Transactions of the Korean Nuclear Society Spring Meeting
Gwangju, Korea, May 30-31, 2013

MELCOR Simulation of Direct Depressurization Strategy for Total Loss of Feed Water Accident

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1. Introduction

The depressurization strategy of reactor coolant system (RCS) is very important for mitigating the severe accidents of high pressure sequences. There are two ways to achieve this goal: first, indirect depressurization by using secondary side (i.e., feed and bleed strategy) and second, by using safety depressurization system (SDS) to directly depressurize RCS.

Total loss of feed water (TLOFW) accident, which is dominant event among severe accidents of OPR1000, cannot be mitigated by using the secondary side feed and bleed strategy because there is no feed water. Therefore, RCS should be directly depressurized by using SDS. In this research, different opening number of valves and opening times are chosen for accident scenarios, and PSA 2 level code, MELCOR version 1.8.6, is used.

2. MELCOR Modeling and Accident Scenarios

2.1 MELCOR Modeling

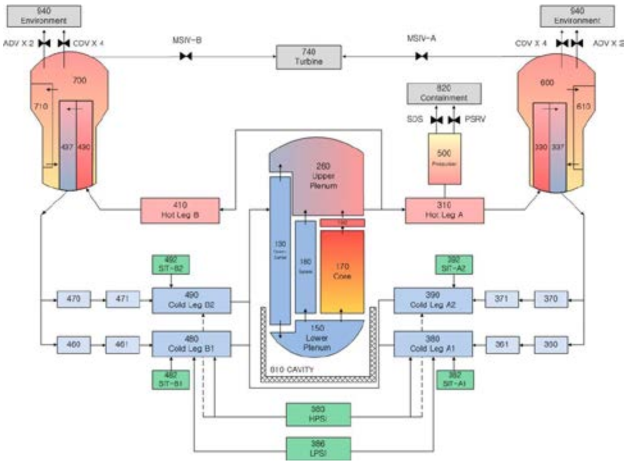

Fig 1. MELCOR Nodalization of OPR1000

MELCOR nodalization of OPR1000 is shown in Fig. 1. There are two hot legs, four cold legs, auxiliary feed water, steam generators (SGs), various safety injection systems, valves, and etc. are modeled. The accident starts at 0sec with not using of main feed water (MFW), and the calculation time is set up to 40,000sec.

2.2 Accident Scenarios

TLOFW accident proceeds as follow: first, water level of the secondary system of SGs decreases continuously to drying up, and the reactor and the RCS are tripped because of low water level of SGs and low sub-cooling margin of coolant, respectively. In addition, the temperature and the pressure of the RCS will increase because the decay heat of the core cannot be eliminated effectively due to the low level of the secondary side of SGs. The safety relief valves (SRVs) of SGs control the pressure of the secondary side. When the pressure of the RCS increases continuously and reaches to 17.2MPa, the SRVs are opened and the pressure decreases. After that, the repetition of opening and closing of SRVs continues between the opening pressure (17.2MPa) and closing pressure (14.1MPa) of the SRV.

In this simulation, four scenarios are postulated: opening one or two safety depressurization valve (SDV) 10 or 30 minutes after opening time of SRV. The times of the relocation to the lower plenum, reactor vessel failure, and the injection of the safety injection tank (SIT) are recorded. The time of reactor vessel failure is chosen faster one between creep-rupture and penetration.

3. Result

Table 1 shows SDS opening time due to the first opening time of SRV. Table 2 shows times of start of the relocation, reactor vessel failure and SIT injection of cases. Fig. 2, Fig. 3 and Fig. 4 show water level change in the core, pressure change in the reactor vessel and the relocated mass in the lower plenum, respectively.

Table 1. Opening time of SDV

	First Opening of SRV	SDV Opening
Base Case	1,432s	-
10m after SRV opened		2,032s
30m after SRV opened		3,232s

In base case there was no injection of the SIT, and the reactor vessel failure occurs at 7,610sec. The relocation of the core materials to the lower plenum starts earlier in case of opening both SDVs than opening only one SDV. However, the reactor vessel failure occurs slower when opening time of SDV is earlier, regardless of opening number of valves.

The water level of reactor vessel starts to decrease earlier when opening time of SDV is earlier, no matter how many valves are opened. Similarly, the pressure of reactor vessel begins to decrease earlier when opening time of SDV is earlier.

Table 2. Summary of simulation results

	Start of Relocation	Reactor Vessel Failure	SIT Injection
Base Case	5,135s	7,610s	-
SDS1-10m	4,645s	13,125s	13,139s
SDS1-30m	4,291s	12,008s	12,018s
SDS2-10m	4,104s	14,770s	13,577s
SDS2-30m	4,195s	10,836s	10,872s

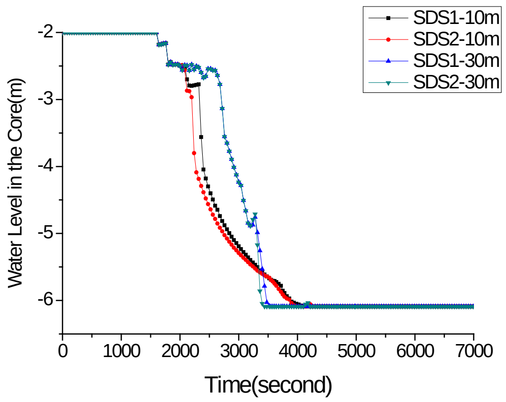

Fig. 2. Water level change in the core.

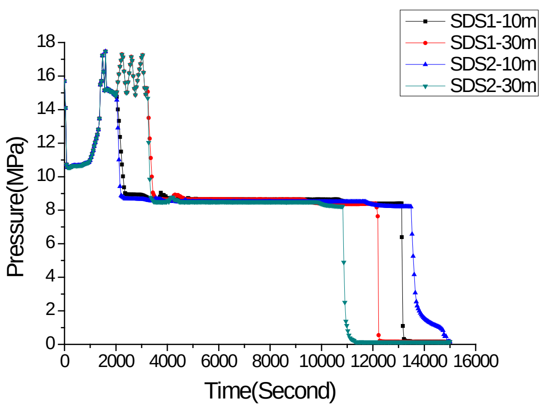

Fig. 3. Pressure change in the reactor vessel

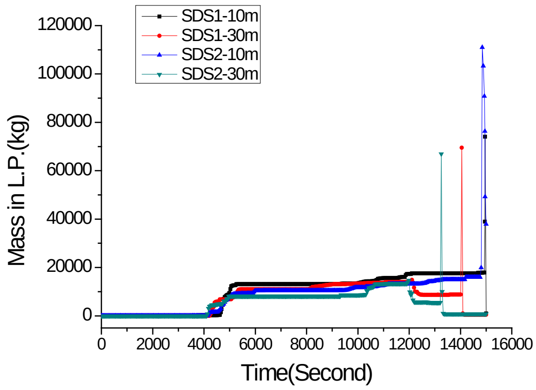

Fig. 4. Relocated mass in the lower plenum

4. Conclusion

The result of simulation of MELCOR for TLOFW accident shows that in order to delay the time of the reactor vessel failure time, opening the SDS early is more effective than increasing the opening number of the valve. However, sensitivity analysis on the opening time of the SDV and analysis on the rate of flow out of SDV and its effect are needed in the next research.

Acknowledgement

This work was supported by the Nuclear R&D Program of Ministry of Education, Science, and Technology (MEST) with grant number, 2012M2A8A4025887.

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