those of the original DVI design features. In the combined ECC injection, the safety injection tank water is supplied to a cold leg injection nozzle while the HPSI water is injected to the DVI nozzle which is attached on the reactor vessel wall. The effect of an ECC injection elevation is also compared with those of the APR1400's DVI design features. For this simulation, both the LBLOCA and the DVI line break accident are simulated to quantify the performance of the peak cladding temperature, downcomer water level, and subcooling degree at the lower downcomer.

2. LOCA Simulation

The MARS code simulation with the APR1400's DVI features were performed as a reference case for both LBLOCA and DVI line break accident. A separate performance tests were performed for the DVI system and the CLI system applying the same thermal hydraulic conditions. For this comparison, the design feature of the direct vessel injection (DVI) system of the APR1400 does not change the configuration of DVI arrangement and its design capacity. The ECC injection locations are considered DVI and CLI separately. For the low DVI case, the elevations of the DVI nozzles are shifted to the lower downcomer region which is low below the center line of the cold leg or hot leg.

The characteristics of the thermal hydraulics with an injection types are summarized in Tables 1 to 3.

3. Results

3.1 CLI vs. DVI

The core cladding temperature behaviors for both the DVI and CLI injections are shown in Fig. 1. The ECC capacities of the flow rate, temperature, and pressure are not changed. For the CLI injection, the core temperature is raised sharply after 400 sec. The collapsed downcomer water level, as shown in Fig.2, is also decreased sharply after the SIT empty during the LBLOCA transient. The cooling efficiency of the DVI system is better than that of the CLI system for the LBLOCA if the ECC system has the same SIT liquid volume and the HPSI flow rate.

Table 1 T/H differences between CLI and DVI

	CLI	DVI
ECC Spillage	Loss of 1-SIT & 1-HPSI	No Loss
Steam Condensation	Strong in cold leg between ECC water and steam	Downcomer ; Condensation by ECC film
D/C Entrainment	SIT injection period; Weak condensation at CL HPSI Inj. Period; weak condensation	Dowoncomer; Strong bypass by cross steam flow

Table 2 characteristics of combined ECC injection

	CLI	DVI	Combined
HPSI	CL	DVI	DVI
SIT	CL	DVI	CL

Table 3 T/H differences between CLI and DVI

	Combined Injection (DVI+CLI)	DVI
ECC Spillage	Loss of 1-SIT	No Loss
Steam Condensation	Strong in cold leg by SIT	Downcomer ; Condensation by ECC film
D/C Entrainment	SIT injection period; Weaken condensation at CL	Dowoncomer; Strong bypass by cross flow

3.2 Combined Injection vs. DVI

The core cladding temperature for the combined ECC injection is shown in Fig. 3. The overall cladding temperature behaviors are not different. The effect of the SIT injection during the blowdown phase of a LBLOCA is not different between the CLI and DVI injections including the combined injection of SIT and DVI.

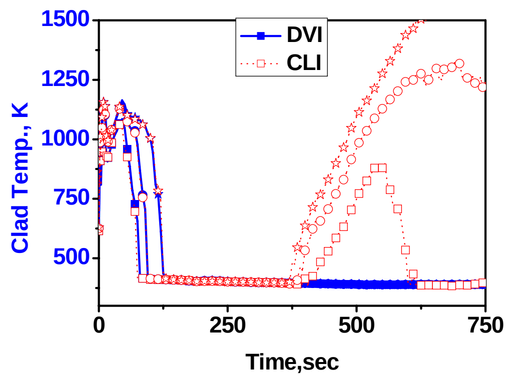

Fig. 1 Peak cladding temperature : DVI vs. CLI

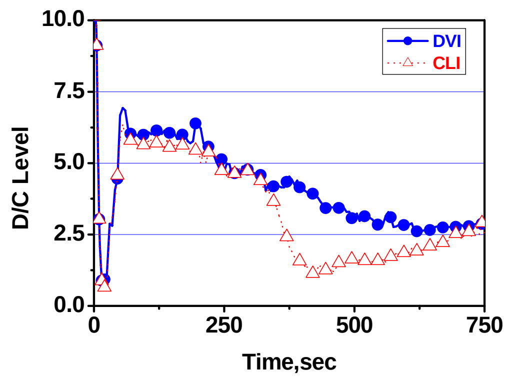

Fig. 2 Downcomer level

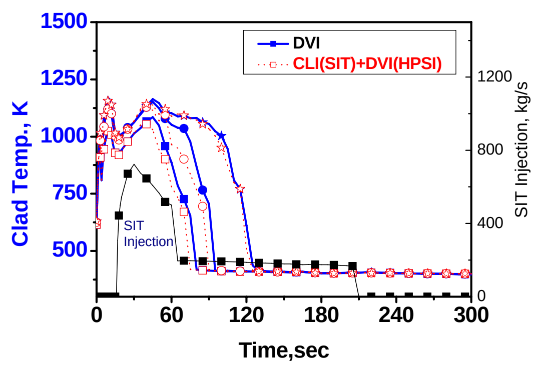

Fig. 3 Cladding temperature for combined injection

3.3 DVI Elevation Effects

The core cladding temperature behaviors of a DVI line break accident with a low level DVI injection are shown in Fig. 4. The cladding temperature is bursting over the LOCA design limit because the downcomer collapsed water level is abruptly decreased by the strong suction force of the DVI line break at the lower downcomer. Therefore, the downcomer water level is much lower that that of the current APR1400's DVI elevation as shown in Fig.5. The low level DVI injection system is not applicable as a LOCA safety system during the DVI line break though the ECC bypass happen to be decreased during a LBLOCA.

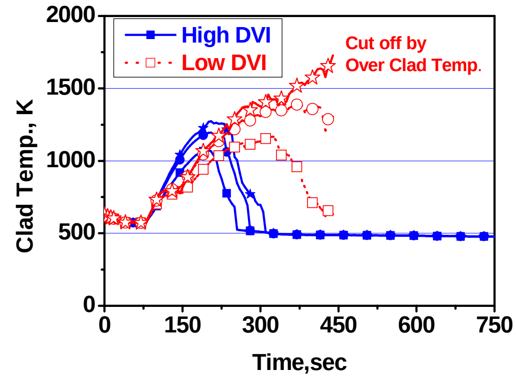

Fig. 4 Cladding Temperature for low DVI elevation

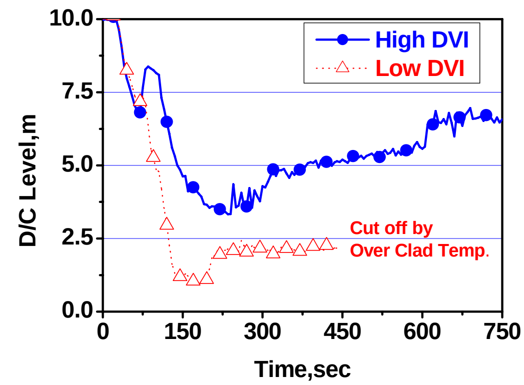

Fig. 5 Downcomer level for low DVI elevation

4. Conclusion

To quantify the performance of an ECC system, several design features such as an injection location and elevation are compared to the reference case of the APR1400. The DVI injection system is more effective than that of the CLI ECC system. The combined ECC injection system has nearly the same cooling capabilities when compared to the DVI injection system. The low level DVI system is not applicable for the DVI line break accident because the downcomer collapsed water level becomes abruptly low.

REFERENCES

[1] Hyun-Sik Park, Dong-Jin Euh, Ki-Yong Choi, Tae-Soon Kwon, and Won-Pil Baek, "An Assessment of a LBLOCA Similarity for a Reduced-Height Integral Effect Test Loop Design for PWRs," *Annals of Nuclear Energy*, Vol. 34, pp.931-937, 2007.